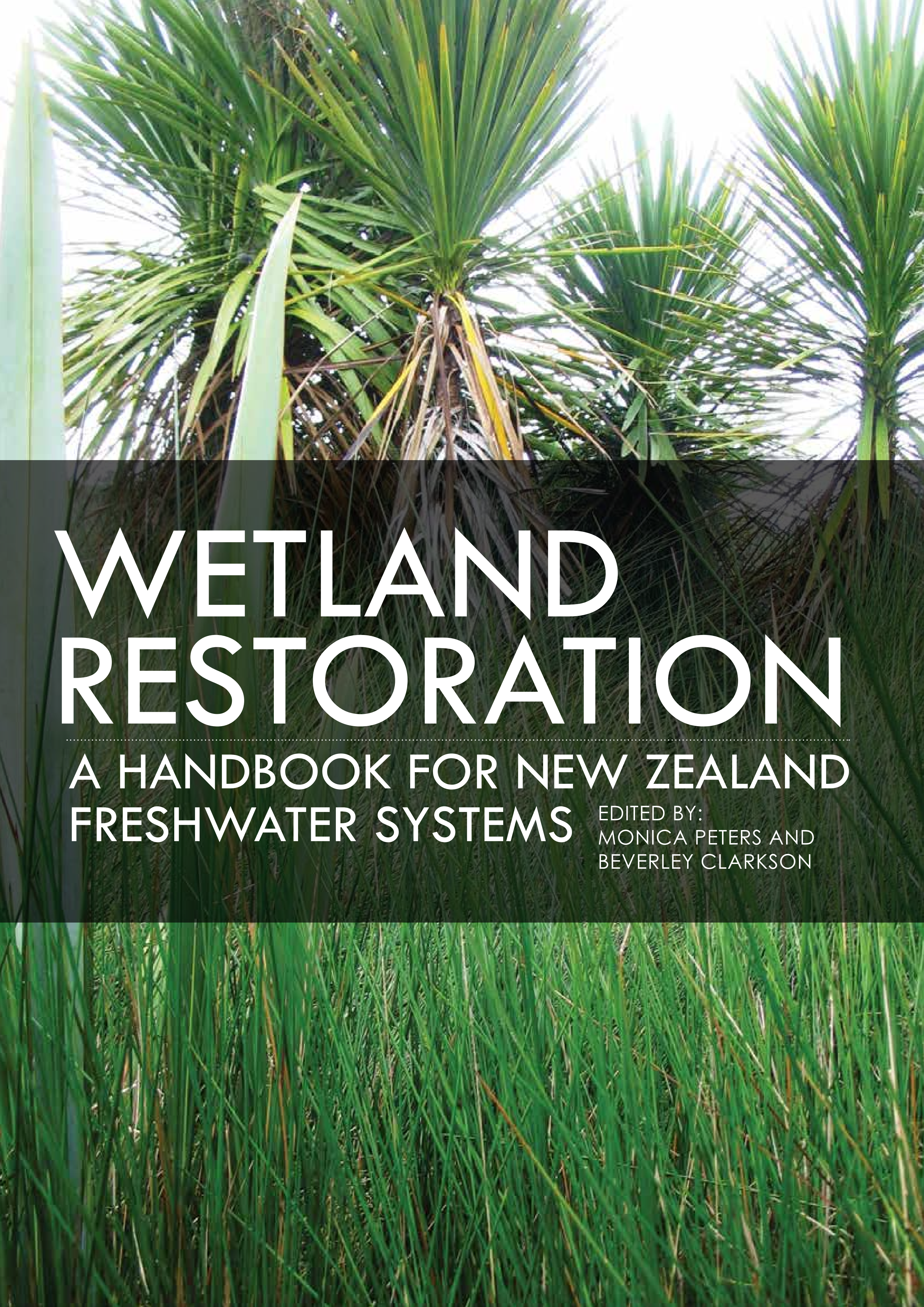

WETLAND RESTORATION

A HANDBOOK FOR NEW ZEALAND FRESHWATER SYSTEMS

EDITED BY:
MONICA PETERS AND
BEVERLEY CLARKSON

WETLAND LOSS COUNTRYWIDE OVER THE LAST 150 YEARS IS CALCULATED AT A STAGGERING 90%. MOST OF OUR MAJOR CITIES ARE BUILT ON WETLANDS – ESTUARIES HAVE BEEN RECLAIMED AND INLAND AREAS HEAVILY DRAINED TO SUPPORT A GROWING, LAND-HUNGRY POPULATION.

WETLAND LOSS CONTINUES TODAY. HOWEVER, FORWARD-THINKING INDIVIDUALS, COMMUNITY GROUPS, SCHOOLS, AGENCY LAND MANAGERS, NON-GOVERNMENT ORGANISATIONS AND ECOLOGISTS, ARE RESTORING WETLANDS FROM NORTHLAND TO SOUTHLAND. THE OBJECTIVES VARY WIDELY BETWEEN PROJECTS BUT THE OVERALL GOAL IS CLEAR: TO RETURN DEGRADED WETLANDS BACK TO WHAT THEY ONCE WERE – HEALTHY, LIVING ECOSYSTEMS. WETLAND RESTORATION: A HANDBOOK FOR NEW ZEALAND FRESHWATER SYSTEMS IS DESIGNED TO HELP ACHIEVE THIS GOAL.

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Cover image: Lake Cameron restoration project, Waikato. Photo: Monica Peters, NZ Landcare Trust

Wetland Restoration

A Handbook for New Zealand Freshwater Systems

Edited by

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Manaaki Whenua PRESS

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FOREWORD

RUUD KLEINPASTE AND TONY ROXBURGH

With a mere 10% of our original wetlands left, New Zealand is an unenviable world leader in wetland loss. We know that changing attitudes and land-use practices developed over several generations can be challenging, particularly if there is no clear path to the outcome desired or examples to follow. Further, change inevitably requires new skills, knowledge, and time to learn and apply that knowledge. Thankfully our attitudes have begun to change and we now understand that wetlands, those small springs, soaks, swamps, and the margins of rivers and streams and lakes, are nature's tools for maintaining water tables, filtering and recycling waste, pollutants, nutrients and sediment washed from the land. In spite of this, the majority of wetland remnants are highly degraded and the unique biota dependent on these ecosystems is under threat.

Wetland Restoration: A Handbook for New Zealand Freshwater Systems brings together expertise from specialists and groups actively engaged in restoring wetlands throughout the country. The Handbook builds on regionally based restoration guides and provides a detailed, comprehensive ecosystem approach towards understanding, protecting and enhancing our remaining wetlands. It is targeted at those who plan to, and those who already are making a difference to improving wetlands, and is written in a way that can easily be understood and, importantly, acted on.

The results, showcased using a diverse range of case studies, speak for themselves. The numbers of individual landowners, interest and conservation groups now restoring wetlands to capitalise on their natural attributes and applying more sustainable land-use practices are increasing. Now that we understand what we have lost, and what we can gain, perhaps New Zealand can become a world leader in wetland restoration. What is being achieved speaks well not only for the future of wetlands but also for the whole country as international pressures associated with climate change, reducing green house gases and conserving indigenous biodiversity drive change towards environmental improvement.

Ruud Kleinpaste
Patron, National Wetland Trust

A J Roxburgh
Chairperson, National Wetland Trust

WETLAND TRUST
NATIONAL WETLAND TRUST OF NEW ZEALAND
www.wetlandtrust.org.nz

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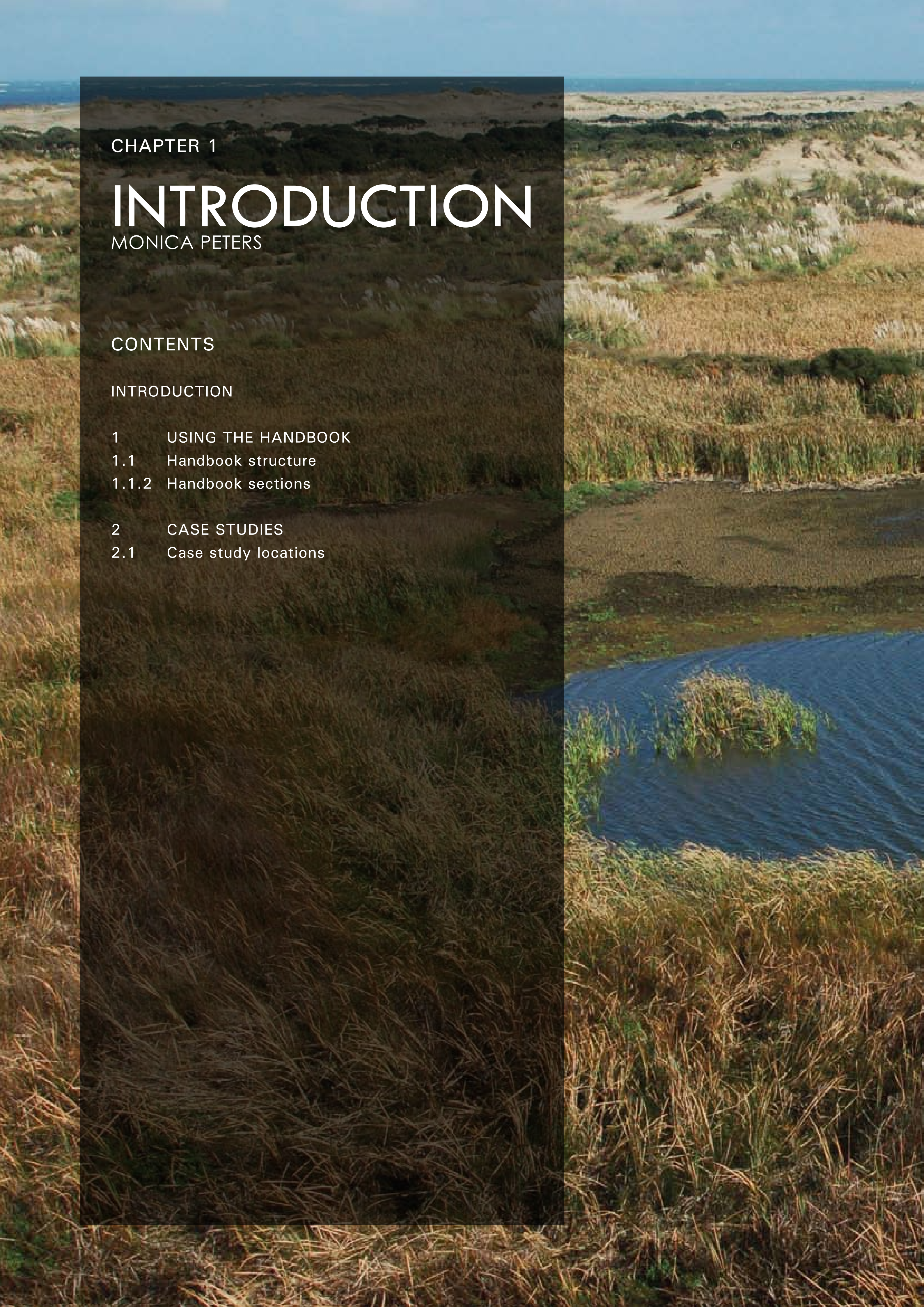

CHAPTER 1

INTRODUCTION

MONICA PETERS

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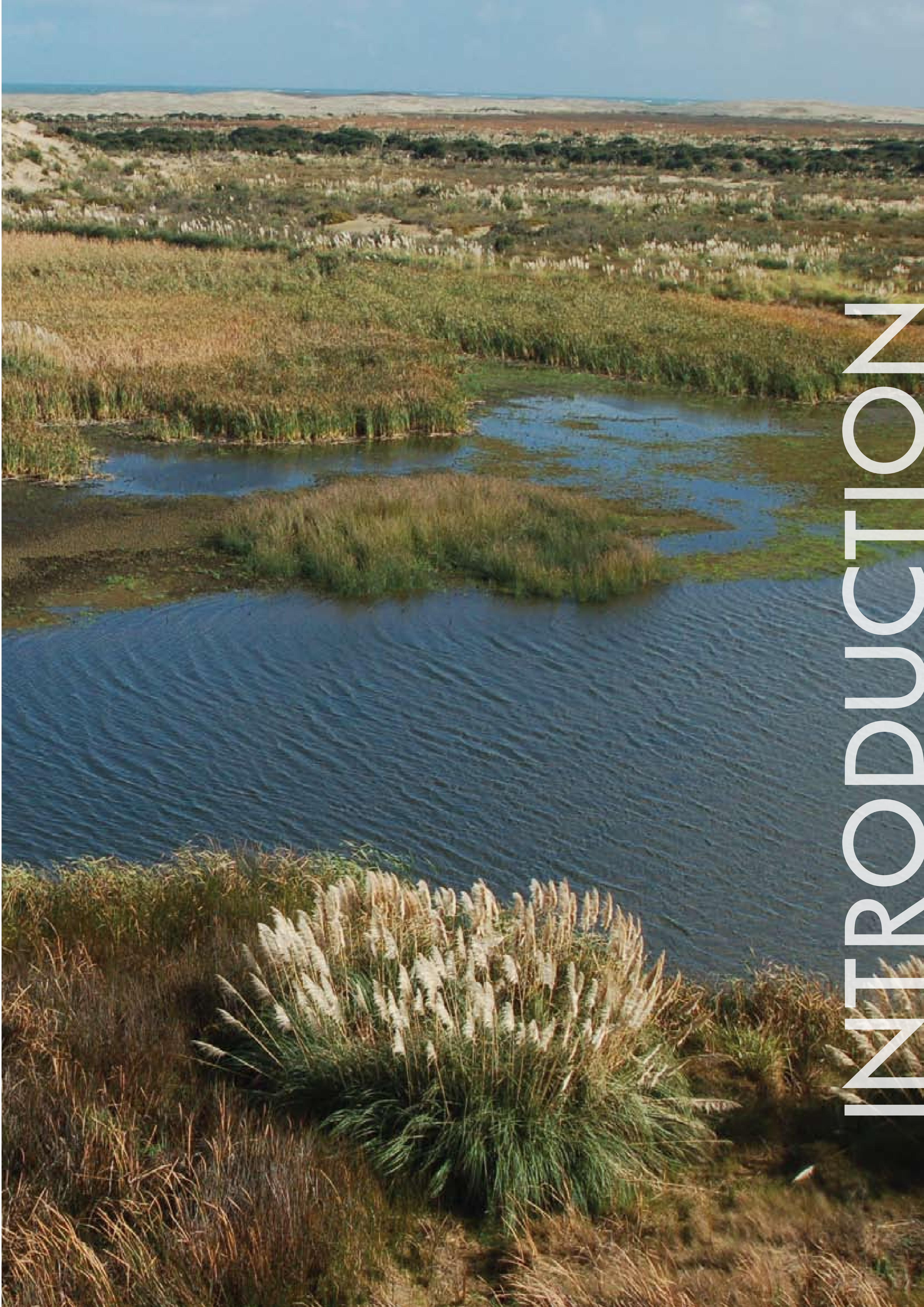
INTRODUCTION



INTRODUCTION

MONICA PETERS

A wetland is literally a "wet" land where surface water collects or where underground water seeps through to the surface. The term "wetland" is used broadly and covers an extremely diverse range of environments including swamps, bogs, salt marshes, lakes and some river edges. The Resource Management Act (1991) definition of a wetland is broad and includes permanently or intermittently wet areas, shallow water, and land water margins that support a natural ecosystem of plants and animals that are adapted to wet conditions.

Wetland loss country-wide over the last 150 years is calculated at a staggering 90%. Most of our major cities are built on wetlands – estuaries have been reclaimed and inland areas heavily drained to support a growing, land-hungry population. Wetland loss still continues today despite a greater acknowledgement and understanding of the important ecosystem services they provide along with their economic, cultural, environmental and recreational values. To address this loss, restoration projects are underway from Northland to Southland, spearheaded by forward-thinking individuals, community groups, schools, agency land managers, iwi, non-government organisations and ecologists. The objectives vary between projects but the overall goal is clear: to return degraded wetlands back to what they once were – healthy, living ecosystems. Wetland Restoration: A Handbook for New Zealand Freshwater Systems is designed to help achieve this goal.

Previous page: Lake Matthews, Northland.
Photo: Danny Thornburrow, Landcare Research

In as little as 150 years, 90% of our wetlands have been destroyed – primarily drained to create farmland, towns and cities.
Photo: Abby Davidson, NZ Landcare Trust

Many of the species associated with New Zealand wetlands are both unique and highly threatened. Canterbury mudfish.
Photo: Sjaan Charteris. Crown Copyright, Department of Conservation

With one of the highest rates of wetland loss in the world, conserving what remains is critical. Whatipu, Auckland.
Photo: Monica Peters, NZ Landcare Trust

1 Using the handbook

The Handbook describes how to restore ecosystem function in naturally occurring wetlands for long-term sustainable outcomes. Not included are the restoration of estuarine environments (such as salt marshes) and the development of constructed wetlands (such as duck ponds and sewerage treatment wetlands).

Although a range of valuable wetland restoration guides and fact sheets have been produced in different regions (e.g., Northland, Auckland, Waikato, Bay of Plenty, Wellington and Southland), the difference between these and the Handbook lies in the level of detail. Wetland Restoration: A Handbook for New Zealand Freshwater Systems is comprehensive and will help guide new projects as well as provide additional useful information for projects already under way.

1.2 Handbook structure

The Handbook is divided into three sections to highlight the key phases of restoring a wetland. Individual chapters in each section cover a key aspect of restoration from planning, to implementation, to monitoring and protecting the restored wetland. Case studies are presented throughout and provide practical examples of the main principles covered in each of the chapters. References and further reading, along with useful websites are included at the end of each chapter.

A CD inside the back cover contains a PDF of all text references and weblinks used within the Handbook.

YOU DON'T HAVE TO BE AN EXPERT!

"Many landowners may be hesitant about embarking upon a restoration and management programme, fearing that an in-depth knowledge of botany and ecology is required. While people with this knowledge will have a head start, it is not a prerequisite for good management. Local knowledge, a keen eye for detail, talking to others involved in managing similar areas, and commitment are the most important requirements."

– Tim Porteous, Native Forest Restoration, 1993

1.1.2 Handbook sections

SECTION ONE

BEGINNING A WETLAND RESTORATION PROJECT

Learn how to:

- determine which type of wetland or wetlands you have
- plan your restoration effectively from the start
- set achievable goals and objectives
- carry out various investigations to learn more about your restoration site

Extensive networks of drains were hand dug in the Waikato, turning swampland into productive pastures. Photo: Waipa District Council

SECTION TWO

ACTION ON THE GROUND

Learn about the:

- basic principles of wetland hydrology, how to carry out basic modifications to benefit your restoration site and how to monitor the results
- role of nutrients in wetland restoration and how to manage and monitor nutrient levels
- key threats weeds pose to wetlands, control methods and how to monitor the results of weed control
- basic principles of planning and carrying out wetland revegetation using native plants and how to monitor plant establishment
- key threats pests pose to wetlands, control methods and how to monitor changes in pest species populations
- basic principles of creating the right habitat to encourage the return of native fauna/prepare for species translocations, and how to monitor changes in native fauna populations

SECTION THREE

MEASURING RESULTS & WETLAND PROTECTION

Learn how to:

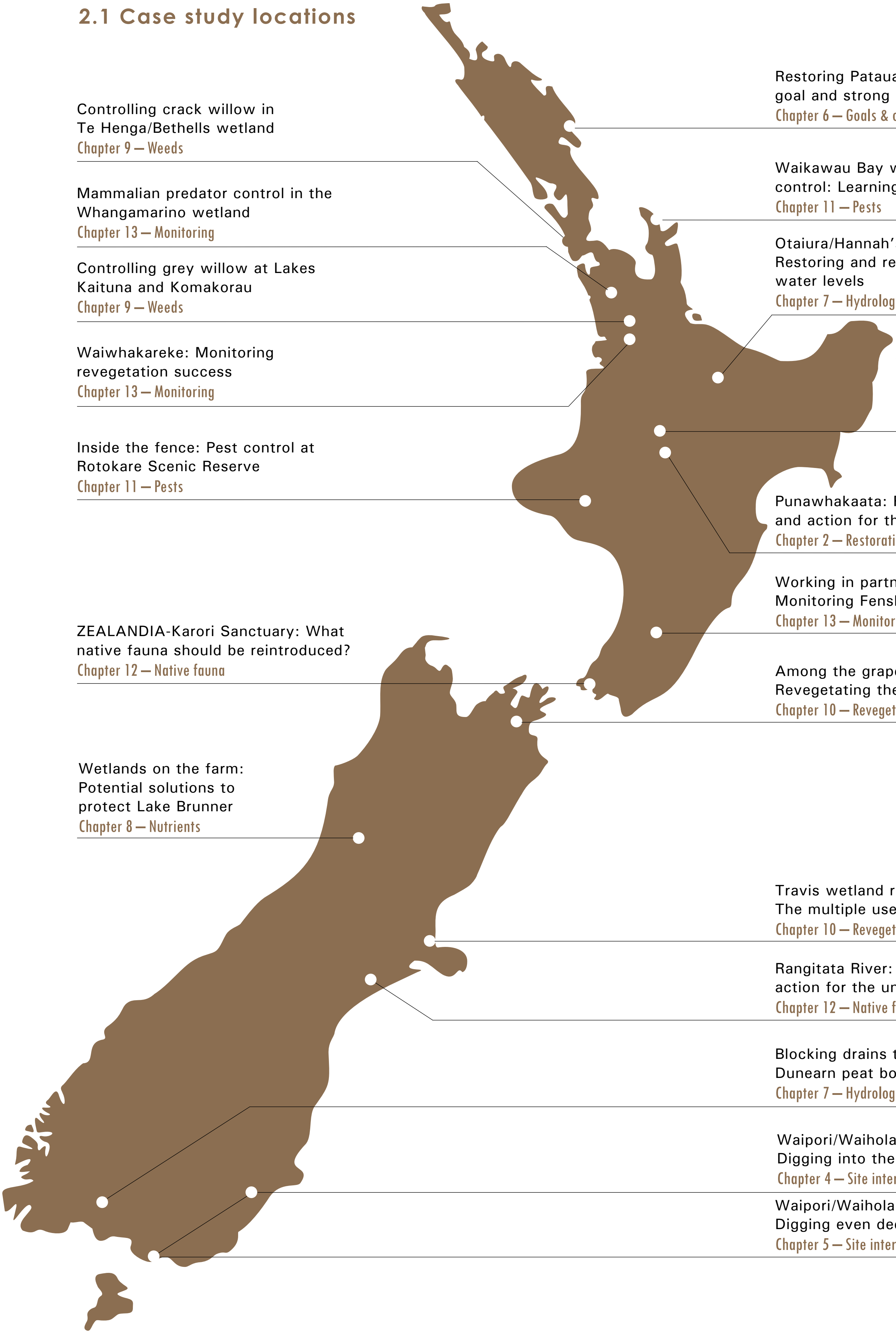
- collate the monitoring results from Action on the ground chapters in order to monitor key changes in wetland condition
- choose and use the mechanisms available to protect your wetland restoration project

2 CASE STUDIES

Stories about our relationship to the land form part of our culture and identity. The case studies featured throughout the Handbook provide insights into wetland restoration. From Northland to Southland, farmers, scientists, iwi, community and agency groups share their valuable experiences of turning wasteland back to wetland. Some of the projects featured are large and will continue for decades, while others are much smaller, achieving their main goals in just a few years. Each case study is a short story about how a technical aspect of restoring a freshwater wetland has been translated into practical action.

Kaumatua George Flavell (Ngati Te Ata) shares his knowledge of the rich pre-colonial history of the once extensive wetlands around Lake Kohekohe and the surrounding landscape. Awhitu, Auckland.
Photo: Anna White, Awhitu Peninsular Landcare Incorporated

2.1 Case study locations



CHAPTER 2

RESTORATION PLANNING

MONICA PETERS

CONTENTS

RESTORATION PLANNING

RESTORATION PLANNING

MONICA PETERS

Several hundred wetland restoration projects are currently underway around New Zealand. Projects cover the full spectrum – from large-scale, multi-wetland initiatives such as the Department of Conservation's Arawai Kakariki programme, to small-scale projects on private land undertaken by community groups and individual landowners. All wetland restoration projects whether large (and involving many stakeholders) or small (and involving a single family) call for good planning.

This chapter briefly outlines what a Wetland Restoration Plan is, and what it should include. To meet ecological restoration goals many projects typically require a range of expertise, hence providing a list of useful agencies and organisations. Key lessons learned by community groups around New Zealand involved in restoring wetlands are also included, given their substantial experience in on-ground works such as volunteer management, sourcing funding, weed and pest control, native plant growing, revegetation and plant releasing. A case study on the Punawhakaata wetland (Taupo) highlights that to achieve significant goals many different people must come together, and that for planning purposes, it can be a lengthy process to find common ground.

Previous page: Waikato Institute of Technology students and the NZ Landcare Trust discussing the planting programme at Lake Serpentine, Waikato.
Photo: Abby Davidson, NZ Landcare Trust

Core samples tell a story: Keith Thompson, a Waikato-based wetland ecologist, explains the development of the Ramsar listed Kopuatai peat dome on World Wetlands Day, 2006. Photo: Monica Peters, NZ Landcare Trust

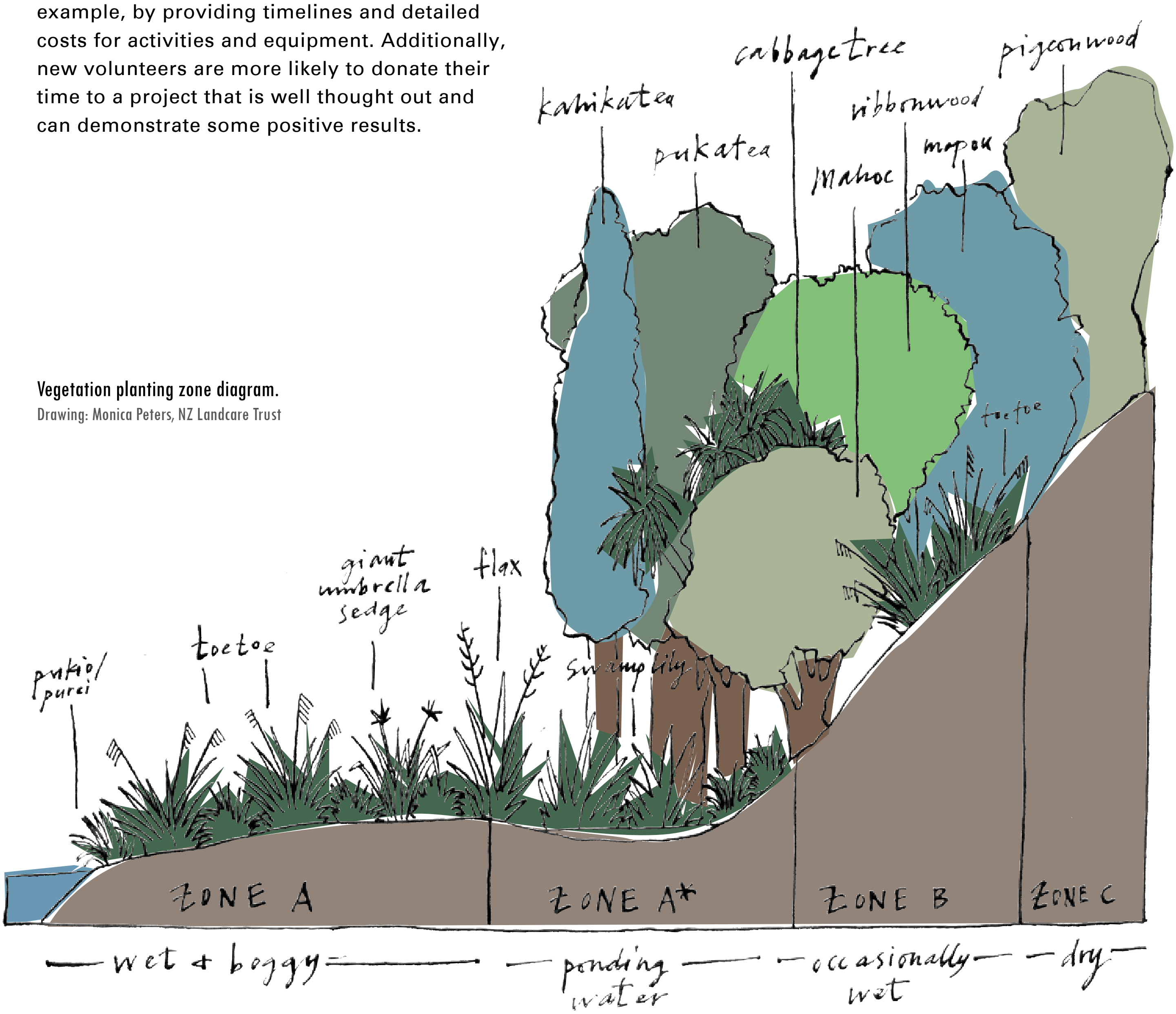
Weed clearance is likely to be one of the most common actions taken in the course of wetland restoration. Te Hapua, Wellington.
Photo: Monica Peters, NZ Landcare Trust

1 Wetland Restoration Plan

The function of a Wetland Restoration Plan is to help you achieve your goals. A Plan need not be complex, instead it should "...help you clarify issues, suggest solutions, estimate likely costs, record the best time for fieldwork and help you keep track of results" (Department of Conservation Action Plan for Landowners and Community Groups). A cohesive Plan is one of the necessary steps for developing a robust monitoring programme to determine whether the restoration is successful or which aspects may need modifying. A Plan is also useful for bringing together funding applications, for example, by providing timelines and detailed costs for activities and equipment. Additionally, new volunteers are more likely to donate their time to a project that is well thought out and can demonstrate some positive results.

1.1 Developing a Wetland Restoration Plan

The following basic set of steps is a summary of several available planning templates, links to which are provided at the end of the chapter. Where relevant, reference has been made to Handbook chapters where steps are outlined more fully.

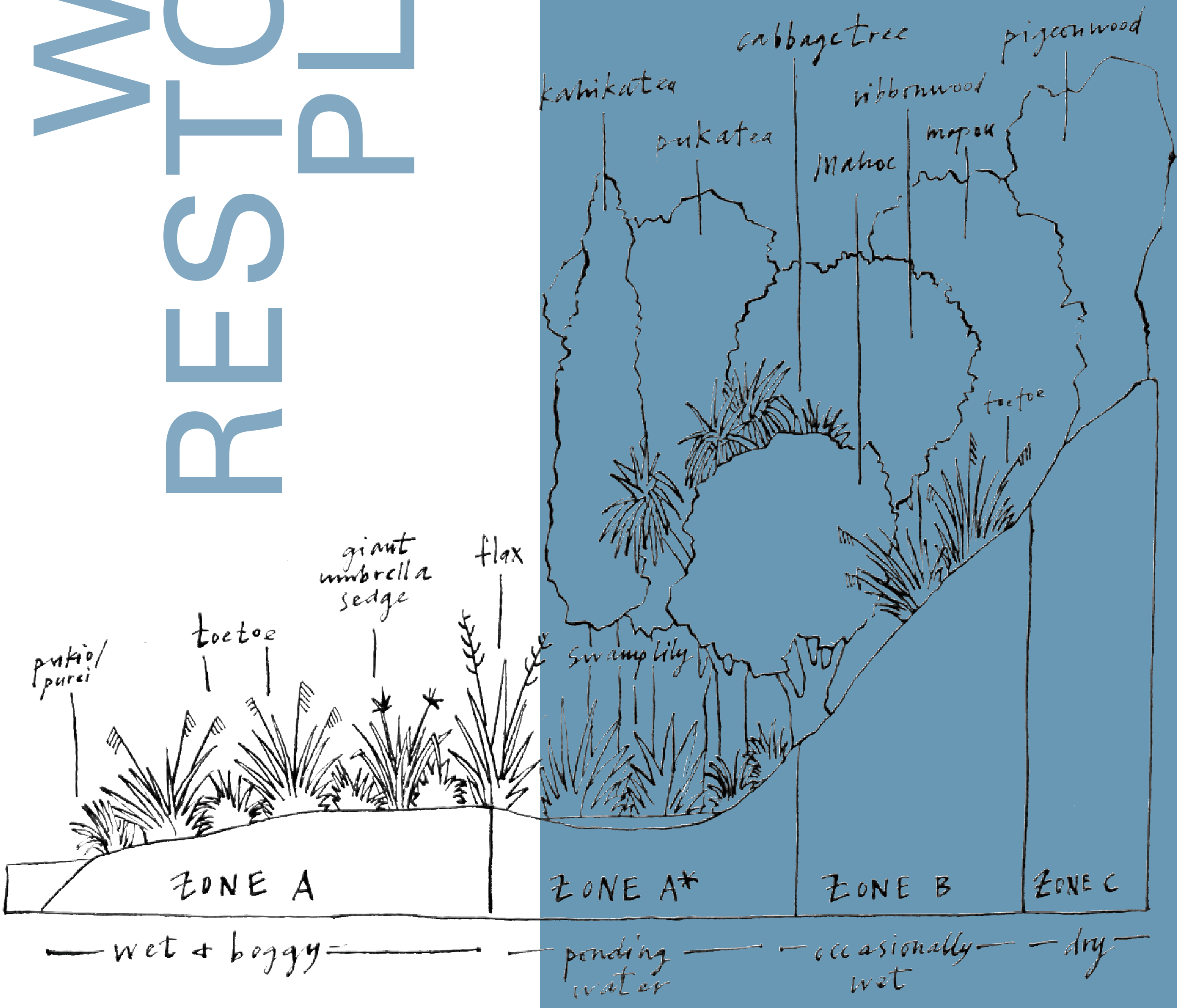


Vegetation planting zone diagram.
Drawing: Monica Peters, NZ Landcare Trust

WETLAND RESTORATION PLANNING

STEP 1 Provide basic details about the wetland

- Ownership and contact details
- Status
  (note that different classifications for public land, e.g., Wildlife Management Reserve, Ecological Area, Amenity Area, will have implications for how the site can be managed)
- Location
- Current size



STEP 2 Describe the key features of wetland restoration site

A useful tool is a sketch map which should include: (see Chapter 10 – Revegetation for a basic example)

VEGETATION

Dominant vegetation types:

- Kahikatea forest, Carex sedgeland, kuta emergent aquatic community, Sphagnum mossfield, raupo reedland

Any species of note:

- Rare species, infestations of invasive weeds, unusual plant communities

HYDROLOGY

Water sources and outflows:

- Streams, rivers and seeps, rain-fed only sites

Water level:

- Permanent open water >1 m deep
- Shallow water 5 cm – 1 m deep
- Saturated –5 cm to +5 cm deep
- Seasonally saturated
- Generally dry
- Dry

Modifications:

- Drains, weirs, culverts, canals and stopbanks

(note that drains may be a source of nutrients into the restoration site)

SOIL TYPE

- Organic (peat), mineral or a combination of both

MAN-MADE FEATURES

Infrastructure:

- Easements for roads and powerlines
- Buildings
- Access points such as gates, paths, boardwalks and tracks, bridges
- Rubbish piles

SPECIAL FEATURES

Sites of cultural significance:

- Archaeological features, e.g., pa, kainga, urupa
- Areas of cultural harvest
- Historical sites, e.g., battle sites, walkways

STEP 3 Determine your wetland type

Swamp, bog, fen, marsh and/or shallow water?

Chapter 3 – Wetland types outlines the basic characteristic of freshwater wetland types found in New Zealand.

STEP 4 Learn as much as you can about your restoration site

- Research the history of the site
- Find a reference wetland
- Understand the ecology of the site

Chapter 4 – Site interpretation 1 and Chapter 5 – Site interpretation 2 summarise a range of basic and in-depth methods that can be used to understand the past and present state of the wetland.

STEP 5 Develop your goals and objectives

Chapter 6 – Goals and objectives provides a basic outline on key consideration for this activity. Chapters 7–12 contain goals and examples of objectives relevant to the chapter subject.

STEP 6 List the activities needed to meet your goals and objectives

Chapters 7–12 outline the major activities required for managing site hydrology and nutrients, controlling weeds and pests, revegetating the wetland restoration site, and encouraging the return of native fauna.

STEP 7 Design your monitoring programme

Chapters 7–12 include a range of monitoring techniques relevant to the chapter subject. Monitoring overall changes in wetland condition is the subject of Chapter 13 – Monitoring.

CASE STUDY

PUNAWHAKAATA: RESTORATION PLANNING & ACTION FOR THE MIRROR SPRINGS

Nestled within the 1540 ha mosaic of wetlands on the southern edge of Lake Taupo lies Punawhakaata, the "mirror springs". Makere Rangitoheriri (deceased) was a former Punawhakaata Trustee and one of the oldest surviving members of the Tuwharetoa iwi (Te Rangiita Hapu). She was the main driver behind the restoration of the wetland. The project is now being led by the family. The goals are ambitious and include recreating habitat for native species, developing walkways, a working marae to showcase Maori arts and culture, and camping sites for visitors.

"The land was in trouble..."

Changes in water levels began in the 1930s with the development of State Highway One on land taken by the Crown under the Ministry of Works Act. The intake for the hydroelectric power station nearby at Turangi artificially raises and lowers water levels. Flood protection works to protect Oruatua village have deprived the area of its main water source. Grey and crack willow, blackberry and other noxious weeds now form the dominant cover in many areas. Stoats and possums impact on bird populations.

Forging new partnerships

When Makere first began to approach her extended family with the plan to restore the wetlands, she met with intense resistance on account of previous land confiscations by the Crown. Opening communication channels between local people, government agencies, private industry and science providers is an important part of the story because it has taken 20 years for this to happen. Linking up with Nga Whenua Rahui, which supports Maori to retain ownership and control of their land, gave Makere the confidence to know she was on the right track.

Raising awareness

The on-going restoration of Punawhakaata will rely strongly on community volunteers. People need to understand how important places like Punawhakaata are for critical functions such as protecting the water quality of Lake Taupo and that their input, no matter how small, plays a valuable part.

What's being done

Noxious weeds such as blackberry are being targeted, and eco-sourced native plants are being established on the wetland margins to enhance forest diversity and bring back native birds. Pest control is being carried out by the Department of Conservation to protect the plants and birds from predation by stoats, rats, possums and rabbits.

– *Monica Peters, NZ Landcare Trust*

REF: *www.doc.govt.nz/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project/funding/nga-whenua-rahui/nga-whenua-rahui-fund/featured-projects/punawhakaata/*

Makere Rangitoheriri and Rob McGowan (Nga Whenua Rahui). Makere used a single word to sum what up what is needed to keep the project going, "Persistence". Photo: Monica Peters, NZ Landcare Trust

Situated at a natural crossroads, Punawhakaata was used as a stopping point by Maori journeying across the central North Island.
Photo: Nick Singers. Crown Copyright, Department of Conservation

The extensive wetlands stretching from Waihi to Punawhakaata have been heavily invaded by crack willow.
Photo: Monica Peters, NZ Landcare Trust

After controlling weeds such as blackberry, the vegetation alongside a drain that cuts through the wetland is regaining its vigour.
Photo: Monica Peters, NZ Landcare Trust

2 Getting good advice

If you need advice, there are a range of avenues that can be explored. This section provides an overview of who can help, while each chapter highlights a range of key contacts most relevant to the given subject area. With the exception of private contractors and consultants, the advice in most cases is free.

Key stakeholders in wetland restoration:

- Regional and District Councils (e.g., Planning, Land/Lake Management Officers, Biosecurity – note department titles will vary between different councils)
- Department of Conservation (e.g., scientists, rangers and Technical Support Officers)
- Science providers, e.g., Landcare Research and the National Institute of Water and Atmospheric Research (NIWA)
- Iwi (e.g., Iwi Liaison Officers at the Department of Conservation, Regional and District Councils)
- Non-government organisations (e.g., National Wetland Trust, Fish & Game, NZ Landcare Trust, Forest and Bird, QE11 National Trust)
- Universities (e.g., Earth Science, Biology, Ecology, Botany and Zoology Departments)
- Voluntary societies (e.g., local botanical societies, ornithological societies)
- Pest control suppliers and contractors
- Weed control contractors
- Private ecological consultants
- Other community wetland restoration groups

Every two years, the National Wetland Trust runs a 2–3 day symposium dedicated to wetland restoration that is attended by many of the abovementioned organisations and groups. The emphasis is on creating a practical forum to share sharing knowledge and best practice for restoring wetlands. See the web links at the end of the chapter for further information.

Constructing an experimental site for wetland restoration at Lake Serpentine, Waikato.
Photo: Monica Peters, NZ Landcare Trust

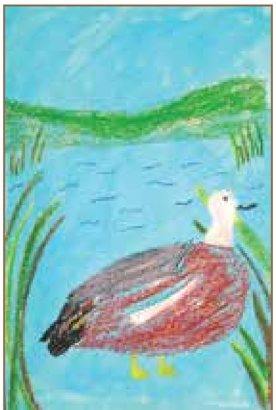
Although restoring a wetland can be a daunting task, advice is available from a wide range of sources. Photo: Monica Peters, NZ Landcare Trust

The result after many years of hard work at Milnthorpe Park, Tasman.
Photo: Monica Peters, NZ Landcare Trust

3 Planning tips

With so many wetland restoration projects underway around New Zealand, a host of valuable lessons have already been learned. The following tips provide a community view based on the practical experience of restoring wetlands. Web links to sites on how to bring a community group together and how to sustain existing community groups can be found at the end of the chapter.

"It takes time to examine the possibilities, to contact the relevant authorities, seek guidance, research historical evidence, raise funds and bring a group together..."



Raising awareness about wetland values – a child's drawing of a paradise duck. Image: Waikato Society of Arts

This sign at Waiwhakareke (Waikato) provides information on the site and restoration goals. Photo: Monica Peters, NZ Landcare Trust

THINK AHEAD

- Be clear in your goals and objectives; plan early, plan well, and plan ahead
- Get as much expert advice as you can
- Divide the planning into phases – be realistic about how much you can achieve

PARTNER UP

- Start building relationships early and consult frequently with the local community to understand their needs
- "I find that local people who I know personally tend to come on a regular basis"
- Although agencies may lack enthusiasm initially, they may come on board when the project is underway
- Regional Council can source help for larger parts of the project such as willow clearing and spraying
- "It's difficult to get enough volunteers to sustain long-term work and people move on, so involve others like a local school"
- Create a positive synergy by mixing age groups – many who have the time to get involved in projects are elderly. "The enthusiasm and interest of Fergusson Intermediate is a spur to the older members – these are after all, the next conservationists in the making and we enjoy working with them and encouraging them to continue caring for the area they helped recreate"

COMMUNICATE CLEARLY

- While time consuming, phoning people is worthwhile. If you need to email, describe what you are doing in the subject line, e.g., Saturday 12th, planting in Robinsons Bay
- Make sure contractors understand what you want – for many contractors the principles behind constructing a wetland are completely contrary to their usual objectives

KEEP THE COMMUNITY INFORMED

- Make sure you can answer questions posed by local people, get them on your side. Questions may start with "why did you remove those large trees?" move to "what a dreadful mess you are making" and then "now we can see what you are doing!"
- Consider creating a notice board with details of work being carried out to raise public awareness and project profile
- As an environmental education experience created wetlands provide a good place to interpret nature and talk about wetland issues.

PROVIDE SOUND TRAINING

- Understand what different skills people can bring to your project
- Coordinating different project stakeholders to help with ecological monitoring is a challenge; so is gauging their level of competence for collecting robust data
- Train your group so that other groups' operating procedures and objectives for environmental monitoring can be matched

AVOID BURNOUT – ENJOY YOURSELVES!

- Value your people: if volunteer travel distances are significant, provide petrol vouchers
- Monthly working bees may not suffice when rapid follow-ups are needed for, e.g., hare repellent
- "It is nice to have some lunch together and just relax in the grass. We usually work from 10am till at most 2pm. There needs to be a coordinator to organize, as well as chat with people. It is easy to get absorbed in work and forget people like to connect and feel they belong. It is a wonderful way to spend time together..."

Auckland Regional Council pest control workshop on Great Barrier Island. Photo: Monica Peters, NZ Landcare Trust

A great days work! Photo: Abby Davidson, NZ Landcare Trust

4 Useful websites

Wetland restoration templates

Waikato Regional Council Wetland Restoration Plan templates

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate1.pdf

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate2.pdf

Wetland restoration guides and factsheets (New Zealand)

Northland Regional Council

www.nrc.govt.nz/upload/2217/Wetland%20Restoration%20Guide%20(second%20edition%20Feb%2009).pdf

Auckland Regional Council

www.arc.govt.nz/albany/fms/main/Documents/Environment/Plants%20and%20animals/wetlandsfacts2.pdf

Waikato Regional Council

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/

Hamilton City Council

www.gullyguide.co.nz/index.asp?pageID=2145821537

Bay of Plenty Wetlands Forum

www.doc.govt.nz/upload/documents/conservation/land-and-freshwater/wetlands/wetland-restoration-guide.pdf

Greater Wellington

www.gw.govt.nz/a-beginner-s-guide-to-wetland-restoration/

Department of Conservation Protecting Natural Areas Design Guide

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/nature-heritage-fund/protecting-natural-areas-design-guide/

Wetland restoration guides (International)

USA Environmental Protection Agency

www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Guides for community projects

Department of Conservation "From Seed to Success – Guidelines and Toolkit"

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/guidelines-for-community-conservation-partnerships/from-seed-to-success-guidelines/

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/guidelines-for-community-conservation-partnerships/from-seed-to-success-tool-kit/

Community net

www.community.net.nz/how-toguides/crk

Seeking advice - Flora and Fauna Societies

Botanical Societies

www.nzbotanicalsociety.org.nz/pages/links.html

Ornithological Society of NZ

www.osnz.org.nz/

Seeking advice – Agencies, science providers and non-government organizations

Regional and District Councils

www.localcouncils.govt.nz/lgip.nsf

Department of Conservation

www.doc.govt.nz

Landcare Research

www.landcareresearch.co.nz

National Institute of Water and Atmosphere (NIWA)

www.niwa.co.nz

Fish & Game New Zealand

www.fishandgame.org.nz

NZ Landcare Trust

www.landcare.org.nz

Queen Elizabeth II National Trust

www.openspace.org.nz/

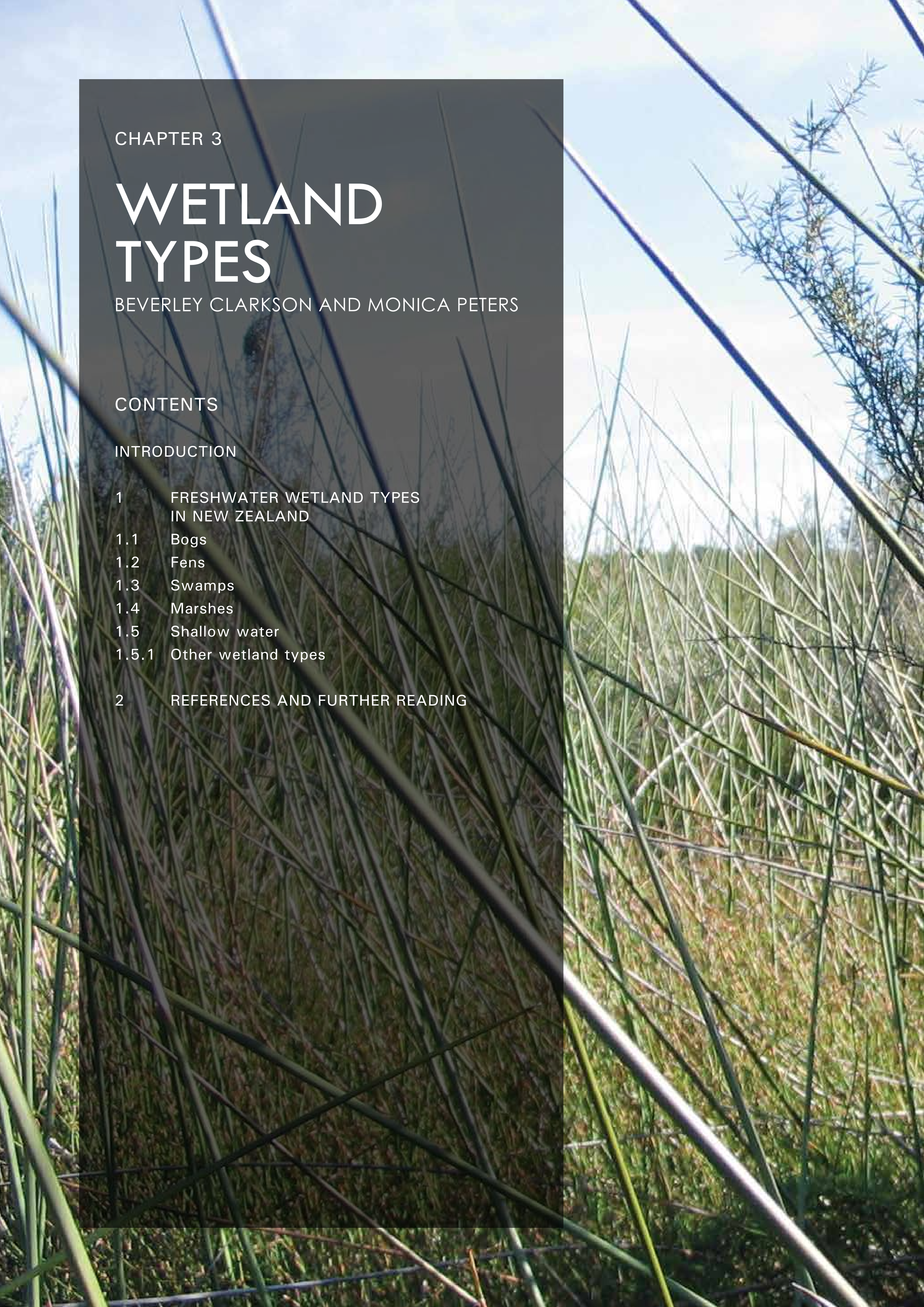
Royal Forest and Bird Protection Society

www.forestandbird.org.nz

National Wetland Trust

www.wetlandtrust.org.nz

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 3

WETLAND TYPES

BEVERLEY CLARKSON AND MONICA PETERS

CONTENTS

WETLAND TYPES

WETLAND TYPES

BEVERLEY CLARKSON AND MONICA PETERS

Understanding which type of wetland you have is integral to the restoration process and will help define appropriate goals for your project. Wetland types are defined by their water regime, nutrient levels, pH, and substrate. These factors produce the characteristic flora and fauna communities associated with each wetland type.

In many cases, determining the wetland type will be relatively easy, e.g., a willow-dominated wetland with *Carex* spp. (sedges) throughout the understorey was, and still is, a swamp. In other cases, where the site has been more modified, the wetland type may not be so obvious, or in larger systems, e.g., the 10,000 ha Kopuatai peat dome, several different wetland types may be represented. Wetlands such as Kopuatai are important – the site retains part of a sequence from freshwater swamp forest through fen to restiad raised bog associated with increasing peat depths. Such sequences are now a rarity. Today, only remnants are left of the larger and complex wetland systems that once covered significant tracts of the New Zealand landscape.

The wetland types described over the next pages are based on Johnson and Gerbeaux (2004), though in keeping with the freshwater focus of this Handbook, saline wetlands have not been included.

Kopuatai is home to one of only three remaining naturally occurring populations of the restiad, giant cane rush (*Sporadanthus ferrugineus*). The dome is recognised for its international significance under the Ramsar agreement on account of its size, intactness and representativeness. Photo: Monica Peters, NZ Landcare Trust

Previous page: Fen vegetation. Kopuatai peat dome, Waikato.
Photo: Monica Peters, NZ Landcare Trust

Situated on a flood plain, the Upper Taieri Scroll Plain (Otago) comprises a meandering river that changes its course during flooding. This system includes a range of wetland types, namely marsh, fen and swamp.
Photo: Gretchen Robertson, NZ Landcare Trust

Though currently classed as a fen, Waipapa mire (Pureora Forest Park, Waikato) is developing into a bog as mounds of wire rush (*Empodisma minus*) – in foreground, begin to establish. Photo: Beverley Clarkson, Landcare Research

1 Freshwater wetland types in New Zealand

The main functional wetland types in New Zealand are bog, fen, swamp, marsh, and shallow water. A simple way of distinguishing between types is based on the gumboot test. Short gumboots or 'Red-bands' are usually adequate for keeping feet dry in bogs because the vegetation and peat will support your weight. Taller gumboots will be needed for fens, and thigh waders are recommended for swamps, which have large areas of open water. Waist waders may be required for marshes when water levels are high, and a drysuit or wetsuit will be useful for traversing shallow water.

Wetland Type	BOG	FEN		SWAMP	MARSH
	SHALLOW WATER*				
Water Source	Rainfall	→	Groundwater	→	Surface water
Water flow & fluctuation	Low	→	Medium	→	High
Nutrient availability	Low	→	Medium	→	High
pH	Low/acidic	→	Medium	→	High/neutral
Peat Content	High	→	Medium	→	Low/none

Figure 1. Key environment characteristics of wetland type. Beverley Clarkson, Landcare Research.

* Shallow water wetlands may form part of bog, fen, swamp and marsh systems.

Whangamarino, Waikato. Photo: Aleki Taumoepeau, NIWA

1.1 Bogs

Bogs are peat-accumulating systems fed only by rainwater and thus have very low nutrient levels. They are usually strongly acid, and water flow is restricted. The water table is either at or just below the surface and remains relatively constant.

LOCATION

Level or gently sloping ground, e.g., hill crests, basins, terraces as well as within other wetland types. Mainly found in Southland, Westland, Waikato and Chatham Is.

VEGETATION

Highly varied, e.g., tree, shrub, liverwort, fern, cushion plant, moss, restiad and sedge types.

Tangle fern (*Gleichenia dicarpa*) and manuka on the shores of Lake Maratoto, one of more than 30 peat lakes in the Waikato region. Photo: Abby Davidson, NZ Landcare Trust

Awarua Bog, a Ramsar listed site administered by the Department of Conservation, hosts a range of plants more commonly associated with alpine regions. Southland. Photo: Beverley Clarkson, Landcare Research

Donatia novae-zelandiae is one of the distinctive cushion forming plants found in the Awarua bog, Southland. Photo: Janet Gregory, NZ Landcare Trust

1.2 Fens

Fens have a predominantly peat substrate, although the peat is shallower and more decomposed than in bogs. They are fed by both rain and groundwater, resulting in low to moderate nutrient and acidity levels. The water table is typically just below the peat surface with small but noticeable fluctuations.

LOCATION

Slight slopes, e.g., fans and toes of hillsides (where they may merge with swamps), and in relatively shallow peat, e.g., on the edge of raised bogs.

VEGETATION

Scrub, tall herb, tussock grass, fern, restiad and sedge types.

Though called a "swamp", Kaitoke on Great Barrier Is. is, strictly speaking, a fen. Photo: Beverley Clarkson, Landcare Research

Waiapa mire (Pureora Forest Park, Waikato) is showing signs of recovery from browsing as deer populations decrease through ongoing control. Photo: Beverley Clarkson, Landcare Research

Carex secta and red tussock swamp/fen upstream of Lake Clearwater (Canterbury), part of the Department of Conservation Arawai Kakariki wetland restoration programme.
Photo: Hugh Robertson. Crown Copyright, Department of Conservation

1.3 Swamps

Swamps are relatively high in nutrients, supplied by nutrients and often sediment via surface runoff and groundwater from surrounding land. Substrates are typically a combination of mineral soils and well decomposed peat. The water table is usually above some of the ground surface, though due to large, seasonal fluctuations can periodically be much higher or lower.

LOCATION

Basins, valley floors, deltas and plains.

VEGETATION

Tree, scrub, tall herb, flax, reed, rush and sedge types. Often heavily invaded by willow.

An ecologically important remnant of kahikatea swamp forest (*Dacrycarpus dacrydioides*) forest in the southwest corner of the Kopuatai peat dome, Waikato. Photo: Monica Peters, NZ Landcare Trust

Raupo in winter dieback colonising the swampy margins of a dune lake. Whatipu, Auckland. Photo: Monica Peters, NZ Landcare Trust

Bands of willow colonising former shorelines are clearly visible at the Waimarino wetland, Lake Taupo.
Photo: Tongariro Natural History Society


Iveagh Bay, Buller District. Marsh at high water level. Photo: Brian Sorrell, NIWA

1.4 Marshes

Marshes are characterised by large periodic fluctuations of water table or water level. They can experience water-level drawdowns that result in portions drying out and exposing the mineral substrate but the soil usually remains moist. They have a lower overall water table than swamps, higher nutrient levels and a higher pH. Ephemeral wetlands are a subset of the marsh type in which ponding and drying out occur on a seasonal basis. In more extreme cases, the vegetation alternates between aquatic and terrestrial.

LOCATION: Valley margins, valley floors, alongside rivers and lakes

VEGETATION: Rush, grass, sedge and herb types. Often infested with pasture weeds and grasses.


The upper Rangataiki catchment (Taupo), is an ephemeral wetland depression still partly ponded in summer. Photo: Peter Johnson

Marsh area on the margins of the Ramsar listed Whangamarino wetland, Waikato. Photo: Kerry Bodmin, NIWA

Shallow water area within the extensive Norske Skog wetland restoration site. Bay of Plenty. Photo: Wildland Consultants Ltd.

1.5 Shallow water

Shallow water wetlands are characterised by the presence of open standing water, generally less than a few metres deep. This includes intermediate-size water bodies not large enough to be considered lakes or lake-like, though more significant than just smaller water bodies and leads (channels of open water). Also included are the margins of lakes, rivers, and estuary waters. Nutrient levels and water chemistry are basically those of the water as opposed to the substrate.

LOCATION: Shallow, open water at lake, estuary and river margins, including gently flowing river channels.

VEGETATION: Submerged, floating or emergent aquatic plants.

Parrot's feather infests this area of shallow water at Te Henga wetland on the west coast of Auckland. Photo: Kerry Bodmin, NIWA

The original vegetation in the shallow water zones of Lake Taharoa have been degraded by stock, though stands of raupo in less accessible areas remain intact, Waikato.
Photo: Monica Peters, NZ Landcare Trust

1.5.1 Other wetland types

Both pakihi and gumland are local terms for wetland types that are often fire induced. The unifying characters are very low fertility and low pH soils, mainly mineral substrate, and sometimes with peat. Soils are old, extremely leached and poorly drained, frequently saturated but seasonally dry. As such, pakihi and gumland may also fit into bog, fen or swamp categories.

Other wetland types include seepages and geothermal. Seepages occur on slopes with an active steady flow of groundwater and sometimes surface water. They are typically small, localised wetlands that feed, drain or occur within other wetland types. Geothermal wetlands are influenced by heated geothermal water or chemistry derived from current or former geothermal activity. They are concentrated in the volcanically active area in the central North Island.

Seepage colonised by pasture grasses. Battle Hill Farm Park, Wellington. Photo: Monica Peters, NZ Landcare Trust

One of the many geothermal wetlands situated in urban Rotorua, Bay of Plenty. Photo: Monica Peters, NZ Landcare Trust

2 References and further reading

Cromarty, P. and Scott, D.A. (Eds). 1995. *A Directory of Wetlands in New Zealand.* Department of Conservation, Wellington, New Zealand. www.doc.govt.nz/upload/documents/science-and-technical/nzwetlands00.pdf

Johnson, P. and Gerbeaux, P. 2004. *Wetland Types in New Zealand.* Department of Conservation, Wellington, New Zealand. www.doc.govt.nz/upload/documents/science-and-technical/WetlandsBW.pdf

Zoltai, S.C. and Vitt, D.H. 1995. *Canadian wetlands: environmental gradients and classification.* Vegetatio 118: 131–137.

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Gumland at Lake Ohia, Northland showing the exposed soil pan.
Photo: Beverly Clarkson, Landcare Research

CHAPTER 4

SITE INTERPRETATION 1

MARC SCHALLENBERG AND ROB CADMUS

CONTENTS

SITE INTERPRETATION 1

Pukatea capsules with seeds.
Drawing: Monica Peters

SITE INTERPRETATION 1

MARC SCHALLENBERG AND ROB CADMUS

The study of informed human perspectives on the present state and recent changes in wetlands is useful for setting restoration goals. For example, a review of historical records before the restoration of the Waipori/Waihola Lake-Wetland Complex, Otago, provided information on historical human modifications to the catchment and historical changes in sea level, hydrology and sedimentation. Collectively, this information gave an excellent account of disturbance events and changes to the ecosystem, providing information on opportunities and constraints to restoration. This research is summarised and presented as a case study.

There are several commonly used approaches for reconstructing the environmental histories of wetlands – all are an important part of developing a Wetland Restoration Plan with associated goals and objectives (See Chapter 2 – Restoration planning and Chapter 6 – Goals & objectives). Included in this chapter are: reviewing historical and scientific records, understanding site ecology, and finding appropriate reference wetlands to compare with the wetland being restored. The relative advantages and disadvantages of each approach are also summarised, along with the resources and type/level of expertise required. In-depth studies for reconstructing the environmental histories of both the human and pre-human eras are the subject of Chapter 6 – Site interpetation 2.

Previous page: Maori Lakes, Ashburton Basin.
Photo: Hugh Robertson. Crown Copyright, Department of Conservation

Opposite page: A transect running from the margin to the centre of Kopuatai peat dome (Waikato) reveals a sequence of vegetation types.
Photo: Monica Peters, NZ Landcare Trust

Chris Bell and Andrew Blayney (both TNHS workers) using sound recordings to determine whether bitterns are present in the South Taupo wetlands, December 2008.
Photo: Tongariro Natural History Society (TNHS)

1 Reconstructing the past to restore for the future

1.1 Reviewing available information

Historical information can come from a wide variety of sources and exists in an equally wide variety of forms. While some historical scientific information may be available in the form of journal articles and published or unpublished reports, non-scientific information can also be very useful. For example, old maps, aerial photographs and survey records can illustrate historical changes to a wetland and its catchment. Collecting oral histories from local elders, visiting museums, reading local histories, and interpreting Maori place names can help develop a timeline of relevant historical conditions and significant changes and events.

1.1.1 Strengths and weaknesses

✓ Uses existing information to identify issues and areas of concern, and to develop an environmental history relevant to the wetland and its catchment.

✗ Sources of information can be numerous and varied and relevant information may not be in an easily accessible form.

1.1.2 Resources and expertise

RESOURCES: Libraries (e.g., local and national public libraries, museum libraries, private collections, Regional and District Council, university and wananga libraries), herbaria (often associated with museums, universities and Crown Research institutes), scientific journals, botanical society newsletters, ornithological society bird lists, local records (e.g., historical societies, local historians, iwi authorities). Note that many resources such as journals and reports are online. Sound recording equipment is useful for collecting oral histories.

EXPERTISE: General interpretation skills and understanding are required.

This Waikato map dates from 1935 and clearly shows that the region's lakes were once much larger than they are today. Photo: Waipa District Council

A current map of the same area reveals that drainage has removed an entire lake as well as shrinking others. Photo: Terralink International LTD and Environment Waikato

1.2 Understanding site ecology

Interpretative visits by experienced ecologists can be useful to assess the historical development, current ecological state, and restoration potential of the wetland. Visits may include vegetation and/or wildlife surveys, assessments of existing hydrology, and analysis of any wetland remnants.

1.2.1 Strengths and weaknesses

- ✓ Can give an understanding of the current ecological functioning and condition of a restoration site and of key species present or absent.
- ✗ Thoroughness and usefulness can vary and will depend on the expertise available and the restoration goals identified.
- ✗ Can be time-consuming and may require visits at different times of the year to determine water levels, wildlife numbers, etc.

1.2.2 Resources and expertise

RESOURCES: Costs vary depending on the intensity of the examination required and whether the expert requires full cost recovery. However, experts working in universities or government laboratories may be able to carry out the work at minimal expense as a voluntary community service. Botanical societies and ornithological groups may also be able to assist.

EXPERTISE: Access to an expert with substantial experience and broad expertise in wetland ecology and hydrology is required. Local knowledge would also be an asset.

Local botanical societies may be able to assist with bringing together plant species lists. Waikato Botanical Society Kawhia field trip, 2006.
Photo: Liz Overdyck, Waikato University

CASE STUDY

WAIPORI/WAIHOLA & WAITUNA WETLANDS: DIGGING INTO THE PAST

THE WAIPORI/WAIHOLA LAKE-WETLAND COMPLEX

The 2000 ha complex 30 km southwest of Dunedin includes several ponds and waterways. Both lakes Waipori (1.05 m deep) and Waihola (2.20 m deep) are tidally influenced. A group of local landowners, stakeholders and regional authorities have expressed interest in restoring the system.

Issues

Upstream flow management by a hydro-electric dam, drainage of farmland, water abstraction for irrigation, and climate all regulate the balance of freshwater and saltwater in the system. Future changes in sea level and possibly climate, could exacerbate saline intrusions. Water quality has declined through land development and agriculture.

THE WAITUNA LAGOON-WETLAND COMPLEX

The 3556 ha complex lies east of Bluff and is a modified, shallow coastal lagoon with surrounding coastal wetlands. The lagoon is separated from the sea by a gravel bar that is often opened to allow discharge of freshwater and influx of saltwater. A group of local landowners, stakeholders and regional authorities have recently begun exploring possibilities for restoring the system to a more natural state.

Issues

A century of native vegetation clearance in the catchment, wetland drainage, increased nutrient inputs into the lagoon, artificial opening of the gravel bar barrier to the sea, agricultural development, and surrounding land use.

Despite being one of the largest remaining wetlands in New Zealand, 150 years ago the Waipori/Waihola Lake-Wetland Complex was seven times larger. Photo: Gretchen Robertson, NZ Landcare Trust

The secretive but inquisitive fernbird prefers swamps, pakahi, rush and tussock covered saltmarsh with low vegetation and emergent shrubs. Photo: R Sutton

Researching the past using common approaches

Fortunately, some relatively good records of historical information exist for both complexes, including maps, paintings, photographs, and historical texts. Recent scientific surveys cover geological, botanical, and limnological aspects of the systems. Local oral histories can also be very informative; however, as the accuracy of the information can be difficult to verify such evidence was not included in this study.

Appropriate reference wetlands were not able to be identified because of the relative size and complexity of both wetland complexes. Virtually all land and wetlands on the east coast of the South Island have been heavily modified. Although a much smaller remnant wetland in the lower Taieri Estuary still supported native vegetation, this site was not used as a reference wetland due to other numerous differences between it and the Waipori/Waihola Lake-Wetland Complex. Native bush is no longer found in the Waituna Wetlands. However, some relatively undisturbed wetland areas persist, providing useful information on appropriate plants and animals, which could be fostered by restoration efforts.

– Marc Schallenberg

The Waituna Lagoon-Wetland Complex is a DOC administered Ramsar site, highly valued for its ecological values and for hunting and fishing.
Photo: Janet Gregory, NZ Landcare Trust

1.3 Using reference wetlands

The examination of appropriate reference sites can be a means to determining the types and degrees of environmental changes that have occurred. As such, reference sites may also be useful for assessing progress towards restoration. The use of reference sites involves the comparison of the ecosystem structure (e.g., hydrology, communities, habitats, etc.) and function (e.g., productivity, biodiversity, nutrient processing, etc.) of a restoration site to one or more similar, existing unmodified or less modified sites. Reference sites with undisturbed (or minimally disturbed) hydrology, vegetation, biomass, biodiversity, etc., can be used to identify important environmental conditions and ecological characteristics to inform restoration goals.

1.3.1 Strengths and weaknesses

- ✓ Can be used to monitor the progress of restoration, by identifying a set of ecosystem functions, activities, or processes such as hydrology, plant community maintenance, biogeochemistry, that define an ecosystem.
- ✗ None available if all similar potential reference wetlands (i.e. matched in climate, hydrology, altitude, wetland type, etc.) in a region have been modified.
- ✗ High ecological variability within and among wetlands can make finding appropriate reference wetlands difficult.

1.3.2 Resources and expertise

RESOURCES: Cost and time depend on the availability of suitable reference wetlands and restoration goals. For example, reference wetlands can be used simply to help establish a list of appropriate species to be planted at a restoration site. On the other hand, where reference wetlands are used to guide the restoration of specific plants and/or hydrological regimes, the study of both restoration and reference wetlands should be conducted throughout the year to capture seasonal variation in plant communities and hydrology.

EXPERTISE: Seek expert advice, as an understanding of ecological principles is needed both to identify and use appropriate reference wetlands

Te Hapua, Wellington. Finding appropriate reference sites can be challenging in regions where the landscape has been substantially modified. Photo: Mari Housiaux

2 References and further reading

Brinson M. M. and Rheinhardt, R. 1996. *The role of reference wetlands in functional assessment and mitigation.* Ecological Applications 6: 69–76.

Schallenberg M., Harper M., and Goff J.R. *Records of a mid-Holocene sea level highstand and European impact from the Taieri Basin, Otago, New Zealand.* Submitted to Journal of Paleolimnology.

Vivian-Smith, D. 2001. Creating a proper restoration framework. In: Zedler, J. B. (Editor), *Handbook for Restoring Tidal Wetlands*, pp. 39–88. CRC Press, Boca Raton, Florida, USA.

2.1 Useful websites

Agencies and Crown Research Institutes (science providers)

Regional and District Councils

www.localcouncils.govt.nz/lgip.nsf

Department of Conservation

www.doc.govt.nz

Crown Research Institutes

www.morst.govt.nz/rst-links/crown-research-institutes/

Scientific journals

NZ Journal of Botany

www.royalsociety.org.nz/Site/publish/Journals/nzjb/default.aspx

NZ Journal of Zoology

www.royalsociety.org.nz/Site/publish/Journals/nzjz/default.aspx

NZ Journal of Ecology

www.nzes.org.nz/nzje/

Notornis

www.notornis.org.nz/

Herbaria in New Zealand

www.nzherbaria.org.nz/herbaria.asp

Societies

Botanical Societies

www.nzbotanicalsociety.org.nz/pages/links.html

Ornithological Society of NZ

www.osnz.org.nz/

Historical societies

www.nzhistoricalsocieties.org.nz/

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CHAPTER 5

SITE INTERPRETATION 2

MARC SCHALLENBERG AND ROB CADMUS

CONTENTS

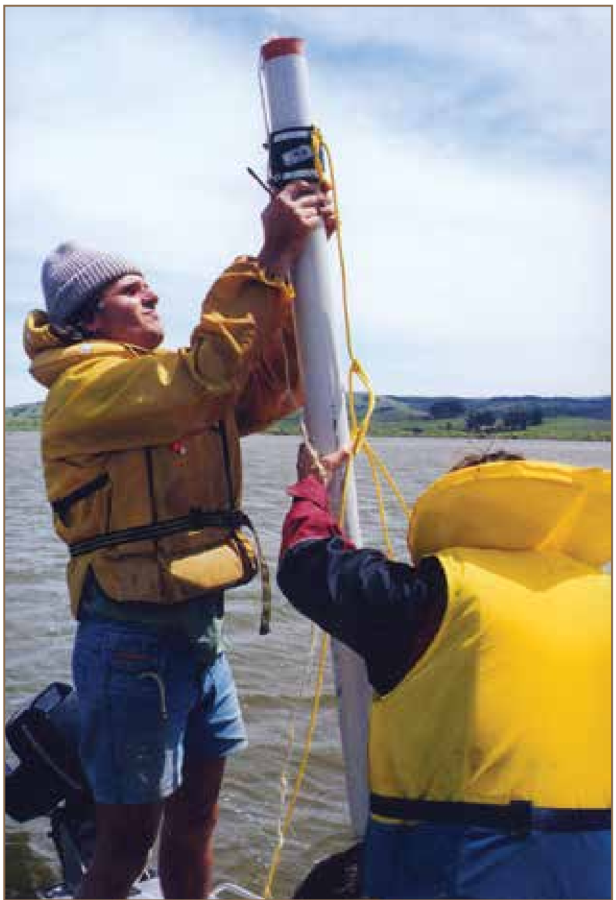
SITE INTERPRETATION 2

SITE INTERPRETATION 2

MARC SCHALLENBERG AND ROB CADMUS

Natural and human-influenced environmental change in many aquatic ecosystems and their catchments can be inferred or reconstructed using data from fossils and subfossils. The techniques used come from the field of palaeo-ecology – the study of ancient ecology. Palaeo-ecological techniques can be used to infer changes in sediment accumulation, soil characteristics, nutrient levels, salinity, disturbance and vegetation in wetlands – all of which are useful for setting appropriate restoration goals. As many of the techniques described in this chapter require specialized equipment and considerable expertise to collect, prepare and interpret the samples, information on who can help, equipment suppliers and laboratories for analysis are included. The costs are only indicative and are based on 2010 pricing in New Zealand.

Objective historical and pre-historical information from palaeo-ecological studies complement the techniques highlighted in the previous chapter (Chapter 4 – Site interpretation 1). Used together, both techniques can provide a detailed picture of the environmental variability in wetlands over extended time periods. This knowledge is important for the long-term sustainability of restored wetlands. The case study included in this chapter demonstrates how palaeo-ecological techniques were used at two different wetland complexes, Waipori/Waihola (Otago) and Waituna (Southland).



Percussion coring is best used in shallow waters where the sediment is fine and soft and wood or vegetation are absent, such as in the middle of Lake Waihola (depth: 2 m).
Photo: Marc Schallenberg, University of Otago

Previous page: Core samples showing peat overlying marine clay. Kopuatai peat dome, Waikato. Photo: Monica Peters, NZ Landcare Trust

1 Collecting sediment/ soil cores

The first step for undertaking palaeo-ecological studies involves collecting cores. Sediment/soil coring works optimally in sites where sediment/soil accumulation is likely to have been continuous. To minimise the number of cores required, coring sites can be selected that are more representative of key, wetland-wide conditions and processes. Several methods can be used, depending on the habitat, water depth, type of sediment, and core length required. Materials from which core tubes or sleeves can be made include readily available materials such as plastic drain pipe or downspouting and aluminium irrigation tubing. However, in some habitats, specialized sediment coring devices may be needed to obtain high quality cores. These are available through some universities and government laboratories.

Note that specialized coring equipment should only be used by experienced operators. An expert in coring can also help with selecting appropriate sites, core transport, storage, opening or extruding, core logging as well as estimating coring artefacts (e.g., core shortening). Costs, constraints, and efficiencies differ among sediment corer types for a given site. Once a core has been obtained, x-raying the intact core can illustrate density variations in the sediment strata and the presence and position of shells, wood, and other macrofossils. Opening, extruding or sectioning (cutting) the core should be carefully carried out to avoid damaging, stretching or compressing the sediment record. Immediately upon opening a core, a core log should be made in which changes in sediment colour, texture, and the presence of macrofossils are recorded along with corresponding depths.

After sub-samples of the core have been taken for palaeo-ecological analyses, the core should be archived by wrapping it in plastic and storing it in a cool location, in case further analyses are required. If the core is cut lengthwise, sub-sampling should be conducted on one half of the core while the other half should be archived intact.

Where water depth is greater than c. 1.5 m, long lengths of plastic pipe can be pushed or driven into the sediment from a boat. Gravity coring in Lake Ellesmere, Canterbury.
Photo: Marc Schallenberg, University of Otago

2 Sediment analyses

2.1 Water and organic content

Water and organic content are determined by calculating changes in mass between fresh, dried and combusted samples, which can reflect changes in organic matter inputs, hydrology, vegetation, eutrophication. Water and organic content can also be useful for determining sedimentation rates and sediment compaction (dewatering).

METHOD

Samples are obtained by subsampling the core at a variety of depths to create depth profiles. Moisture content is determined after drying to constant mass at 60 degrees C. Organic content is determined after combustion of the dry sediment at 550 degrees C until all organic matter has combusted. Note: a lid is required on crucibles to avoid loss of inorganic material upon combustion. Hot samples should be cooled in a desiccator prior to weighing.

EQUIPMENT

Balance, oven, muffle furnace, desiccator, crucibles, mortar and pestle.

COST

*$5-30 per sample.

WHERE ANALYSED

Universities, other environmental institutes, and environmental consultants.

EXPERTISE

Basic laboratory skills. Some expertise required for interpreting the environmental conditions that cause changes in water and organic content.

NOTES: Interpretations can be improved if combined with sediment grain size and sediment density analyses.

2.2 Sediment grain size analysis

Sediment grain size can be used to infer changes in hydrology and sedimentation. In general, fine sediments are deposited in calm environments whereas the presence of coarse sediments indicates higher energy environments. Particle grain size analysis of wetland sediment or soil can also provide information on, e.g., soil drainage, water holding capacity, nutrient retention and cation exchange capacity.

METHOD

While x-ray densitometry and visual analysis of sediment can indicate abrupt and large changes in sediment grain size, particle grain size analysis is recommended for quantification of gradual and fine-scale patterns. Samples are obtained by subsampling the core at a variety of depths to create depth profiles.

EQUIPMENT

Simple Bouyoucos hydrometer method can be used (hydrometer, mortar & pestle, blender, glassware, stopwatch); however, laser particle size analyzers can save considerable time and are more accurate.

COST

*$70–90 per sample.

WHERE ANALYSED

Universities, other environmental institutes, and environmental consultants.

EXPERTISE

Basic laboratory skills required for sample preparation. Particle size analyzer requires specialized training. Interpretation of small changes requires an understanding of sedimentological processes.

NOTES: Interpretations can be improved if combined with sediment grain size and sediment density analyses.

2.3 Sediment density (X-ray densitometry)

Wetlands in river floodplains often experience seasonal flooding. Similarly, coastal wetlands may occasionally be influenced by high seas. In addition, land-use changes can increase erosion of soils, which can alter the composition, input rate and density of sediments. Failure to take these into consideration during restoration planning can result in over-siltation of restored or constructed wetlands and, therefore, failure to meet restoration goals. Examining the density changes in sediment cores illustrates the historical frequency of extreme sedimentation events.

METHOD

By x-raying whole sediment cores, photographic prints can be made from the x-ray negatives revealing stratigraphic structures, including the presence of shells, gravel, peat, etc. X-rays are also useful for determining whether bivalve shells are articulated and in living position, which is important for determining if the bivalves inhabited the site or if their shells were washed in from the sea. Sediment density is related to the organic and water content, sediment grain size, the level of compaction (de-watering). Stratigraphic patterns from flooding or other changes in hydrology and other sedimentation changes can therefore be observed in x-rays. X-rays can be used for the quantitative analysis of variation of sediment density.

EQUIPMENT

Medical x-ray scanner or dedicated sediment core scanner.

COST

*$10-100 per metre of sediment core. Additional costs for photographs. Minimal time is required for x-ray densitometry.

WHERE ANALYSED

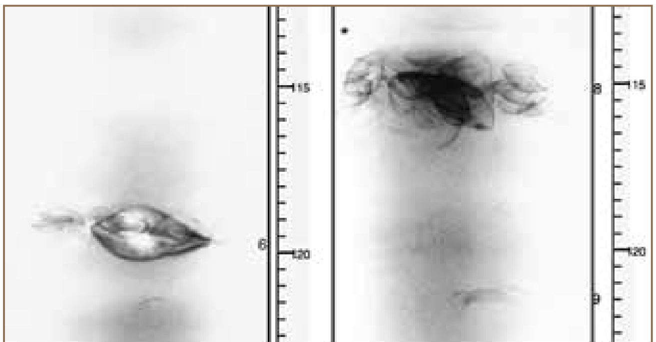
Hospital radiology departments or geosciences laboratories in universities or other research institutes.

EXPERTISE

Interpretation of abrupt changes in density and the presence of shells and other macro-fossils is straightforward, but some expertise in sedimentology allows for more density variations to be interpreted.

NOTES: X-ray densitometry is complementary to sediment grain size and organic and water content analysis, and can substitute for these methods when funds are limited and quantitative data are not required. Interpretations can be improved if combined with sediment grain size and sediment density analyses.

*Unit costs are usually dependent on sample number. The costings here are rough estimates based on a run of 30 samples.



Positive renderings of x-rays of a cockle (*Austrovenus stuchburyi*) from c. 1200 mm below the sediment–water interface in Lake Waihola, Otago. Shells were carbon 14 dated as c. 4000 years old.
Image: Marc Schallenberg, University of Otago

3 Methods for dating sediments

3.1 Caesium-137 (^{137}Cs)

Caesium-137 is a radioactive isotope, globally distributed as a result of the atmospheric testing of thermonuclear weapons. ^{137}Cs can be used to identify sediment strata deposited during the period of elevated atmospheric fallout.

TIMESCALE

Detects ^{137}Cs fallout from atmospheric thermonuclear bomb testing which peaked in the Southern Hemisphere c. 1959–1964.

METHOD

Gamma particle counting.

MATERIAL

Bulk dry sediment.

COST

c. $100-250 per sample, but may be analysed in conjunction with 210Pb. A number of samples should be analysed to determine the peak.

WHERE ANALYSED

Specialist laboratories in universities and other environmental research institutes.

EXPERTISE

Interpretation is relatively straightforward but can be complicated by bioturbation, translocation of ^{137}Cs rich soil from upstream erosional areas.

3.2 Lead-210 (^{210}Pb)

The method is based on inferring changes in atmospheric and background ^{210}Pb levels in relation to its degree of equilibrium with other isotopes in the uranium decay series.

TIMESCALE

Present to c. 1850s.

METHOD

Alpha or gamma particle counting.

MATERIAL

Bulk dry sediment.

COST

$100-250 per sample, however ^{210}Pb analysis may sometimes be carried out in conjunction with ^{137}Cs analysis. Usually 10 to 20 samples are required to obtain reliable ^{210}Pb dates and estimates of sedimentation rates.

WHERE ANALYSED

Specialist laboratories in universities and other environmental research institutes.

EXPERTISE

Data interpretation requires statistical analyses and an understanding of radiochemistry.

Kahikatea pollen. Studying fossilized pollen can reveal historical vegetation patterns, and imply changes in land use, climate, and disturbance regimes. Photo: Marc Schallenberg, University of Otago

Pine pollen. Both the pine (introduced) and kahikatea (native) pollen samples are stained with carbol fuchsin dye. Photo: Marc Schallenberg, University of Otago

3.3 Indicator pollen

Vegetation changes can be used to infer changes in land use, climate, and disturbance regimes. Pollen is separated from the sediment, stained and identified microscopically. Where known vegetation changes are described in historical records, indicator pollen can be used to date sediment. Useful indicator pollen for wetlands and their catchments include pine (*Pinus radiata*), kahikatea (*Dacrycarpus dacrydioides*), bracken fern (*Pteridium esculentum*). Note that pollen may be rare in coarse sediments from high-energy environments.

TIMESCALE

Decades to millennia before present. Usefulness depends on preservation of the pollen in the sediments.

METHOD

Light or electron microscopy.

MATERIAL

Bulk fresh sediment. Pre-treatment is necessary.

COST

c. $170 per sample for preparation of pollen slides and $250 per sample for the pollen identification.

WHERE ANALYSED

Specialist laboratories in universities and other environmental research institutes.

EXPERTISE

Pollen identification and interpretation requires strong botanical and palynology skills.

3.4 Carbon-14 (^{14}C)

Radioactive isotope of carbon. By analyzing the different isotopes of carbon, objects (e.g., shells, wood) can be dated back thousands of years with relatively high accuracy. With care, this method can be used to infer sediment ages and sedimentation rates.

TIMESCALE

c. 1,000 – 25,000 years before present.

METHOD

Beta particle counting or accelerator mass spectrometry. Marine/freshwater/terrestrial calibration required.

MATERIAL

Macrofossils (e.g., wood, shells) and bulk sediment. Sample pre-treatment necessary.

COST

Standard beta particle emission analysis costs c. $310–400. With small sample sizes, accelerator mass spectrometry may be required and this costs c. $800 per sample.

WHERE ANALYSED

Specialist laboratories in universities and other environmental research institutes.

EXPERTISE

Expertise and experience essential.

Bracken is a key indicator of human-induced environmental change: as a valuable food source, early Maori cleared land by burning to encourage its growth. Photo: Monica Peters NZ Landcare Trust

CASE STUDY

WAIPORI/WAIHOLA & WAITUNA WETLANDS: DIGGING EVEN DEEPER INTO THE PAST

Palaeo-ecological techniques were used at both the Waipori/Waihola Lake-Wetland Complex (Otago) and the Waituna Lagoon wetland complex (Southland). The techniques yielded important ecological information on the effects of past saline intrusions and sea level rise on the systems. This information is of great relevance to setting appropriate restoration goals for these tidal ecosystems. See previous chapter – Site interpretation 1 for further information on the two wetland complexes profiled.

Date	Determination	Findings	Methods used
Waituna Lagoon			
> c. 7000 ybp	Wetland formation	• Post-glacial formation due to mid-Holocene sea level rise	• ^{14}C dating • Grain size analysis • Organic matter analysis • X-ray densitometry
Waipori/Waihola Lake-Wetland Complex			
> c. 5000 ybp to present	Long-term state of lake/wetland system	• Continued presence of standing water in lakes surrounded by wetlands that were inundated at times	• ^{14}C dating • Grain size analysis • Organic matter analysis • X-ray densitometry
Waituna Lagoon and Waipori/Waihola Lake-Wetland Complex			
c. 7000 ybp to c. 1860	Wetland state prior to significant anthropogenic impact	• Wetland consisted of a large area of standing water (lagoon/ lake) surrounded by temporally stable, vegetated wetland • Minimal marine influence • Low sediment accumulation rate in open waters • Established dominant native vegetation	• Radio-isotopic dating (^{14}C, ^{210}Pb, ^{137}Cs) • Grain size analysis • Organic matter analysis • X-ray densitometry • Pollen analysis and dating • Reference site analysis • Historical research
c. 1860 to present	Anthropogenic effects	• Increased in marine influence • Vegetation changes (local and in catchment) • Increased sediment accumulation rate • Increased hydrological throughout and energy • Reduced hydrological buffering	• Radio-isotopic dating (^{210}Pb, ^{137}Cs) • Grain size analysis • Organic matter analysis • Pollen analysis • X-ray densitometry • Site evaluation/interpretation • Historical research
Present to future	Environmental constraints for restoration	• Shift to estuarine conditions • High hydraulic energy and sediment accumulation rates • Determine appropriate restoration goals	• Palaeo-limnological interpretation • Literature research • Site evaluation/interpretation • Reference site analysis

– Marc Schallenberg

4 Biological indicators/ proxies

These are specialist methods best employed in collaboration with experts from universities or environmental research laboratories. As such, no cost estimates are provided.

4.1 Macrofossil plant and animal remains

These include leaves, seeds, shells and wood. These indicators are commonly found in sieved wetland sediment samples and are useful in providing information about plants and animals which lived in and around wetlands. With the help of skilled specialists, past physico-chemical conditions can be inferred from the types of organisms that inhabited the wetland.

METHOD

1. Identify species present in sediment strata; 2. Confirm that the species that produced the macrofossils were likely to have been living at the site; 3. Research present types of environments (e.g., salinity, hydrology, etc.) in which the species live; 4. Infer similar conditions existed in the past at the site

EQUIPMENT

Sieves, chemicals and a laboratory for sample preparations, microscope.

SAMPLE COLLECTED FROM

Various aquatic environments.

WHERE ANALYSED

Specialist laboratories in universities and other environmental research institutes.

EXPERTISE

Microscopy, taxonomy.

4.2 Microfossil plant and animal remains

These include diatom frustrules (the silicate shells of microscopic algae known as diatoms), chironomid head capsules (from aquatic midge larvae), phytoliths (inorganic crystals produced in some terrestrial plants), foraminifera shells (from small marine animals called foraminiferans), planktonic crustaceans (zooplankton) and the pollen and spores of wetland plants.

METHOD

1. Identify species present in sediment strata; 2. Confirm that the species that produced the macrofossils were likely to have been living at the site; 3. Research present types of environments (e.g., salinity, hydrology, etc.) in which the species live; 4. Infer similar conditions existed in the past at the site.

EQUIPMENT

Sieves, chemicals and a laboratory for sample preparations, microscope.

SAMPLE COLLECTED FROM

Diatoms, phytoliths and pollen can be collected from most wetland sediments and soils. Chironomids and zooplankton can be collected from sediments underlying open water in lakes, ponds, wetlands and lagoons. Foraminifera can be collected from aquatic sediments which have had some marine influence.

WHERE ANALYSED

Specialist laboratories in universities and other environmental research institutes.

EXPERTISE

Microscopy, taxonomy, statistical skills.

4.3 Charcoal

Charcoal grains are indicators of fire in the catchments and are useful for reconstructing fire histories.

METHOD

Microscopic identification and quantification of charcoal grains.

EQUIPMENT

Sieves, chemicals and a laboratory for sample preparations, microscope.

SAMPLE COLLECTED FROM

Sediments, soils.

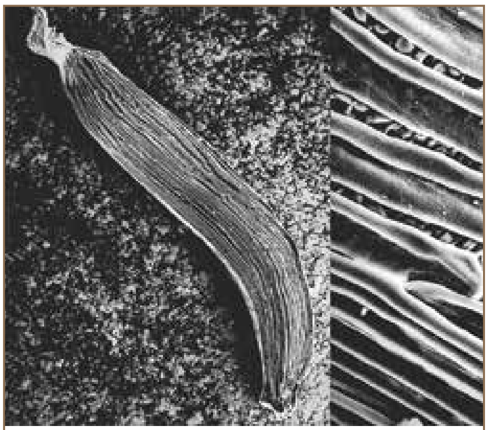
WHERE ANALYSED

Specialist laboratories in universities and other environmental research institutes.

EXPERTISE

Microscopy.

ACKNOWLEDGMENTS: The following organsiations kindly contributed information and current (2010) costings to this chapter: The Cawthron Institute, Hill Labs, the Waikato Radiocarbon Dating Laboratory, the National Radiation Laboratory, the Rafter Radiocarbon Dating Laboratory, the Geography Department University of Otago and the Zoology Department University of Otago.



Manuka seed enlarged x30 and x300.
Photo: Colin Webb, Landcare Research

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5.1 Useful websites

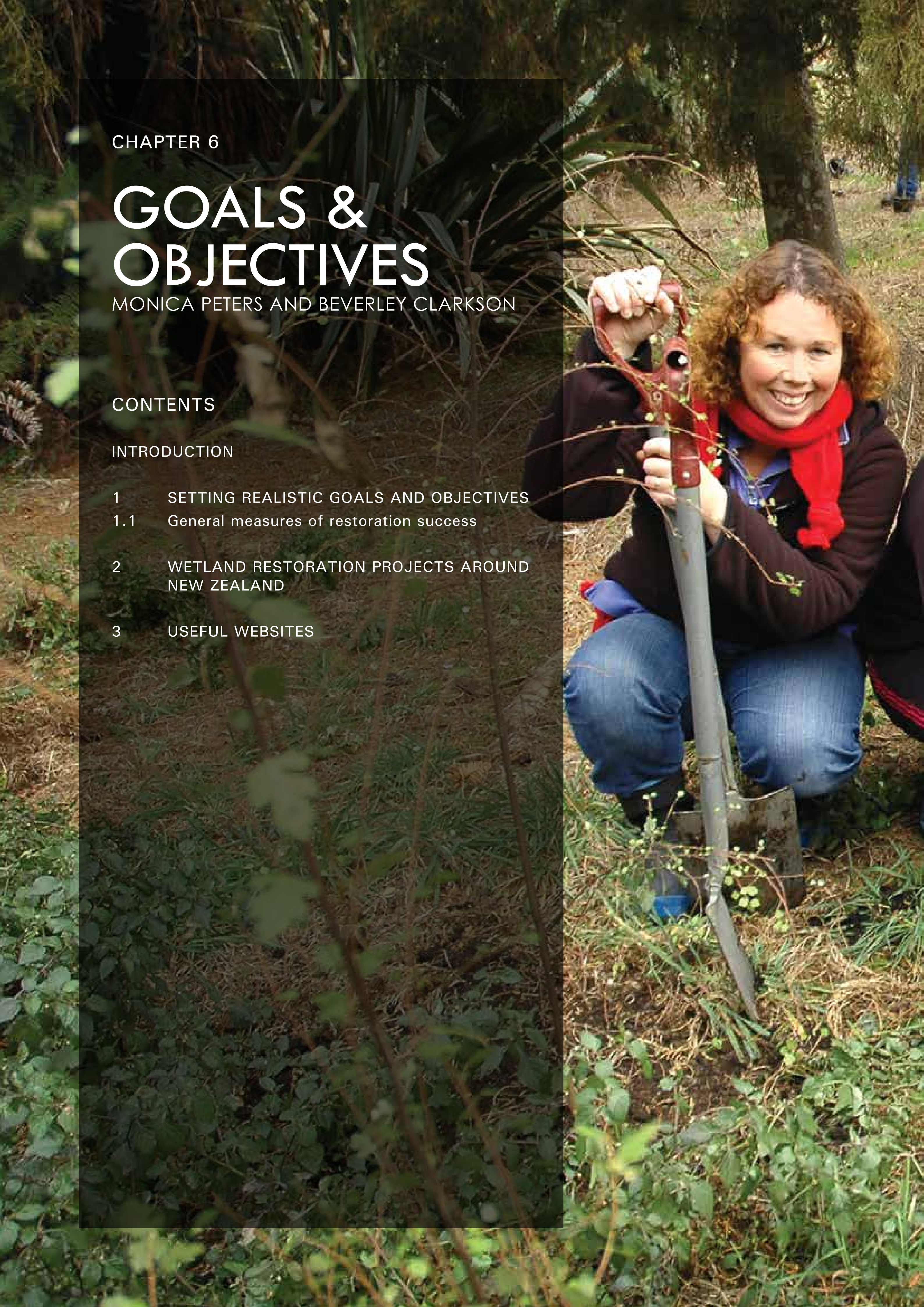
National Radiation Laboratory

www.nrl.moh.govt.nz/

University of Waikato Radiocarbon Dating Laboratory

www.radiocarbondating.com/

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 6

GOALS & OBJECTIVES

MONICA PETERS AND BEVERLEY CLARKSON

CONTENTS

GOALS & OBJECTIVES

GOALS & OBJECTIVES

MONICA PETERS AND BEVERLEY CLARKSON

Goals are general statements about desired project outcomes and, as such, a goal is a vision of what you want the wetland to be in a given time frame. Clear goals and specific objectives linked to them will help you explain to other people, including potential funders, partners (e.g., Regional and District Councils, Department of Conservation, iwi) and the local community, what you are aiming to achieve. In the process, having a clear picture of what you are aiming for will assist with preparing strong funding proposals as well as inspiring new volunteers to join the project.

Defining your goals (e.g., to replace an area dominated by introduced plants with appropriate native plants), objectives and the time frames you want to achieve them in (e.g., remove 30% of willow in the area by the end of Yr 1) are integral to developing a strong monitoring programme. A monitoring programme will enable you to determine the overall success of the restoration as well as guide ongoing site management.

To cement the links between goal and objective setting, and developing a monitoring programme a brief section on ecological measures of restoration success is included in this chapter.

Previous page: Planting day at Lake Serpentine, Waikato.
Photo: Abby Davidson, NZ Landcare Trust

Banded kokopu are one of the endemic species – many of which are threatened – that make our wetlands and waterways unique.
Photo: Stephen Moore, Landcare Research

An example of a goal may be to improve native plant and animal populations, enable sustainable harvesting of food, medicine and fibre (e.g., the piupiu pictured). Photo: Monica Peters, NZ Landcare Trust

Two major fires in recent years have been a management challenge for the Friends of the Mangarakau Swamp that reshaped the group's restoration goals and objectives.
Photo: Monica Peters, NZ Landcare Trust

1 Setting realistic goals and objectives

The achievability of the wetland restoration project will depend on a number of factors such as the size and scale of the project, how much the wetland has changed compared with the original extent and condition, and what funding and labour are available. If the wetland has been highly modified, e.g., altered water regime, impaired connectivity, or dissected into fragmented remnants, then realistic goals may, at least originally, centre on removal of weeds and planting native species in a small, more manageable portion of the wetland. Specific restoration actions can be undertaken in achievable steps along the path to the overall restoration. Some actions, however, may not be possible or practical, such as restoring connections and buffers in the middle of urban areas.

Setting goals and objectives can be an iterative process, just as the management of your restoration site will adapt over time in response to restoration progress, or unexpected events such as fires or floods. Your goals and objectives can be refined for example as you learn more about your wetland or as unexpected events take place such as a fire, or if you receive further funding. Many restoration projects will have a range of goals and objectives, as is demonstrated by the project examples and case study included in this chapter.

Raising awareness of wetland values as a component of wetland restoration at Battle Creek Farm Park, Wellington.
Photo: Monica Peters, NZ Landcare Trust

1.1 General measures of restoration success

Most wetland restoration projects' primary goal is to restore the wetland as a relatively self-sustaining ecosystem with natural values representative of those existing before major modification.

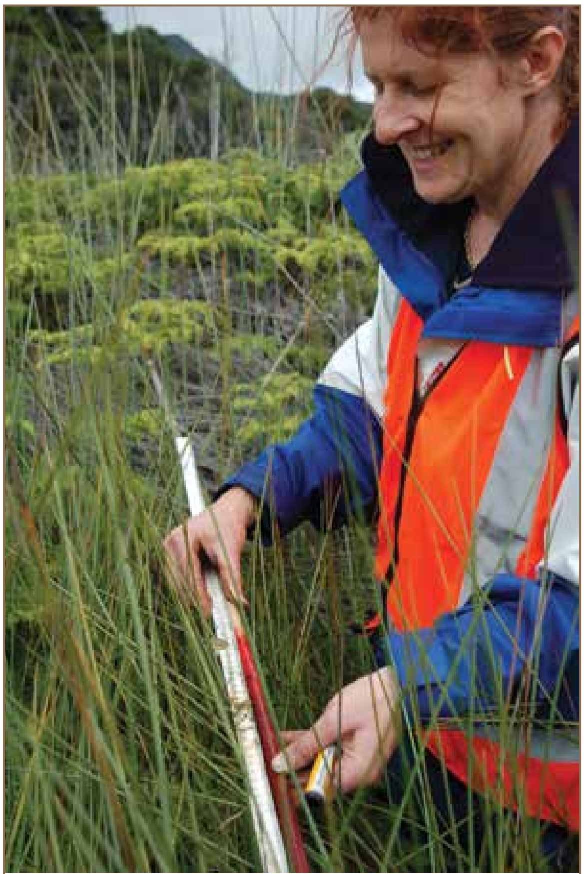
General measures of restoration success	
1	For each habitat/ecosystem type: • Plantings are appropriate • The majority of plantings survive to maturity • There is recruitment of new individuals into the population (habitat/ecosystem type becomes self-sustaining) • Weed problems have decreased
2	There is an increase in the frequency of native bird visits and residency
3	Key processes are restored to within their range of natural variability: • Water levels are restored similar to previous levels • Vegetation is dominated by native species • Nutrient enrichment is mitigated • Accidental or deliberate fires no longer occur
4	Vertebrate pests are controlled
5	Overall biodiversity/ ecological values have increased

Further examples of setting goals and objectives are included in Chapters 7–12, (Hydrology, Nutrients, Weeds, Revegetation, Pests, Native Fauna) and Chapter 13 – Monitoring.

"SMART" GOALS AND OBJECTIVES

The "SMART" principles provide a useful framework for developing a set of goals and objectives for your wetland restoration project. They should be:

- SPECIFIC
- MEASURABLE
- ACHIEVABLE
- REALISTIC
- TIME-BOUND



Measuring restoration progress: strong goals and objectives are needed for developing monitoring programmes.
Photo: Danny Thornburrow, Landcare Research

Both photos show the same wetland – this end has been severely impacted by vegetation clearance, drainage, with stock trampling and weed incursion. Hangitiki, Waikato.
Photo: Monica Peters, NZ Landcare Trust

The other end of the Hangitiki wetland (a Department of Conservation Reserve) is in very good condition and provides a valuable reference site for any future restoration of nearby wetlands. Photo: Monica Peters, NZ Landcare Trust

CASE STUDY

RESTORING PATAUA NORTH: A CLEAR GOAL AND STRONG OBJECTIVES

The privately owned Tahi (from the original Ohuatahi – "First place of plenty") is a 300 ha farm at Pataua North (Northland). The two largest wetlands on the property include a former dune lake and a freshwater to marine wetland abutting the Pataua Estuary. Drainage works and over a century of grazing – first dairy and then beef cattle – have severely impacted all remaining wetland areas. The current owners (two of whom are ecologists) bought the property in 2004 and have since been actively retiring and restoring the wetlands.

Restoration goals

The overarching goal for the property with its wetlands, forested areas and coastline is to preserve both the ecological and the cultural heritage of the land, while providing a sanctuary for people, fauna and wildlife. Maximising native biodiversity – mainly birds but also fish and wetland plants, is the goal for the wetland restoration in general.

Objectives

Objectives for the 13 wetlands now in the process of restoration:

- Maximise faunal diversity (predominantly birds) through a diversity of water depths and plant associations
- Sustain ground water levels

Objectives for the first wetland to be restored:

- To provide year round water

Objectives for the dune wetland:

- Reflood part of a former dune lake system
- Enhance water quality flowing to the beach

Restoration works

Mercer grass and pampas are being controlled with glyphosate. Cattle were removed from the total catchment of the estuarine wetland in 2007 with 50:25:25 funding (DOC Biodiversity Fund, Northland Regional Council (NRC) Environment Fund and landowner contribution). The one-way gate on the drain into the estuary was also removed. The same 50:25:25 funding was used in 2006 to initiate restoration of the former dune lake. Along with fencing, a 0.8-m weir was put into the outlet drain to retain water and some areas of pasture were dug out to provide deeper water. Riparian margins were planted with a mix of native shrubs and trees. All cattle have now been removed from the surrounding paddocks and the neighbouring section has also been fenced. Planting continues on both properties.

Results

Bird numbers have increased. Full pest control now extends across all neighbouring properties through NRC's Community Pest Control Scheme. Fernbird have expanded their range, bittern, 3 shag species, ducks and pied stilt are now common residents, and grey teal and dabchick have made their first appearance. Liaison with the Brown Teal Recovery Group has the properties listed for future reintroduction. Tui have increased markedly in areas with flax.

What next?

Many wetland areas remain smothered in rank kikuyu. Some areas will be planted with kahikatea or flax, some will be partly flooded by constructing small dams and blocking drains. Extensive planting of steeper areas in all catchments will also continue. Infill planting with kahikatea will continue in the more exposed wetlands as the other plantings mature. Nest boxes will be added for grey teal and nest structures for welcome swallow are being trialled.

– John Craig

REF: www.tahinz.com/sustainability.html

The old dune lake after a major rain event and before damming for restoring wetland flora and fauna. One of the objectives here is to improve water quality flowing to the beach. Photo: John Craig

Wetland planting maturing. The results are promising: grey teal, NZ dabchick and NZ shoveller bred here for the first time in 2009. Brown teal arrived in the same year by themselves. Photo: John Craig

The first wetland in the process of restoration and enhancement. (Year 1) Photo: John Craig

The same wetland three years later. Keeping the wetland wet in a very dry landscape is a challenge and therefore a key objective. Photo: John Craig

The eleventh wetland in the process of restoration and enhancement. (Year 3) Photo: John Craig

The same wetland five years later. Photo: John Craig

2 Wetland restoration projects around New Zealand

Wetland restoration takes many forms. The goals of the following projects highlight the diverse motivations – cultural, ecological, economic, social, recreational and aesthetic – which shape wetland restoration in the New Zealand landscape.

COMMUNITY GROUP PROJECT, HULLS CREEK, WELLINGTON

"Protect banks from erosion during flooding and improve water quality and flow. Reintroduce native fish fauna by constructing a fish ladder at junction with Hutt River. Construct a bush walk below the stream railway."

LAKE CAMERON CARE GROUP, WAIKATO

"Improve water quality, enhance views, improve access to and around lake. Maintain duck shooting and maimais, plant trees to attract native birds. Manage plant and animal pests, enhance species diversity and the educational potential of lake."

LAKE ROTOKARE TRUST, TARANAKI

"Build and maintain an 8.4-km totally pest-proof fence around Rotokare Scenic Reserve, eradicate all mammalian animal pests and reintroduce threatened species (including kiwi, kokako, takahe, and tuatara). Develop visitor infrastructure (access gates and tracks), provide guided tours and 'ecological experiences' for visitors, including nocturnal 'kiwi-listening' cruises on the lake. Establish an education facility for school groups, visitors and researchers, and develop a successful business capable of sustaining the operating costs of the whole project area into the future."

FISH & GAME NZ, SOUTHLAND

"Re-create suitable habitat to benefit whitebait (Inanga) and other native fish populations and whitebait fishery as the reduced flows of the Waiau River and land development of the low lying tidal areas of land have dramatically reduced spawning and rearing habitats."

LANDCARE RESEARCH FRST-FUNDED WETLAND PROGRAMME

"Provide scientifically based guidelines, techniques, and tools as input into effective management and restoration strategies in wetlands that are most threatened."

PRIVATE FARM WETLAND RESTORATION PROJECT, BANKS PENINSULAR

"Return the present practically bare paddock to its original status when it was covered in native bush and wetland species."

DEPARTMENT OF CONSERVATION ARAWAI KAKARIKI RESTORATION PROGRAMME

Whangamarino, Waikato; O Tu Wharekai, Canterbury; Awarua-Waituna, Southland

Biodiversity

- Maintain or enhance the extent of wetland habitat
- Maintain and enhance water regime and water quality to support wetland values
- Protect intact wetland habitat and restore degraded wetland habitat
- Maintain and enhance species diversity, including threatened species

Community and Cultural

- Conserve and interpret important historic and cultural sites
- Promote sustainable catchment management
- Improve facilities and recreation opportunities for public
- Maximise community awareness, appreciation and involvement

Learning and Development

- Support research that improves wetland management
- Support the development of best practice management and monitoring

NZ LANDCARE TRUST, WAIKATO

"Recreate 2 areas of rare restiad wetlands in the Waikato trialling a range of best practice techniques. Monitor plant growth and establishment over a 5-year period or until 100% restiad cover has been achieved."

Before restiad wetland re-creation...

Adding restiads and other plant species... digitally to begin with.

What a recreated wetland might look like!
Image: Monica Peters, NZ Landcare Trust

Wetlands, waterways and whitebait go hand-in-hand.
Photo: Peter Hamill, Marlborough District Council

What is now wetland was once farmland. The overall goal for Otipua was to bring the wetland back. Otaki, Wellington.
Photo: Monica Peters, NZ Landcare Trust

3 Useful websites

Wetland restoration templates

Waikato Regional Council Wetland Restoration Plan templates

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate1.pdf

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate2.pdf

Wetland restoration guides and factsheets (New Zealand)

Northland Regional Council

www.nrc.govt.nz/upload/2217/Wetland%20Restoration%20Guide%20(second%20edition%20Feb%2009).pdf

Auckland Regional Council

www.arc.govt.nz/albany/fms/main/Documents/Environment/Plants%20and%20animals/wetlandsfacts2.pdf

Waikato Regional Council

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/

Hamilton City Council

www.gullyguide.co.nz/index.asp?pageID=2145821537

Bay of Plenty Wetlands Forum

www.doc.govt.nz/upload/documents/conservation/land-and-freshwater/wetlands/wetland-restoration-guide.pdf

Greater Wellington

www.gw.govt.nz/a-beginner-s-guide-to-wetland-restoration/

Department of Conservation Protecting Natural Areas Design Guide

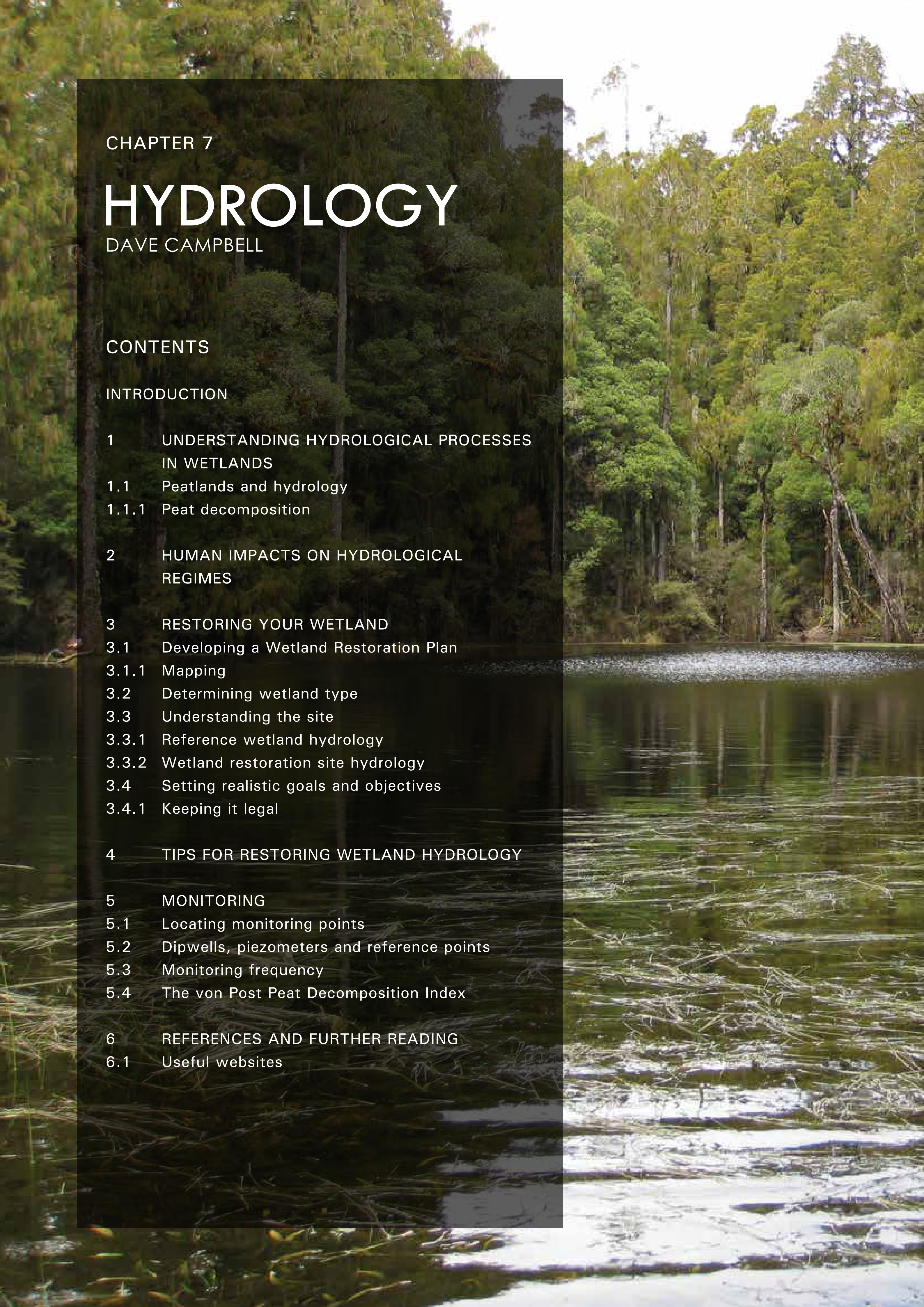
www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/nature-heritage-fund/protecting-natural-areas-design-guide/

Wetland restoration guides (International)

USA Environmental Protection Agency

www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 7

HYDROLOGY

DAVE CAMPBELL

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HYDROLOGY

HYDROLOGY

DAVE CAMPBELL

When applied to wetlands, the science of hydrology is concerned with how the storage and movement of water into and out of a wetland affects the plants and animals, and the soils on which they grow. Most wetland scientists agree that the single most important factor determining both wetland type and function is hydrology. Consequently, changes in hydrology are the leading causes of wetland degradation or destruction. The two case studies in this chapter illustrate how water was returned to a previously drained lowland swamp and a peat bog and the effects on the vegetation communities. Both sites had been drained as further dry land was desired for farming and urban development, a common scenario throughout New Zealand.

Hydrologists often start their studies by defining the size and shape of a catchment, in other words, the area of land that contributes liquid water to a downstream location, either as surface water in streams or groundwater that may emerge in seepages or springs. Wetlands often occur in the lower parts of catchments where there is an excess of water input so that the water table is permanently or seasonally close to the ground surface. This includes valley bottoms, low-lying areas alongside streams and rivers, and down slope of seepages. Alternately, in very wet climates they can occur just about anywhere drainage is restricted. This means most wetlands are intimately connected to the upland parts of their catchments and restoration efforts may be stymied by water quality or quantity issues deriving from land-use practices considerable distances away. An integrated approach to whole-catchment water quality and quantity issues may be necessary for successful restoration, such as stream fencing and riparian planting upstream.

Previous page: Waihora Lagoon, Pureora Forest Park, Waikato.
Photo: Karen Denyer, National Wetland Trust

Most of the Waikato shallow lakes have been lowered through drainage. Further drainage is prevented by weirs that now establish minimum water levels.
Photo: Monica Peters, NZ Landcare Trust

Pooled water after heavy rain shows provides an indication of how far the wetland originally extended prior to clearing for pasture. Raglan, Waikato.
Photo: Monica Peters, NZ Landcare Trust

The seepage in this modified wetland clearly shows as bright green grass. Batlle Hill Farm Park, Wellington. Photo: Monica Peters, NZ Landcare Trust

1 Understanding hydrological processes in wetlands

Research has identified that the most significant problem limiting the success of wetland restoration projects is inadequate hydrological regimes. The hydrological regime or hydroperiod refers to the characteristic changes in hydrological variables over time, the most notable being water levels and water flows or discharge. It follows that getting the hydrology right is a key factor for successful wetland restoration.

Natural wetlands form because of landscape and hydrological interactions that lead to an excess availability of water or water convergence. If these hydrological conditions are provided a wetland will form, although it might not be the type of wetland you are setting out to establish. It follows that wetland restoration is only likely to be successful in locations where water flows already converge, unless you're prepared to carry out major engineering works. Any planned modifications to water flows such as blocking drains should aim to reinstate the natural degree of water convergence by slowing water flows rather than creating an artificially imposed hydrological regime, such as damming streams.

This intricate scroll plain in the upper Taieri (Otago) is the result of a river meandering across an area with a very low gradient.
Photo: Aalbert Rebergen, Otago Regional Council

1.1 Peatlands and hydrology

An intimate relationship exists between hydrology, plants, and the wetland substrate in peatlands. Peat forms because decomposition of accumulating plant matter is limited by low oxygen levels in saturated soils, and the dominance of low nutrient water sources (especially rainwater). Peatlands may begin to form during wetter climate conditions that promote high water levels, and many thousands of years are often required for significant layers of peat to accumulate. Once formed, peat itself restricts water flows and eventually true bogs may develop, where the wetland water table is raised above the regional water table and the bog becomes isolated from external water flows. When a peatland is drained the peat oxidizes and compresses, lowering the land surface, meaning it can be very difficult to restore a functioning wetland system. For this reason, peatland restoration poses very significant challenges.

Peat substrates in fens and bogs have the ability to expand and contract (and sometimes even float) in response to rising and falling water levels. This phenomenon is termed peat *surface oscillation*. It has the very important property of stabilising water level fluctuations relative to the surface, which may be a critical factor determining where particular plants will grow. For example, the jointed wire rush *Empodisma minus* will not grow well in situations where its roots are regularly flooded. There is some evidence that this plant forms peat that is capable of floating at high water stages, allowing the roots of the plants to remain moist but not flooded. Drainage activities, physical damage by stock trampling or vehicles, or weed invasion all lead to degradation of peat physical properties and destroy its ability to oscillate. Restoration of these peat functions is extremely difficult and may take a very long period of time.

1.1.1 Peat decomposition

A further consideration for restoration is the degree to which the peat is decomposed. Using a simple "squeeze test" a handful of undecomposed peat will show obvious plant structure and yield clear water. At the other end of the scale, well-decomposed peat will not show any plant structure and will ooze out between the fingers like toothpaste. The level of decomposition is closely linked to nutrient levels, hence to vegetation type. As undecomposed peat is lower in nutrients than well-decomposed peat, the plants selected for revegetation will need to be considered based on how decomposed the peat is. The von Post Index (included in the monitoring section of this chapter) is widely used to determine the level of peat decomposition.

Wire rush (*Empodisma minus*) with its dense mass of upward growing roots is a key peat forming species. Moanatuatua Scientific Reserve, Waikato. Photo: Monica Peters, NZ Landcare Trust

The fluctuating levels of the Waikato River (the result of power generation) have a pronounced effect on wetlands such as Hardcastle Lagoon. Photo: Monica Peters, NZ Landcare Trust

2 Human impacts on hydrological regimes

Human interventions in the landscape often result in "flashy" hydrological regimes in rivers and wetlands. For example, forest clearance and conversion to pasture will lead to higher rates of surface water runoff, which can cause scouring in downstream wetlands, or deposition of sediment, or both. For these reasons, upstream restoration may be the key ingredient for successful wetland restoration. This might only be feasible in small catchments, unless integrated catchment management principles are followed that involve entire communities and local government, as well as conservation groups.

Natural wetlands require water tables that fluctuate seasonally and in response to pulses of water inputs (e.g., from rainfall, tides, flooding rivers) – but not too much fluctuation, or too little. For example, artificial water control structures often result in unnaturally stable or high water tables. On the other hand, extreme water table lowering caused by artificial drainage or drought will challenge the survival of some wetland plants and animals, and may allow dryland weeds to invade.

The Taieri River (Otago) is a highly modified system – with many wetland areas in the catchment drained, severe flooding can result after heavy rainfall. Photo: Gretchen Robertson, NZ Landcare Trust

3 Restoring your wetland

3.1 Developing a Wetland Restoration Plan

A Wetland Restoration Plan is extremely useful for gathering information about the restoration site, clarifying goals and objectives and guiding restoration activities. Either use an existing template (see the Useful websites section at the end of the chapter) or create your own based on the steps outlined in Chapter 2 – Restoration planning.

3.1.1 Mapping

A useful starting point for developing a Wetland Restoration Plan is a sketch map. A bird's-eye view sketch map is important as it helps summarise knowledge about the natural and man-made character of the restoration site. It is a practical tool for defining, for example, management zones and locations of permanent plots for monitoring. The map can be hand drawn using a range of resources such as aerial photos, topographic maps, and Google Earth, combined with your own knowledge.

The following features should be included:

- Vegetation types
- Water sources and outflows, hydrological modifications, water level
- Soil type
- Man-made, natural and cultural features

For more detail on what to include, see Chapter 2 – Restoration planning.

3.2 Determining wetland type

An important step for developing a Wetland Restoration Plan is to determine the wetland type of the restoration site. This will also help with finding an appropriate reference wetland. Freshwater wetland types and the features that characterise them are outlined in Chapter 2 – Wetland types.

3.3 Understanding the site

Use maps and aerial photographs to locate a reference wetland or enlist help from agencies such as the Department of Conservation. To be useful, any reference wetland should be in a similar landscape position to the one you are intending to restore, at a similar point in its catchment, and with similar water flows. To take an extreme example, an extensive peat bog will not provide a suitable reference for the restoration of a valley bottom flax swamp because the types of water and sediment sources are completely different. Further information on reference wetlands can be found in Chapter 5 – Site interpretation 1. For more in-depth information on historical aspects of the wetland, see Chapter 6 – Site interpretation 2.

Two key steps will guide your Wetland Restoration Plan by informing you about hydrological factors. First, determine what the natural hydrological regime would once have been at the restoration site. Second, determine what changes have occurred to alter the natural regime. A reference wetland can help with the first step, and can then provide a yardstick against which to judge the success of any restoration efforts over time. The key questions to ask are:

Why is this reference wetland more pristine than the one we are planning to restore?

How does the hydrology differ between the reference and the restoration wetlands?

3.3.1 Reference wetland hydrology

Make a careful evaluation of the factors affecting the hydrological regime at your reference wetland(s), particularly those that affect water quantity and quality. The questions below provide a useful starting point. Additionally, tapping into the local knowledge of adjacent landowners could be very helpful.

What are the primary sources of water for the reference wetland?

- If the wetland is at the toe of a slope, seepage is likely to be important, even if you can't see any springs.
- If there are streams flowing into the wetland then there are likely to be strong linkages between the stream water and the wetland, so surface water inflows will be important, as will the water quality.
- If the wetland is alongside a major river, flooding by the river may be a major factor, or the level of water in the river will likely control the level of water in the wetland.
- How often will flooding of adjacent large and small streams and rivers impact on the wetland – several times a year, or maybe only one year in 10?
- Is the wetland affected by tidal water flows?
- Is the wetland predominantly rain fed?

What factors affect the quality of water flows into the reference wetland?

- Is the land upstream or upslope forested?
- If forested, is it native or exotic?
- If the land is used for agriculture, what type and intensity of agriculture?
- Are there any signs of erosion such as landslips, turbid stream water, or fresh deposits of silty material?

How do water levels vary in the reference wetland?

To answer this fully requires a detailed monitoring programme carried out over one or more years; however, there may be clues you can obtain from a site visit.

- Are the summer (low) water levels above or below the surface in different parts of the wetland?
- Are there any signs left of high flood stages (e.g., debris in fences or trees)?

Opposite page: Pukio/purei (*Carex secta*) is typical of swamps. Lake Koromatua, Waikato. Photo: Monica Peters, NZ Landcare Trust

3.3.2 Wetland restoration site hydrology

Given the critical nature of hydrology for wetland restoration success, you should clearly identify all the hydrological changes that have affected your restoration site, either directly (e.g., excavation of a network of drainage ditches) or indirectly (e.g., conversion of catchment headwaters from native forest to dairy farms that have increased water, nutrient and sediment inputs to the wetland).

Rank these factors according to their likely importance in creating the situation as it now exists.

Which of the highly ranked factors might feasibly be changed to return the system closer to its natural state?

Moanatuatua Scientific Reserve (120 ha) is a rain-fed bog remnant situated close to Hamilton (Waikato): The original bog covered an estimated 7500 ha. Photo: Monica Peters, NZ Landcare Trust

The following is a list of possible hydrological effects from factors that may be impacting on your wetland:

- Increased water flows due to upstream forest removal
- Reduced water flows and improvements to water quality by forest planting or reversion to scrub
- Pulses of sediment from the natural adjustment of forest streams
- Sediment and nutrient runoff increases due to land-use intensification. Crops have very high fertiliser inputs, dairy moderately high, while sheep and beef are comparatively low
- “Flashy” runoff and reduced low-flows through urbanisation – impervious paving and roofs prevent infiltration through the soil and groundwater recharge. This may lead to scouring and/or reduced summer inflows to downstream wetlands
- Lowered water tables though drainage (e.g., tile drains, ditches), which also leads to drier soil, oxidation and shrinkage of organic soils, and invasion by dry-land species
- Faster water flows and reduced local flooding by artificial straightening of stream channels, which may also exacerbate flooding downstream
- Unnaturally long flooding regimes in flood detention areas through flood protection works such as stop banks
- Isolation of wetlands from natural periodic inundation by flooding rivers through flood protection works such as stop banks
- Heavily impacted natural system functions by weed invasion
- Unnaturally stable and high water tables by damming, which also leads to very narrow wetland zones around aquatic habitat
- Soil types, e.g., peat or mineral

The vegetation of this dune lake on Matakana Island reflects changes in salinity as the narrow barrier separating the wetland from the sea is periodically breached. Photo: Monica Peters, NZ Landcare Trust

The Lower Kaituna Wildlife Management Reserve (BoP) is bordered by stopbanks and drained farm land, creating a "perched" wetland with water management problems. Photo: Environment Bay of Plenty

CASE STUDY

OTAIURA/HANNAH'S BAY WETLAND: RESTORING & RETAINING HIGHER WATER LEVELS

Near Rotorua lies a remnant of a swamp significantly reduced in size due to the development of the surrounding lands for agriculture, residential settlement and the Rotorua Regional Airport. Drainage allowed the colonization of a wide range of introduced species such as willow, hawthorn, pampas, blackberry and Himalayan honeysuckle.

Thorough planning

A restoration strategy was first developed by Wildlands in 2000 (Shaw et al.) with an implementation plan produced in 2005 (Wildlands Contract report #1197). The highly degraded state of the wetland, restoration constraints imposed by its location, and a variety of conflicting community interests meant significant planning was required before beginning on the ground works.

Key activities

- Identification of an ecologically acceptable route for a stormwater channel to pass through it
- Liaison and supervision of the earthworks contractor
- Meetings with all affected parties
- Large-scale weed control
- Restoration planting over 5 seasons (>27 000 plants)
- Restoration updates produced for on-site bulletin boards
- Water levels monitored using a staff gauge and 4 piezometers
- Restoration progress documented from photo points and vegetation monitoring plots

Restoration goal

The goal of the restoration is to re-establish and maintain the natural ecosystem processes and the indigenous character of the Otauira wetland. From a hydrological perspective, this meant restoring and retaining higher water levels within the wetland by redirecting surface runoff and other airport-derived water and by "fixing" other areas where water was being lost. Resource consents were required for the development of bunds in low-lying areas, stormwater channels and a weir to control water levels within the wetland. Today, water levels in the wetland area have been raised significantly by blocking off two culverts formerly draining the wetland and by redirecting water from the airport into the wetland through the newly developed stormwater system. Funding for the hydrological works was covered by the Rotorua Regional Airport as mitigation for the loss of wetland habitat due to runway extension.

Positive outcomes

The raised water levels have resulted in the die back both of introduced plants and native species (e.g., tree ferns and karamu) not well adapted to standing water. Over time these native species will be replaced by wetland plants better adapted to the new conditions. More important, elevation of water levels coupled with sustained weed control and an extensive planting programme have restored the quality and quantity of wetland habitats that formerly characterized this area.

REF: Wildland Consultants Ltd. 2005. *Otauira (Hannah's Bay) Wetland Ecological Restoration and Development Plan*. Wildland Consultants Contract Report No. 1197. Prepared for the Rotorua District Council.

Culvert with removable concrete inserts to enable further hydrological manipulation when required. Photo: Wildland Consultants Ltd.

Native plant regeneration inside the wetland view from the boardwalk. Photo: Monica Peters, NZ Landcare Trust

Hannah's Bay/Otaiura wetland is situated on the shores of Lake Rotorua. Photo taken in 2006 showing stormwater channel.
Photo: Wildland Consultants Ltd.

3.4 Setting realistic goals and objectives

Setting realistic goals is the key to success in wetland restoration (See Chapter 6 – Goals & objectives). Hydrological goal setting is one component of the overall restoration goals, with more or less importance depending on the situation at hand. For instance, if you are dealing with a wetland where weed invasion is the key challenge, but there has been little hydrological modification, your hydrological goals might be focused on improving upstream water quality, for example, keeping stock out of streams and improving riparian planting. Your goals and objectives will help you develop a monitoring programme to determine the success of your restoration activities.

Make a list of the main challenges confronting your restoration plans. Do they include water quantity and/or quality? Weed infestations? Erosion or deposition of sediments? Significant soil shrinkage?

Evaluate the role hydrology might play in these challenges, and decide whether you can feasibly overcome them. Over-ambitious or unrealistic goals are a recipe for failure in wetland restoration. Examples include situations where large-scale engineering works are required, or where the effects of drainage over large areas have caused a wholesale shrinkage of the land surface, common in drained peatlands. Restoration in these situations may be unfeasible or lead to long-term and expensive maintenance commitments.

For any restoration project there should be multiple goals, but identify one major goal. Hydrological goals may include: enabling ecosystem functions; improving water quality; providing wildlife habitat. Specific objectives linked to these goals may be to:

- install a weir to establish minimum water levels
- modify inflow drain design to include silt trap for improving water quality
- raise water levels by 30 cm to flood broom infestation
- create suitable habitat to reintroduce mudfish

CREATING AREAS OF OPEN WATER

"It is not a good idea to create areas of open water by excavating material out of, or damming, existing wetlands. Areas of open water can be difficult to keep free of weed and algae in summer and dams can block fish access. Often wetlands do not have sufficient water flow to support good ponds. If you want to create open water for wildlife (e.g., for hunting), choose bare paddocks or badly degraded areas. Include gently sloping irregular shorelines as well as areas of water three metres deep. This allows birds, particularly waders, chicks and ducklings, easy access to and from the water and will extend the belt of reeds and rushes growing around the edge. Note that you may need a Resource Consent for pond construction."

– Northland Regional Council

Opposite: A kahikatea swamp forest in good ecological condition. Kopuatai Peat Dome, Waikato. See overleaf for a nearby remnant that has been drained. Photo: Monica Peters, NZ Landcare Trust

3.4.1 Keeping it legal

If you are planning to divert water courses, alter water levels or impound water you should first check with your local authority. Any work you carry out that causes changes to water levels on neighbouring properties or floods an area of 1 hectare or greater is likely to require a resource consent, as will any earthworks close to flowing water courses. Construction or alteration of any structure that will impact on minimum water or bed levels of existing rivers, lakes or wetlands are likely to be controlled activities, and appropriate advice and consent must be sought.

Your local or regional council may also suggest an appropriate expert with whom you can discuss your restoration plans. You will need to ensure any proposed works do not block fish access, and the Department of Conservation should be consulted in these cases. You should also consult affected parties such as surrounding landowners. Consider whether there will be any downstream effects, such as changes to stream flows.

4 Tips for restoring wetland hydrology

- Plan any hydrological works for minimal maintenance and allow for nature's ability to self-design.
- Avoid over-engineering with rigid structures and channels where these do not occur in nature. They will result in unnatural water velocities (possibly leading to erosion), unrealistically high and stable water levels or excessive amounts of open water.
- Drains should be filled with locally sourced materials (e.g., original excavations). Filling entire lengths of drains may be preferable to plugging drains at one or two locations as open, flowing water can develop considerable erosive power during floods. The greatest maintenance issues will occur where water flows steepen and accelerate, potentially "blowing out" any earth plugs – see the case study on Dunearn peat bog.
- Utilise the natural energy of water rather than fight against it. Wetlands form in parts of the landscape where water flows naturally converge. Wetlands adjacent to rivers or estuaries will be linked to them, and pulses of water into and out of wetlands may be dominant natural drivers of nutrients and sediments.
- Natural ecosystems have resilience to cope with cyclic and extreme phenomena. In a hydrological context, water stored in a wetland (reflected by wetland water levels) will have seasonal highs and lows, and extremes associated with floods and droughts. At the extremes, plants may die, weeds may invade, and erosion may occur. A resilient restored ecosystem should be able to recover from these impacts given enough time. Remember that wetlands, like other ecosystems, are always changing.

Opposite: Drainage has left this Waikato kahikatea remnant high and dry, destroying its wetland character. This photo was taken only a few kilometres away from the photo on the previous page.
Photo: Monica Peters, NZ Landcare Trust

CASE STUDY

BLOCKING DRAINS TO RE-WET THE DUNEARN PEAT BOG

The 60-ha Dunearn peat bog in western Southland is an excellent example of a raised peat bog system. The site was bought by the Department of Conservation (DOC) in 2003 through the Nature Heritage Fund. To develop the surrounding land for agriculture, deep drains c. 2.5 m wide and 2 m deep were dug through the wetland remnant and around the periphery. Key indicators for the declining health of the wetland took the form of peat shrinkage and the dieback of wire rush – a key peat-forming species. Hydrological restoration took the form of blocking the drains with sods of peat at 100-m intervals in order to raise water levels to prevent further peat degradation and encourage wetland plant recovery.

Monitoring change

Environment Southland have been monitoring the condition and trend of the Dunearn peat bog in collaboration with DOC. To monitor changes in the groundwater regime dip wells were installed in February 2003 when the hydrological restoration work began. Along with a transect through the bog, 21 2 x 2 m plots were established for annual vegetation monitoring. A series of photo points are used to record general vegetation change over time.

Seeing results

From 2004 wire rush coverage climbed 27% to an average of 68% cover in 2008, clearly showing that the raising of the water table was resulting in a rapid increase in wire rush cover. Furthermore, those plots closer to the drains responded more than those furthest away (c. 24% vs c. 7% increase) showing that the low water table around drains had further impacted on total wire rush cover. These results are preliminary and better statistical analyses are needed to strengthen findings and model future trajectories.

Plot 8 in 2003. Photo: Crown Copyright, Department of Conservation

Plot 8 remeasured in 2009. Photo: Crown Copyright, Department of Conservation

Challenges

In October 2007, water pressure build up behind the peat sods used to block one of the drains resulted in a "blowout", again lowering the water table in one part of the peat bog and damaging adjacent farmland. An excavator was originally used for blocking the drains. Along with almost getting stuck in the soft substrate, the excavator transported weeds into the wetland through seed lodged in the tread of its tracks. This highlights the challenges (and associated costs) of restoring wetland hydrology in highly modified environments. DOC and Environment Southland are now investigating alternative ways of re-blocking the drains.

REF: *Dunearn peat bog: The restoration of a wire rush peat bog through the raising of its water table.* Dept of Conservation internal report DOCDM-367540

With drainage species tolerant of drier conditions were able to colonise areas formerly dominated by wire rush (*Empodisma minus*). Photo: Crown Copyright, Department of Conservation

Aerial view of the Dunearn peat bog remnant clearly showing the network of deep drains . Photo: Crown Copyright, Department of Conservation

Standing away from piezometers when collecting data from sites with high water tables prevents water surging in and out of the sampling zone.
Photo: James Sukias, NIWA (with permission from DOC)

5 Monitoring

If you are considering making modifications to the hydrology of your restoration site, it is a good idea to carry out hydrological monitoring before, during, and after modification, so the effect of the modifications can be evaluated. Prior and parallel monitoring at a reference wetland can help set restoration goals, provide a basis for comparison, and inform decisions about restoration success.

Hydrological monitoring in wetlands often focuses on measuring water levels at representative locations, although water quality and water flows are also important aspects of hydrology. Rainfall should also be measured. A local farmer, NIWA or the regional council may already do so at a nearby site, and there are good long-term records available in most regions. Changes to water levels in a wetland reflect the changes to water storage, and also highlight the sensitivity of the wetland to external influences such as rainfall, floods and droughts. It is important to monitor water levels for several years to build up knowledge of typical and extreme patterns.

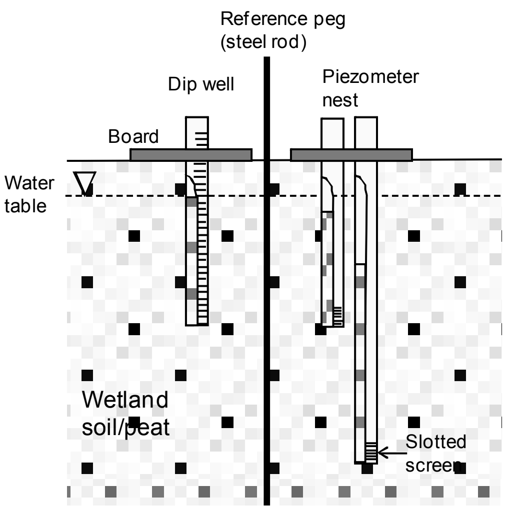

Figure 1. Setting up a dipwell and piezometer nest.

5.1 Locating monitoring points

Hydrological monitoring should encompass the major ecosystem types in your wetland, and sites are often best set up along a transect. Access to monitoring sites can be a problem, especially during high water stages, and vegetation and soil damage can result from frequent site visits. Choosing the appropriate number of monitoring sites depends on wetland size and complexity. Don't be too ambitious.

5.2 Dipwells, piezometers and reference points

Installing a dipwell is an inexpensive way of measuring the water table elevation. A dipwell usually consists of a plastic tube 30–60 mm in diameter with small holes or 1–2 mm slots cut along its length, sealed at the base with an end-cap and wrapped in a geotextile such as shade cloth, to prevent fine material clogging the tube. Because wetland soils are usually very soft, dipwells can often be pushed in by hand, otherwise a hand auger may be used. Dipwells need to extend deep enough to intersect with the water table in very dry spells. Piezometers have a similar construction except that the section with holes or slots is at a specific depth, and they are mainly used in groundwater studies to determine the direction of vertical water movement.

The textile is folded over the top of the well to prevent the build up of algae inside. Photo: James Sukias, NIWA (with permission from DOC)

Water-level measurements must be referenced to a known elevation. In many wetland studies this is simply the local ground surface adjacent to the dipwell because this best describes the conditions experienced by plants. If there is a need to determine the water-table slope or variations relative to adjacent water bodies or groundwater systems, it is important to measure water levels relative to an absolute datum, commonly sea level, or to a fixed benchmark on an adjacent hillside. The skills of a land surveyor are probably needed to do this. At each dipwell site a reference peg can be inserted through the wetland soil and into underlying stable ground (Figure 1). Each time the water level is manually read, the vertical distances between the top of the reference peg and the top of the dipwell, and from the top of the dipwell to the water table inside the tube, should be measured. A simple tape measure is usually sufficient where the water table is shallow, but a specialised water contact sensor might be needed to access deeper water tables.

5.3 Monitoring frequency

While manual measurements of water levels are relatively cheap, they are costly in time, although they can be combined with other regular tasks. No matter how frequently manual measurements are made, they will always yield an incomplete record and inevitably the full range of water level fluctuations will not be captured. Automatic methods for measurement are ideal, but the costs can be considerable. Relatively cheap electronic sensors are available (a few hundred dollars each – see equipment supplier at the end of the chapter) but inevitably you get what you pay for. Even when automatic sensors are used, frequent manual check-measurements are required to ensure good quality data. Figure 2 shows how monitoring frequency can have a big impact of interpretation of water level data. Weekly and monthly spot measurements lead to smoothed water level trends and extreme minimum and maximum levels are less likely to be recorded, compared with automatic measurements.

Manual measurements do not need to be equally spaced in time. Over long dry periods monthly measurements may be sufficient, weekly when the wetland is "wetting up", and immediately following large amounts of rain. You should aim to record the baseline water levels during rain-free periods in each season as well as the response to typical and large rainfalls.

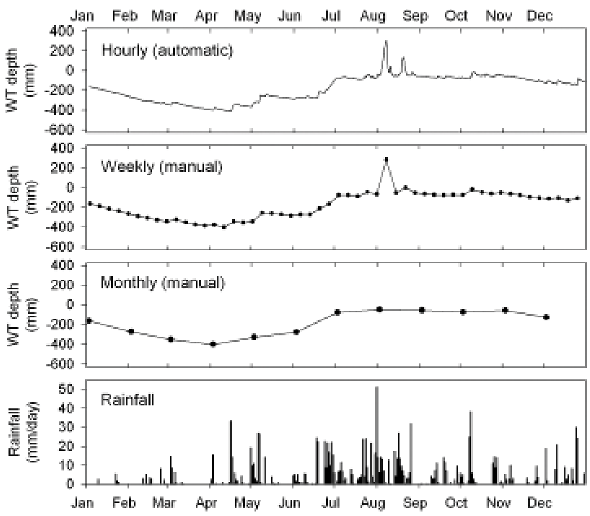

Figure 2. Measurements of water table elevation at Opuatia wetland in 2008. Peat surface is at 0 mm, negative depth is below the surface. Measurements were made automatically (top panel), weekly and monthly manual measurements are simulated. Daily rainfall totals in bottom panel. Graph: Dave Campbell, University of Waikato

5.4 The von Post Peat Decomposition Index

The amount of decomposition is gauged in the field by assessing the distinctness of the structure of plant remains and colour, determined by squeezing a handful of wet peat. The following standards (Table 1) are based on those of von Post (Clymo 1983).

von Post 2: almost decomposed; plant structure distinct, yields only clear water coloured light brown. Torehape peat mine, intact bog. Waikato. Photo: Richard Lowrance, USDA, Georgia, USA

von Post 8: very strongly decomposed; about two-thirds of peat escapes like toothpaste between fingers. Torehape peat mine, degraded margin. Waikato. Photo: Richard Lowrance, USDA, Georgia, USA

Table 1. Level of peat decomposition and characteristics

1. Undecomposed Plant structure unaltered. Yields only clear colourless water
2. Almost undecomposed (see photo) Plant structure distinct. Yields only clear water coloured light yellow-brown
3. Very weakly decomposed Plant structure distinct. Yields distinctly turbid brown water; no peat substance passes between fingers, residue not mushy
4. Weakly decomposed Plant structure distinct. Yields strongly turbid water; no peat substance passes between fingers, residue rather mushy
5. Moderately decomposed Plant structure still clear but becoming indistinct. Yields much turbid brown water; some peat escapes between the fingers; residue very mushy
6. Strongly decomposed Plant structure somewhat indistinct but clearer in the squeezed residue than in the undisturbed peat. About half of the peat escapes between the fingers; residue strongly mushy.
7. Strongly decomposed Plant structure indistinct but still recognisable. About half of the peat escapes between the fingers
8. Very strongly decomposed (see photo) Plant structures very indistinct. About two-thirds of the peat escapes between the fingers; residue consists almost entirely of resistant remnants such as root fibres and wood
9. Almost completely decomposed Plant structure almost unrecognisable. Almost all of the peat escapes between the fingers
10. Completely decomposed Plant structure unrecognisable. All of the peat escapes between the fingers.

6 References and further reading

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6.1 Useful websites

Wetland restoration templates

Waikato Regional Council Wetland Restoration Plan templates

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate1.pdf

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate2.pdf

Wetland restoration guides and factsheets (New Zealand)

Northland Regional Council

www.nrc.govt.nz/upload/2217/Wetland%20Restoration%20Guide%20(second%20edition%20Feb%2009).pdf

Auckland Regional Council

www.arc.govt.nz/albany/fms/main/Documents/Environment/Plants%20and%20animals/wetlandsfacts2.pdf

Waikato Regional Council

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/

Hamilton City Council

www.gullyguide.co.nz/index.asp?pageID=2145821537

Bay of Plenty Wetlands Forum

www.doc.govt.nz/upload/documents/conservation/land-and-freshwater/wetlands/wetland-restoration-guide.pdf

Greater Wellington

www.gw.govt.nz/a-beginner-s-guide-to-wetland-restoration/

Department of Conservation Protecting Natural Areas Design Guide

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/nature-heritage-fund/protecting-natural-areas-design-guide/

Wetland restoration guides (International)

USA Environmental Protection Agency

www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Understanding wetland hydrology

www.gw.govt.nz/assets/council-publications/wetland_hydrology.pdf

Creating ponds

www.gw.govt.nz/so-you-re-thinking-about-a-pond/

Technical resources

Hydrological instruments, monitoring advice and training

www.scottech.net/

National climate database

cliflo.niwa.co.nz/

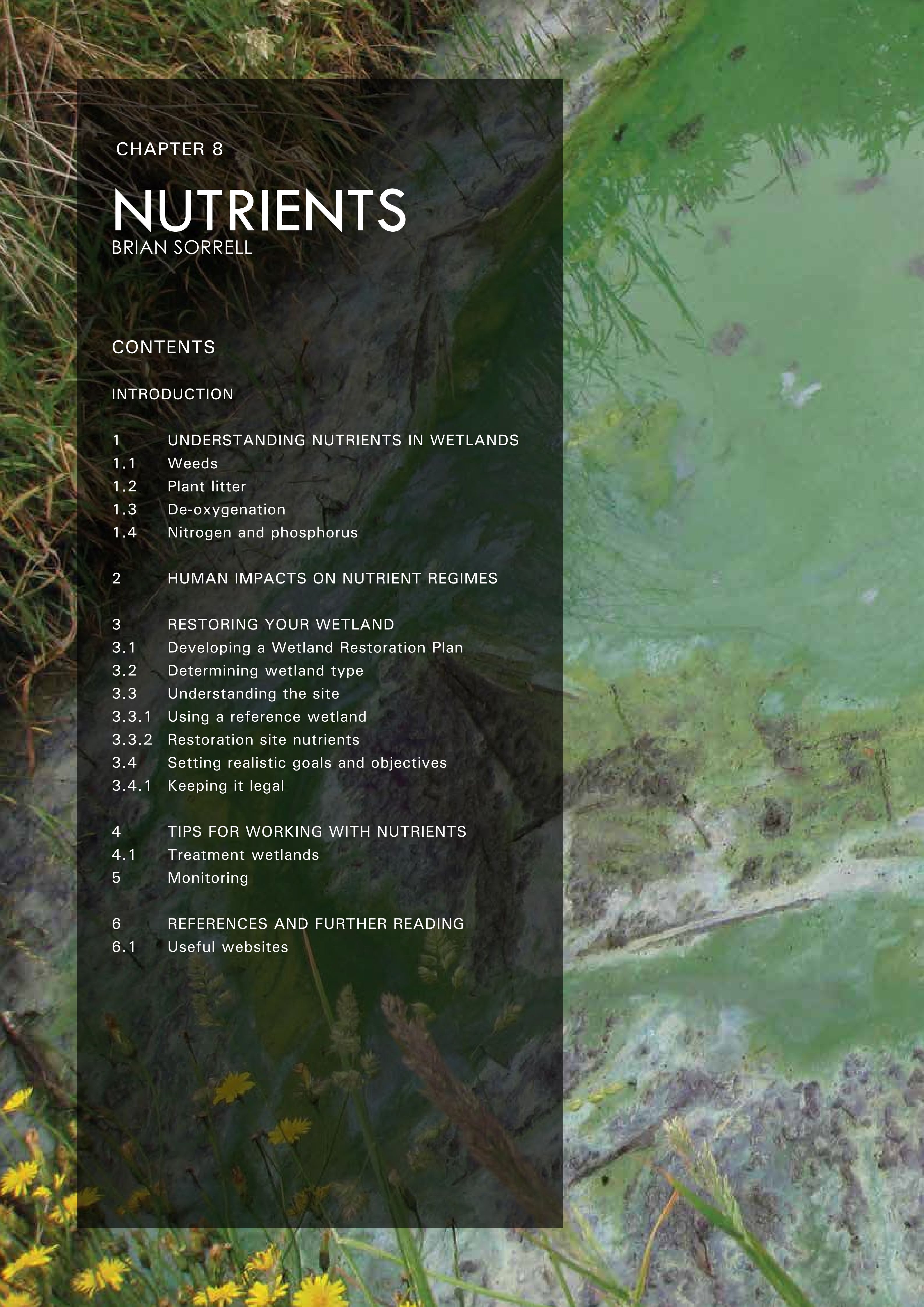
Note that regional council websites also have information on climate

Reports

Ecohydrological characterization report Opuatia wetland, Waikato

www.waikatoregion.govt.nz/Services/Publications/Technical-Reports/Ecohydrological-characterisation-of-Opuatia-wetland-and-recommendations-for-future-management/

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 8

NUTRIENTS

BRIAN SORRELL

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NUTRIENTS

NUTRIENTS

BRIAN SORRELL

Excess nutrients are second only to hydrological disturbance as a cause of loss of natural character in wetlands. Unnatural nutrient enrichment occurs because human societies have historically managed their nutrient-rich wastes by discharging them directly into the environment with little treatment. Although much progress has been made in recent decades in pollution control in waterways, wetlands are very sensitive to the amount of nutrients they receive, and many New Zealand wetlands continue to suffer excess nutrient inputs. Managing the nutrient inputs and the nutrient availability in your wetland is therefore essential in a wetland restoration project. It is a key aspect of achieving the goals of your project, such as getting the desired plant community, water quality and animal habitat. Failure to manage nutrients effectively will almost inevitably lead to a wetland that suffers from excess growth of undesirable plants, low plant species diversity, algal blooms in the water, weed invasion, and poor habitat value for many aquatic insects and native fish.

The case studies included in this chapter highlight the important roles wetlands play in the agricultural landscape.

Previous page: Algal bloom at Lake Kainui, Waikato.
The lake is situated in an intensively farmed catchment.
Photo: Monica Peters, NZ Landcare Trust

Mangarakau swamp flax community
Photo: Monica Peters, NZ Landcare Trust

Mangarakau swamp sedge community
Photo: Monica Peters, NZ Landcare Trust

The 400 ha Mangarakau swamp complex (Nelson/Tasman) showcases a range of wetland types, from flax communities in nutrient rich swamp areas to nutrient poor sedgelands in pakihi areas. Photo: Monica Peters, NZ Landcare Trust

1 Understanding nutrients in wetlands

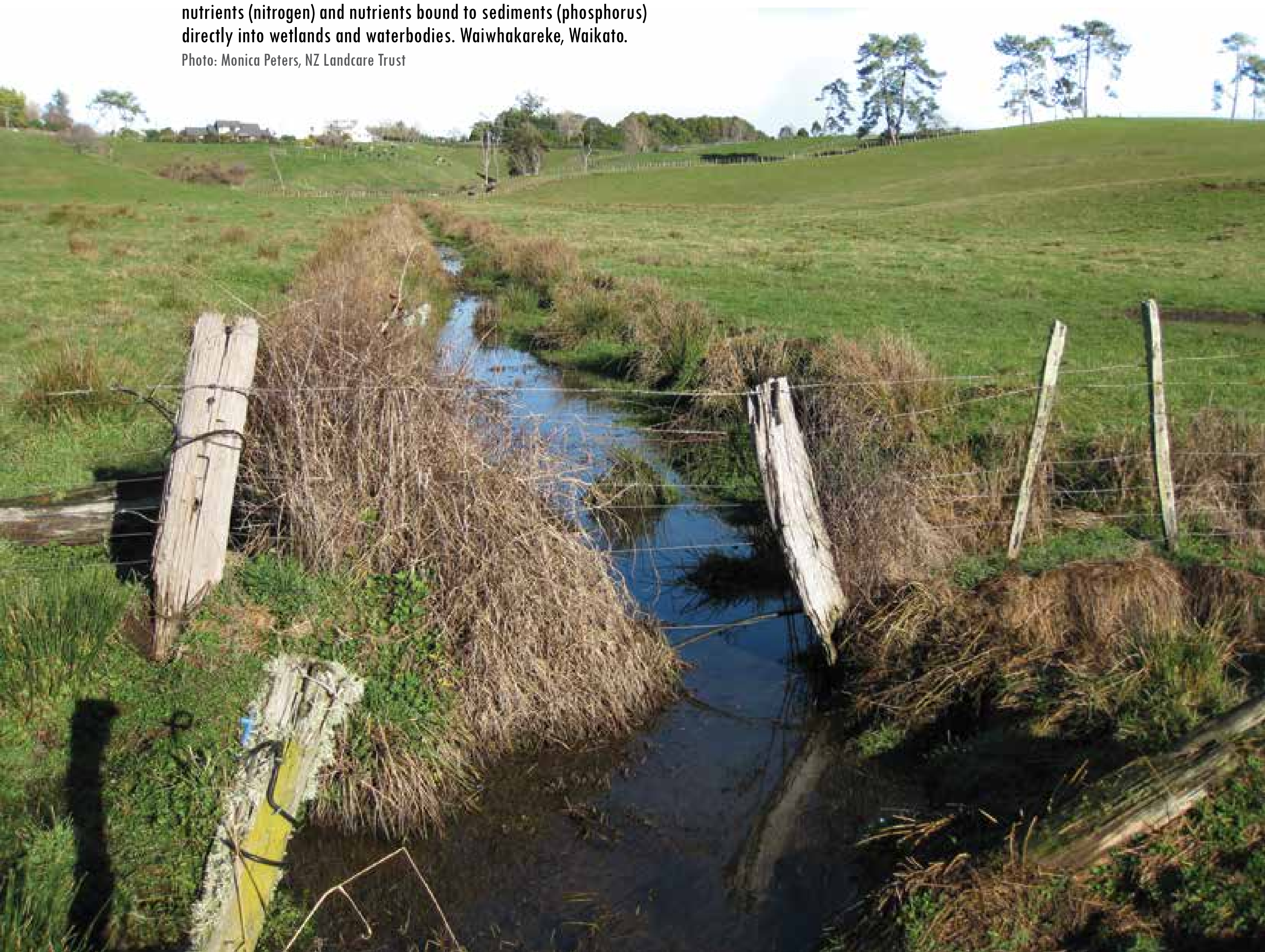
Natural wetlands vary enormously in their nutrient contents, from very low-nutrient (called oligotrophic) to high-nutrient (called eutrophic) conditions. Nutrients enter wetlands from a variety of sources including streams, creeks and drains, in groundwater from the surrounding catchment, from the air in rainfall and spray drift. Once in a wetland, nutrients tend to stay there and accumulate, initially in the soil, then in the plants, and then in the surface water. Nutrients are essential in wetlands to support healthy plant growth, but can easily accumulate to excessive levels that cause problems. This is called eutrophication. The first consequence of eutrophication is that the plants begin to grow taller and denser. When this happens, the different species start to compete with each other for light and space, and so tall, fast-growing species like raupo and willow tend to out-compete smaller species by shading them and pushing them aside. Hence, nutrient enrichment usually causes loss of plant species, and the community to change from a diverse multi-species mixture to one that is dominated by one or two fast-growing competitors. Prolific vegetation growth can then block channels and increase sediment build-up and evapotranspiration rates, reducing the water availability in the wetland and the aquatic habitat. A very common scenario in wetland restoration failure is where people spend a lot of time and money establishing the correct hydrology and planting an attractive, diverse plant community, only to see species like raupo, or exotic weeds, spread explosively and completely dominate the site. Too much nutrient is usually responsible for this.

A Waikato wetland much degraded through the impact of agriculture – despite the fencing, the cows are on the wrong side of it! Photo: Fred Lichtwark, Whaingaroa Harbourcare

At Lake Kaituna (Waikato) raupo, an indicator of high nutrient levels is periodically removed to ensure it doesn't colonise too much of the shallow lake bed. Photo: Monica Peters, NZ Landcare Trust

Like raupo, sedges have high nutrient demands. Lake Hakanoa, Waikato. Photo: Monica Peters, NZ Landcare Trust

Point source pollution: farm drains frequently channel dissolved nutrients (nitrogen) and nutrients bound to sediments (phosphorus) directly into wetlands and waterbodies. Waiwhakareke, Waikato. Photo: Monica Peters, NZ Landcare Trust



1.1 Weeds

Most exotic weeds are plants that like high nutrient levels. Weeds are discussed further in Chapter 9, but it's worth stating here that almost all of the problem weeds in New Zealand wetlands are strongly favoured by high nutrient levels, and that their impact can be minimised by paying attention to keeping nutrient levels down to low or moderate levels. Specific examples are reed canary grass and reed sweetgrass (both of which respond explosively to groundwater nitrate inputs in particular) and willows.

1.2 Plant litter

The next problem that develops is that too much plant litter accumulates. In a low-nutrient wetland, the plants retain most of the nutrients they take up in their live tissues, and only produce small amounts of dead litter. In a nutrient-enriched wetland, fast-growing plants shed lots of dead litter, that can build up and choke the site and that further inhibits the less-competitive plant species from establishing. Litter produced in eutrophic wetlands has more nitrogen and phosphorus in it than litter produced in oligotrophic wetlands, so bacteria decompose it easily and release the nutrients into the water. This is the next, and perhaps most undesirable, problem. Enrichment of the water with nutrients causes algal blooms, and changes the algal community from a slow-growing, diverse mixture into one dominated by problem algae like thick filamentous mats and blue-green algal scums. Recent research has shown that New Zealand's lower-nutrient wetlands are a treasure trove of desirable native algal biodiversity, but that nutrient enrichment causes the loss of most of these species and their replacement with a few common species.

1.3 De-oxygenation

The final negative consequence of nutrient enrichment is that all of this excess plant and algal biomass chokes the water and decomposes, causing de-oxygenation and anaerobic conditions. A de-oxygenated site with stagnant water is one that accumulates thick, smelly layers of mud, is prone to mosquito invasions, and may even lose all its plants as they become stressed and killed by lack of oxygen and build-up of toxic chemicals in the anaerobic mud. These are the kinds of negative perceptions of wetlands that are so pervasive in many people's minds and that can often be an obstacle to carrying out wetland restoration, so it's important to recognise that they can be mitigated or avoided by sound nutrient management.

1.4 Nitrogen and phosphorus

The two nutrients that usually need to be managed in wetlands are nitrogen and phosphorus. They are the two main growth-limiting nutrients for plants. Most plants need about ten times as much nitrogen as phosphorus, and they can take it up from the soil in the form of either ammonium or nitrate. In general, they grow best when given a mixture of ammonium and nitrate, rather than one or other alone. Because plants need much more nitrogen than phosphorus, nitrogen tends to be the most important growth-limiting nutrient in the more eutrophic wetlands, where plants are growing faster. Phosphorus is most likely to be limiting in the very oligotrophic wetlands, especially those that get most of their nutrient input from rainwater. In some low-nutrient wetlands, potassium is another nutrient that can become growth-limiting along with either nitrogen or phosphorus. Commercially available fertilisers are therefore usually sold with a specified ratio of these three nutrients (N:P:K ratio, where K is the chemical symbol for potassium) that provides for balanced growth of different types of plants.

Scum on the surface of Lake Kainui, Waikato.
Photo: Monica Peters, NZ Landcare Trust

CASE STUDY

Hollow on farm in Lake Brunner catchment.
Photo: NIWA

WETLANDS ON THE FARM: POTENTIAL SOLUTIONS TO PROTECT LAKE BRUNNER

Farmers around Lake Brunner (Westland) often create a series of long ridges and valleys known as "humps and hollows" across their fields to cope with high rainfall and improve drainage. However, the public perception is that intensive farming coupled with humping and hollowing are increasing the nutrient runoff into the iconic lake. One of the key strategies to mitigate nutrient runoff proposed by NIWA scientists involves encouraging small wetlands at the end of the hollows to process some of the nutrients before they eventually enter the lake. This approach could be used where water is retained in the hollows situated on deep peaty soil, poorly drained heavy silts and clays. Where the hollows reach free draining material nutrients will directly enter groundwater. Most of the nutrient removal is associated with sediment accumulation, denitrification of N in the soil, and accumulation of plant litter in the hollow or further downstream.

Farmer perceptions: wetlands as positives

Farmers around the lake were interviewed to gauge whether they perceived wetlands to be a potential solution to nutrient runoff. For several farmers, wetlands in hollows were a reasonable solution because "there are wetlands there anyway, naturally". In particular, this solution appealed to those who could not use the hollows because they were simply too wet for most of the year.

Farmer perceptions: wetlands as negatives

Leaving wetlands (or planting wetlands) in hollows was generally negative, as this would:

- Increase the spread of unpalatable, weedy plants, e.g, rushes "moving up the hollows"
- Increase hump and hollow maintenance
- Act as havens for pests such as possums and weeds such as blackberry and gorse
- Add costs and make paddock management more difficult
- Lead to the expansion of wetlands at the expense of pasture
- Increase area of pugging

Reaching potential solutions

Vegetated drains emerged as a possible system for nutrient mitigation. Almost all farmers interviewed had extensive drainage networks on their properties that they maintained, which are periodically deepened and cleared of wetland vegetation. They were quite happy to clean these out in sections and retain areas with wetland vegetation to act as filters "The water can sit there comfortably and won't affect the pasture and you have to have drains anyway". Overall, a range of solutions need to be developed so that farmers can select a suitable alternative that fits their beliefs and individual farming situation.

REF: maxa.maf.govt.nz/sff/about-projects/search/06-064/summary-for-farmers.pdf

2 Human impacts on nutrient regimes

Generally, human activities in landscapes lead to nutrient enrichment in downstream wetlands. Scientists have clearly shown in recent decades how urban and agricultural development in catchments increases nutrient run-off, for a number of reasons. Catchment development increases water flows and erosion, loading the in-coming water with nutrients. Many human activities involve fertilisation, for example, for pasture development, and this almost always involves increasing the flow of nutrients into downstream waterways. Managing nutrients in the catchment, and minimising nutrient inputs from the catchment, are therefore the most important strategy for protecting your wetland from excess nutrients. Wetland restoration projects need to be carried out in the context of which activities are taking place in the vicinity, and in cooperation with other land users. Small projects on private properties need to take into account what else the property is being used for, and whether the planned project can be achieved, for example, in an agricultural landscape. Larger projects may require considerable planning and cooperation among adjacent landowners to manage nutrients effectively.

An intermediate level of nutrients – enough to support healthy plant growth, but not so much as to cause excessive production and nutrient pollution – is usually optimal for wetland restoration projects. Too little nutrient, for example if a sandy or clay-based substrate is used in the project and the site does not have a good water supply, may lead to sickly, sparse and unnaturally short plants that are prone to die-back and fail to develop good cover. Too much nutrient leads to the species loss, weed invasion and eutrophication problems discussed above.

NEWS The New Zealand Herald ★ Wednesday, November 26, 2008

Toxins in shallow lakes spark health warning

Risks include skin and eye irritation, allergies like hayfever and asthma and stomach upsets

People are being warned to avoid contact with water in the Waikato shallow lakes because of cyanobacteria.

While it does not affect everyone, Waikato District Health Board says the risks include rash, skin and eye irritation, allergy symptoms such as hayfever and asthma and possibly stomach upsets such as diarrhoea and vomiting.

The lakes are in farmland north of Huntly.

A cyanobacterial health warning has been reinstated at Lake Whangape after the latest monitoring results from the six shallow lakes which are routinely tested. Warnings remain in effect at Kainui and Waikare.

Waikato medical officer of health Dr Dell Hood said, "Waikato shallow lake users should always avoid contact with water which looks cloudy green or brown, or has scum forming, even when there is no warning in place.

"Most lakes are not tested, and summer-time conditions generally increase the growth of algae. Users must consider the possibility of cyanobacterial blooms in any water body before they use it — at any time of year."

Dr Hood said test results should be used for general guidance only, as cyanobacteria and their toxins would not be evenly spread through any lake and might be concentrated in some areas by wind and water movements.

"During blooms, lakes should not be used for any activity which involves skin contact with the water.

"If people choose to do this, they should shower and change their clothing as soon as possible afterwards, even if no symptoms are noticeable."

Swallowing water from lakes affected by blooms should also be avoided.

The board's Population Health Service wants to hear about health problems which followed exposure to any of the Waikato lakes.

— *NZPA*

3 Restoring your wetland

3.1 Developing a Wetland Restoration Plan

Your Wetland Restoration Plan should specify the type of soil and the water sources at your site. These two factors control the nutrient level of the wetland, and guide you as to what actions you should be taking to manage nutrients. See Chapter 2 – Restoration planning, for further information. Actions in your plan related to nutrients may include fencing (to exclude stock and create buffer zones), installing sediment traps, or harvesting plants (see Section 3).

Farmers attending a workshop on effective nutrient management. The farm adjoins Lake Komakorau (Waikato), which is currently being restored, with weeds removed and drains ending in silt traps and vegetation filters. Photo: Monica Peters, NZ Landcare Trust

3.2. Determining wetland type

New Zealand is blessed with a wide variety of wetland types, with a correspondingly diverse range of plant communities and habitat types for animals. Much of this variation is due to the natural variation in nutrient availability. Different types of wetlands are characterised by different nutrient regimes, which is further reason to find out what type of wetland you are trying to restore before starting. In order of increasing nutrient availability, the main wetland types are bogs, fens, swamps and marshes, which reflect a gradient from being mainly fed by rainfall (rainfall has very low nutrient concentrations) to being mainly fed by surface water or groundwater. Within one wetland type, there can also be a range of different plant communities favoured by different nutrient ranges. See Chapter 3 – Wetland types for further information on wetland types and their characteristic nutrient regimes.

3.3 Understanding the site

3.3.1 Using a reference wetland

The reference wetland approach discussed in Chapter 4 – Site interpretation, will help identify the nutrient availability that is characteristic of wetlands in your local area, and the plant communities supported by it. Different levels of nutrient availability are suited to different plant communities, and to different vegetation structure. In general, it is much easier to restore wetlands to the type that was originally there, and this is especially true for nutrients.

Look at other wetlands that may still be present in the area, and historical publications or local knowledge, to define the target wetland you should be restoring. What type of wetland is or was common in this landscape? Features to look for include:

- Were the natural wetlands in this area typically forming peaty soils and relatively infertile (very likely in high rainfall regions)? In this case it will be especially important to keep nutrients low.
- Or are they depressions in the landscape with lots of tall and productive plants like harakeke/NZ flax, cabbage trees, raupo and tussock sedges? In this case much higher nutrient levels can be allowed, although they still should be kept low enough to prevent eutrophication.
- Is there a river or stream in the site, with a good through-flow of water? This can help minimise stagnation and eutrophication, even when there are high nutrient levels.

3.3.2 Restoration site nutrients

The nutrient regime you should be aiming for in your project depends on how far along the bog-fen-swamp-marsh nutrient gradient the site should be. Most degraded wetlands that people want to restore have been subject to excess nutrient inputs, and these can be an obstacle to successful restoration. Look for changes that might have occurred in and around the wetland leading to nutrient enrichment. Things to look for include:

- Channelised water courses flowing into the wetland, especially if these appear to be sluggish and coated with oily or slimy biofilms (i.e. they've probably had wastewater flowing in them at some point).
- Extensive pasture development in the surrounding catchment, and especially if there has been a history of nitrogen fertiliser use. Also, other catchment activities that might be associated with point sources of nutrients: dairy sheds, roads, and waste dumps.
- Digging and clearing of unnatural deep, open ponds in the wetland, for example to create waterfowl habitat. These often become badly eutrophicated.

Further information on gathering information about your wetland can be found in Chapters 4 and 5 – Site interpretation.

3.4. Setting realistic goals and objectives

Nutrients are one of the biggest challenges in setting realistic goals in a wetland restoration project. Excess nutrients are perhaps the most common reason for a disappointing failure for a project to achieve the vision of the planning stage. When a restored site suffers from lots of weed invasion, or dominance by the wrong plant species, or turbid water with algal blooms, or anoxic water that kills fish, it is usually because the nutrient concentrations are too high. Considerations are as follows:

- If values associated with low fertility (e.g., clear open water, diverse plant communities, game fish habitat) are an important goal of the project, a source of clean, low-nutrient water is essential. This may require considerable time and/or money to achieve.
- If the project is taking place in a locality with very high fertility, it may be better to accept this at the start and produce a plan that works with the nutrients rather than wasting precious time and money trying to reduce them. As an extreme example, creating a low-nutrient bog featuring sundews and wire rushes is unlikely to be a practical proposition for a wetland in a depression at the bottom of a pasture valley used for dairy farming. Instead, a wetland more characteristic of high nutrient levels is a more suitable goal. It will also provide benefits for other aquatic habitats further downstream, as it will probably intercept and accumulate nutrients.

Most of the wetlands that are being restored on private land in New Zealand are in fertile lowlands with extensive agricultural activity, and projects in such areas need to be realistic about these issues.

Occasionally, wetland restoration projects have been unsuccessful due to the nutrients being too low rather than too high. This occurs when a high yield of a productive, nutrient-demanding species like raupo is the aim of the project, for example, if harvesting for cultural purposes is an important value of the site. In these cases, careful consideration of the soil type and the feasibility of fertilisation without harming other values are the issues to consider in determining whether a higher yield is a realistic goal. Nitrogen is almost always the lacking nutrient in these cases. Incorporating slow-release fertiliser into the soil can help, or using a nutrient-rich mud as the substrate. Avoid using the rapid-release types of fertilisers commonly used in garden projects (e.g., ammonium nitrate), as these are likely to wash through readily and pollute downstream waterways.

3.4.1 Keeping it legal

Most sites where people carry out wetland restoration activities will have some connection to other waterways, either via surface or groundwater. Most Regional Plans specify a number of rules to protect waterways from human activities. In particular, disturbance of riverbeds and discharges to waterways of sediments and nutrients are possible inadvertent side-effects of carrying out restoration activities. Contact your Regional Council as early as possible to obtain advice on the impact your project may have on waterways (usually classified as minor, more than minor, and significant), which will determine the extent to which you need to mitigate your activities or obtain a Resource Consent.

Wetland restoration success: this wetland on a farm in Marlborough highlights what can be done when appropriate native species are used and nutrient inputs to the wetland well managed. Photo: Doug Avery

An example of a low nutrient environment: the naturally peat stained waters of Lake Serpentine east, Waikato. Photo: Monica Peters, NZ Landcare Trust

The Howarth Memorial Reserve lies at the edge of the extensively farmed Hauraki Plains creating challenges for effectively managing nutrients entering the wetland from both the river and farm drainage networks Photo: Monica Peters, NZ Landcare Trust

CASE STUDY

TUTAEUAUA: MEASURING NITRATE REMOVAL WITHIN A NATURAL WETLAND

At 620 km^2, Lake Taupo is the country's largest lake. In spite of the Lake's size, nitrogen and chlorophyll concentrations have increased over the past 30 years. Soils are highly porous, allowing a high proportion of the rainfall onto surrounding catchments to soak to the groundwater, taking with it dissolved nitrogen. The nitrogen is mostly derived from surrounding urban and rural land. To maintain current lake water quality, a reduction of 20% in the nitrogen load from urban and pastoral land (the two major manageable sources of nitrogen) is predicted to be necessary. Wetlands comprise 0.7% of the Lake Taupo catchment area, and are commonly found in riparian parts of upland pastoral areas. These permanently wet features can exceed 1000 m^2 in size and are vegetated with sedges, rushes and NZ flax (*Phormium tenax*, a predominantly wetland species), although non-native pasture grasses dominate in some areas. Many of the wetlands are unfenced, allowing grazing by cattle, particularly during the summer months.

In 2004, the National Institute of Water and Atmospheric Research (NIWA) conducted two trials in wetlands in the Tutaeuaua catchment (located on the northern side of Lake Taupo) to determine how much nitrate was removed from water travelling through the wetland before eventually entering the Lake.

Methods

A tracer solution of nitrate nitrogen was added to 4 piezometers placed upstream. More piezometers were placed at intervals downstream, and at different depths to intercept surface and groundwater flows (see Chapter 7 – Hydrology for information on using piezometers). A well downstream also provided a convenient place to measure nitrate levels.

Results

- Results from the routine monitoring and the tracer experiment both demonstrate that the wetland was attenuating significant amounts of nitrogen from entering the stream, and along with other potential nutrient removal areas such as riparian zones, was acting as an important buffer protecting stream water quality. The role of wetlands in reducing fluxes of nutrient and sediments to downstream surface waters is well known; however, the significance of this function differs depending on what proportion of water in streams has passed through these zones.
- 95% of the nitrate was lost between the upstream piezomoters and the down stream piezometers/well.
- Most of the nitrate removal occurred in the first 24 hours.

Conclusions

Wetlands and stream-bank riparian zones typically will remove significant amounts of nutrients, particularly nitrate, so long as there is effective contact between groundwater and the organic rich sediments within these zones.

- Wetlands can reduce the flux of nitrate into streams within short time frames and over short distances, due to the sponge like capacity of plants and soils, and the microbial processes within the ecosystem.
- Excluding stock from wetlands prevents damage to the plants and soils, therefore protecting wetland function.

REF: Sukias, J. P.S., Long Nguyen, M., Collins, R. and Costley, K. 2004. *Nitrate removal within a natural wetland in the Taupo catchment.* Limnological Society Conference, Waiheke.

Experimental set up with piezometers Photo: James Sukias, NIWA

Well-fenced riparian area protecting the wetland values. Photo: James Sukias, NIWA

4 Tips for working with nutrients

If very low fertility is needed, the only certain method is to collect rainwater in tanks and ensure that this is the only water source for the wetland. A lining in the soil may be necessary to isolate the site from nutrient-enriched groundwater.

Low fertility sites need to be protected from adjacent human activities. Wide buffers (minimum 5 m width) around the wetland from which stock are excluded may be necessary if a healthy, low-nutrient wetland is the target.

If the site is badly nutrient-enriched at the start (you can see this if there has accumulated a lot of dead plant material, or dark smelly mud), time and effort will have to be put in to dig or pump out the accumulated material, and possibly re-contour to an appropriate soil and water depth for the plants and animals you want.

The following methods can be used to reduce the nutrient load into wetlands when low fertility is an important goal for the project outcomes:

- Treat agricultural products such as effluent and sileage leachate on the property before it has a chance to enter streams that flow into the wetland. Protect streams that flow into the wetland from catchment nutrients by fencing and riparian strips, and planting buffer zones around the margins to absorb nutrients before they enter the wetland.
- Use sediment traps in streams that flow into the wetland. Many Regional and District Councils have staff that can assist with the design of sediment traps.

When moderate to high fertility is unavoidable at a restored site (most often the case), the following practices can help minimise its impact:

- Avoid having too much water or the water too deep – reduce the rate of in-flow if necessary. Lots of deep, nutrient-rich water will probably kill your plants and will certainly produce algal blooms.
- Instead, having a reasonable rate of water through-flow (lowering the residence time of water in the wetland) will reduce problems such as algal blooms, sedimentation and oxygen depletion.
- When planting, choose species that have high nutrient demands and retain nutrients in their vegetation. Harakeke/NZ flax, tussock sedges such as purei, raupo and lake club rush are all species that thrive in high nutrient regimes.
- In landscaping the wetland, consider planting nutrient-loving species furthest upstream to intercept the nutrients, which will allow you to have areas of lower-nutrient communities and open water further downstream.
- Avoid having large areas of deep, open water, as algal blooms and de-oxygenation are likely.
- Use shade to reduce algal growth – plant faster-growing flood-tolerant trees (e.g., kowhai, manuka) at the margins of the wetland and use shady native plants like cabbage trees, harakeke/NZ flax and purei (all of which do well in fertile environments) in the wetland.
- Remove dead plant litter regularly and compost it off-site, away from the wetland. This can be done at any time of the year, but the best time to do it is winter.

Nutrient rich sediment harvested from a silt trap can be reused away from the restoration site. Lake Kaituna, Waikato. Photo: Monica Peters, NZ Landcare Trust

At Lake Kainui (Waikato) a shallow vegetated excavation at the end of a drain enables some nutrient removal prior to water entering the lake
Photo: Monica Peters, NZ Landcare Trust

4.1 Treatment wetlands

The well-documented ability of some types of swamps and marshes to accumulate large amounts of nutrients and still remain healthy ecosystems has led to considerable interest all over the world in using wetlands as a method for pollution control. Restored wetlands of this type can be useful amenities in the landscape provided they are designed well, as they can help protect the local water quality in streams and small lakes. Some artificial wetlands are specifically designed as treatment wetlands, constructed with linings and artificial substrates that allow them to receive and treat large amounts of nutrient-enriched wastewaters. Creating a treatment wetland on your property can be a very useful way of generating a clean water source that you can use to feed a more natural restoration project. Talk to your local Council about the benefits of treatment wetlands and their applicability to your project. Science organisations such as NIWA have considerable research experience with treatment wetlands and can provide advice on designing and constructing them.

To prevent further nutrient enrichment of the 30 ha Lake Okaro (Rotorua), a 2.3 ha treatment wetland was constructed to capture and processes diffuse farm nutrients from the surrounding catchment.
Photo: Environment Bay of Plenty

Lake clubrush (*Schoenoplectus tabernaemontani*) is commonly planted in NZ constructed wetlands. Photo: Kerry Bodmin, NIWA

Marsh clubrushes (*Bolboschoenus medianus* – pictured, and *B. fluviatilis*) are useful species for providing seasonal diversity in treatment wetlands. Photo: Kerry Bodmin, NIWA

Once mature, the Lake Okaro wetland is predicted to be able to remove around 40–50% of the total nitrogen intercepted. This will complement nutrient reduction from riparian restoration and improved farming practices as well as provide wildlife habitat, enhance biodiversity, landscape and public amenity values.
Photo: Environment Bay of Plenty

5 Monitoring

Most private land-owners and community groups involved in wetland restoration do not have the financial resources to carry out regular chemical monitoring of nutrient levels in wetlands.

However, the height and density of the vegetation in a reference wetland give an indication of the nutrient regime you should be aiming for, and towards which your monitoring should be aimed. What is the height and density of the plants in the reference site? Monitor the height and density at your restoration site after completing your restoration actions. Make sure you do this at permanently fixed points, so that it's a genuinely comparable set of measurements (see Chapters 9 – Weeds and 10 – Revegetation for monitoring methods). If the plants stay much lower than you expected, then some (careful) fertilisation may be needed. However, if the plants begin to exceed the reference site, then you probably have too many nutrients and these need to be reduced. Methods include removing excess litter, digging out any accumulated sediment, and looking at practical ways of reducing nutrient inputs (see previous section).

There are also other inexpensive, indirect indicators of excessive nutrient enrichment that you can use to monitor eutrophication at your site. Things to watch for include:

- Filamentous green algae. All wetlands, even the most nutrient-poor, have some flocculent algal growth in them. However, if the more still and sheltered water in your wetland starts to develop tangled mats of long, bright green filamentous algae, this is a sure sign that eutrophication is occurring.
- Build-up of dark, black, smelly sediment – especially if there is a strong smell of hydrogen sulphide (rotten eggs).

Low nutrient pakihi community, Milnthorpe Park Scenic Reserve, Nelson. Photo: Monica Peters, NZ Landcare Trust.

6 References and further reading

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Wheeler, B. 2002. Restoration of freshwater wetlands. In: Perrow, M., Davy, A. (Editors), *Handbook of Ecological Restoration: Volume 2, Restoration in Practice.* Cambridge University Press, U.K.

Zedler, J. 2000. *Progress in wetland restoration ecology.* Trends in Ecology and Evolution 15: 402-407.

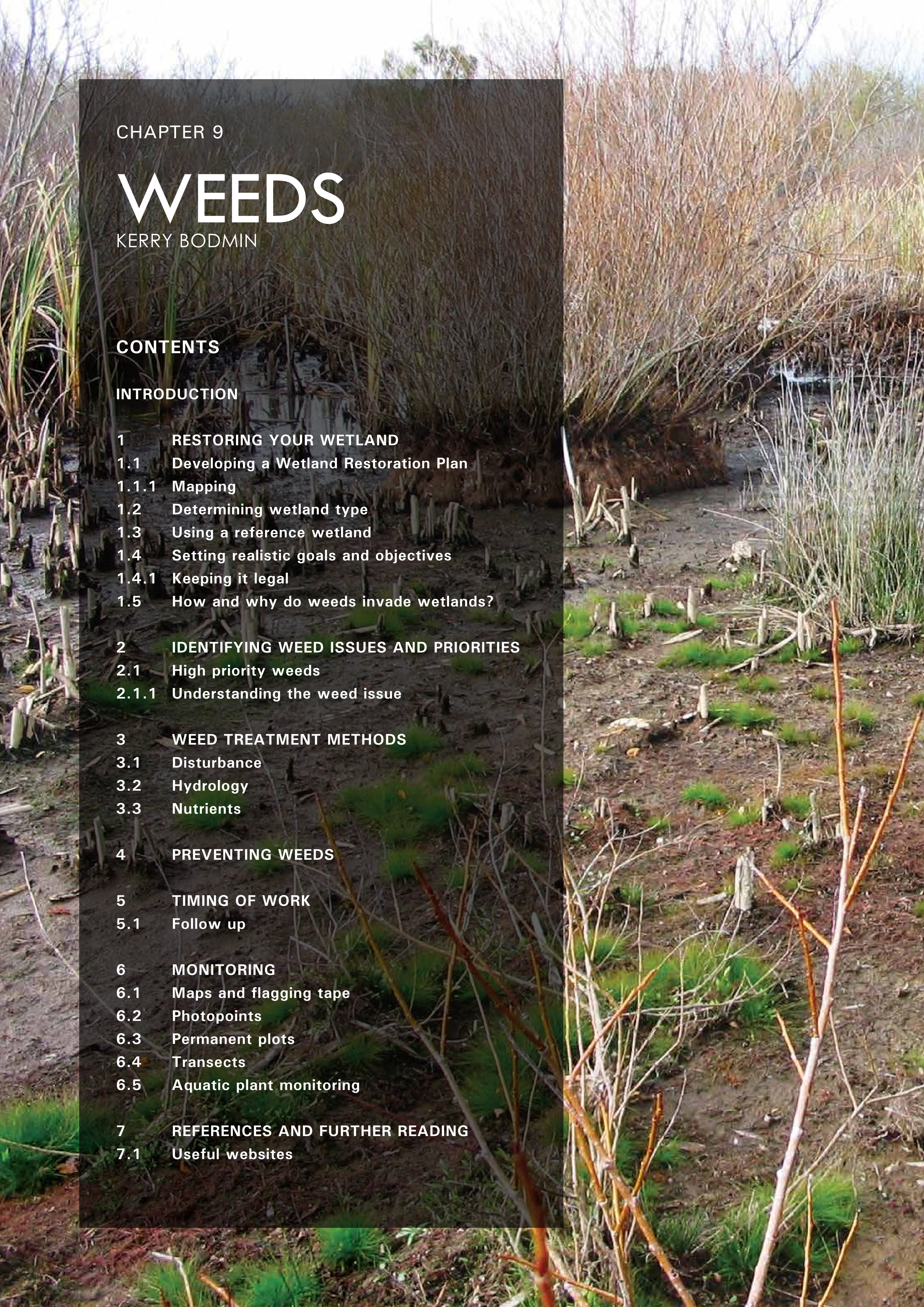
6.1 Useful websites

Constructed wetlands

New Zealand constructed wetland planting guideline

www.waternz.org.nz/Category?Action=View&Category_id=106

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 9

WEEDS

KERRY BODMIN

CONTENTS

WEEDS

WEEDS

KERRY BODMIN

Weed pressure on environmentally sensitive places such as wetlands is increasing, with approximately 20 new plants per year becoming naturalised in New Zealand ecosystems. Weeds are one of the most visually obvious signs of human-induced impacts on a wetland. A weed, also commonly called a pest plant, can simply be defined as a plant growing where it is not wanted. In restoration projects weeds are usually introduced or exotic plants that are not native to New Zealand. Weeds pose a threat to wetlands as they can modify the structure or function of the wetland (including nutrient and hydrology regimes), out-compete native plants, change the vegetation, alter the habitat and resources available for native insects, birds and fish, and affect access or restoration activities.

This chapter provides a step-by-step guide on how to achieve effective weed control through clear project aims or restoration goals, identification of weed issues, selection and application of appropriate treatment methods, timing of work, follow up, and monitoring. Although a range of priority weeds has been included, the list is not exhaustive. Comprehensive weed lists to help identify what weeds you have in and around your wetland can be accessed from the useful websites listed at the end of the chapter.

The two case studies in this chapter demonstrate approaches to controlling crack and grey willow, as both are a serious threat to freshwater wetlands. The first case study is situated in the Waikato and showcases a largely community-led restoration project around two shallow lakes; the second is a large, freshwater swamp in west Auckland surrounded by a mosaic of land uses. Both provide valuable lessons on how to control major weed infestations.

Previous page: Crack willow invading margins of Lake Taupo, Waikato.
Photo: Monica Peters, NZ Landcare Trust

Keeping remnant wetlands intact by minimising disturbance helps buffer them from weed invasion. The extensive raupo sward is in winter dieback. Matakana Island, Bay of Plenty. Photo: Monica Peters, NZ Landcare Trust

Mechanical vegetation clearance, drainage and ongoing disturbance, e.g., fire, have left wetland remnants highly vulnerable to weed invasion. Waihi, Bay of Plenty.
Photo: Monica Peters, NZ Landcare Trust

1 Restoring your wetland

Any restoration programme will need to address weeds and outline actions for their control. Effective weed reduction or removal will not only aid the survival of native plant species but also provide wider benefits to the wetland including increased habitat for native fauna, conservation of rare species, and retention of ecosystem processes.

1.1 Developing a Wetland Restoration Plan

A Wetland Restoration Plan is extremely useful for clarifying goals and objectives as well as on ground activities. Either use an existing template (links are at the end of the chapter) or create your own based on the format provided in Chapter 2 – Restoration planning.

1.1.1 Mapping

A bird's-eye view sketch map of the wetland is a useful tool for summarising knowledge about the natural and man-made character of the site as well as assisting with planning and management. The map can be hand drawn using a range of resources such as aerial photographs, topographic maps and Google Earth combined with your own knowledge. Once the features listed below have been included, management zones can be defined. Locations of permanent plots for monitoring and isolated weeds (including GPS co-ordinates if available) can also be included to aid restoration site management.

General features to include:

- Vegetation types
- Water sources and outflows, hydrological modifications, water levels
- Soil type(s)
- Natural, man-made and cultural features

For more detail on what to include, see Chapter 2 – Restoration planning

1.2 Determining wetland type

Find out what type your wetland is/was, e.g., swamp, fen, bog, marsh and/or shallow water, because different wetland types have specific nutrient and hydrological regimes that favour distinctive plant communities. Note that larger wetlands may be made up of more than one wetland type. See Chapter 3 – Wetland types for further information.

1.3 Using a reference wetland

You can get some clues on wetland type from what native plant species remain in your wetland, from the soil type (e.g., presence of peat), by visiting similar wetlands in the vicinity, or by researching historical records. A little investigation on the relevant wetland type in your region should also reveal information on the typical or main vegetation communities (including current and potential weeds), habitats, plant and wildlife species, and rare species, which can help focus your restoration project. Historical photographs and/or local knowledge may also reveal useful information about weeds. These sources could help determine whether weeds are spreading and if so, how quickly, or whether weeds have remained in discrete areas. Further information on finding and using reference wetlands can be found in Chapter 4 – Site interpretation 1. More in-depth studies to learn about the history of the wetland can be found in Chapter 5 – Site interpretation 2.

Aquatic habitats are under threat from introduced plants such as egeria (*Egeria densa*), which also negatively affect populations of native fauna such as koura. Photo: Rohan Wells, NIWA

1.4 Setting realistic goals and objectives

Goals need to be realistic and in line with the resources (time and money) that are available. An example of a goal may be to carry out regular surveillance to ensure no new weeds become established, and to rapidly eliminate any new weeds discovered. The goal(s) of the restoration project will determine if an introduced plant is considered a weed. For example, oak and feijoa trees are important duck food sources and willows can provide trout habitat, but none of these plants would be desirable in a native ecological swamp restoration project.

Objectives linked to goals should be clear and concise, and if possible measurable within a set time frame such as:

- Reduce the grey willow area from 70% to 20% in three years
- Determine high priority weeds and control in the most intact part of the wetland first
- Reduce invasion by marginal weeds such as gorse, broom and pampas by restoring water inflows and preventing wetland margins from drying out.

Rewetting Hannah's Bay wetland (Rotorua) has resulted in a change of species from dryland to wetland, aided by weed control and plantings of natives. Photo: Monica Peters, NZ Landcare Trust

Mechanical disturbance coupled with changing the hydrology of the wetland have enabled weeds including grey willow, gorse and royal fern to establish. Kopuatai peat dome, Waikato. Photo: David Stephens for DOC

1.4.1 Keeping it legal

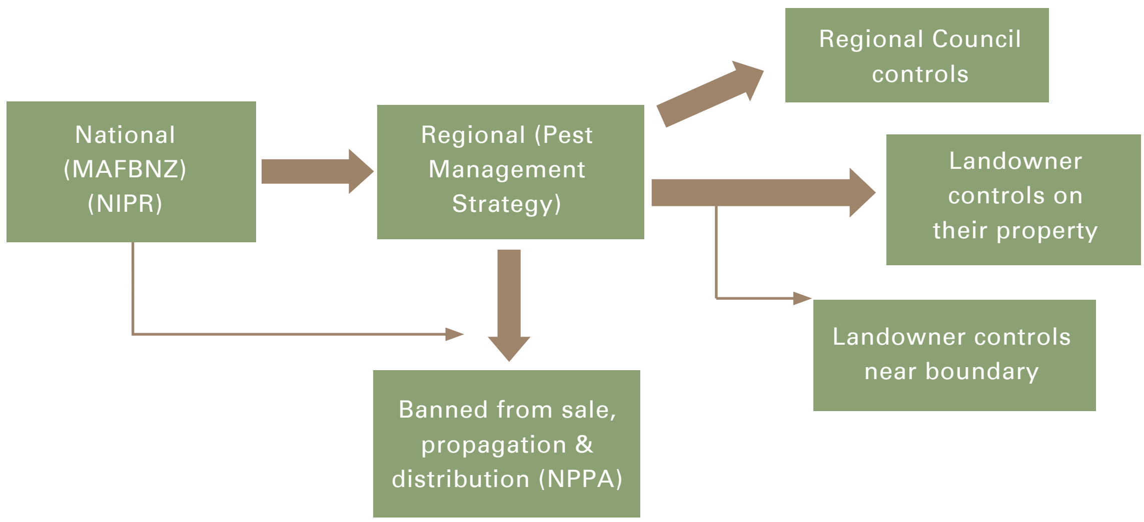
There are a limited number of herbicides registered for use in or near waterways. It is important to check the herbicide label for application instructions, and be aware that in some cases resource consent is required from your local or regional council.

Once you have determined your wetland weeds, check them against national and regional biosecurity weed lists to determine their legal status. If the weed is new to New Zealand or has been identified as a plant of national priority then notify the Ministry of Agriculture and Forestry Biosecurity New Zealand (MAFBNZ) as it falls under their jurisdiction (see the end of the chapter for links to websites).

Regional Councils each have their own Regional Pest Management Strategy (RPMS). The purpose of the strategy is to set out the strategic and statutory framework for the effective management of pest plants/weeds and pest animals. Under the RPMS, selected pest species are either the responsibility of the regional council or the landowner.

The majority of weeds listed, however, are simply banned from sale, propagation and distribution (Figure 1). RPMS for different regions can be found on Regional Council websites.

Before conducting any weed control also check council rules, plans and regulations at both a regional and district or city council level. Regional council plans, such as the Air, Land & Water Plan, set out restrictions on the use of fires, discharges to water, or earth works. District or city councils have district plans that may include restrictions on vegetation clearance, work within riparian margins or landscape protection.



NIPR = National Interest Pest Response
NPPA = National Plant Pest Accord

Figure 1. The national and regional weed management strategy designating responsibility for weed control and distribution.

Of the 24 700 introduced plants currently in New Zealand, 10% will establish in the wild, and 10% of these will become serious weeds. Arum lilies at Whatipu, Auckland.
Photo: Monica Peters, NZ Landcare Trust

1.5 How and why do weeds invade wetlands?

The number of introduced species in New Zealand already significantly outnumbers native species. Weeds can become established in a wetland through a variety of ways. Lower wetland water tables through drainage enable plants tolerant of drier conditions to become established – typically these include gorse (*Ulex europaeus*), blackberry (*Rubus fruticosus*), and pampas (*Cortaderia selloana* and *C. jubata*). Vegetation clearance in landscapes that are already heavily modified and have well-established weed populations enables rapid weed colonisation aided, for example, by wind, birds or people. Weeds can be spread unintentionally (e.g., on clothing, footwear or machinery) as well as intentionally. An example is the introduction of weedy aquatic species in the belief that beneficial habitat is being provided for coarse fish species.

However, even relatively undisturbed wetlands are vulnerable to invasion. Some of the weeds outlined in the next section – the "environmental weeds" – are extremely aggressive invaders capable of exploiting native plant habitat, particularly if it is nutrient enriched. Good examples are some of the aquatic weeds that, due to their dense growth habit and sheer size, are able to successfully outcompete smaller growing natives. Grey willow (*Salix cinerea*) is a species able to colonise undisturbed sedgelands by producing prolific quantities of seeds. Possibly the only exception for suceptibility to grey willow invasion because their naturally low nutrient status and acidic conditions are not as favourable for the higher nutrient-demanding, introduced species currently found in wetlands throughout New Zealand. However, the case study in Chapter 7 – Hydrology, demonstrates that bogs too become vulnerable to weed invasion once the water table has been lowered or nutrient enriched.

2 Identifying weed issues and priorities

Identifying what wetland weeds you have can be a daunting task; however, there are several weed identification guides available on websites listed at the end of this chapter. One easy, on-line key for weeds listed in the National Pest Plant Accord (NPPA) is the LucidKey, which starts with the easiest characteristics (like flower colour, for example) and works through the other characteristics.

WEED IDENTIFICATION – WHO CAN HELP?

It is important to identify your wetland plants correctly so that natives are not inadvertently killed as weeds, and weeds aren't accidentally fostered as natives. A number of web-based identification guides are available – see the useful websites section at the end of the chapter. Other resources to help you with plant identification are herbarium collections, your local botanical society, Regional Council biosecurity staff, and wetland experts from, e.g., NIWA, Landcare Research and universities.

Introduced pampas (*Cortaderia* ssp.) flowering heads have a strongly upright habit. The dead plants in the foreground show the typical mounding of rhizomes and curled remnants of leaf bases.
Photo: Monica Peters, NZ Landcare Trust

Dead leaf bases of introduced pampas are tightly curled. Photo: Monica Peters, NZ Landcare Trust

Weeds can be ranked as high, medium or low priority according to the threat they pose to the ecological integrity of the site. Factors to consider are the life form of the weed, where it is growing, how fast it can spread, and what impact it can have. The most damaging weeds are known as environmental weeds, which are capable of:

- changing the structure or function of a wetland, e.g., sedgeland (low growing) invaded by grey willow (tree)
- spreading rapidly, e.g., alligator weed
- outcompeting native plants, e.g., royal fern

Leaf bases of native *Cortaderia* ssp. have a waxy bloom.
Photo: Monica Peters, NZ Landcare Trust

Friend or foe? There are several features that distinguish native *Cortaderia* species (toetoe, *Cortaderia fulvida* shown) from their introduced cousins. Native flowering heads are mostly lax, and leaf bases have a distinctive waxy bloom. Photo: Rohan Wells, NIWA (with permission from Mighty River Power)

By contrast, low priority weeds integrate into the wetland with little or no perceived impacts. Pasture grasses and ragwort, for example, may not threaten the long-term health of the wetland but may require control to ensure they are kept lower than any native vegetation regenerating or planted.

Weeds can be both low and high priority, depending on where they grow and where they have highest impact. For example, Mercer grass (*Paspalum distichum*) is a low priority in paddock margins but a high priority when floating mats reduce the area of open water. Oval sedge (*Carex ovalis*) is a minor weed of tall vegetation but is a major turf weed. Pampas grass inhabits drier areas, making it a low priority weed on wetland margins but a high priority weed on ephemeral wetlands.

2.1 High priority weeds

Examples of high priority weeds that can transform a wetland are listed below according to their growth form (Table 1); and Table 2 illustrates some of the worst weeds to look out for in each wetland type. The Department of Conservation (DOC) has produced a list of 300 environmental weeds found on conservation estate land. A range of weed species are banned from sale, propagation and distribution throughout New Zealand under the National Pest Plant Accord. Regional councils and unitary authorities expand this list to include weeds that are of particular concern for their areas (see the Useful websites section at the end of the chapter).

Floating mat of Mercer grass (*Paspalum distichum*) in foreground encroaching on native wetland plants. Lake Mangahia, Waikato.
Photo: Kerry Bodmin NIWA (with permission from Environment Waikato)

Table 1. High priority weeds: Wetland transformers by growth form

Growth form	Common name*	Latin name	Wetland type
Trees	crack willow	*Salix fragilis*	Swamp, riparian zone
	grey willow	*Salix cinerea*	Swamp, fen
	alder	*Alnus glutinosa*	Swamp, riparian zone
Subcanopy/ shrubs	Chinese privet	*Ligustrum sinense*	Swamp, fen
	Chilean rhubarb	*Gunnera tinctoria*	Seepages
	gorse	*Ulex europaeus*	Bog
Vines and ferns	Japanese honeysuckle	*Lonicera japonica*	Marginal zone, swamp forest
	old man's beard	*Clematis vitalba*	Marginal zone, swamp forest
	royal fern	*Osmunda regalis*	Fen, bog
Herbaceous	purple loosestrife	*Lythrum salicaria*	Swamp, fen
	yellow flag iris	*Iris pseudacorus*	Swamp, salt marsh, fen, riparian margins
	arum lily	*Zantedescia aethiopica, Zantedescia aethiopica 'green goddess'*	Swamp
Rushes	sharp rush	*Juncus acutus*	Dune ephemeral wetland
	heath rush	*Juncus squarrosus*	Bog, ephemeral wetland turfs
	Californian club rush	*Schoenoplectus californicus*	Estuarine margins
	bulbous rush	*Juncus bulbosus*	Turf communities, seepage
Sedges	oval sedge	*Carex ovalis*	Fen, ephemeral wetland turfs
	Carex scoparia	*Carex scoparia*	Swamp, fen
Grasses	reed canary grass	*Phalaris arundinacea*	Swamp
	reed sweet grass	*Glyceria maxima*	Swamp
	Phragmites	*Phragmites australis*	Swamp, fen
	Manchurian wild rice	*Zizania latifolia*	Swamp, riparian zone
	pampas	*Cortaderia jubata* *C. selloana*	Ephemeral wetlands, marginal zone, pakihi, gumland
	Spartina	*Spartina alterniflora, Spartina anglica, Spartina x townsendii*	Saltmarsh, dune ephemeral wetland
Sprawling	alligator weed	*Alternanthera philoxeroides*	Swamp, marsh
	parrot's feather	*Myriophyllum aquaticum*	Swamp, marsh
Submerged	Lagarosiphon/ oxygen weed	*Lagarosiphon major, Elodea canadensis*	Shallow water
	hornwort	*Ceratophyllum demersum*	Shallow water
	Egeria	*Egeria densa*	Shallow water

* Note that common names can vary widely

Californian clubrush flowering heads.
Photo: Paul Champion, NIWA

Reed sweet grass forms dense mats on water and in damp areas. Photo: Paul Champion, NIWA

Long lived, arum lilies form dense patches. Photo: Monica Peters, NZ Landcare Trust

Gypsywort growing among raupo and smothering Carex spp.
Photo: Monica Peters, NZ Landcare Trust

Purple loosestrife produces abundant long-lived, highly viable seeds. Photo: Kerry Bodmin, NIWA

Grey willow poisoned and left to break down. Howarth Memorial Reserve, Waikato.
Photo: Monica Peters, NZ Landcare Trust

Table 2. Worst weeds by wetland type

Wetland type	Common name*	Latin name
Bog	royal fern	*Osmunda regalis*
	heath rush	*Juncus squarrosus*
	strawberry myrtle	*Ugni molinae*
	blueberry	*Vaccinium corymbosum*
	gorse	*Ulex europaeus*
Fen	royal fern	*Osmunda regalis*
	grey willow	*Salix cinerea*
	Phragmites	*Phragmites australis*
	oval sedge	*Carex ovalis*
	purple loosestrife	*Lythrum salicaria*
Swamp	grey willow	*Salix cinerea*
	crack willow	*Salix fragilis*
	alder	*Alnus glutinosa*
	gypsywort	*Lycopus europaeus*
	jointed rush	*Juncus articulatus*
	purple loosestrife	*Lythrum salicaria*
	reed canary grass	*Phalaris arundinacea*
	reed sweet grass	*Glyceria maxima*
	Phragmites	*Phragmites australis*
	Manchurian wild rice	*Zizania latifolia*
	alligator weed	*Alternanthera philoxeroides*
	yellow flag iris	*Iris pseudacorus*
	parrot's feather	*Myriophyllum aquaticum*
Marsh	alligator weed	*Alternanthera philoxeroides*
	parrot's feather	*Myriophyllum aquaticum*
	tall fescue	*Schedonorus phoenix*
	Mercer grass	*Paspalum distichum*

* Note that common names can vary widely

Wetland type	Common name*	Latin name
Seepage	rush	*Juncus acuminatus*
Ephemeral	blackberry	*Rubus fruticosus*
	gorse	*Ulex europaeus*
	pampas	*Cortaderia jubata, C. selloana*
	sharp rush	*Juncus acutus*
	bulbous rush	*Juncus bulbosus*
	oval sedge	*Carex ovalis*
Shallow water	parrot's feather	*Myriophyllum aquaticum*
	Mexican waterlily	*Nymphaea mexicana*
	Lagarosiphon	*Lagarosiphon major*
Pakihi and gumland	pampas	*Cortaderia jubata, C. selloana*
	prickly hakea	*Hakea sericea*
	downy hakea	*H. gibbosa*
	Spanish heath	*Erica lusitanica*
	gorse	*Ulex europaeus*

* Note that common names can vary widely

Royal fern displaying autumnal colours. Photo: Abby Davidson, NZ Landcare Trust

2.1.1 Understanding the weed issue

For each habitat type within your wetland you can determine what pest plants you have, where they're located, and what area they cover. If you have access to historical information, either photographs or local knowledge, you can determine if the weed population is invading and how fast it is spreading or if the spread has been relatively constant over time.

Often there will be more weeds than you can tackle at once. Weeds that you have the least of, but which could rapidly invade your wetland, should generally be prioritised above those weeds that are already abundant and have occupied much of their available wetland habitat. Also check the lists of environmental weeds in the useful websites section at the end of the chapter to see what weeds you don't have. Are these weeds nearby? If so, what's the likelihood of their spreading to your wetland?

Alligator weed, native to South America, is regarded as one of the world's worst weeds. Photo: Paul Champion, NIWA

Attractive flowers are one reason the Mexican waterlily was introduced. Photo: Rohan Wells, NIWA

The banana shaped tubers are a key diagnositic feature of the Mexican waterlily – useful when no flowers are present. Photo: Rohan Wells, NIWA

CASE STUDY

CONTROLLING GREY WILLOW AT LAKES KAITUNA AND KOMAKORAU

The lakes to the north of Hamilton City form part of a chain of more than 30 shallow peat lakes that extend along historical routes of the Waikato River. Over the course of a few decades, grey willow (*Salix cinerea*) invaded the margins of both Lake Kaituna (15 ha) and the adjacent Lake Komakorau (2.6 ha), considerably reducing the area of open water. Much to the concern of the landowners, the invasion of willow and other weeds combined with declining lake water impacted on native wildlife populations – few birds were to be seen. To remedy this, a lake care group was formed, and partnerships developed between the group, Environment Waikato and DOC.

The beginnings

Ground work to clear dense thickets of grey willow at Lake Kaituna started in 1999. A host of other weeds including royal fern (*Osmunda regalis*), blackberry (*Rubus fruticosus*), crack willow (*Salix fragilis*) and Japanese honeysuckle (*Lonicera japonica*) were also removed in the process. Both lakes were fenced to prevent stock access, and silt traps and vegetation filters were constructed on drains to prevent direct entry of nutrient and sediment laden water to the lakes.

Ground-based control

Beginning upwind to avoid reinfestation of cleared areas, grey willow was felled and stumps painted with 4 parts diesel and 1 part Roundup™. These works were carried out Dec–Jan to take advantage of low water levels. A digger then stacked the willow in piles working from the margins further into the wetland. Willow rots quickly and this method allowed native sedges and eventually other wetland species to reestablish quickly. After 3–5 years, the felled willow has almost entirely rotted away, with the area now largely colonized by native sedges.

Aerial control

Areas where the water was too deep were helicopter sprayed with 9L Roundup™, 500 ml Pulse penetrant and 1 L Delfoam anti-drift agent in 200 L water. Follow-up work is focused on controlling willow seedlings, blackberry, beggars tick (*Bidens frondosa*), and gypsywort (*Lycopus europaeus*), through a combination of handpulling/grubbing and spot spraying with Roundup™.

Funding

Complete removal of ~16 ha of willow from both lakes took 7 years at a total cost of around $60,000. This sum includes financial contributions from Environment Waikato, DOC (both lakes are Wildlife Management Reserves), the landowner farming around the lakes, and the local lake care group. Not included in this sum is the considerable unpaid time and resources the landowner and lake care group have contributed toward weed clearance, planting, pest control, and plant maintenance.

– Monica Peters, NZ Landcare Trust and Andrew Hayes, Lake Kaituna and Komakorau Care Group

REF: www.landcare.org.nz/files/file/841/Hayes%20Case%20Study%20Revised%20May%202012.pdf

Willows completely cleared from Lake Kaituna and regeneration well underway. The grayish stands of willow on the adjacent lake (Komakorau) have since been removed. Photo: Environment Waikato

Large-scale restoration takes large-scale approaches: a digger was necessary to remove the dense stands of grey willow. Photo: Rodney Hayes

Lake Kaituna as seen from the farm. Photo: Monica Peters, NZ Landcare Trust

3 Weed treatment methods

What treatment methods you use will depend on the project aims or restoration goals you have set and the resources available. The aim of treating a particular section or pest plant within your wetland falls into one of three categories:

- **Containment** – to restrict further spread
- **Control** – to reduce the population or knock it back periodically
- **Eradication** – to eliminate the population

Eradication is generally the most expensive option, but may be appropriate when there are only a few plants or they occupy a limited area, there is a good treatment method, and the risk of reinvasion is low. You may select a combination of different aims for your wetland depending on the site and the weeds present. When selecting a treatment option consider the effectiveness of the treatment on your target weed and also in the type of wetland you have, the practicality of using that method, the cost and resources required, the environmental impacts, the risk of reinvasion by water, birds, wind and people, and the acceptability of the method to the community.

The most effective initial control method may differ from the ongoing control method.

Examples of weed treatment options include:

- **Manual** – hand weeding, digging, using animals to graze site
- **Mechanical** – chainsaw
- **Biological** – biocontrol such as willow sawfly
- **Chemical** – herbicide application
- **Physical** – fire, temporarily flooding
- **Combination of approaches** – drilling and injecting with herbicide; cutting, frilling and painting with herbicide
- **Do nothing** – no action taken

3.1 Disturbance

Try to keep disturbance at a site to a minimum as most weeds thrive on disturbance. It may be that a ‘do nothing’ approach is required when the collateral damage to non-target (desirable) plants will be too great or when control of a weed could lead to a worse weed invading. Restoration works carried out at Te Henga wetland (Auckland) provides a striking example of two very different

Willows were drilled and injected with herbicide. Large-scale disturbance through mechanical removal has allowed weed invasion. Photo: Paul Champion, NIWA outcomes from willow control. The sites in the photographs below were directly adjacent to each other in Te Henga Wetland. Disturbance through removal of poisoned willows from the site exposed bare soil that allowed pampas grass to invade. By contrast, dead willows were left standing in the directly adjacent site where a predominantly native understorey has established.

There are added benefits to keeping willow as standing deadwood as they also provide moderate shade, shelter and habitat, e.g., bird roosting sites. Over time, dead willow wood density declines and the trees break down very easily. Small branches fall regularly, minimising damage to regenerating vegetation.

3.2 Hydrology

Water levels in modified wetlands are often significantly reduced, contracting the wetland and allowing more terrestrial plant pests such as blackberry, gorse and pampas to take hold. Restoring the amount of water in the wetland, and reinstating the natural seasonal fluctuations, can prevent many weeds from establishing and assist with control of terrestrial species. See Chapter 7 – Hydrology, for further information.

Willows were drilled and injected with herbicide and left as standing deadwood. An understory of native species has successfully begun to regenerate. Photo: Paul Champion, NIWA

3.3 Nutrients

The addition of nutrients to a wetland system can alter the type of wetland and therefore facilitate the introduction of new weeds. If nutrient input to the wetland cannot be prevented, consider the planting of high nutrient stripping plants, such as raupo, at the inflows. See Chapter 8 – Nutrients, for further information.

HERBICIDES – WHICH ONE TO USE?

A wide range of herbicides are available for controlling weeds. Diquat® can be used in water for the control of some submerged species. Glyphosate® (or Roundup) is a broad spectrum herbicide with some formulations registered for use on or near waterways. Gallant® is specifically targeted to control grasses but should not be used where contamination of water can occur. Vigilant® gel is applied directly to target weeds such as gorse. People applying the herbicides should have "Growsafe" (www.growsafe.co.nz) certification for safe handling and chemical application.

4 Preventing weeds

A regular surveillance regime provides early detection of new weeds and allows a rapid response. Control of recent invaders at an early stage is usually cheaper, more likely to be successful in eradication, and prevents the formation of a seed bank.

Several tools and practices can be used to minimise weed invasion. If control of a pest plant is problematic, removal of the seed head prevents further spread. Good weed hygiene practices, such as removing seeds from boots and clothing, prevent seed spread. Maintaining a good vegetation cover also prevents weeds establishing. At a larger scale you may consider a vegetation buffer around your wetland to reduce weed invasion. A buffer also has the added benefits of intercepting runoff, excluding stock, and providing different fauna habitat. A catchment management plan can be used as a tool for weed control beyond the wetland, particularly from immediate neighbours and those upstream of the wetland.

WEEDS: TOP TIPS FROM THE COMMUNITY

- Know your weeds from your natives, how the weed grows, spreads and thrives
- When targeting an area, tackle all the weeds in that area
- Don't bite off more than you can chew
- Plan and do follow-up weed control, about every 3 months
- Aim to eradicate priority weeds from the site
- Prevent weed spread from or to the site on shoes, clothing and equipment
- Reduce habitats that favour weeds through planting or minimising disturbance

Dead grey willow with royal fern (reddish colour) invading Whangamarino, a Ramsar wetland administered by the Department of Conservation. Waikato. Photo: Kerry Bodmin, NIWA

5 Timing of work

Selecting the appropriate time of year for treatment is one of the most critical steps for successful weed control. It is important to consider not only the optimal time to strike your target weed, but also when other non-target species are least susceptible, such as undertaking weed control after orchids have flowered and died back to a bulb below the ground. The optimal time for herbicide applications is generally when the plant is actively growing, but before it flowers or sets seed. Avoid control when plants are stressed, such as from too much or too little water. Most weed control usually occurs in spring or summer when plants are growing vigorously and in full leaf.

5.1 Follow up

Successful control or eradication of weeds requires skilful targeted application of treatment, appropriate timing, and rigorous follow up, follow up, follow up. The method selected for follow-up weed control may differ from initial control methods. For example, a large expanse of crack willow that is initially treated by aerial spray has follow-up control by ground-based spot spraying or drilling and injecting. Multiple treatments are often required with regular follow up.

Weeds that require light to survive will be less vigorous or die out once a canopy of desirable plants is established. These light-demanding weeds can provide some intermediate benefits, such as soil moisture retention, but need to be kept below planted natives to prevent the native plants from being out competed and smothered. Other pest plants, such as Chinese privet and royal fern, tolerate shade and will require ongoing maintenance. Timing of follow-up control work needs to be scheduled regularly, usually every 2–3 months, or more regularly in good growing conditions. Any follow-up work needs to take account of other activities on which it may impact, especially planting.

Controlling weed infestations in wetlands is without a doubt challenging! Good safety gear and a sound knowledge of chemical and tool handling are essential. Photo: Wildland Consultants Ltd.

Weed reinvasion remains a constant threat. Grey willow seedling, Hannah's Bay wetland, Rotorua. Photo: Monica Peters, NZ Landcare Trust

An island of willows that has been controlled.
Photo: Danielle Hancock, Waitakere City Council

The amphibian boat used for weed control work.
Photo: Danielle Hancock, Waitakere City Council

General view of the wetland central water body, looking upstream.
Photo: Danielle Hancock, Waitakere City Council

Wetland edge showing emergent native vegetation among controlled willow saplings. Photo: Danielle Hancock, Waitakere City Council

A patch of sprayed alligator weed with willows in the background.
Photo: Danielle Hancock, Waitakere City Council

A stretch of water once was covered in Mexican waterlily. Parrot's feather now unfortunately dominates. Photo: Danielle Hancock, Waitakere City Council

CASE STUDY

CONTROLLING CRACK WILLOW IN TE HENGA/BETHELLS WETLAND

At 153 ha, Te Henga is the largest freshwater wetland in the Auckland region. The wetland is of national importance for wildlife, and supports a high diversity of freshwater wetland bird species and native vegetation. However, crack willow (*Salix fragilis*) has invaded the wetland, forming dense stands that totally exclude native vegetation, and has blocked water channels causing localised flooding and erosion. Grey willow (*S. cinerea*) is sparse throughout the swamp but has the potential to invade the majority of the wetland. The desired outcomes of the Waitakere City Council led restoration project are long-term flood control and enhanced wetland habitat for native plants, fish and birds.

Ground and aerial control

Crack willow control work started from the top of the catchment working downstream to avoid reinvasion from fragments broken off accidentally during work or through natural events. Over a 10-year period, willows in the main wetland body and channels were accessed by boat, and trunks were drilled and injected using a herbicide mix (1 L Roundup Renew extra, 10 g Escort, 20 mL Pulse, 2 L water) or seedlings and saplings foliar sprayed (1.5% Glyphosate).

Aerial treatment of willows was considered for the Mokoroa Arm portion of Te Henga wetland as it is a dense and inaccessible area. Consultations with individual landowners, a public meeting, and an open day were held as part of the resource consent process. A small pilot area was used for the initial aerial treatment. Willows were aerially mapped before aerial spray control to define areas suitable for boom spraying and those needing spot spraying (i.e. individual plants/small clusters surrounded by native vegetation). Glyphosate Green™, approved and recommended for use over water, was used for both treatment methods.

Monitoring

Vegetation monitoring plots were established in the wetland to track the results of the aerial spray work. As well as measuring willow control, any effects on non-target vegetation (e.g., native species) will be assessed, and the success of natural native regeneration evaluated.

Willow control – the benefits

- Water flow opened up from previously willow-choked channels
- Flooding reduced by allowing water to spread through the wetland
- Native regeneration where dead willow trees were left standing
- Greater recreational use of the wetland for locals (e.g., kayaking)

Willow control – the drawbacks

- An explosion of the aquatic weed parrot's feather (*Myriophyllum aquaticum*) due to more light penetrating the water
- Pampas (*Cortaderia* spp.) and other weeds invaded where dead willow trees were removed

Funding

To date, more than $320,000 has been spent on weed control, with joint funding from the Auckland Regional Council, Waitakere City Council and Rodney District Council, and assistance from the Department of Conservation. Agency support has been crucial: complete willow eradication requires a high level of coordination and individual landowners within the catchment lacked the resources to fully support such a large-scale conservation initiative.

REF: www.waitakere.govt.nz/cnlser/pw/greennetwk/pdf/tehenga-willow-control-report.pdf

6 Monitoring

Monitoring is important to record progress made, to evaluate the success of weed control, and to feed back into wetland management decisions. Monitoring data allows measurement of what actually happened compared with general targets for weed control, such as reducing the area occupied by introduced plants from 25% to 10% of the wetland.

Part of evaluating success is to look at what species replace the treated weeds. Are native plants colonising or weeds – either a new population of the weed (seed bank or invasion from nearby plants) or invasion of a different weed that requires follow up control? Your wetland system will show recovery in 1–2 years for small, targeted weed control, such as individual plant treatment, compared with 4–5 years or more for an aerial spray operation. Recovery will also happen in phases. Initial colonisers are likely to be fast-growing, light lovers such as annual plants and grasses. These are followed by sedges and rushes and finally by shrubs and trees (if they are part of the wetland).

Along with weed maintenance, monitoring is an ongoing activity that you need to plan and for which you need to allow time. Chapter 13 – Monitoring includes further methods for monitoring restoration progress. Remember to make the monitoring regular and to keep good records.

NIWA is monitoring the results of management experiments for highly invasive weeds such as Manchurian wild rice. Photo: Paul Champion, NIWA

6.1 Maps and flagging tape

Maps and flagging tape are two complementary methods to monitor and document weed infestations at the restoration site. Infestations can be marked on a map and, as such, provide a visual record of weed location, etc.

Supporting documentation should include:

- Weed location (e.g., GPS coordinates and photos taken from strategic photo points – see below)
- Weed species and site identification code (e.g., species, infestation number if more than one site of same species and management zone)
- Method of control
- Timing of control
- Results of control

Flagging tape (a brightly coloured plastic tape) can be used to mark infestations at the restoration site. A permanent marker can be used to record information on the tape such as the name of the weed, site identification code, and amount of weed seedlings removed. Note that flagging tape may not last longer than a year in the field.

6.2 Photo points

To record changes visually from precise locations throughout the wetland, set up a series of photo points throughout the wetland. Use marker posts labelled with a number and an arrow to indicate camera direction to take the same view each time. Include photo points at the permanent plots by sitting the camera on one of the corner pegs. Take the photographs at the same time each year, preferably mid-late summer, to eliminate seasonal changes.

6.3 Permanent plots

Establish permanent plots, selected as representative of each main vegetation type, and monitor immediately before restoration starts and at intervals afterwards (yearly if rapid change is expected, less frequently for minor change). Aim for at least 3–5 replicate plots per vegetation type/habitat as these will provide baseline information. Plot size will depend on wetland structure and number of permanent plots established; use several plots of at least 2 m × 2 m or 4 m × 4 m quadrats in low vegetation, and larger sizes, e.g., 5 m x 5 m or 10 m x 10 m for taller vegetation and/or fewer plots. In areas that have been completely transformed by weed removal, cleared land, new soil surface, etc., set up the plots immediately after planting.

The basic parameters to use are:

- Species composition
- Species cover
- Species height

For more detailed monitoring information on how to sample vegetation, soil and water parameters, follow the Wetland Condition Handbook methodology and fill in the Handbook plot sheet (see weblink at the end of the chapter). Add any additional monitoring components specific to your wetland.

DOC Aerial herbicide willow control trials in 2001 at Kopuatai peat dome, Waikato. Monitoring results show that limited damage occurred to native understory vegetation though seedling and sapling grey willows have re-established. Open areas of willow have been colonised by native sedges, invasive grasses and annual weeds. Photo: David Stephens (with permission from DOC)

6.4 Transects

Transects may be used instead of, or in addition to, permanent plots to monitor vegetation changes over time. A transect is a straight line, usually using a tape measure, that is placed along a gradient, such a decreasing water table, that causes different vegetation types. The length and location of your transects will depend on the physical drivers of the wetland and the resulting vegetation communities. For example, at a lake with wetland vegetation, the transect would run on a compass bearing (or at right angles) from the dry land margin, through the wetland to the lake.

When establishing or monitoring the transect, a tape measure can be attached to a fixed post and run out on a bearing and pulled in once completed. Alternatively, two fixed marker posts, each labelled with a compass bearing, can be used to mark the start and end of an established transect. The width of vegetation recorded either side of the transect line will depend on wetland structure – use 1 m or 2 m in low vegetation and 5 m or 10 m for taller vegetation.

The basic parameters to record are:

- Species composition
- Species cover
- Species height
- Species maximum distance along the transect

Monitor immediately before restoration starts and at intervals afterwards (yearly if rapid change is expected, less frequently for minor change). Add any additional monitoring components specific to your wetland.

Vegetation transect line. Whakamaru, Waikato. Photo: Kerry Bodmin, NIWA

6.5 Aquatic plant monitoring

Although terrestrial monitoring is easier, finding out what aquatic species exist in underwater areas of the wetland is just as important. Donning a wetsuit and snorkel, or a drysuit and snorkel as the team has in the picture below, reveals a whole new world of submerged plants in shallow waters and margins and can be a fun activity in hot summer months.

The tools used for submerged plants, otherwise known as macrophytes, are similar to those described above, combined with indices to assess and monitor submerged vegetation. Where streams or channels enter a wetland the rapid assessment guidelines developed by Environment Waikato can be used to assess macrophyte cover. The extent of aquatic plant cover along five transects can be measured and scored to give an index of total plant cover over the stream bottom, an index of plant cover through the water column, and an index of the naturalness of the macrophyte community (Collier et al. 2007).

In shallow waters, transects may be established in a similar manner to those used in emergent wetland vegetation. Transects run along the water gradient, from shallow margins into the depths. A width of 1 m or 2 m is commonly used to record vegetation either side of the transect line including species, cover, maximum depth and maximum height – the latter can be measured using a weighted tape measure.

Where a wetland borders a deep water body, the LakeSPI method (see links to useful websites at the end of the chapter) can be used to assess and monitor the ecological condition of the lake through submerged plant indicators (SPI). Divers record information on both native and exotic submerged plants, including species, cover, maximum depth and maximum height, over several transects; usually five transects are recommended. A simple scoring sheet provides a description of the condition of native vegetation (native condition index), the condition of submerged weeds (an invasive condition index), and the overall ecological state of the lake (lake condition index). Any change in these indices can be monitored over time for a particular lake and also compared with other lakes throughout New Zealand.

Carrying out Lake SPI monitoring at Lake Waikaremoana, East Coast/ Hawke's Bay. Photo: John Clayton, NIWA

Snorkelling can also be used in shallow water wetlands to gain a better understanding of the species present and the ratio of native aquatic plants to introduced species. Lake Ngatu, Northland. Photo: Kerry Bodmin, NIWA

7 References and further reading

Champion P., James T., Popay I. and Ford K. 2012. *An illustrated guide to common grasses, sedges and rushes of New Zealand.* New Zealand Plant Protection Society, Canterbury, New Zealand.

Collier K., Kelly J. and Champion P. 2007. *Regional guidelines for ecological assessments of freshwater environments: Aquatic plant cover in wadeable streams.* Environment Waikato Technical Report 2006/47.

Johnson P.N. and Brooke P.A. 1989. *Wetland plants in New Zealand.* DSIR Publishing, Wellington, New Zealand.

Popay I., Champion P. and James T. 2010. *An illustrated guide to common weeds of New Zealand*. 3rd ed. New Zealand Plant Protection Society, Canterbury, New Zealand.

7.1 Useful websites

Wetland restoration templates

Waikato Regional Council Wetland Restoration Plan templates

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate1.pdf

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate2.pdf

Wetland restoration guides and factsheets (New Zealand)

Northland Regional Council

www.nrc.govt.nz/upload/2217/Wetland%20Restoration%20Guide%20(second%20edition%20Feb%2009).pdf

Auckland Regional Council

www.arc.govt.nz/albany/fms/main/Documents/Environment/Plants%20and%20animals/wetlandsfacts2.pdf

Waikato Regional Council

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/

Hamilton City Council

www.gullyguide.co.nz/index.asp?pageID=2145821537

Bay of Plenty Wetlands Forum

www.doc.govt.nz/upload/documents/conservation/land-and-freshwater/wetlands/wetland-restoration-guide.pdf

Greater Wellington

www.gw.govt.nz/a-beginner-s-guide-to-wetland-restoration/

Department of Conservation Protecting Natural Areas Design Guide

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/nature-heritage-fund/protecting-natural-areas-design-guide/

Wetland restoration guides (International)

USA Environmental Protection Agency

www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Introduced plant identification resources

NZ Plant Conservation Network

www.nzpcn.org.nz

NIWA aquatic quick guides for flora and fauna

www.niwa.co.nz/our-science/freshwater/tools/quickguides

Landcare Research

www.landcareresearch.co.nz/resources/identification/plants/weeds-key

Weedbusters

www.weedbusters.co.nz/

Priority weed lists

Biosecurity N.Z.

www.biosecurity.govt.nz/pests/surv-mgmt/mgmt/prog/nipr

Auckland Regional Council

www.arc.govt.nz/environment/biosecurity/pest-plants/pest-plants_home.cfm

Environment Bay of Plenty

www.boprc.govt.nz/environment/pests/pest-plants-and-weeds/weed-index

LucidKey for National Pest Plant Accord weeds

www.landcareresearch.co.nz/resources/identification/plants/weeds-key

Weeds control methods

Weedbusters

www.weedbusters.co.nz

Willow control

www.arc.govt.nz/albany/index.cfm?63E0F20E-14C2-3D2D-B905-50098EBBE4B9&plantcode=Salcin

Herbicide use

www.arc.govt.nz/environment/biosecurity/pest-plants/herbicides.cfm

Certification for herbicide use

www.growsafe.co.nz

Botanical Societies

www.nzbotanicalsociety.org.nz/pages/links.html

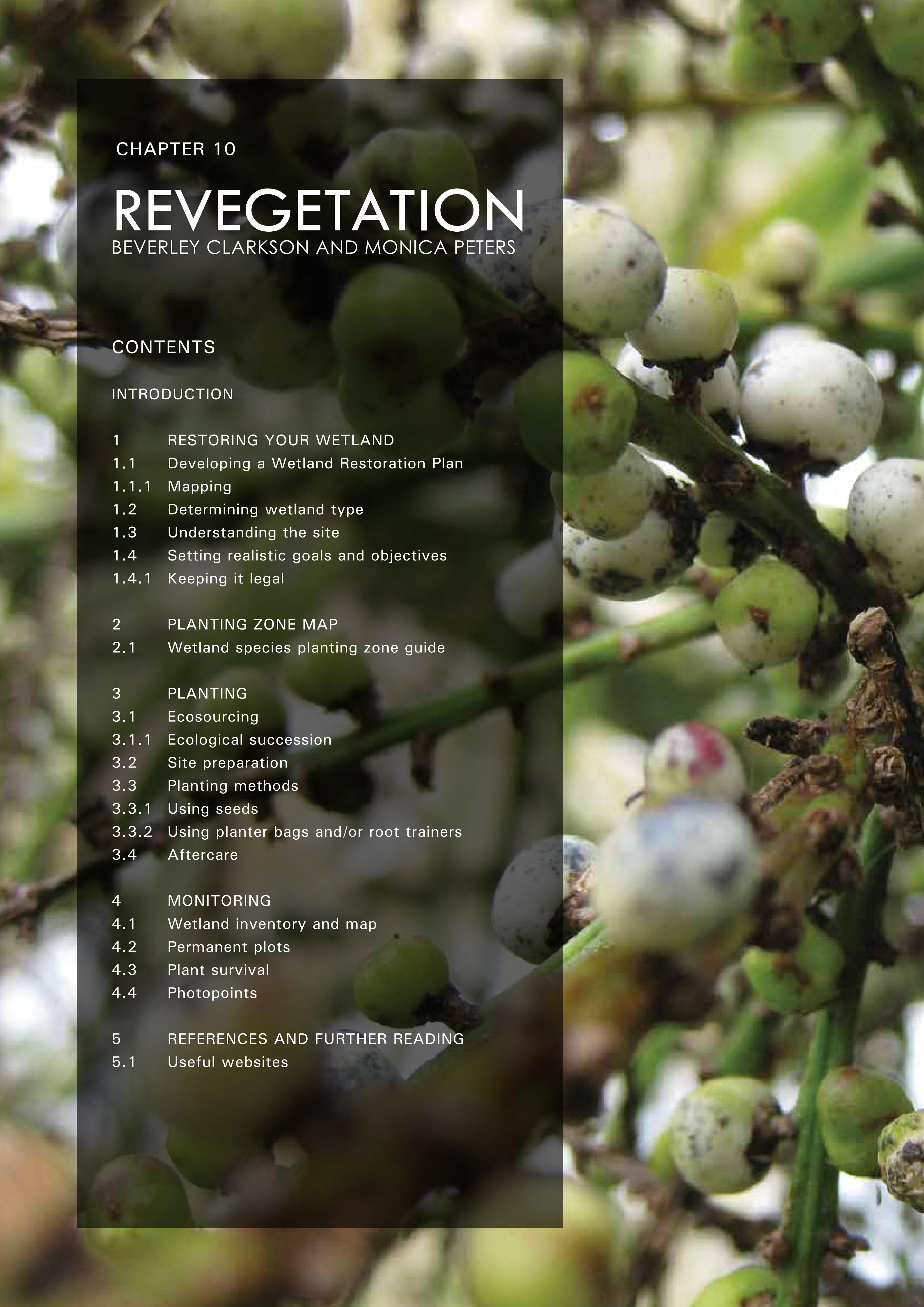
Herbaria in New Zealand

www.nzherbaria.org.nz/herbaria.asp

NZ Journal of Botany

www.tandfonline.com/loi/tnzb20

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 10

REVEGETATION

BEVERLEY CLARKSON AND MONICA PETERS

CONTENTS


REVEGETATION

REVEGETATION

BEVERLEY CLARKSON AND MONICA PETERS

Many of New Zealand's iconic wetland species are endemic, i.e. found nowhere else in the world. Examples of such species include kahikatea (*Dacrycarpus dacrydioides*), swamp maire (*Syzygium maire*), cabbage tree (*Cordyline australis*), red tussock (*Chionochloa rubra*), purei (*Carex secta*), and cane rush (*Sporadanthus ferrugineus*), which often dominate large areas to form distinctive vegetation types. Wetlands also contain a disproportionately high number of New Zealand's threatened plants and animals, a consequence of extreme habitat loss and ongoing human-induced degradation. Restoration of wetland structure and function is therefore extremely important to provide suitable habitat for wetland species and ensure that biodiversity values will be preserved for future generations.

The most common action undertaken for restoration of wetlands is revegetation. In most cases this involves removal of introduced weeds, such as willow, and then the planting of native species appropriate to the habitat conditions and region. Revegetation frequently focuses on increasing scenic, biodiversity, or functional values of the wetland site. Whatever the reason, there are a few key steps to follow to ensure your revegetation project is successful.

Previous page: The ripe seeds of the cabbage tree (*Cordyline australis*).
Photo: Monica Peters, NZ Landcare Trust

Involving the community helps with planting out and aftercare as well as providing a valuable opportunity to educate the public about wetlands.
Photo: Abby Davidson, NZ Landcare Trust

The Battle Hill Farm Park in Wellington is a working farm that also showcases a wide range of wetland restoration initiatives.
Photo: Monica Peters, NZ Landcare Trust

1 Restoring your wetland

1.1 Developing a Wetland Restoration Plan

A Wetland Restoration Plan is extremely useful for gathering information about the restoration site, clarifying goals and objectives and guiding restoration activities. Either use an existing template (see the Useful websites section at the end of the chapter) or create your own based on the steps outlined below.

1.1.1 Mapping

An effective starting point for developing a Wetland Restoration Plan is a sketch map. A bird's-eye view sketch map is important as it helps to summarise knowledge about the natural and/or man-made features of the restoration site. It is a practical tool for defining, for example, management zones and locations of permanent plots for monitoring. The map can be hand drawn using a range of resources such as aerial photos, topographic maps and Google Earth combined with your own knowledge.

The following features should be included:

- Vegetation types
- Water sources and outflows, hydrological modifications, water level
- Soil type(s)
- Natural, man-made and cultural features

For more detail on what to include, see Chapter 2 – Restoration planning

1.2 Determining wetland type

Find out what type your wetland is/was, e.g., marsh, swamp, fen, bog, ephemeral, because different wetland types have specific nutrient and hydrological regimes that favour distinctive plant communities. Note that larger wetlands may be made up of more than one wetland type. This information will provide a framework for the most appropriate species and environmental conditions to aim for (See Chapter 2 – Wetland types).

1.3 Understanding the site

You can get some clues on wetland type from what native plant species remain in your wetland, and from the soil type (e.g., presence of peat), by visiting similar wetlands in the vicinity, or researching historical records. A little bit of investigation on the relevant wetland type in your region should also reveal information on the typical or main vegetation communities, habitats, plant and wildlife species, and rare species, which can help focus your restoration project. Further information on finding and using reference wetlands along with a range of other useful information from, e.g., historical sources can be found in Chapter 4 – Site interpretation 1 and Chapter 5 – Site interpretation 2.

1.4 Setting realistic goals and objectives

Set goals that are achievable. An overall goal for revegetation may centre on re-establishing vegetation cover characteristic of the original wetland type. As the restoration progresses and the first plantings mature, short-term goals can be refined – see Chapter 2 Goals and objectives for advice.

Specific objectives linked to revegetation goals could be to:

- provide food and habitat for wetland birds
- reintroduce plant species that have historically been present
- develop a useable resource of culturally important species for fibre and medicine
- re-establish peat forming species (in bogs)
- create a seed source for other local wetland restoration projects
- establish a buffer to trap sediments and process nutrients from the surrounding catchment

Right: Flax harvested from Punawhakaata wetland, South Taupo.
Photo: Monica Peters, NZ Landcare Trust

1.4.1 Keeping it legal

If your wetland restoration site is located on Department of Conservation land and you want to introduce native plants not currently found there, then a species translocation permit is required. All translocations of native species are under the control of the Department of Conservation, and must adhere to the strict guidelines set out in the 'Standard Operating Procedure for Translocation of New Zealand's Indigenous Flora and Fauna', 2002. Contact the Department of Conservation for further information.

The cultural harvest of plants such as flax and raupo may also require a permit from the Department of Conservation if the activity takes place on DOC administered sites.

2 Planting zone map

The wetland sketch map opposite shows the site in its current state and includes the planting zones as detailed in Table 1. The concept diagram overleaf shows the same site with restored vegetation appropriate to the planting zones. The diagram summarises the overall planting aims for the site and provides an indication of how it might look 10–20 years after restoration.

Intact vegetation sequence from swamp in the valley to dryland on the slopes, Waikato. Photo: Monica Peters, NZ Landcare Trust

Table 1. Planting zones

A = Aquatic • Permanent open water usually >1 m deep • Plants are submerged entirely except for flowering parts. They may be floating or rooted and will generally not survive dry-down conditions • Aquatic plants are established as tubers, rooted plants, or plant fragments
E = Emergent • Shallow water usually 5 cm – 1 m deep • Plants are partially submerged with leaves, stems and flowering parts partially or entirely out of the water • Emergent plants are generally installed as plants. When planted, they need to have a portion of their leaves or stems above the water surface or they will drown • If seeded, the seed should be placed either on a mud flat or at the water's edge
S = Saturated • Soils are saturated most of the year with water levels averaging –5 cm to +5 cm, i.e. at or near the ground surface • Plants will tolerate periodic flooding and dry-down periods • 'Saturated' species can be established as plants or seeds and grow well at the water's edge
M = Moist • Moist soils are saturated seasonally with flooding in winter, or after periods of heavy rain, and dry-down in summer • Species can be established as plants or seed
MZ = Mesic • Upland soils may be saturated for short periods of time but are generally dry • Many mesic species will tolerate saturated and moist conditions for extended periods of time • Species are established as plants or seed
D = Dry • Upland soils on slopes or free-draining sites that are generally dry • This non-wetland zone usually supports forest and shrub species

Links to planting guides are included in the reference section at the end of the chapter.

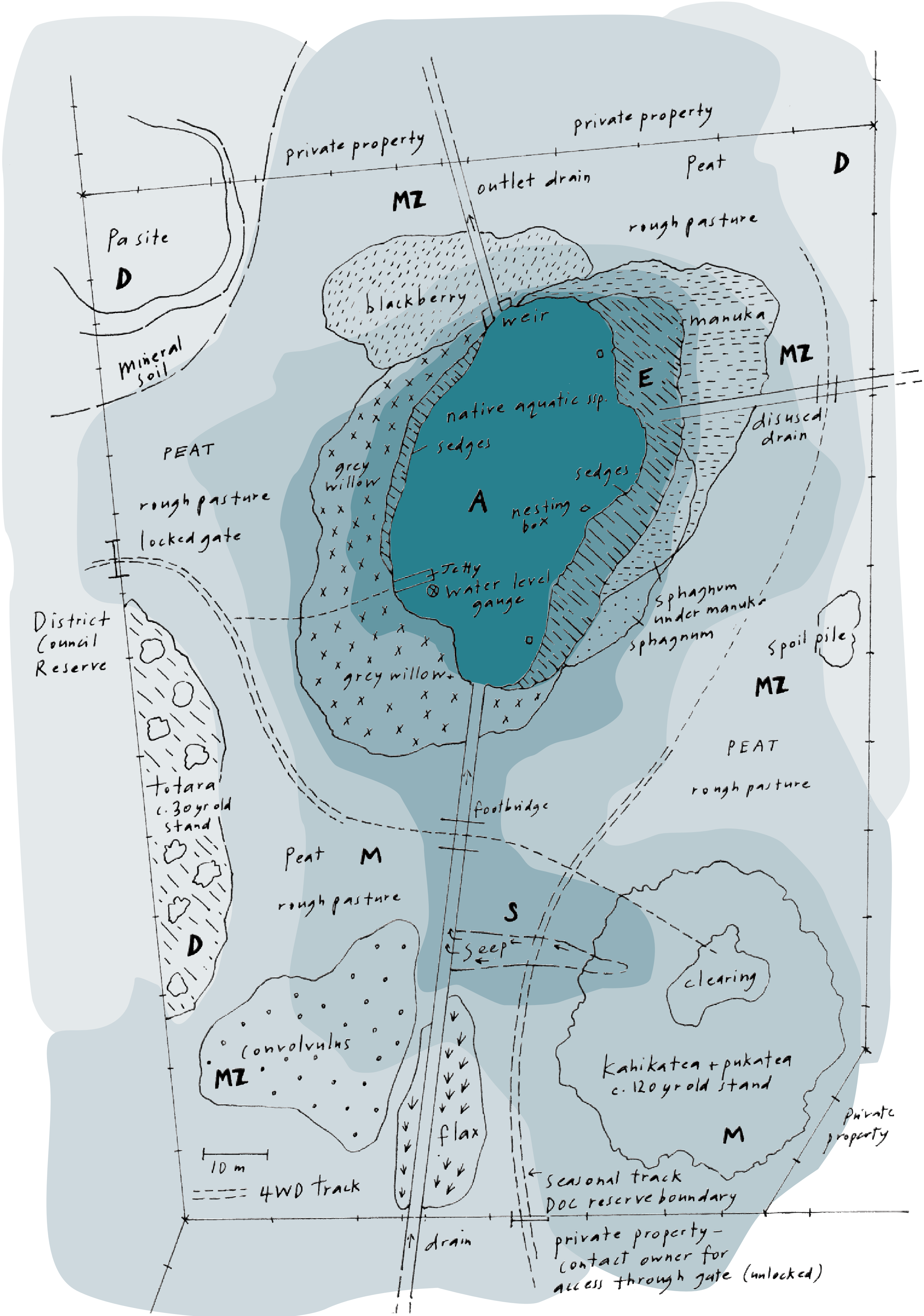


Figure 1. Wetland sketch map including planting zones. Drawing: Monica Peters, NZ Landcare Trust

Once weeds are suppressed with densely planted manuka, small areas can be opened out to allow for enrichment planting, including other native species requiring sheltered conditions to establish. Awhitu Regional Park, Auckland. Photo: Monica Peters, NZ Landcare Trust

Heritage weaving flaxes sourced from the Rene Orchiston collection are being grown in partnership with Ngaati Te Ata at the Earthtalk@Awhitu restoration project, Auckland. Photo: Tanya Cumberland, Earthtalk@Awhitu

Lake Serpentine east and catchment, Waikato, showing all 6 planting zones detailed in Table 1. Photo: Monica Peters, NZ Landcare Trust

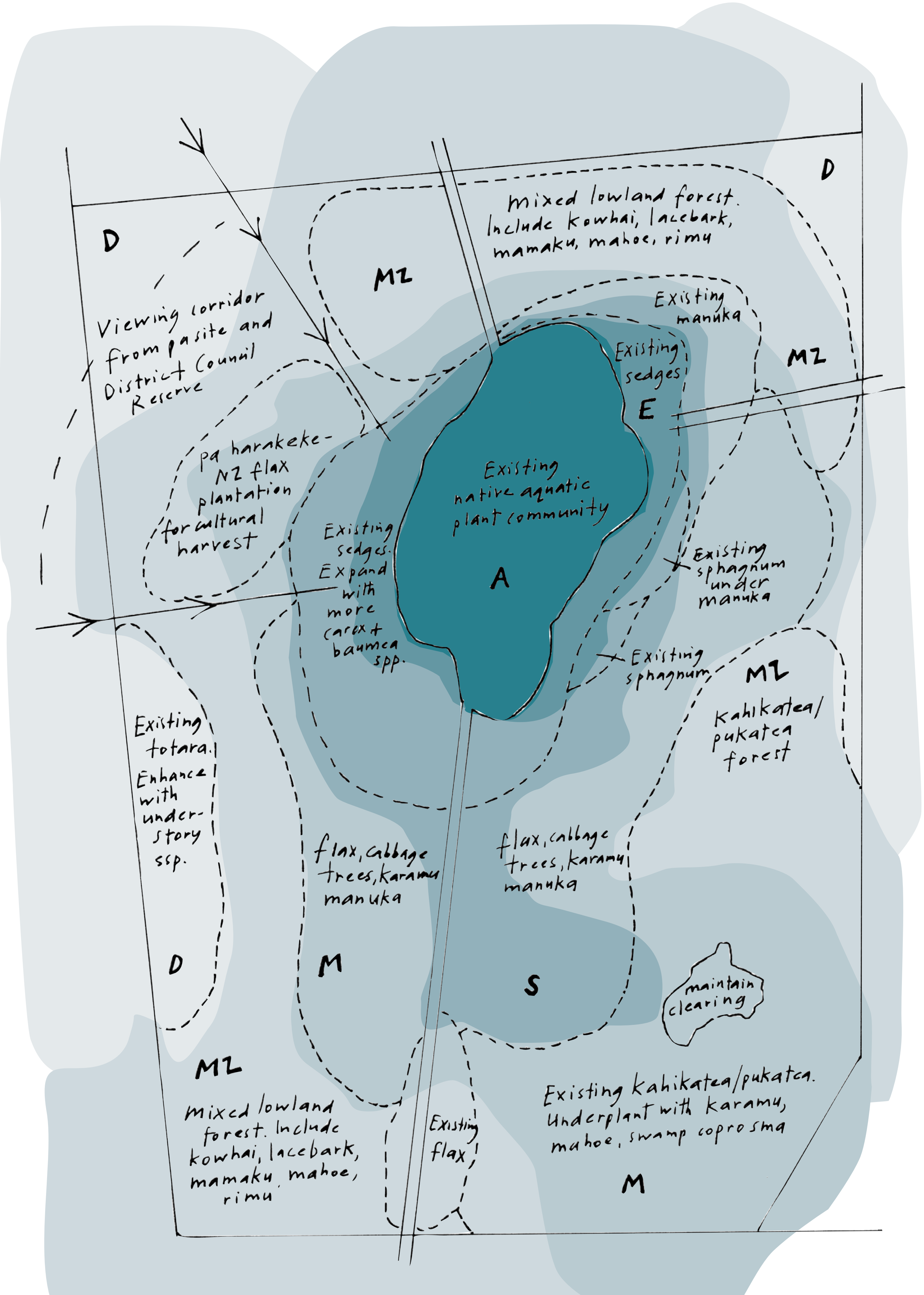


Figure 2. Planting concept map showing the site after restoration. Drawing: Monica Peters, NZ Landcare Trust

2.1 Wetland species planting zone guide

Table 2. Wetland species and their planting requirements

Planting zone	Common name*/Botanical name	Wetland type/habitat	Installation	Additional planting zone
A = Aquatic	duckweed *Lemna minor*	shallow water, swamp	plants	
	pondweed *Potamogeton cheesemanii*	shallow water, swamp	plants	
	water milfoil *Myriophyllum propinquum*	shallow water, swamp	plants or fragments	
E = Emergent	jointed twig rush *Baumea articulata*	shallow water, lake edge	plants	Also shallower parts of A
	kuawa *Schoenoplectus tabernaemontanii*	shallow water, lake edge	plants	
	kuta, tall spike sedge *Eleocharis sphacelata*	swamp, shallow water, lake edge	plants, seeds, or rhizomes	Also shallower parts of A
	marsh clubrush *Bolboschoenus fluviatilis*	lake edge	plants or rhizomes	
	raupo *Typha orientalis*	swamp, shallow water, lake edge	plants or rhizomes	Also shallower parts of A

*Note that common names and Maori names for plants can vary between regions

E = Emergent Kuta. Photo: Monica Peters, NZ Landcare Trust

E = Emergent Raupo.
Photo: Monica Peters, NZ Landcare Trust

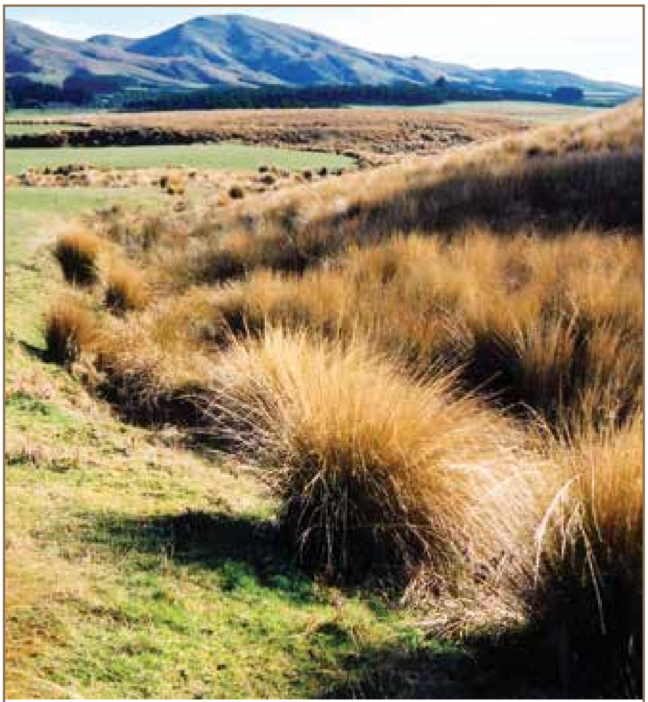
A = Aquatic Water milfoil.
Photo: Monica Peters, NZ Landcare Trust

Table 2. Wetland species and their planting requirements

Planting zone	Common name*/ Botanical name	Wetland type/habitat	Installation	Additional planting zone
S = Saturated	baumea *Baumea arthrophylla*	swamp, lake edge	plants or rhizomes	Also shallower parts of E
	baumea *Baumea rubiginosa*	swamp, fen	plants or rhizomes	
	cabbage tree, ti kouka *Cordyline australis*	swamp, fen	plants, seeds	Also M
	harakeke, NZ flax *Phormium tenax*	swamp, fen	plants (can be divided), seeds	Also M
	mingimingi *Coprosma propinqua*	swamp	plants, seeds	Also M
	pakihi sedge *Baumea teretifolia*	fen, bog	plants or rhizomes	
	pukio *Carex virgata*	swamp	plants	Also M
	purei/pukio *Carex secta*	swamp, lake edge	plants (can be divided), seeds	Also shallower parts of E
	red tussock *Chionochloa rubra*	fen, bog	plants (can be divided), seeds	Also M
	swamp coprosma *Coprosma tenuicaulis*	swamp, fen,	plants, seeds	Also M Prefers shelter
	waiwaka, swamp maire *Syzygium maire*	swamp	plants, seeds	Also M Requires shelter Frost-prone
	wire rush *Empodisma minus*	bog	plants	

*Note that common names and Maori names for plants can vary between regions

S = Saturated *Baumea* community with cabbage trees. Photo: Monica Peters, NZ Landcare Trust



S = Saturated Red tussock.
Photo: Aalbert Rebergen, Otago Regional Council

S = Saturated Harakeke/ NZ flax community.
Photo: Monica Peters, NZ Landcare Trust

M = Moist Manuka with bracken.
Photo: Monica Peters, NZ Landcare Trust

Table 2. Wetland species and their planting requirements

Planting zone	Common name*/ Botanical name	Wetland type/habitat	Installation	Additional planting zone
M = Moist	kahikatea *Dacrycarpus dacrydioides*	marsh, swamp	plants, seeds	Also MZ
	karamu *Coprosma robusta*	marsh, swamp	plants, seeds	Also MZ
	manuka *Leptospermum scoparium*	marsh, swamp, fen, bog	plants, seeds	Also S, MZ
	pokaka *Elaeocarpus hookerianus*	marsh, swamp	plants	Also MZ
	pukatea *Laurelia novae-zelandiae*	marsh, swamp	plants	Also MZ
	toetoe *Cortaderia toetoe* *C. richardii*	marsh, swamp	plants (can be divided)	Also MZ,
	wheki *Dicksonia squarrosa*	marsh, swamp, fen	plants, spores	Also MZ
MZ = Mesic	kowhai *Sophora microphylla*	marsh, swamp edge	plants, seeds	
	lacebark *Hoheria sexstylosa* *H. populnea*	marsh, swamp edge	plants, seeds	
	Mahoe, whiteywood *Melicytus ramiflorus*	marsh, swamp edge	plants, seeds	
	mamaku *Cyathea medullaris*	marsh, swamp edge	plants, spores	
	rimu *Dacrydium cupressinum*	marsh, swamp edge	plants	
D = Dry	Forest/shrub species			

*Note that common names and Maori names for plants can vary between regions

M = Moist Wheki-ponga. Photo: Monica Peters, NZ Landcare Trust

MZ = Mesic Rimu with tree ferns. Photo: Monica Peters, NZ Landcare Trust

M = Moist Pukatea. Photo: Monica Peters, NZ Landcare Trust

3 Planting

From the planting zone map, work out the approximate area of each zone to be planted. Compile a list of species for each zone characteristic of your region, with approximate proportions according to microtopography (e.g., narrow *Carex secta* fringe close to water's edge, merging into a harakeke/NZ flax zone behind). Try to replicate an existing natural wetland of the same type in the region; however, bear in mind that some species will require the shelter of other plants to become successfully established (see Section 3.1.1 – Ecological succession). Using the approximate planting rate of 1–3 plants per square metre depending on initial and final size, calculate the number of plants required for planting. Although some zones may typically be dominated by one species, include a range of species where possible to increase biodiversity benefits, e.g., bird attractants (see chapter 12 – Native fauna).

3.1 Ecosourcing

Use ecosourced plants where possible as these are adapted to local growing conditions. A range of commercial and community nurseries now specialise in ecosourcing. Propagating your own plants from seeds and cuttings ensures certainty of plant origins and is extremely cost-effective. Involving a local school can be mutually beneficial. Larger operations can also provide employment and horticultural training for members of the local community. Collecting and growing on small seedlings or vegetative fragments (e.g., rhizomes), and dividing grasses and sedges are other useful propagation techniques.

3.1.1 Ecological succession

Understanding ecological succession is an important part of developing a planting plan. Succession is the process whereby one plant community gradually changes into another. It involves both arrivals and losses of species, coupled with changes in the relative abundance of different plants. This process is brought about by changes in environment and biotic interactions, e.g., declining light levels, competition. Wetland species that can cope with full sun, exposed and/or frosty conditions are typical of early succession and can be planted in the first crop. They are usually hardy, fast-growing species that often attract birds to encourage natural seeding of other native species. They will provide protection for later successional plants that are slower growing, more shade tolerant, and more susceptible to frost and wind. Most wetland species can be planted in the first successional stages but a few, e.g., swamp maire and pukatea, perform better later, within a nurse crop. Others, e.g., mahoe, *Coprosma rotundifolia*, and mamaku are susceptible to frost, and in frost-prone areas will require shelter from other plants. Epiphytes (perching lily), climbers/scramblers (kiekie) and some small ground cover species (*Nertera* spp.) also establish better in later successional stages. Enhancement planting of later successional wetland species may be required for restoration projects that do not have seed-source wetlands nearby.

Educating the public about succession in Seeley's Gully, Hamilton.
Photo: Monica Peters, NZ Landcare Trust

Kuta (*Eleocharis sphacelata*) and kuawa (*Schoenoplectus tabernaemontanii*) establish readily from divided plants.
Photo: Wildland Consultants Ltd.

Hamilton City Nursery has created simple shallow lined pools for propagating wetland plants. Azolla helps keep the water from stagnating. Photo: Monica Peters, NZ Landcare Trsut

WHY USE ECO-SOURCED PLANTS?

By planting eco-sourced native plants you will:

- help maintain the unique local characteristics of native plants in your region
- protect the local character of natural plant communities from being swamped by plant forms from other areas
- obtain plants that have a greater chance of growing successfully because they are adapted to the local conditions

HOW ARE ECO-SOURCED PLANTS GROWN?

"First the planting site is identified, for example, a wetland in Hamilton. Seed is then collected from local native plant populations growing as close to that site as possible in wetland habitats. Seed is collected from as many plants as possible for each species to obtain a broad genetic base. If there is little or no seed material meeting these criteria for a particular species, seeds may be able to be collected from adjoining catchments or ecological districts."

– *Wayne Bennett, Eco-sourced Waikato*

CASE STUDY

Newly planted natives on the edge of the wetland are marked with bamboo poles (photo taken 2007).
Photo: Nicky Eade, Marlborough District Council

AMONG THE GRAPEVINES: REVEGETATING THE RAPAURA WETLAND

The privately owned Rapaura wetland (3 ha) is regarded as "one of the best examples remaining of a spring fed wetland in the lower Wairau Valley". The owners were attracted to the property both for its wetland and for the potential of the dry areas to become vineyards. A survey under the Marlborough District Council's (MDC) Significant Natural Areas (SNA) programme revealed a single mamaku fern (*Cyathea medullaris*), a surprise find on the otherwise arid plains. The mamaku was surrounded by a dense stand of crack willow (*Salix fragilis*).

The landowners, in recognizing the potential of the wetland, had already begun with weed removal, using machinery to take out a number of willows before the SNA survey in 2003. At this stage, a detailed Management Plan (using a contract consultant funded by the Council) was developed through the MDC's Landowner Biodiversity Assistance Programme. The plan divided the 3-ha area into zones and set up a three-stage restoration programme for the wetland. The two main tasks identified were weed control and restoration planting.

Stage one (2005)

Vigorous willow regrowth and other weeds, including old man's beard (*Clematis vitalba*), barberry (*Berberis glaucocarpa*), broom (*Cytisus scoparius*), gorse (*Ulex europaeus*), and Japanese honeysuckle (*Lonicera japonica*), were sprayed with glyphosate. Spring plantings were preceded and followed by release spraying (2 months before and c. 2 months after). Stage one total cost: c. $5,000.00 shared between MDC and the landowner.

Stage two (2006)

Further willow was removed, regrowth and other weeds were sprayed. A total of c. 5000 plants were planted. Stage two total cost: $35,000.00 shared between the government Biodiversity Fund (50%), Council (25%), and the landowner (25%).

Stage three (2008)

A further 3300 plants were planted, general maintenance and weed control were carried out. Stage three total cost c. $12,000.00 (shared 50/25/25 as above).

What's been planted?

To date, a diverse range of around 9500 native plants have been used to revegetate the wetland. Species that have been planted include harakeke/NZ flax (*Phormium tenax*), toetoe (*Cortaderia richardii*), kowhai (*Sophora microphylla*), manuka (*Leptospermum scoparium*), carex species, cabbage tree (*Cordyline australis*), akeake (*Dodonea viscosa*), small-leafed coprosmas, hebes, olearia, kohuhu, and lowland ribbonwood (*Plagianthus regius*). Kahikatea (*Dacrycarpus dacrydiodes*) seedlings were sourced from the only remaining grove on the Wairau Plain. The MDC's Landowner Assistance Programme helped the owners apply for funding for revegetation and weed control. The landowners have dedicated much time and effort to weed control and plant aftercare – both of which are major tasks.

REF: www.marlborough.govt.nz/Environment/Land/Publications-and-Reports/~/media/Files/MDC/Home/Environment/Land/NewsletterSNAFebruary2007NEa.ashx

3.2 Site preparation

Prepare your site for planting or seeding by controlling weeds or invasive species using herbicide or physically removing them (see Chapter 9 – Weeds). In some cases, such as where areas of paddock are being retired for incorporation into wetland margins, light grazing before planting can be carried out. For spot planting, clear a circular patch up to 1-m diameter for each plant. For major weed infestations, you may have to start weed control well ahead of planting. The best time to plant the site is late summer/early autumn when water levels are lowest. In some cases, planting may be carried out virtually any time of the year if the site retains enough moisture and does not receive heavy frosts in the winter.

Kahikatea seed.
Photo: Colin Webb, Landcare Research

Shade cloth laid out underneath kahikatea to collect falling seeds (season: Feb–Apr). Photo: Wildland Consultants Ltd

3.3 Planting methods

The following sections outline common methods for planting. Factors to consider include:

- Goals and objectives, e.g., native canopy cover in 3–4 years in a given management zone
- Planting budget
- Availability of plants of the desired size
- Nature of management zone, e.g., degree of weed infestation, types of weeds present, access
- Available labour and time for site preparation, planting out, and aftercare

Planting can be dramatically sped up with this novel hydraulic hole-puncher which pulls PB3-sized plugs out of the ground.
Photo: Alec Bennett, Lake Cameron Care Group

Growing from eco-sourced seeds requires a lot of prior planning to ensure plants are big enough to use when required. Pauatahanui, Wellington. Photo: Monica Peters, NZ Landcare Trust

3.3.1 Using seeds

Sowing eco-sourced seeds directly onto the wetland is possible if the site has been well prepared. Thorough weed control is essential for this method to be successful, as germinating native seedlings tend to be out-competed by faster growing introduced species. In many cases seed sowing is used in conjunction with plantings. For example, once a native cover has been re-established by initial plantings, sowing seeds by hand is a cheaper and less labour-intensive way of increasing species diversity. Use freshly collected seed, as viability in most species declines rapidly once the seed is harvested.

Wetlands also have a seed bank that can supplement plantings and add diversity. Often just clearing a dense overstorey of willow or other introduced plants will release the seed bank. *Carex secta*, for example, has a long-lasting seed bank and will often germinate in large numbers following clearing and opening canopy gaps. However, also be aware of the possibility of a flush of exotic species, which may also respond to the enhanced light or other changes in environmental conditions.

3.3.2 Using planter bags and/or root trainers

Most revegetation projects involve planting 1–2-year-old plants (usually the larger the better) grown in planter bags (PBs) or similar containers either from seed, rhizomes or divisions (see Table 1. Wetland species and their planting requirements).The following principles apply to both PBs and root trainers. Just before planting, water plants thoroughly and then set them out with desired spacing in the appropriate planting zones according to your concept map. When planting, dig a hole larger than the root ball to ensure plenty of growing space. Remove the plant from the container, loosen or clip the roots if root bound, insert the plant in the hole, replace the soil around the plant, and finish by heeling in firmly. Fertiliser is not recommended for wetland plantings, particularly in fens and bogs that have inherently lower nutrient levels, as this may promote

ROOT TRAINERS (RTs) vs PLASTIC BAGS (PBs) – WHICH TO USE?

Use root trainers (RTs) when:

- site is not too cold in winter or too dry in the summer, particularly in the year of planting
- plants can be well cared for during delivery and until planting
- weed control and releasing are undertaken diligently and in a timely fashion
- fast results are required – at 8000–10000 RT/ha, canopy closure = 2–4 yrs
- costs need to be minimized – RTs are cheaper to buy, easier to move around a site and quicker to plant than PBs

Use planter bags (PBs) when:

- species are not suited to being produced in RT grades (or are less likely to survive as RTs)
- site conditions include severe winter frosts, irregular/out of season frosts, summer droughts or wind
- there are weeds or competitive grasses that cannot be readily suppressed (e.g., kikuyu)
- there are herbivorous pest animals that cannot be effectively controlled (e.g., hares)
- there is a lower standard of site preparation
- there is likely to be less frequent maintenance
- wider spacings can or need to be used, meaning fewer plants are required (generally meaning a longer time until canopy closure)

– *Sarah Beadel, Wildland Consultants Ltd* increased weed growth. Surround the plant with mulch, compost, bark chips or similar to keep the weeds down and the soil moist, and water the plants in drier sites. A variety of methods such as plastic sleeves or cloches can be used to promote plant establishment and exclude problematic weedy species. Mark each plant with a bamboo stake for easy relocation later. Dipping the ends of the bamboo stakes in brightly coloured paint will make them easier to see.

REVEGETATION: TOP TIPS FROM THE COMMUNITY

- Ensure good site access: quality tracks for planting and on-going maintenance are a must
- Don't plant more than you have the manpower to maintain
- Harden off trees thoroughly before planting
- Sensitive plants, e.g., puriri and some tree ferns (e.g., *Cyathea* spp.) may require protection from frost and sun damage
- Use plant stakes 60 cm and taller, and biodegradable ties, e.g., cut up t-shirts
- Use dense or prickly plants to discourage vandalism of/entry into sensitive areas
- If you can't see any improved results in 4 years, then you may need to rethink what you are doing

3.4 Aftercare

Your plantings will need on-going maintenance. Probably the most time-consuming task will be releasing or removal of weeds from around the plantings. Removal using a tool like a grubber or slasher, or hand pulling is effective in small areas. In larger areas, herbicides are often used (see Chapter 9 – Weeds).

After care will probably also involve pest control (see Chapter 11 – Pests) and animal exclusion, e.g., fencing, plastic sleeves or boxes. Introduced browsing animals, e.g., possums, goats, rabbits, hares, cattle, etc., will target recent plantings of nursery-grown plants as these provide rich sources of nutrients. In addition, rats will devour viable seeds that are important for seed banks and the ongoing viability of your wetland. Birds such as pukeko, though native to New Zealand and a natural part of a wetland ecosystem, may undo a lot of your restoration work by nibbling and uprooting plants. To deter pukeko, use larger and heavier potted plants and try placing a hedge of short sticks or some other form of barrier around young plantings.

Keep a record of any plant losses and the reasons you think they might have died. For example, if a microsite appears too wet for plants to grow, plant a more water-tolerant species there, or mound up the soil so the plant roots are not so waterlogged.

Rigid plastic sleeves are suitable for larger plants and pegged using stakes. Te Hapua, Wellington. Photo: Monica Peters, NZ Landcare Trust

A plastic sleeve fitted over two U-shaped wire frames anchored into the ground exclude problem weeds and pests. Fensham wetland, Wellington. Photos: Beverley Clarkson, Landcare Research

Spray shield constructed from an old plastic container.
Photo: Environment Waikato

Old fertiliser bags can used as weed matting and pegged around the bases of new plants. Otatara, Southland.
Photo: Monica Peters, NZ Landcare Trust

CASE STUDY

TRAVIS WETLAND RESTORATION: THE MULTIPLE USES OF NATIVE PLANTS

Travis Wetland (119 ha) is the largest freshwater wetland in Christchurch. A comprehensive Landscape Development Plan was developed in 1998 to transform the wetland, which was partially dominated by willow with areas of open pasture. To date, more than 60 000 plants have been planted out, with thousands more propagated by a keen group of Travis Wetland Trust members.

Providing habitat for birds

Dense fringing vegetation is made up of harakeke/NZ flax (*Phormium tenax*), raupo (*Typha orientalis*), sedges, e.g., purei/pukio (*Carex secta*), clubrush (*Bolboschoenus caldwellii*), kuawa (*Schoenoplectus tabernaemontanii*), and rushes (*Juncus* spp.). These plants function as islands when water levels are high and provide waterfowl with nest sites, shelter and food (insects and plant material). They also help provide shade over the water – a means of reducing eutrophication. Existing crack willow and male grey willow are kept as they provide nursery conditions for kahikatea forest seedlings and interim roosts. Tall trees, mostly kahikatea, have been planted and will eventually provide roosting and nesting sites for birds.

Reducing nutrient impacts

In riparian zones, plants help reduce the chances of algae forming by intercepting nutrients and promoting zooplankton. Plantings include rushes (*Juncus gregiflorus, J. sarophorus, J. pallidus*), sedges (*Carex virgata, C. secta, C. coriacea, C. maorica*), umbrella sedge (*Cyperus ustulatus*), toetoe (*Cortaderia richardii*), ferns (*Blechnum minus, Polystichum vestitum*), raupo (*Typha orientalis*), and kuawa (*Schoenoplectus tabernaemontanii*).

Maintaining native turf plants

Paddocks have been fenced as grazing marsh. Cattle are grazed between October and April when the ground is drier to minimize pugging – with mixed success as some areas never harden up. Strong fences, gates and culverts over drains prevent access to sensitive areas. Mowing of some grazed and ungrazed areas is carried out in late summer or early autumn following the nesting season to maintain a short grassland and control dock, hemlock, and thistles. Canada geese are useful grazers and numbers of up to 1600 birds maintain a short grass sward from late autumn and winter. Several native pond margin species appear to have benefited from this grazing regime, such as button daisies (*Leptinella dioica, L. maniototo*). Recently, attempts are being made to establish other turf formers in the grazing marsh, namely *Gunnera dentata*, pratia (*Lobelia angulata*), and dwarf musk (*Mazus novaezelandii*).

Screening public access areas

Kahikatea (*Dacrycarpus dacrydioides*) and pokaka (*Elaeocarpus hookerianus*), along with smaller, faster growing species including karamu (*Coprosma robusta*), mingimingi (*Coprosma propinqua*), manuka (*Leptospermum scoparium*), kohuhu (*Pittosporum tenuifolium*), flax, toetoe and ribbonwood (*Plagianthus regius*), were planted to screen public access areas. In some areas, temporary screens of shade cloth were used to dissuade premature public access until plantings reached sufficient size. Screens also protect the new plants from the effects of over-grazing by pukeko and Canada geese.

REF: www.ccc.govt.nz/learning/educationforsustainability/naturalenvironment/traviswetland.aspx

View over the central pond planting projects after 5 years (photo taken 2005). Photo: John Skilton, Christchurch City Council

4 Monitoring

Monitoring the overall progress of your restoration project can be very rewarding and can help secure funding for further restoration works. Sound protocols as well as good documentation are important. Many of the vegetation monitoring techniques are not complicated, e.g., before and after photographs using photopoints and recording any natural establishment of new native plant species. More detailed methods on monitoring changes in overall wetland condition are outlined in Chapter 13 – Monitoring.

4.1 Wetland inventory and map

Using your wetland maps of vegetation types and/ or planting zones as outlined earlier in the chapter, indicate the location of monitoring sites e.g. permanent plots and photo points. Provide a description of the methods being used, the frequency of data collection, and how the data are to be presented. Lists of all plant and animal species should be compiled and updated at regular intervals. Indicate whether the species are native or introduced, and also the relative abundance of each, using a simple scale such as rare, occasional, common and abundant. A local botanical society may be able to help you do this.

4.2 Permanent plots

Establish permanent plots, selected as being representative of each main vegetation type, and monitor immediately before restoration and at intervals afterwards (yearly if rapid change is expected, less frequently for minor change). Aim for at least 3–5 replicate plots per vegetation type/ habitat as these will provide baseline information. Plot size will depend on wetland structure and number of permanent plots established; use several plots of at least 2 m × 2 m or 4 m × 4 m quadrats in low vegetation, and larger sizes, e.g., 5 m x 5 m or 10 m x 10 m for taller vegetation and/or fewer plots. In areas that have been completely transformed by weed removal, cleared land, new soil surface, etc., set up the plots immediately after planting.

The basic parameters to use are:

- Species composition
- Species cover
- Species height

For more detailed monitoring information on how to sample vegetation, soil and water parameters follow the Wetland Condition Handbook methodology and fill in the Handbook plot sheet (see weblink at the end of the chapter). Add any additional monitoring components specific to your wetland. Laboratory analysis can be quite costly so you may decide to analyse the soils and/ or foliage from just one plot per vegetation type/ planting zone to provide baseline information, and then only reanalyse at a later stage if you suspect a change has occurred.

4.3 Plant survival

Keep a database of what plant species, what size (e.g., PB 2), and how many were planted in each planting zone. Record any pertinent comments, e.g., planted during drought, water depth, health of plant, and method of weed control. At the end of each growing season determine plant survival based on parameters such as plant height and cover, health, impact of any browsing, e.g., by hares, or foraging, e.g., by pukeko, and whether the plant has produced flowers or seed (see the case study on Waiwhakere Natural Heritage Park in Chapter 13 – Monitoring). With larger restoration projects, instead of tracking individual plants, use permanent monitoring plots set up immediately following major planting events. This information will help you decide which plants are most suitable for specific habitats or environmental conditions present in your wetland, and how to modify planting programmes for the following season (e.g., by targeting certain weeds or pests). Share your knowledge with other wetland restoration groups to help minimise wasted effort and costs.

4.4 Photopoints

To visually record changes from precise locations throughout the wetland, set up a series of photopoints throughout the wetland. Use marker posts labelled with a number and an arrow to indicate camera direction so you can take the same view each time. Include photo points at the permanent plots by using one of the corner pegs to sit the camera on. Take the photographs at the same time each year, preferably mid-late summer, to eliminate seasonal changes.

Also note any regeneration, e.g., self seedings and spread of planted species. This is particularly important when new species planted in the wetland (indicate as 'planted' in the species list) begin to seed and spread by natural seedling recruitment.

A photopoint provides a very useful record of plant establishment. October 2006, Lake Serpentine, Waikato.
Photo: Monica Peters, NZ Landcare Trust.

Beverley Clarkson at the same site in March 2009. Lake Serpentine, Waikato. Photo: Monica Peters, NZ Landcare Trust.

5 References and further reading

Jacobson, R.L. 2006. *Restoring and managing native wetland and upland vegetation*. Minnesota Board of Soil and Water Resources, U.S.A.

Johnson, P.A. and Brooke, P.N. 1998. *Wetland plants in New Zealand*. DSIR, New Zealand.

Poole, A.L. and Adams, N.M. 1994. *Trees and shrubs of New Zealand*. Government Printer. Wellington, New Zealand.

Porteous, T. 1993. *Native forest restoration – a practical guide for landowners*. Queen Elizabeth the Second National Trust, Wellington, New Zealand.

Salmon, J.T. 1996. *The native trees of New Zealand*. Reed, New Zealand.

5.1 Useful websites

Wetland restoration templates

Waikato Regional Council Wetland Restoration Plan templates

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate1.pdf

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate2.pdf

Wetland restoration guides and factsheets (New Zealand)

Northland Regional Council

www.nrc.govt.nz/upload/2217/Wetland%20Restoration%20Guide%20(second%20edition%20Feb%2009).pdf

Auckland Regional Council

www.arc.govt.nz/albany/fms/main/Documents/Environment/Plants%20and%20animals/wetlandsfacts2.pdf

Waikato Regional Council

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/

Hamilton City Council

www.gullyguide.co.nz/index.asp?pageID=2145821537

Bay of Plenty Wetlands Forum

www.doc.govt.nz/upload/documents/conservation/land-and-freshwater/wetlands/wetland-restoration-guide.pdf

Greater Wellington

www.gw.govt.nz/a-beginner-s-guide-to-wetland-restoration/

Department of Conservation Protecting Natural Areas Design Guide

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/nature-heritage-fund/protecting-natural-areas-design-guide/

Wetland restoration guides (International)

USA Environmental Protection Agency

www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Native and introduced plant identification resources

NZ Plant Conservation Network

www.nzpcn.org.nz

www.nzpcn.org.nz/flora_search.asp?scfSubmit=1&scfNative_Or_Exotic=2

NIWA aquatic quick guides for flora and fauna

www.niwa.co.nz/our-science/freshwater/tools/quickguides

Landcare Research

www.landcareresearch.co.nz/resources/identification/plants/weeds-key

Weedbusters

www.weedbusters.co.nz

Wetland planting guides
(use the guides relevant to your region)

Canterbury Region

www.ecan.govt.nz/advice/your-land/land-restoration/wetlands/Pages/wetland-planting-guide.aspx

Waikato Region

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/Restoring-a-wetland/Wetland-planting-guide

Auckland Region

www.nznativeplants.co.nz/Articles/Wetland+Planting+Guide+for+the+Auckland+area.html

Botanical Societies

www.nzbotanicalsociety.org.nz/pages/links.html

Scientific journals

NZ Journal of Botany

www.tandfonline.com/loi/tnzb20

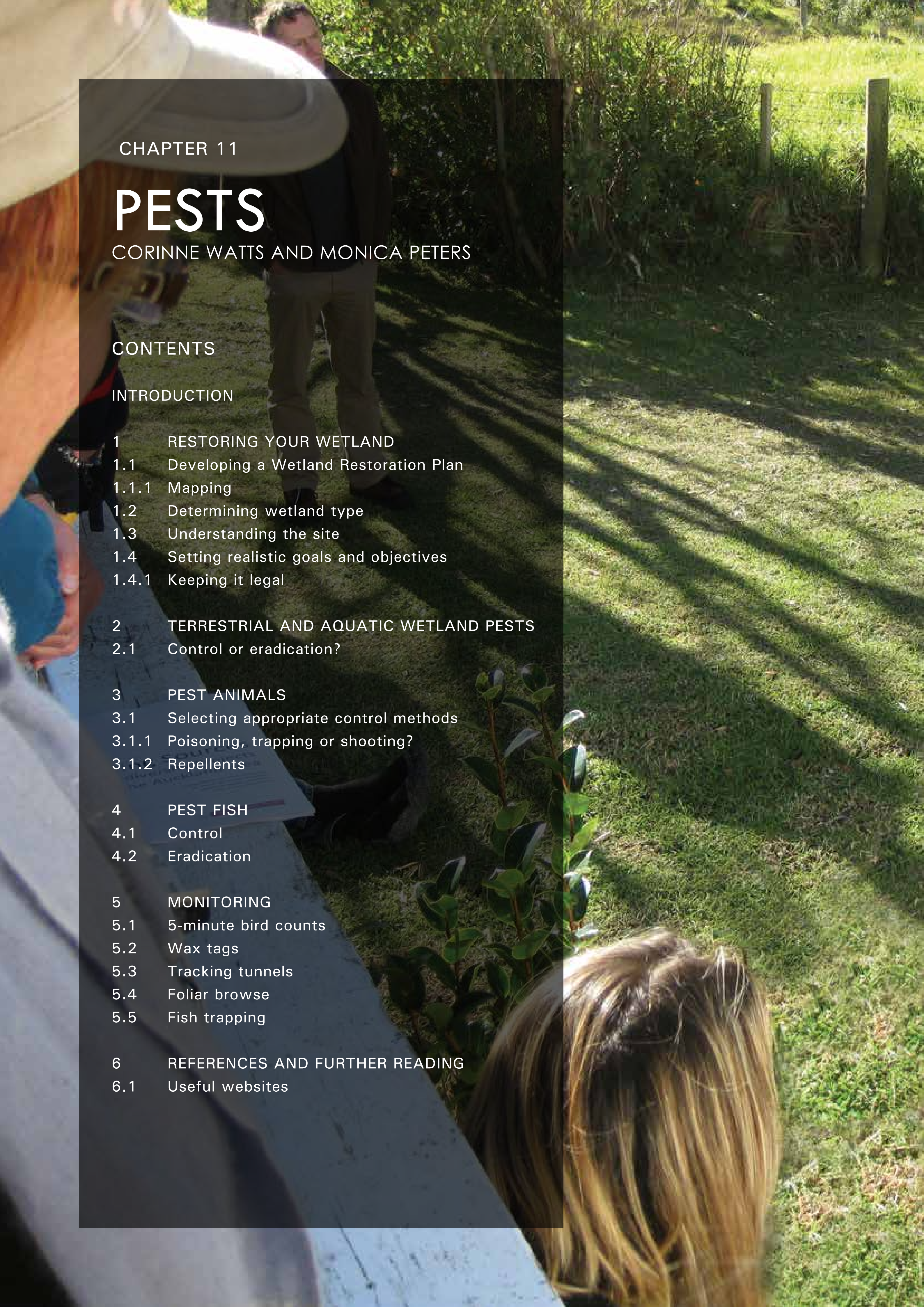
NZ Journal of Ecology

www.nzes.org.nz/nzje

Herbaria in New Zealand

www.nzherbaria.org.nz/herbaria.asp

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 11

PESTS

CORINNE WATTS AND MONICA PETERS

CONTENTS

PESTS

PESTS

CORINNE WATTS AND MONICA PETERS

Since the human colonization of New Zealand began, many new animals have arrived. Some species have been intentionally introduced – the Australian brushtail possum for the fur trade, and stoats to kill previously introduced rabbits that had begun to reach plague proportions. Others have arrived unintentionally, often as stowaways on boats. Irrespective of the method of arrival, the proliferation of non-native mammalian, invertebrate and aquatic fauna – many of them now regarded as serious pests – has forever changed the New Zealand landscape. Our unique native flora and fauna are now their source of food. This chapter introduces a range of wetland pests, both terrestrial and aquatic, and outlines a range of management and monitoring methods to enhance and protect native biodiversity.

To date, very little research has been carried out on the effects of pests on native wetland plants and animals, and controlling pests in wetlands. However, based on knowledge of pest species within forest and other ecosystems, we know that rodents, possums, hedgehogs, mustelids, and cats all eat invertebrates, birds' eggs, chicks and even adult birds. Introduced browsing animals, e.g., possums, goats, rabbits, hares and cattle eat native vegetation and will target recent plantings of nursery-grown plants as they provide rich sources of nutrients. In addition, rats will devour seeds that are so important for seedbanks. To a lesser extent, dogs may harass wetland birds. Trout, koi carp, catfish and mosquito fish, along with introduced insects, all place further pressure on native biodiversity.

Two case studies highlight comprehensive pest control programmes carried out by community groups. The first case study centres on a large wetland complex situated on the eastern shore of the Coromandel peninsula. The second case study outlines a pest control programme within a fully "predator proof" fenced reserve in rural Taranaki. An additional case study profiles a Department of Conservation project that aims to understand the behaviour, territorial dynamics, and feeding habits of predators in a wetland environment.

Previous page: Pest control workshop on Great Barrier Island sponsored by Auckland Regional Council.
Photo: Monica Peters, NZ Landcare Trust

The owners of this portion of Te Hapua swamp (Wellington) trap rodents, possums and mustelids, as well as protect new plantings from hare browsing. Photo: Monica Peters, NZ Landcare Trust

The widely used DOC 200 kill trap is designed to dispatch hedgehogs, stoats and rats humanely. Photo: Monica Peters, NZ Landcare Trust

1 Restoring your wetland

The theory and practice of pest control in and around wetlands is a rapidly evolving field. New products are being trialled, as are new techniques and monitoring methods. Maintaining regular contact with experts in the field is essential to keep up to date with new developments. Contacts may include contractors and suppliers as well as end users, including the Department of Conservation (DOC), councils, science providers (e.g., Landcare Research and universities), and established community groups undertaking pest control work.

1.1 Developing a Wetland Restoration Plan

A Wetland Restoration Plan or Action Plan is extremely useful for clarifying the goal setting, implementation and monitoring phases of the restoration project. Follow the steps laid out in Chapter 2 – Restoration planning or use one of the templates in the Useful websites section at the end of the chapter.

1.1.1 Mapping

A useful starting point for developing a Wetland Restoration Plan is a sketch map. A bird's-eye view sketch map is important as it helps summarise knowledge about the natural and man-made character of the restoration site. It is a practical tool to define, for example, management zones and locations of trapping lines, bait stations, etc. The map can be hand drawn using a range of resources such as aerial photos, topographic maps and Google Earth combined with your own knowledge.

The following features should be included:

- Vegetation types
- Water sources and outflows, hydrological modifications, water level
- Soil type
- Man-made, natural and cultural features

For more detail on what to include, see Chapter 2 – Restoration planning.

1.2 Determining wetland type

Determining the type of wetland you have is important as each type has specific nutrient and hydrological regimes that favour specific plant communities and therefore faunal communities. Further information can be found in Chapter 3 – Wetland types.

1.3 Understanding the site

Researching historical records and locating similar wetlands (outlined in Chapter 4 – Site interpretation 1) may yield important information on the types and population numbers of animals – both introduced and native. Knowledge of the species that were once likely to be present in the wetland will help guide restoration goals.

Talon rat bait with chew marks. Te Anau.
Photo: Crown Copyright, Department of Conservation

Hare damae on karamu. Hawke's Bay.
Photo: Crown Copyright, Department of Conservation

Fenn trap on the edge of a wetland. Battle Hill Farm Park, Wellington.
Photo: Monica Peters, NZ Landcare Trust

The Great Barrier Island Trust found a novel way to raise awareness of the damage rats do to native biota: a Christmas float dressed as a rodent!
Photo: Fenella Christian, Great Barrier Island Trust

1.4 Setting realistic goals and objectives

Before tackling animal pest control, begin with a goal – what needs protecting, e.g., native wetland vegetation, young plantings, and/or native wetland birds, such as fernbird and bittern. An important goal of any restoration project should be to control animal pests to enhance and restore native biodiversity to your wetland and in addition, protect any young plantings. The examples provided by the case studies demonstrate the importance of having clear goals to guide the control/ eradication activities. Objectives for a pest control programme may be to:

- control stoats, ferrets, ship rats, Norway rats, and feral cats year round to protect nesting waterfowl, their ducklings and other birds such as marsh crake, spotless crake, fernbird, and bittern
- control deer, goats, possums, hares, and rabbits to minimise damage to young plants in revegetated areas

Once the restoration goal and objectives have been established, activities for pest control/ eradication should focus on the following:

Initial knock-down methods

- Identify pests for initial control
- Identify methods to be used
- Establish timing of control

Maintenance control methods

- Identify control methods
- Identify timing for ongoing maintenance

Monitoring techniques

- Identify techniques for the target pest(s)
- Identify techniques for the biodiversity attribute (e.g., native plants, fernbirds) you are trying to help
- Baseline information on the site before starting pest control can be used to evaluate the success of your pest control

Costs for, e.g., equipment, training, poison, baits, and labour) should be included along with an overall cost. This information is also needed when applying for funding to carry out pest control activities.

Victor professional rat trap with wire mesh to prevent accidental damage to ground foraging native birds.
Photo: Bevan Brent. Crown Copyright, Department of Conservation

Signage for use in public places warning of potential threats to animal, pet and human health. Photo: Monica Peters, NZ Landcare Trust

1.4.1 Keeping it legal

Regional Councils each have their own Regional Pest Management Strategy (RPMS). The purpose of the strategy is to set out the strategic and statutory framework for the effective management of pest animals and pest plants/weeds. Under the RPMS, selected pest animals (and weeds) are either the responsibility of the regional council or the landowner. RPMS for different regions can be found on Regional Council websites. See Chapter 9 – Weeds, for a diagrammatic representation of how responsibility is designated for pest control.

When using toxins, always follow the instructions on the label. Compliance with these restrictions is required by law and is also likely to provide a greater chance of success and less impact on the environment (and those applying the toxin). You must have a Controlled Substance License to handle some toxins (e.g., cyanide, 1080) and consent from the Medical Officer of Health before they can be used. Some restrictions are placed on the use of certain leg-hold traps and also restrictions on where they can be used. Read the animal welfare guidelines and seek advice from your local Department of Conservation office, Regional or District Council.

TOP TIPS FOR HEALTH AND SAFETY IN THE FIELD

- Tell someone where you are going and when you expect to return!
- Always follow label instructions when using toxins – be extra careful around water
- To avoid picking up, e.g., campylobactor and leptospirosis (carried by rats and hedgehogs), you should:
    - wear disposable gloves for all handling of traps
    - use water-proof bandaids over cuts
    - sterilize your hands with alcohol-based anti-bacterial wipes or gels before eating
- Mind those sedges! – wear glasses to protect your eyes

– NZ Landcare Trust , Pest Control Guidelines

CASE STUDY

INSIDE THE FENCE: PEST ERADICATION AT THE ROTOKARE SCENIC RESERVE

The Great Wall! Photo: Rotokare Scenic Reserve Trust

The Rotokare Sanctuary Project is led by a community-based charitable trust, Rotokare Scenic Reserve Trust (est. 2004).
Photo: Monica Peters, NZ Landcare Trust

The 230-ha Rotokare Scenic Reserve lies east of Eltham on the edge of the Taranaki hill country. An 8.2-km predator-proof fence (completed in 2008) completely surrounds the forested catchment, which contains extensive wetlands and a lake. Significant native fauna include fernbird, spotless crake and banded kokopu. The fence and eradication programme have been supported by the South Taranaki District Council, TSB Community Trust, Taranaki Regional Council, Taranaki Electricity Trust, Lotteries Environment & Heritage, Significant Community-based Projects Fund, Biodiversity Condition Fund, WWF Heritage Protection Fund and many others, including by donations. Community and neighbour support and goodwill have been vital to this project. Rotokare will be a prime site for studying what happens when a large, natural wetland is free from pests.

Pest control: changing tack

The Rotokare Scenic Reserve Trust (www.rotokare.org.nz) quickly recognised that ongoing control of pest species, i.e. Norway and ship rats, mice, ferrets, stoats, weasels, hedgehogs, rabbits, hares, feral cats, possums, and goats, within the previously unfenced reserve was financially and operationally unsustainable. Breeding of surviving pests continued, as did reinvasion from outside the reserve. A new objective was established: create a pest-free sanctuary through construction of a pest-proof fence and eradication of all pests inside the fence.

Fixing fence surveillance equipment. Photo: Rotokare Scenic Reserve Trust

Meticulous planning

A successful eradication programme requires meticulous planning that involves setting realistic objectives and timeframes, having the financial and operational capacity to do the work, and ensuring the community is supportive. The Trust sought external help in planning, contracted a technical advisor/planner, and established a mulit-party advisory group. The Animal Pest Eradication Plan (Natural Logic Environmental Management 2007) adapted methods for controlling single or multi-species from successful Department of Conservation, community and private conservation programmes. The Plan included detailed information on:

- eradication best practice and lessons from other mainland multi-species eradication attempts
- aerial baiting specifications and eradication techniques to be used
- monitoring methods
- project management

Pest control methods

Goats were eradicated by hunting before completion of the fence. Pestoff 20R (a brodifacoum-based cereal bait) was used in an aerial baiting operation (2009) to eradicate rodents. Other pests were also likely to be affected: possums, rabbits, hares and hedgehogs would directly eat the bait, and mustelids, feral cats and hedgehogs would be susceptible to secondary poisoning. The Trust monitored fernbird numbers before, during and after the bait drops. Data to date suggest fernbirds were not affected at all.

Aerial baiting – the follow up

A ground-based "mop up" programme to remove any survivors began in November 2009. An intensive (50 m x 50 m grid) tracking tunnel and trapping system maximises the chances of detecting and removing survivors as quickly as possible. Once survivors have been detected, localised areas are either intensively hand-baited with brodifacoum and/or trapped, depending on the species detected. As of July 2009, it appears that possums, cats, mustelids, hedgehogs, rabbits and hares have been removed. Rats have not been detected in the tunnels. Two stoats, two rats and a small number of mice have been caught since the bait drops. As eradication work is ongoing, it is unlikely the area will be declared pest free until late 2010.

– Jo Ritchie and Jenny Steven, Rotokare Scenic Reserve Trust

2 Terrestrial and aquatic wetland pests

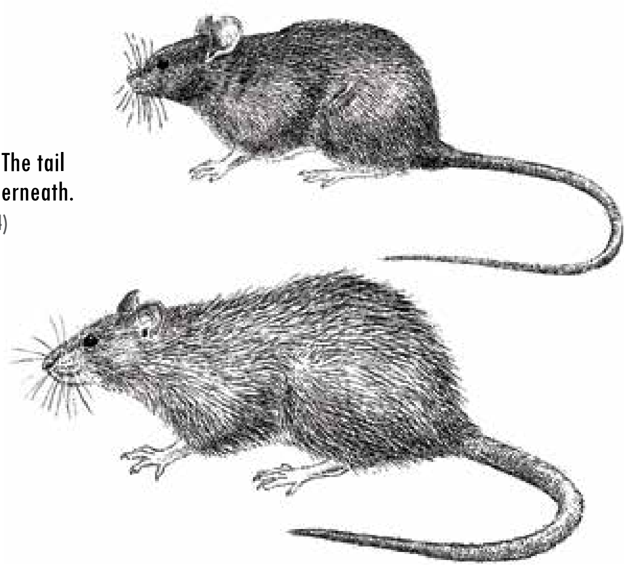
The following table outlines some of the pests that may be present in wetlands. Further detailed information can be found in fact sheets and publications listed in the References and further reading section at the end of the chapter.

Table 1. Wetland pests, their characteristics and threats to native biodiversity

Pests	Characteristics and threats to native biodiversity
Possums	• Alter forest composition by heavily browsing favoured food trees • Disrupt vital ecological processes such as flowering, fruiting, seed dispersal and germination • Compete with native wildlife for food, and are wildlife predators (eat eggs, chicks, and a wide range of invertebrates)
Mustelids *(ferrets, stoats and weasels)*	• All good swimmers • Can breed rapidly in response to the availability of food – rats, rabbits and mice are staples, but also target birds, bird eggs, lizards and invertebrates • Difficult to trap – seek advice from an experienced mustelid trapper
Rodents *(ship/black rat and Norway rat)*	• Ship rat (or black rat) is highly agile and able to climb trees • Norway rat is large, usually found near water and is an excellent swimmer • Both are rapid breeders – ship rats producing 3 litters per year with approximately 5 young, and Norway rats (in suitable environments) producing 3–6 litters per year of up to 10 young • Ship rats are key ecosystem changers, frequently predating small forest birds, seeds, invertebrates, and possibly lizards • Norway rats may be a greater threat to waterfowl
Hares	• Damage native flora through browsing
Rabbits	• Damage native flora through browsing • Rabbits are a major source of prey for ferrets and feral cats, but when rabbit numbers are low, native fauna are eaten as secondary prey
Mice	• Mice impacts on native plants and animals are poorly known, though it seems they can have serious impacts on insects, e.g., weevils, some lizards, and plant germination rates • Effective control for other pests, e.g., rodents, may lead to increases in mice numbers. Control methods for mice are not perfected and any attempts to control mice should be carefully designed and monitored
Cats *(feral and domestic)*	• Predate insects, eels, koura, fish, lizards, birds, rabbits and rodents • Often present in far greater numbers than is obvious – they are highly alert and quick to hide • Have large overlapping home ranges (males roam up to 20 km, though females with kittens seldom move more than 500 m from their den)
Hedgehogs	• Primarily insectivores but will eat a wide variety of food including eggs of ground nesting birds
Dogs *(domestic, hunting, working and wild)*	• Some dogs kill and eat wildlife • Can also disturb wildlife during breeding season

Insects ***(wasps, Argentine ants, etc.)***	• The common wasp, Asian and Australian paper wasps and German wasps prey on native invertebrates • Argentine ants colonies combine to reach large numbers and are highly aggressive toward native insects
Fish ***(koi carp, catfish, feral goldfish, Gambusia, rudd, perch, etc.)***	• Stir up sediments and reduce water clarity • Increase nutrient levels and algal concentrations • Contribute to erosion • Compete with native species by feeding on, and removing aquatic plants, preying on invertebrates, native fish and their eggs • Can be unintentionally introduced to waterbodies as eggs and juveniles by boats and fishing gear

Many people are unaware of the damage pest fish such as koi carp do to our waterways. Photo: Nelson Mail



The tail of the ship rat (top) is longer than the body and all dark. The tail of the Norway rat (bottom) is shorter than the body and pale underneath.
Image: The Handbook of British Mammals (Blackwell Scientific Publications 1964)

A quick clean kill of a ferret in a DOC trap.
Photo: Matthew Brady. Crown Copyright, Department of Conservation

A section of the 42-km pest-proof fence at the Maungatautari Ecological Island, Waikato. Photo: Monica Peters, NZ Landcare Trust

2.1 Control or eradication?

The aim of pest control is not to remove every single pest. Control operations manage the impacts of pest animals and fish by reducing their numbers and therefore reducing the impacts on native flora and fauna. By contrast, eradication operations permanently remove the impacts of pest animals and fish by eliminating the entire population. This may be feasible, if for example, pest numbers are initially low or the area is protected from reinvasion such as inside a pest-proof fence. Understanding the difference between control and eradication is important as this can affect public perception of why and how an operation is being undertaken.

Pest control and pest eradication require a long-term commitment, and both have advantages and disadvantages. For example, pest-proof fences to create a pest free ecosystem are initially expensive to set up and require ongoing maintenance and monitoring to assess potential pest animal re-invasion. Ongoing terrestrial pest control using poisons, trapping and/or shooting, or aquatic pest control using nets requires long-term funding and an obligation to keep pests at low levels if gains in native biodiversity are to be made. Links to further information on pest proof fences can be found at the end of the chapter. Section 4 provides more information on controlling and eradicating pest fish.

3 Pest animals

It is important to identify the pest species for control as this will help define the methods used (e.g., a combination of trapping, poisoning and shooting may be used for possum control), as well as the timing of control. However, in most cases, multiple species will need to be controlled. To optimise control solutions, consideration will need to be given to the:

- dynamic nature of interactions between suites of animal pests (carnivores, omnivores and herbivores)
- different impacts of pest species on different site values at different population densities
- different rates of pest species recovery following control

For example, reducing possum or stoat numbers may result in an increase in rat numbers. Reducing rat or mice numbers can result in increased predation by stoats on native birds. A suite of animals such as mice, rats, feral pigs, and deer may affect native plant regeneration, which will eventually alter ecosystem structure, with consequences for both native flora and fauna. Effectively managing a suite of pests (as the case studies in this chapter demonstrate) means a shift from a single-species focus to a site-based focus.

Hare's teeth (like a rabbit's) grow throughout their life, thus needing constant chewing to keep them from growing too long.
Photo: Crown Copyright, Department of Conservation

Conditions are so favourable for possums in New Zealand that they can breed twice a year. Photo: David Mudge, Nga Manu Images

Stoats are considered "public enemy number one" for New Zealand birds.
Photo: Crown Copyright, Department of Conservation

CASE STUDY

WAIKAWAU BAY WETLAND PEST CONTROL: LEARNING BY DOING

The restoration goal of the Moehau Environment Group (www.meg.org.nz) is to reduce mammal (particularly rodents and possums) densities to very low levels within the wetland to halt the decline of native wetland bird species, including fernbird, pateke, Australasian bittern, spotless crake and banded rail. Pest control methods are based on other DOC and MEG rat control projects on the Coromandel Peninsular. The group is "learning by doing" as very little information on predator control in NZ wetlands is available. The project began in June 2006 and involves 9 landowners and DOC.

Poisoning and trapping

(24 hrs per week, including track maintenance)

- 150 bait stations @ 50 m intervals around wetland perimeter and 2 parallel lines of stations 75 m apart within the wetland. Poisoning began September 2006 with Brodifacoum for the initial knock down and to target possums. After 6 weeks, pulses of Racumin were put out as needed. Stations filled every 3 months
- 250 rat traps @ 25 m intervals around the wetland perimeter, initially checked weekly, now fortnightly
- 10 mustelid traps in the vicinity of the wetland
- 6 cat traps c. 250 m apart around wetland perimeter and sand dunes. Checked Dec–mid-Feb as needed (dependent on sightings); additional 12 hours 4 times a year.

Traps

'Victor Professional' rat traps are used that have a plastic tread plate and are double sprung for rodents. These are placed inside boxes to protect them and stop by-catch of birds. DOC 200 traps are used for mustelids and these are mounted in tamper-proof boxes for safety.

Monitoring

(32 hours x 4 times per year)

- 25 tracking tunnels layout modified from DOC Small Mammal Index (SMI) protocols – 5 lines with 5 tunnels each through representative habitats. 2008: tracking tunnels monitored every 3 months
- Bird monitoring using 5-minute bird counts along 2 km x 2 km transects through all wetland habitats – 144 hrs twice a year
- 10 large pitfall traps installed to assess invertebrate increases over time. Monitored twice annually. A qualified entomologist carries out the invertebrate identification.
- 3.5 km of tracks for bait stations and traps cut and marked.

Results

- June 2006: 95% rodent tracking
- August 2006: 85% rodent tracking
- April 2008: 27% rats, 30% mice, 20% weta, 25% skink
- Pest catches 2007: 350 rats, 112 mice, 19 feral cats, 9 stoats, 6 weasels and 13 hedgehogs. Number poisoned unknown
- Bird observations: June and August 2006: spotless crake, c. 20 fernbirds, 2 bittern, several banded rail, 14 pateke. May 2008: 85 fern birds, 47 pateke
- New baiting regimes and toxins investigated and new trapping techniques trialled (especially in regularly inundated areas)
- Students from Bay of Plenty Polytech Environmental Management Studies Group help carry out bird monitoring and Global Volunteers Network carry out the 3-monthly Small Mammal Indexing.

– *Wayne Todd, Moehau Environment Group*

The 42 ha Waikawau Bay wetland on the remote north eastern tip of the Coromandel Peninsula comprises an almost unbroken sequence from saline to fresh water wetland types. Photo: Wayne Todd, Moehau Environment Group

Minimising disturbance to the wetland means keeping to established tracks for pest control and other activities such as monitoring.
Photo: Wayne Todd, Moehau Environment Group

3.1 Selecting appropriate control methods

When selecting appropriate methods for controlling pest species, a range of factors must be considered. These include:

- Project scale
- Available human and financial resources
- Species being protected
- Restoration site accessibility (e.g., high water levels, dense vegetation)
- Surrounding land accessibility (e.g., steep hills; gorse or hakea covered areas) if required for pest control/monitoring
- Restoration site and surrounding land tenure (e.g., Recreation Reserve, covenant, private land, DOC Wildlife Management Reserve)
- Public use of the restoration site and surrounding area
- Public understanding of, and attitudes toward, e.g., toxins

Once the pests you are going to target have been identified, the most appropriate initial control method may be different from the maintenance control methods. For example, it is important to lower possum densities before controlling rats when a first generation anticoagulant is being used. The next important step is to select the appropriate timing for your pest control. In some cases, year-round control may be chosen. In other cases, control may be confined to winter and spring when pest animals are limited by food supply and protection is important for spring nesting birds and plant growth. Web links to fact sheets on pest species, as well as control methods can be found at the end of the chapter.

3.1.1 Poisoning, trapping or shooting?

The use of poisons versus trapping or shooting has been widely debated. Controlling pests with any of these methods needs to be ongoing, and is therefore time-consuming and expensive. The advantages and disadvantages are outlined below. A number of websites (e.g., Department of Conservation and Regional/District Councils) provide practical advice and factsheets on using poisons and trapping – links to websites are included at the end of the chapter.

Poisons: advantages and disadvantages

- ✓ Long lasting
- ✓ Kill multiple numbers of the target pest before needing to be checked/ refilled
- ✓ No associated noise, bang or trigger
- ✓ Cost effective and can be associated with multi-species pest control (e.g., brodifacoum is toxic to both rats and possums)
- ✓ New poisons are being released that are more efficient, pose less risk to non-target organisms and are less toxic to terrestrial and aquatic ecosystems
- ✗ Some active ingredients have associated ecosystem effects such as bio-persistence and bio-accumulation in food webs (e.g., brodifacoum)
- ✗ Can affect non-target species though can be minimised with signage and warnings (e.g., cholecalciferol possum and rat poison is very toxic to dogs)
- ✗ If either too little, or the wrong poison is used, it won't last long and won't kill any target pests

Some poisons used to control possums are not effective and/or cannot legally be used for controlling rodents (e.g., cyanide), so knowledge about appropriate use of poisons when making your selection is important. It is also important to note that anticoagulants such as Pindone can be ecotoxic in aquatic environments. Doing your homework into the poisons classification is critical along with knowing the best poison to use and in which form to present it (e.g., pastes, gels, pellets or liquids).

Traps: advantages and disadvantages

- ✓ No non-target deaths resulting from secondary poisoning
- ✓ Effective in wetlands (though need to be attached to stakes in wet situations)
- ✓ Designed for the target species alone and must meet stringent ethical criteria
- ✓ Often regarded more favourably by the wider community than poisons
- ✗ Labour intensive to set, clear and bait
- ✗ When sprung or the pest captured the trap can kill no more until cleared and reset
- ✗ Some species, e.g., feral cats, can be 'trap shy'
- ✗ Can be faulty, jam or not fine-set enough, leading to trap shyness of target species
- ✗ Can kill non-target species, e.g., kiwi caught in possum traps

When trapping pest animals it is advisable to consider the welfare of the animals you are intending to trap as well as the effectiveness of the trap. Test results for traps are available on the Landcare Research website – see the Useful websites section at the end of the chapter.

Shooting: advantages and disadvantages

- ✓ Relatively low cost
- ✓ Able to be selective
- ✗ Can be difficult to follow-up if not killed outright
- ✗ Time consuming and diminishing returns
- ✗ Skilled shooters/markspeople required
- ✗ Possums and other pests can become light and gun shy

Every person shooting must either hold a firearm license, or be under the supervision of a person over 20 years old who holds a firearms license. Neighbouring properties should be informed of intentions to shoot.

3.1.2 Repellents

In some cases it may be worthwhile using repellents, for example, if poisoning is not feasible, if rabbit/hare populations are not very large or if plastic plant protectors are not available.

HOME-MADE RABBIT REPELLENT RECIPE

Repellents rely on grazing (vegetarian) animals disliking animal protein and are therefore based on blood and bone, egg or fish meal.

- 5 eggs (or equivalent in egg powder)
- 150 ml white acrylic paint
- 600 ml water

Mix it all up together and spray directly onto the plant. Repeat as required — after a long period of rain and when rabbits' food sources are getting low (autumn).

– *www.bioprotection.org.nz/system/files/Greening+Waipara+Newsletter+No+1.pdf*

Hare control using sturdy plastic frames that wrap around plant stakes. Te Hapua, Wellington. Photo: Monica Peters, NZ Landcare Trust

Two cats, three ferrets and a stoat (a single day's haul from the wetland), would likely put a dent in the native bird population.
Photo: Matthew Brady. Crown Copyright, Department of Conservation

The elusive Australasian bittern.
Photo: Crown Copyright, Department of Conservation

Whangamarino (Waikato) is an extensive mosaic of different wetland types and is administered by the Department of Conservation.
Photo: Kerry Bodmin. NIWA (with permission from DOC)

CASE STUDY

MAMMALIAN PREDATOR CONTROL IN THE WHANGAMARINO WETLAND

The Waikato's Whangamarino wetland was designated a site of international significance (Ramsar site) in 1989, predominantly for its bird life. Along with significant populations of waterfowl, and specialist wetland birds like fernbird (*Bowdleria punctata*), marsh crake (*Porzana pusilla affinis*) and spotless crake (*Porzana tabuensis plumbea*), Whangamarino has one of the largest populations of endangered Australasian bittern (*Botaurus poiciloptilus*) in New Zealand.

The wetland is part of Department of Conservation's Arawai Kākāriki Wetland Restoration Programme, and predator control is important for safeguarding and increasing the native bird populations. However, to do this efficiently and effectively it is necessary to understand the behaviour, territorial dynamics, and feeding habits of predators in a wetland environment, a field about which there is a decided lack of knowledge.

How many predators are there?

Monitoring of the distribution and abundance of mammalian predators in the Whangamarino wetland has proved troublesome. Many traditional methods are ineffective due to variable water levels and areas of very dense grasses, sedges and rushes (e.g., wire rush *Empodisma minus*). Initial monitoring in 2008 concentrated on cats and mustelids (ferrets, stoats and weasels). Approximately 70 traps were set up across swamp, fen and bog habitats, using varied types of bait. Traps were checked regularly, catch numbers recorded, and all mustelids and cats collected for gut analysis. Over a year 10 cats, 71 ferrets, 23 stoats and 37 weasels were caught. Further research is planned to begin in January 2010 and will focus on recapture techniques, to increase our understanding of movement patterns and predator abundance.

Status of native wetland birds

We also require an understanding of the habits and habitats of native wetland birds. DOC has recorded the distribution and abundance of bittern in Whangamarino in 2004, 2006 and 2008. Relative abundance of bittern was measured by recording the 'booming' of male bittern at selected sites. Preliminary analysis suggests bittern abundance was lower in 2008, possibly because high water levels reduce the availability of suitable foraging and breeding habitat. Further testing of cryptic bird survey methods at Whangamarino is planned for Sept–Nov 2009.

Management implications

Early observations suggest mammalian predators do not frequently move into the centre of the Whangamarino peat bogs, keeping to high ground and around wetland fringes. This means predator control may be most effective by targeting peripheral areas. However, critical knowledge gaps remain on the population dynamics of cats, stoats, ferrets and other predator species, and ultimately, on the extent of damage to our native wetland birds.

– *Matthew Brady & Hugh Robertson, Department of Conservation*

www.doc.govt.nz/documents/conservation/land-and-freshwater/wetlands/ak-whangamarino-factsheet-web.pdf

4 Pest fish

There are over 35 species of native freshwater fish in New Zealand and also 22 species of introduced fish, some of which have a devastating effect on native biodiversity and waterways. Pest fish are already well established in many regions. In the Waikato, for example, koi carp make up 80% of the total fish biomass in lakes and rivers. To help stop the spread of koi carp, a containment area between Auckland and Hamilton was created. Although recreational fishing is permitted in the containment area, all koi carp must be killed when caught.

Pest fish present a considerable management challenge as once established they are able to spread rapidly through whole catchments and are very difficult and expensive to remove. Pest fish eggs, juveniles and water weeds can be unintentionally introduced to water bodies by boats and fishing gear. In some cases pest fish such as koi carp may be deliberately introduced by sports fishermen. Preventing both the colonisation of new water bodies and recolonisation of cleared water bodies may therefore depend on strong awareness-raising campaigns. Preventing pest fish incursions is the preferred option but physical interventions to preclude colonisation of pest fish free water bodies can be problematic. Placing barriers along waterways will prevent the passage of some native fish species, hence the challenge of designing structures that will allow the movement of some fish species but not others.

4.1 Control

Pest fish breed rapidly, so any control programme must have specific outcomes in mind and long-term – possibly indefinite – commitment. The standard approach used by DOC is trapping and netting, which can simultaneously be used as a monitoring tool. Special permits are normally required from the Ministry of Fisheries to use nets and traps used in pest fish control. However, as with terrestrial pest control, new techniques are evolving such as electrofishing using a specially constructed boat to deliver an electric charge. This technique is currently being used both to collect baseline data on both native and pest fish as well as to remove pest fish from water bodies.

A novel control method is the "Koi Carp Classic". This is an annual weekend-long recreational event run by the NZ Bow Hunters Society and sponsored by a range of organizations, including DOC. The results are impressive, – in 2008, 1770 koi weighing 4269.5 kg were harvested from Lake Whangape (1450 ha). As different waterbodies in the Waikato are targeted each year, the event helps raise awareness of pest fish numbers in the region. Additionally, fish caught over the 2 days are weighed and measured and data provided to researchers to help understand population dynamics and find ways of stopping their spread in New Zealand.

4.2 Eradication

The eradication of pest fish is only possible in small lakes and ponds <5 ha in area. Where possible, draining the water body is a most effective technique. Other options include electrofishing and poisoning using cube-root powder, which has the same active ingredient as derris dust. However, as all fish and invertebrates are killed, currently only DOC is allowed to use this method.

The ability of Gambusia/mosquito fish to control mosquitoes has been exaggerated. They are highly aggressive, attacking fish much larger than themselves. Photo: Nelson Mail

University of Waikato researchers electrofishing in Whangamarino. Photo: Wayne Barrar

Sign to help raise awareness and stop the spread of pest fish. Lake Janet, Canterbury.
Photo: Ferne McKenzie. Crown Copyright, Department of Conservation

5 Monitoring

It is important to monitor not only pest animal densities, but also the resource you are trying to protect as this shows whether your pest control has been successful. Recording a range of information will help you build up a database, which may identify likely invasion routes and areas of preferred habitat, both of which will help planning and refining pest control operations.

Due to the difficulty in measuring absolute abundance, relative density measures are used instead. Determining absolute abundance would mean the study area would need to be fully checked, with all individual pests measured and counted and no other individuals or populations entering the study area. By comparison, relative density measures (using, e.g., bird counts, wax blocks, and tracking tunnels) are cheaper and less time consuming to measure, don't require all individuals in a population to be accounted for, and, in many situations, can provide similar information to direct counting methods.

This section summarises several widely used methods primarily to determine native/exotic bird abundances, as well possum, rodent and hedgehog abundance, and presence/absence. In some cases, the methods to monitor native and introduced species are the same (e.g., using 5-minute bird counts) and are therefore repeated in both chapters. For more methods to monitor native plants and native fauna, refer to Chapter 10 – Revegetation and Chapter 12 – Native fauna. Chapter 13 – Monitoring provides a method for determining overall wetland condition.

5.1 5-minute bird counts

In a 5-minute bird count the observer records the number and species of all birds seen and heard. Each bird is counted only once. As with other index counts, it is important to remember that a 5-minute bird count does NOT result in an accurate count of all birds present. The numbers recorded are used to indicate the number of birds present, though many factors need to be taken into account including observer skill levels and hearing ability, bird habitat preferences, and bird visibility.

Bird counting stations can be set up throughout the wetland. These should be at least 200 m apart to avoid duplication of bird calls from one station to another. Small wetlands therefore may only have one station. In larger wetlands, stations should be distributed so that they cover all vegetation types. In the original method (Dawson & Bull 1975) 200 m was specified as the cut-off distance for recording birds. Although many current studies don't stipulate an actual cut-off distance, recording birds that are obviously very far away (e.g., on the other side of the valley) is not recommended. The number and species of all birds seen and heard should be documented, along with the station location, name of person doing the bird count, date, start time, temperature, wind, other noises, sun, and precipitation. The DOC website listed at the end of the chapter details the method more fully and includes field sheets and digital data entry sheet.

Additionally, keep an annual list of bird sightings and observations throughout the year. Information on specific monitoring of bird populations, e.g., threatened species, can also be accessed via the DOC website.

5.2 Wax tags

Wax tags area used by possum control contractors, DOC, regional and city council staff, and scientists to detect and monitor possums. The tags are nailed c. 30 cm above the ground to a tree or post and marked either with a luminescent strip, or a piece of flagging tape nearby. The location and number of each tag is documented. Depending on the sampling design, the wax blocks are retrieved after 3 or 7 days for analysis. The Bite Mark Index (BMI) is a series of calculations used to determine relative possum abundance. The BMI (reported as a percentage) is the mean proportion of wax blocks bitten by possums over a 3- or 7-night period for a sample of lines.

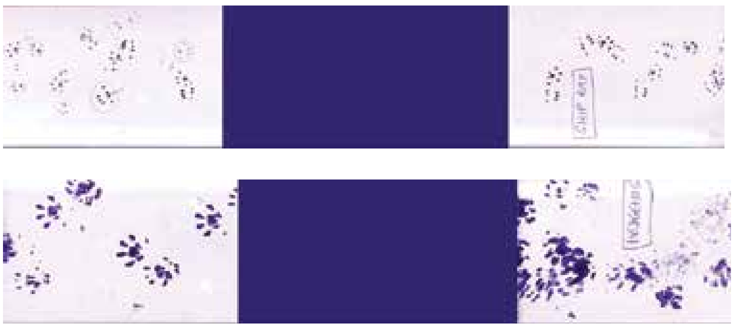
Peanut-butter flavoured wax tags are available for rodent detection and mapping. These are widely used for rodent incursion, detection and monitoring, in particularly on mainland and offshore island sanctuaries. The wax tags can be left out as surveillance devices for months at a time. Links to protocols for using wax tags can be found at the end of the chapter.

As sampling needs be unbiased, seek expert advice on how to lay out the wax tags – in other words, all potential possum habitats have to have an equal chance of being sampled. Systematic sampling creates an effective spatial sampling pattern over the landscape.

Relative possum abundance can be calculated using wax tags and the Bite Mark Index (BMI).
Photo: Monica Peters, NZ Landcare Trust

5.3 Tracking tunnels

Tracking tunnels are used widely to gain an index of the density of introduced small mammals (e.g., possums, mustelids, rodents, and hedgehogs) and to determine whether wetland predator control has been successful. In recent years, use of such tunnels has largely replaced the use of kill-trapping as the main rodent density index. Tracking tunnels rely on ink-pads and paper to record the tracks of target species (e.g., rats). Their abundance is calculated by extrapolation. Inked papers are laid out within a plastic tunnel and baited with a small amount of peanut butter or rabbit meat. Tunnels are pegged to the ground using wire. Footprint guides are available – see the Useful website section for links.



Tracking tunnels prints showing ship rat (top) and hedgehog. Solid blocks of colour are the ink pads. Image: Corinne Watts, Landcare Research

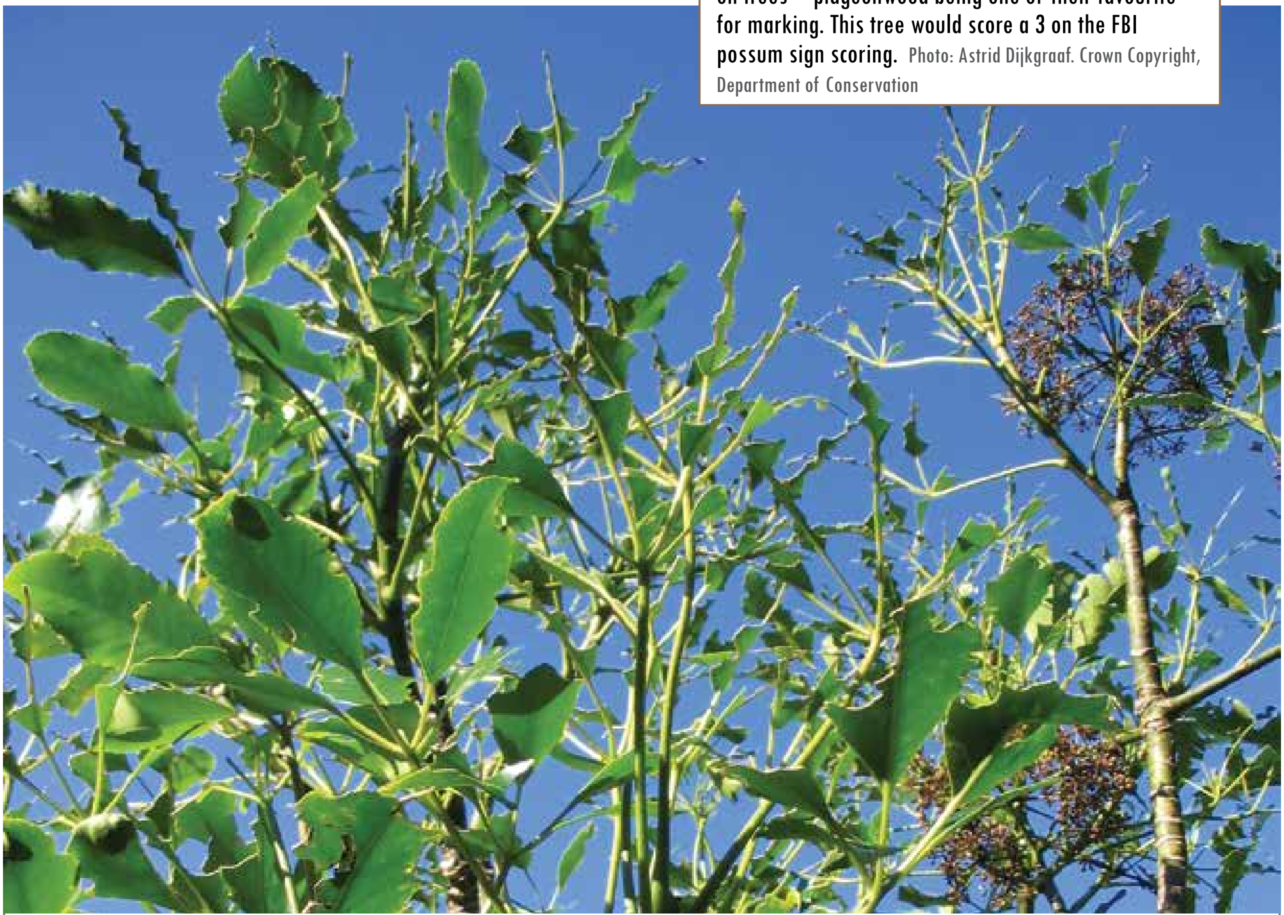
5.4 Foliar browse

The foliar browse index (FBI) method (Payton et al. 1999) measures the impacts of possum browsing on natural area "health" by monitoring trends in canopy and sub-canopy tree condition. A range of factors are subjectively measured including:

- canopy cover
- canopy dieback and recovery
- possum browse
- stem use by possum
- fruiting and flowering levels of individual trees of palatable species

Note that this method does not provide answers to longer term questions such as recruitment rates of palatable species.

Possums mark their territory by leaving chew marks on trees – pidgeonwood being one of their favourite for marking. This tree would score a 3 on the FBI possum sign scoring. Photo: Astrid Dijkgraaf. Crown Copyright, Department of Conservation



Take care not to misidentify the browser. Damage to this five finger was most likely caused by insects, not possums. Waihi beach, Waikato.
Photo: Monica Peters, NZ Landcare Trust

5.5 Fish trapping

A basic monitoring method is to use traps or fyke nets. However, it is worth noting that each type of sampling gear has a bias toward different fish species so it pays to use a range of methods to get a full picture of the fish community. The traps and nets are easy to use and if set properly are unlikely to kill fish – an important consideration as native species may also be caught. Set traps/ nets in a secure place overnight, for example under overhanging stream banks or vegetation.

Mark the spot with flagging tape so that the traps can easily be found the next morning. Leave an air gap at the top of the traps and nets because water in wetlands can become de-oxygenated overnight. Care should also be taken to avoid setting gear during floods when water levels can drop and expose fish. If pest fish are caught, contact DOC as this information could help the Department and other interested parties keep track of the spread of these species.

Fyke net set up underwater for freshwater fish surveying. Canterbury. Photo: Sjaan Charteris. Crown Copyright, Department of Conservation

6 References and further reading

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6.1 Useful websites

Wetland restoration templates

Waikato Regional Council Wetland Restoration Plan templates

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate1.pdf

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate2.pdf

Wetland restoration guides and factsheets (New Zealand)

Northland Regional Council

www.nrc.govt.nz/upload/2217/Wetland%20Restoration%20Guide%20(second%20edition%20Feb%2009).pdf

Auckland Regional Council

www.arc.govt.nz/albany/fms/main/Documents/Environment/Plants%20and%20animals/wetlandsfacts2.pdf

Waikato Regional Council

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/

Hamilton City Council

www.gullyguide.co.nz/index.asp?pageID=2145821537

Bay of Plenty Wetlands Forum

www.doc.govt.nz/upload/documents/conservation/land-and-freshwater/wetlands/wetland-restoration-guide.pdf

Greater Wellington

www.gw.govt.nz/a-beginner-s-guide-to-wetland-restoration/

Department of Conservation Protecting Natural Areas Design Guide

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/nature-heritage-fund/protecting-natural-areas-design-guide/

Wetland restoration guides (International)

USA Environmental Protection Agency

www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Pest animals

Control methods, fact sheets and literature references

www.doc.govt.nz/conservation/threats-and-impacts/animal-pests/

www.landcare.org.nz/files/file/80/pest-control-guidelines.pdf

www.npca.org.nz/index.php/landowner-information

Pesticides

Facts about 1080 and the use of 1080 for pest control

www.doc.govt.nz/documents/conservation/threats-and-impacts/animal-pests/use-of-1080-04.pdf

Traps and predator proof fences

Independent test results for traps

www.landcareresearch.co.nz/science/plants-animals-fungi/animals/vertebrate-pests/traps

Predator proof fences, pests and pest control

www.sanctuariesnz.org

Restrictions on using leg-hold traps

www.legislation.govt.nz/regulation/public/2007/0353/latest/whole.html

Monitoring

5 minute bird count methods, field sheets and digital data entry sheet

www.doc.govt.nz/conservation/native-animals/birds/five-minute-bird-counts/

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=54:5minbird&catid=52:landmethods&Itemid=74

Footprint Identification Guide for tracking tunnels

www.rimutakatrust.org.nz/downloads/download.htm

www.gotchatraps.co.nz/html/photo_gallery.html

Protocols for using wax tags

www.pestcontrolresearch.co.nz/docs-monitoring/waxtagprotocol.pdf

Bird counts, setting up photopoints, pest animal transects

www.formak.co.nz

Foliar browse index

nvs.landcareresearch.co.nz/html/FOLIAR_BROWSE_INDEX.pdf

Freshwater Fish

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=53:fish-surveying&catid=51:watermethods&Itemid=75

Lizards and frogs

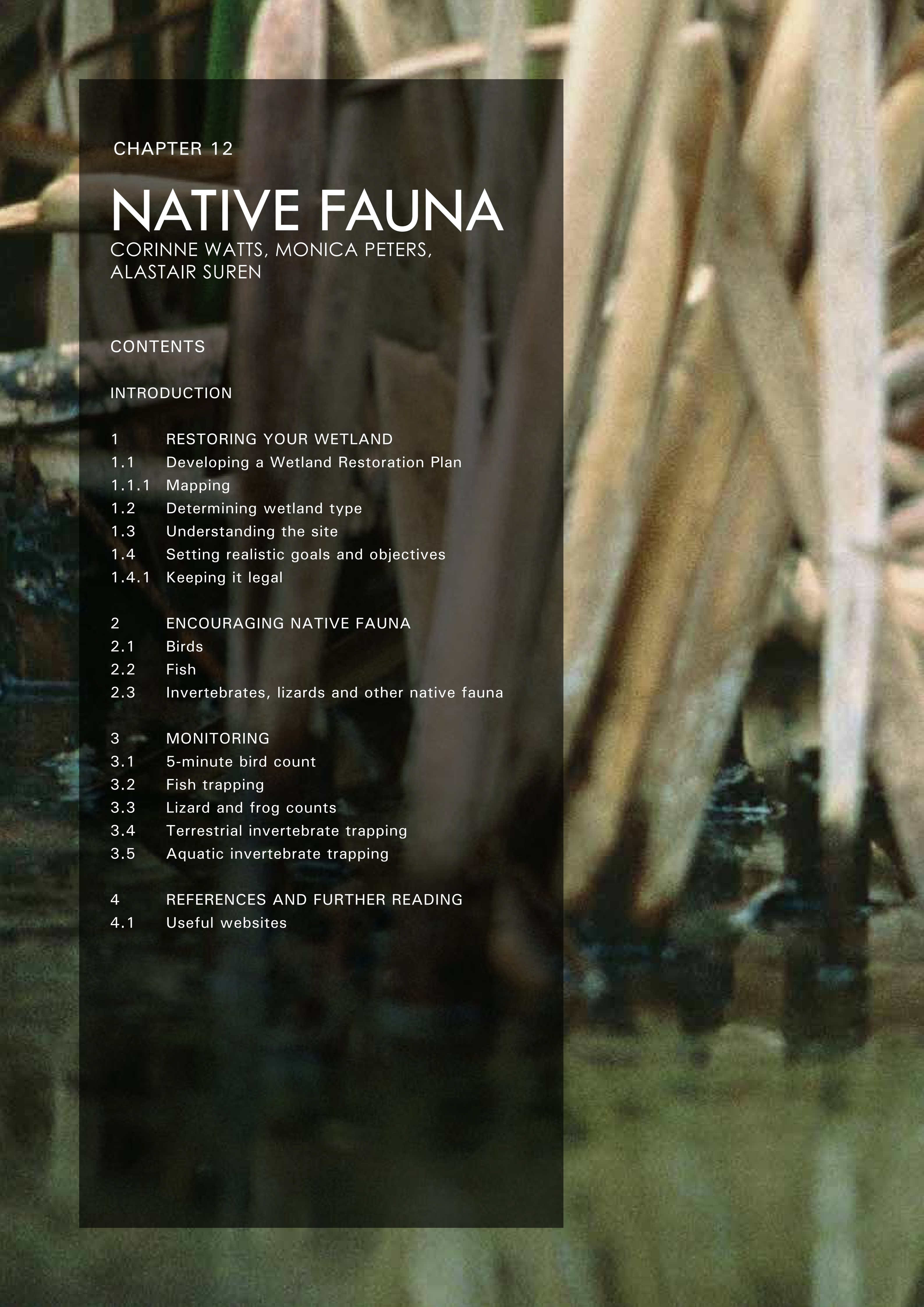
www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=90:tracking&catid=52:landmethods&Itemid=74

www.gotchatraps.co.nz/html/photo_gallery.html

Invertebrates (terrestrial and aquatic)

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=55:inverts&catid=52:landmethods&Itemid=74

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 12

NATIVE FAUNA

CORINNE WATTS, MONICA PETERS,
ALASTAIR SUREN

CONTENTS

NATIVE FAUNA

NATIVE FAUNA

CORINNE WATTS, MONICA PETERS
AND ALASTAIR SUREN

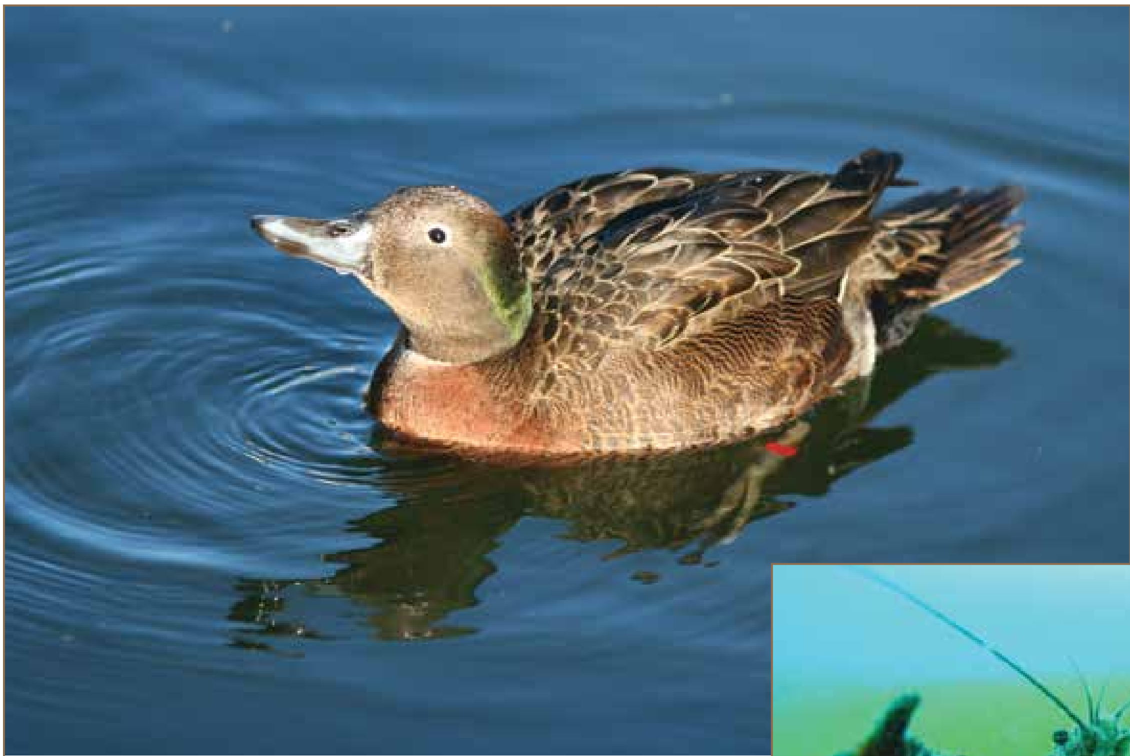
Wetlands provide specialised habitats for a variety of fauna, including birds, fish, skinks, geckos, frogs and invertebrates – both terrestrial and aquatic. Many of New Zealand's wetland fauna are endemic, in other words, found nowhere else in the world. Species in this category include the green skink (*Oligosoma chloronoton*), fernbird/matata (*Bowdleria punctata*), brown teal/pateke (*Anas aucklandica*). New Zealand dabchicks/weweia (*Poliocephalus rufopectus*), scaup/papango (*Aythya novaeseelandiae*), paradise shelducks/putangitangi (*Tadorna variegata*), kokopu (*Galaxias* spp.), mudfish/kowaro (*Neochanna* spp.), and freshwater crayfish/koura (*Paranephrops* spp.). The majority of invertebrates are unique to New Zealand. This includes the recently discovered moth named *Houdinia flexilissima* (which describes its hidden threadlike larval form), beetles, dragonflies and midges, as well as snails, and small crustaceans called "seed-shrimps" and "water fleas".

Despite the limited area covered by remnant wetlands in New Zealand, wetlands are home to 22% of our bird species and 30% of our native freshwater fish. We do not know what proportion of New Zealand's invertebrates live within wetlands, but we do know that similar numbers of different invertebrate species are found in wetlands as in rivers and streams. Wetland restoration projects provide important wetland habitat that this diverse range of fauna need and also help ensure our wildlife survives into the future.

The two case studies in this chapter profile the ZEALANDIA - Karori Sanctuary in urban Wellington and wrybill conservation efforts in the braided rivers of the Ashburton lakes area. The goal of the first case study is to reintroduce native fauna characteristic of region, while the second case study highlights the challenges of managing and monitoring a unique endemic bird.

Previous page: A glimpse of the secretive spotless crake.

There is still much to be learned about wetland insect fauna – *Houdinia flexilissima* is a recently named new genus of moth associated with a rush species endemic to the Waikato. Larvae and rush stem (on right) showing distinctive feeding scars. Photo: Birgit Rhode, Landcare Research



Brown teal is the rarest waterfowl species on the New Zealand mainland with fewer than 2000 remaining. Photo: Tom Lynch. Copyright ZEALANDIA Karori Sanctuary Trust

Koura, the freshwater crayfish can burrow well down into swamps that dry out over summer, waiting there until the water returns. Photo: John Clayton, NIWA

1 Restoring your wetland

1.1 Developing a Wetland Restoration Plan

A Wetland Restoration Plan is extremely useful for gathering information about the restoration site, clarifying and setting goals, as well as the designing the implementation and monitoring phases of the project. A list of actions such as pest control (see Chapter 11 – Pests) will be necessary to successfully encourage native fauna into your wetland, and/or provide the best conditions for species translocations. Follow the steps outlined in Chapter 2 – Restoration planning or use one of the templates listed at the end of the chapter.

1.1.1 Mapping

A useful starting point for developing a Wetland Restoration Plan is a sketch map. A bird's-eye view sketch map is important as it helps to summarise knowledge about the natural and man-made character of the restoration site. It is a practical tool to define, for example, management zones and locations of permanent plots or sites for monitoring. The map can be hand drawn using a range of resources such as aerial photos, topographic maps and Google Earth combined with your own knowledge.

The following features should be included:

- Vegetation types
- Water sources and outflows, hydrological modifications, water level
- Soil type
- Man-made, natural and cultural features

For more detail on what to include, see Chapter 2 – Restoration planning.

Opposite: All five whitebait/inanga species spend part of their lifecycle in freshwater and part in the sea.
Photo: Phillippe Gerbeaux. Crown Copyright, Department of Conservation

1.2 Determining wetland type

Determining the type of wetland you have is important, as each type has specific nutrient and hydrological regimes that favour specific plant communities and therefore animal communities. For example, recent studies have shown that acidic fens and bogs support very different aquatic invertebrate assemblages than less acidic swamps, with many species of snails being absent in wetlands with acidic water. This absence reflects that fact that snails cannot obtain enough calcium from acidic waters to build their shells. Detailed information to help with determining what type (or types) of wetland the restoration site is, can be found in Chapter 3 – Wetland types.

1.3 Understanding the site

Researching historical records and locating similar wetlands (outlined in Chapter 4 – Site interpretation 1) may yield important information on both species and population sizes of fauna (though is usually limited to birds and fish). Knowledge of the types of species that were once likely to be present in the wetland, or that are found in similar, but unimpacted wetlands can help guide restoration goals (see also Chapter 5 – Site interpretation 2).

The New Zealand dabchick is called weweia by Maori for the sound of its occasional shrill call "wee–ee–ee".
Photo: Dick Veitch. Crown Copyright, Department of Conservation

1.4 Setting realistic goals and objectives

An important goal, and normally the last to be implemented, of any wetland restoration project is to encourage native fauna into your restored wetland. Specific objectives linked to this goal may, for example, be to:

- encourage native waterfowl to visit your wetland to establish a breeding population
- reintroduce an iconic wetland species, e.g., brown teal and fernbird
- build populations of eel/tuna for sustainable harvest
- establish new populations of endangered species within their former range (e.g., mudfish)
- remove barriers from streams and ditches connected to the wetland restoration site to promote colonisation by native fish species
- increase suitable habitat for whitebait within the wetland and connecting waterways
- create a refuge for lizards by carrying out pest control and planting suitable food species
- improve invertebrate numbers as food for native fauna

Other general goals may be to restore wetland habitat to create more natural conditions to enable natural colonisation by desired species. This is particularly true for aquatic habitats, which have often been dramatically altered or destroyed as a result of wetland drainage. Aquatic habitats in modified wetlands have often been reduced to little more than small straightened channels, with poor habitat quality. Their banks are also often vertical, giving little cover to animals among overhanging material. Any aquatic plants growing in these channels are often mechanically or chemically removed, further lowering the habitat value of drains. Restoration activities such as blocking up flowing channels can help improve aquatic habitats by encouraging both native aquatic and native wetland plants to grow.

1.4.1 Keeping it legal

Most native wetland bird species are fully protected under the Wildlife Management Act (1993), which is administered by the Department of Conservation. This means that the majority of species translocations you may consider as part of a restoration project will need specific approval. For example, releasing fish into a restored waterway may require a number of permits, namely from the Department of Conservation Fish and Game Council, and/or the Ministry of Fisheries. The Department of Conservation has strict guidelines, set out in the 'Standard Operating Procedure for Translocation of New Zealand's Indigenous Flora and Fauna', 2002), The translocation proposal must, for example, consider:

- the effect of translocation on the source population and release site
- the method of translocation
- monitoring, research, and management requirements

Even releasing invertebrates into newly restored wetlands will require permits. Permits are also required to trap, catch and handle all lizards (i.e. skinks and geckos), hence the focus in the last section of this chapter on "passive" monitoring methods that do not involve handling. Contact the Department of Conservation for further advice if you are considering translocating native fauna or may be handling or trapping any native fauna for monitoring purposes. You will also need to contact the Department of Conservation for a permit to undertake customary and recreational fishing in Department of Conservation Wildlife Management Reserves.

Example of a degraded aquatic habitat in a highly modified wetland. Mechanical clearing, herbicide use and trampling by cattle further reduces any potential habitat values for aquatic fauna.
Photo: Alastair Suren, NIWA

Example of a healthy habitat dominated by native wetland plants. Despite the canal being a man-made feature, note the dense growth, lack of weeds and stock damage on the banks. Kopuatai peat dome, Waikato.
Photo: Monica Peters, NZ Landcare Trust

CASE STUDY

ZEALANDIA – KARORI SANCTUARY: WHAT NATIVE FAUNA SHOULD BE REINTRODUCED?

In the heart of Wellington lies the ZEALANDIA - Karori Sanctuary. An 8.6-km predator-proof fence surrounds 225 ha of regenerating lowland forest and wetlands. The goal is to reintroduce native fauna characteristic of the southern lowland North Island, both before human settlement and naturally established since then. This includes 35 species of bird (of which 10 are now extinct), 2 species of semi-aquatic amphibian (1 now extinct), and approximately 19 species of fish (1 now extinct). There are no historical data on wetland invertebrates. As a "mainland conservation island", successful reintroductions to ZEALANDIA already include tuatara, little spotted kiwi, brown teal/pateke, saddleback/tieke, and stitchbird/hihi.

The brown teal occupies a unique ecological niche among waterfowl with its omnivorous diet, restricted annual range, and mainly terrestrial lifestyle. Photo: Tom Lynch © ZEALANDIA/Karori Sanctuary Trust

Native fish

Wetland areas developed around two old water reservoirs will provide habitat for a range of aquatic species. Long- and short-finned eels/tuna, and banded kokupu are already present. Bullies and other galaxiids are some of the native fish species that will be introduced as they are able to:

- pass through the predator-proof fence; or
- be caught and transferred over the fence to complete their migration.

However, before any new native fish species can be released, brown trout and perch (both exotic fish species) will need to be eradicated.

Aquatic Birds

The lakes, streams and wetlands in ZEALANDIA provide a variety of habitats that are attractive to a range of aquatic birds. A recent self-introduction is the pied shag/ karuhiruhi; however, other species need help. Brown teal and New Zealand scaup/papango (all sourced from captive breeding programmes) have already been released. As the wetland and lake habitats improve, further releases could include the Australian coot and grey teal/ tete. Species such as dabchick, marsh crake, and spotless crake have never been transferred and new techniques may need trialling. Source populations for each will also need to be identified.

Invertebrates

Diverse freshwater invertebrates inhabit the streams in ZEALANDIA. To date 2 new species of water beetle have been discovered. Wetland invertebrate reintroduction is an unknown science therefore any transfers will need careful monitoring and evaluation. As with reintroducing native fish, exotic fish will need to be eradicated first.

– *Raewyn Empson, ZEALANDIA – Karori Sanctuary*

REF: www.sanctuary.org.nz/

Following protocols: powhiri to welcome tuatara (gifted by kaitiaki Ngati Koata) 2007. Photos: Alan Dicks © ZEALANDIA/Karori Sanctuary Trust

ATTRACTING BIRDS WITH PLANTS

- Paradise shelducks feed on pasture next to wetlands
- Rails, crakes, pukeko and fernbirds feed and nest around damp areas of vegetation
- Fernbirds prefer wetlands with dense ground cover under a selection of shrubs and small trees (e.g., manuka)
- The spotless crake and marsh crake are secretive birds that feed in permanently shallow water under cover of dense raupo or flax. They build nests under sheltering sedges among stands of manuka. You would need less than half a hectare of this habitat to support a breeding pair of spotless crake
- Pied stilts feed on worms and insects in temporary winter pools in paddocks and nest in scattered clumps of rushes
- Tui, waxeyes and bellbirds will feed on flax and kowhai. Kereru will visit fruiting kahikatea

– *www.waikatoregion.govt.nz "Attracting birds"*

2 Encouraging native fauna

Given the legal requirements for translocating native fauna, it will be much better (and easier) in many cases to try and create the right habitat conditions within a restored wetland, and then wait for these habitats to be naturally colonized by desired native fauna such as birds, fish, lizards and invertebrates (terrestrial and aquatic). The advantages of natural recolonisation are that it is much less labour intensive, cheaper, and most species by virtue of their proximity will be eco-sourced. However, the further away a restored wetland is from natural populations, the harder it will be for them to colonise.

2.1 Birds

Well over 50 species of native bird use wetlands at some time in their lifecycles. Some, such as the kingfisher/kotare (*Halcyon sancta*), use a variety of water locations including the coast, while others, such as the fernbird/matata (*Bowdleria punctata*), rely on specific types of freshwater wetlands. A number of birds that depend on freshwater wetlands are highly secretive and therefore not very visible, e.g., the spotless crake/puweto (*Porzana tabuensis*) and marsh crake/koitareke (*Porzana pusilla*), banded rail/moho-pereru (*Rallus philippensis*), and the Australasian bittern/matuku (*Botaurus poiciloptilus*). Many wetland birds nest on or close to the ground or on floating platforms of vegetation, which makes them highly vulnerable to predation. Pest animal pressure combined with habitat loss mean many native wetland birds are now highly dependent on wetland restoration and conservation initiatives for their survival. Species currently most at risk include the New Zealand dabchick/weweia (*Poliocephalus rufopectus*) – currently classified as threatened, the black stilt/kaki (*Himantopus novaezelandiae*) – highly endangered, and the brown teal/pateke (*Anas aucklandica*) – endangered.

Opposite: Fernbirds are very weak flyers, and reluctant to leave cover.
Photo: P. Thompson. Crown Copyright, Department of Conservation

A basic need for wetland birds is pest control. Rodents, possums, hedgehogs, mustelids and cats all take invertebrates, birds' eggs, chicks, and even adult birds. Weed control and planting desirable natives will also help create a better habitat for birds. 'Extras' you can provide during the course of the wetland restoration include:

- Logs and trees for perching sites and shelter for birds
- Gently sloping, irregular shorelines to allow easy access to and from any water within the wetland
- Safe nesting sites, e.g., islands or floating rafts of plants on open water within the wetland
- Nesting boxes (links are included at the end of the chapter)
- A 'green corridor' of native plants to join the wetland to native bush areas or other wetlands

Importantly, stopping or significantly reducing grazing and other activities near the wetland during the bird breeding season (Sept–Dec for most species) will help minimise any unnecessary disturbance.

Although pukeko are native they are naturally inquisitive and can uproot areas of new plantings (see Chapter 10 – Revegetation for tips on "pukeko proofing" your plantings).
Photo: Monica Peters, NZ Landcare Trust

Opposite: A dead tree is put to good use as a strategically placed bird perch and is viewable from the hide. Otatara, Southland. Photo: Monica Peters, NZ Landcare Trust

The marsh crake inhabits fresh and salt water swamps and can also be found along the marshy banks of rivers. Photo: Peter Moore. Crown Copyright, Department of Conservation

The substantial Kaitoke Swamp on Great Barrier Island provides a wide range of different habitat types including shrubland, sedgeland, and shallow water. Photo: Danny Thornburrow, Landcare Research

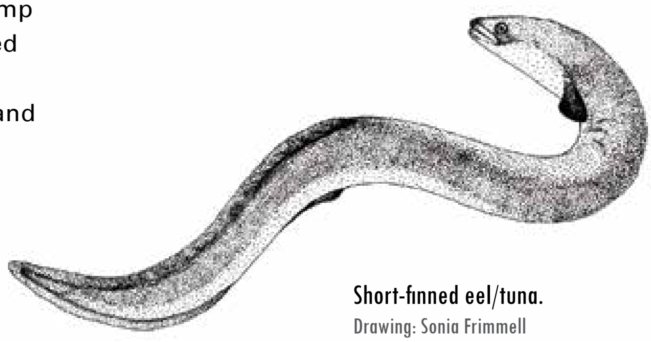
ATTRACTING BIRDS WITH WATER

- All waterfowl need open water to moult in safety, away from predators
- New Zealand scaup like deep, open, clear water
- Mallards, grey ducks, shoveler, and grey teal favour shallow water around the edges of a pond or lake
- New Zealand dabchicks feed in deep, open water, but build their nests on floating rafts of vegetation among reeds

2.2 Fish

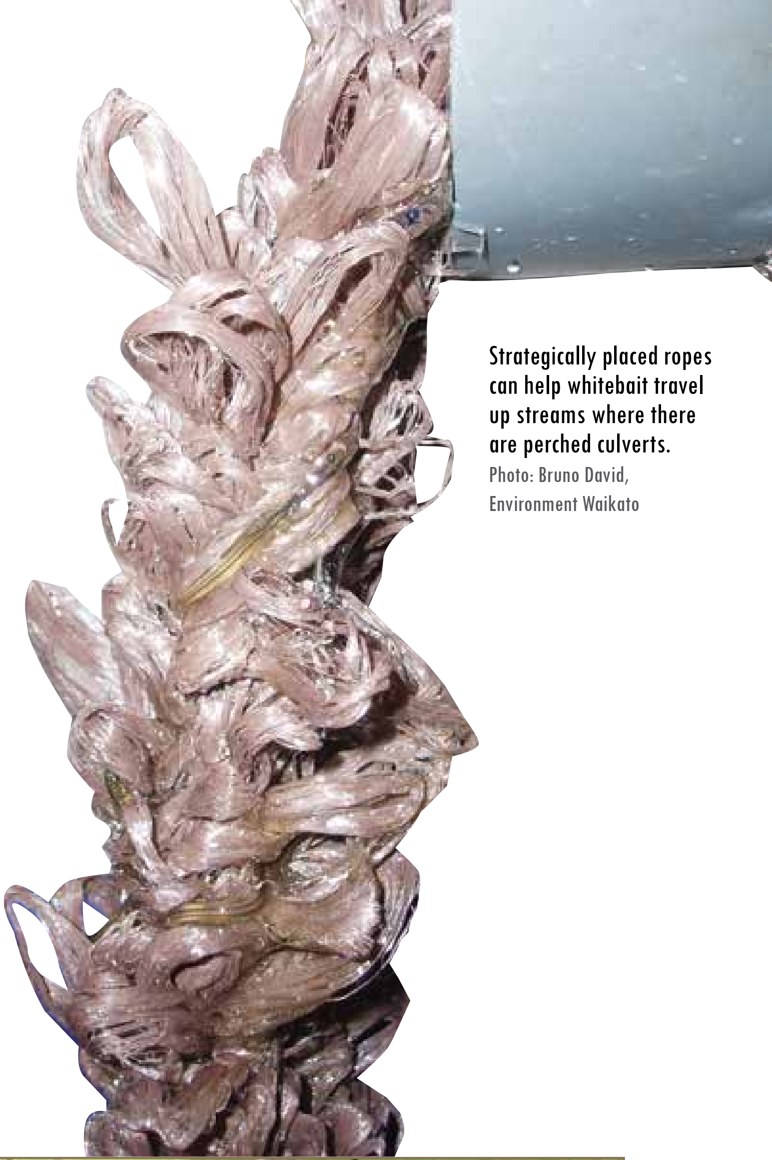
Short finned eels (*Anguilla australis*), whitebait/ inanga (five separate galaxiid species), and giant kokopu (*Galaxias argenteus*) are some of the native fish that live in wetlands for some or all of their lives. These fish are diadromous, in other words they travel between fresh and salt water. To complete their lifecycles, they journey to and from the sea along rivers, streams and drains. Whitebait has similar needs. Whitebait is the collective term for giant, banded and short jawed kokopu (*Galaxias argenteus, G. fasciatus and G. postvectis*), inanga (*Galaxias maculatus*), and koaro (*Galaxias brevipinnis*). Their eggs hatch in autumn and the larvae are washed out to sea. Six months later as juveniles they return to streams and wetlands, some migrating over 100 kms upstream from the sea. Juvenile kokupu and koaro can even climb up damp rocks alongside steep waterfalls to reach sheltered streams and wetland habitats. Wetlands are also home to our native freshwater crab, pea mussel and crayfish/koura (*Paranephrops* spp.).

Although birds, plants and many insects can migrate into newly restored wetlands from surrounding areas, the colonization of aquatic habitats by fish is only possible if they are linked to other habitats via rivers, streams or ditches. In other words, creating an isolated pond within a wetland is unlikely to result in fish being found there. Long stretches of fast-flowing or polluted water, flap gates, or over-hanging culverts act as impassable barriers for fish movement. Instead, native fish need streams with fairly clear water, shading and cover, though bear in mind that pest fish will also use these routes to invade wetlands (see Chapter 11 – Pests).

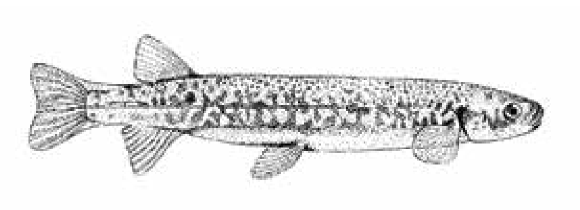


Short-finned eel/tuna.
Drawing: Sonia Frimmell

Giant kokopu. Photo: Stephen Moore, Landcare Research



Strategically placed ropes can help whitebait travel up streams where there are perched culverts.
Photo: Bruno David, Environment Waikato



Whitebait/inanga.
Drawing: Sonia Frimmell

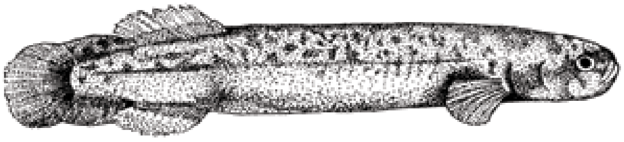
Coromandel potter Barry Brickell uses discarded plates and bowls to create novel fish ladders in the Driving Creek Wetland Sanctuary.
Photo: Monica Peters, NZ Landcare Trust

Perched culvert preventing fish passage. Raglan, Waikato.
Photo: Monica Peters, NZ Landcare Trust

HELP FISH FIND YOUR WETLAND BY:

- ensuring watercourses (natural and manmade) connected to wetlands are at least 10 cm deep
- planting overhanging plant species (flax and sedges) for shelter and to keep the water cool
- placing a hay bale at the head of a ditch entering your wetland to act as a simple silt trap as muddy water limits their vision and reduces their food supply of aquatic insects
- leaving one side of drains untouched when you are cleaning them
- placing culverts low in the stream bed to enable fish passage through them
- roughing up the bottom of long culverts with, e.g., concrete and rubble or ropes to slow the speed of the water

– *www.ecan.govt.nz "Wetland wildlife"*



Mudfish.
Drawing :Sonia Frimmell

Mudfish (five species located in the North, South and Chatham Islands, all classified as threatened) spend their entire lives in wetlands or other habitats such as drains or weed-filled creek beds. In contrast to diadromous fish, mudfish (*Neochanna* spp.) are able to burrow deep into mud or under logs where they aestivate (hibernate) for weeks at a time during dry spells. In doing so, mudfish occupy a unique niche not accessible to other fish. However, at other times, mudfish still fall prey to introduced fish like trout and mosquito fish, which also impact on other native fauna. Creating isolated ponds just for mudfish where these predators can not gain access may be the key to their survival in our wetlands.

Canterbury mudfish (*Neochanna burrowsius*) habitat. Hororata, Canterbury. Photo: Sjaan Charteris. Crown Copyright, Department of Conservation

2.3 Invertebrates, lizards and other native fauna

Although wetland restoration projects are often focussed on introducing, maintaining and/or enhancing populations of wetland fish, birds and lizards, it is also important to consider the invertebrates. Despite their small size, invertebrates perform key roles in many ecosystem processes, including pollination of wetland plants, litter decomposition and nutrient cycling, soil aeration, herbivory, seed dispersal and predation. Invertebrates also provide a source of food for native vertebrate populations. For example, many of the small snails, crustaceans and midges that live in wetlands are important components of the diets of fish and wading birds. Typical wetlands can have hundreds of unseen invertebrate species – both terrestrial and aquatic.

Encouraging aquatic invertebrates into restored wetlands is relatively easy. Small drains can easily be blocked, turning flowing water into standing water. This was successfully done at Bullock Creek, a small wetland on the West Coast (north of Greymouth). Though now under the stewardship of DOC, the wetland had been subject to human disturbance for over a hundred years. Part of the restoration included blocking drains to raise the water table, which enabled wetland plants to re-establish. Invertebrate communities within the drains were also monitored to assess the effect of drain blockage. The resulting invertebrate community became increasingly similar to those found in natural wetlands, suggesting blocking the drains helped return the wetland to a more natural condition. The fascinating thing about this work was that, apart from the initial drain blocking, no further actions were taken, yet the invertebrate community changed itself and began to resemble those in other natural wetlands.

Terrestrial invertebrates will also disperse into restored wetlands relatively quickly if the habitat created is favourable – 'if you build it, they will come!' To encourage invertebrates provide habitats that include dead logs, a dense leaf litter and native vegetation. Other important factors are controlling those pest animals that are predators and competitors (see Chapter 11 – Pests), and creating a 'green corridor' between other wetlands or native bush areas. Experiments undertaken at Torehape peat mine (Hauraki Plains) showed that insect communities dispersed into restored habitats using 'stepping stones' of native vegetation. The furthest distance insect communities (particularly beetles) were able to travel over bare ground was 400 m, highlighting the importance of green corridors and the presence of a source population of insects to colonise restored areas.

Even the smallest inhabitants of wetlands, such as the nursery web spider, are often overlooked, despite their important ecological role. Te Hapua, Wellington. Photo: Monica Peters, NZ Landcare Trust

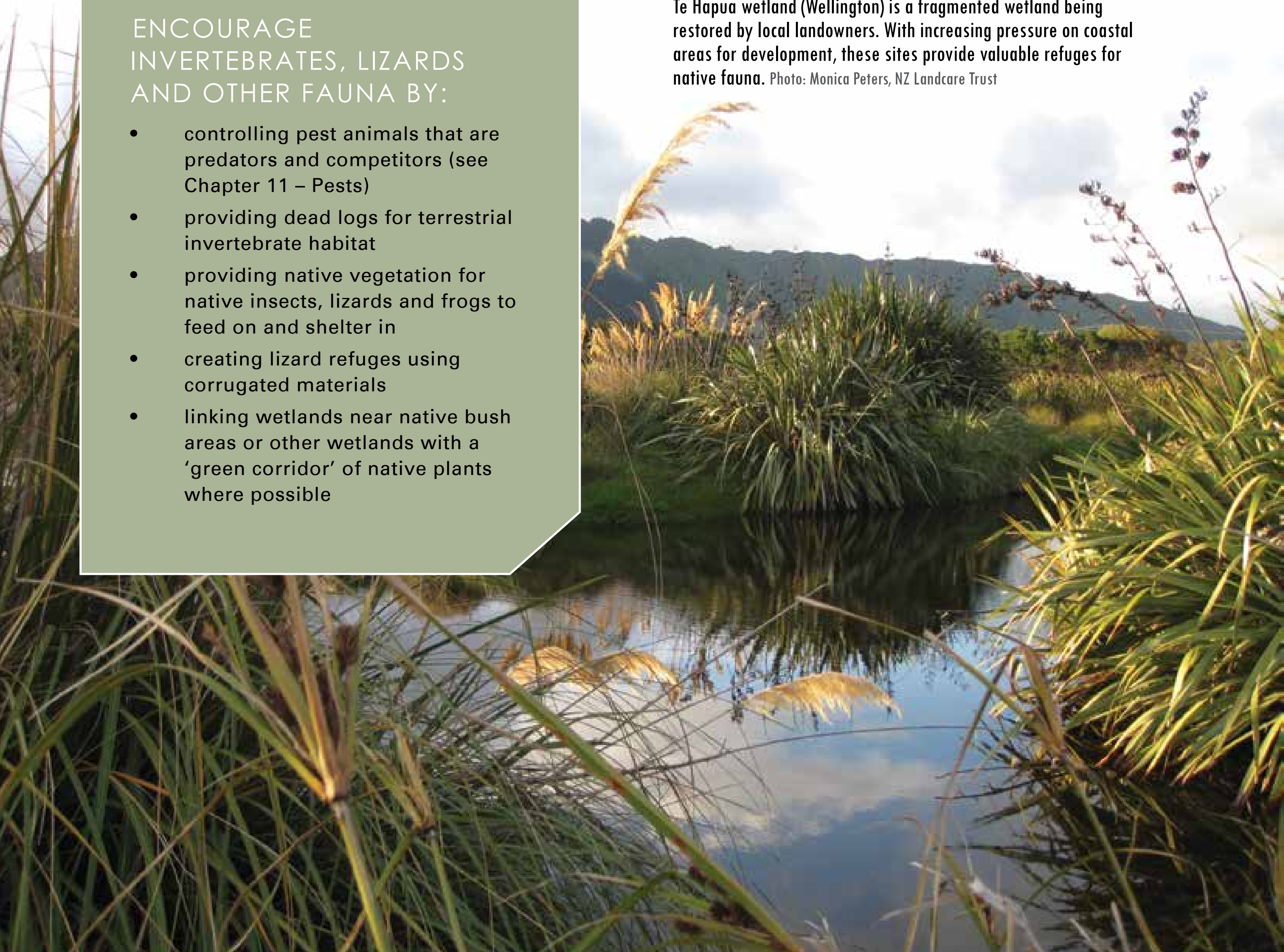
Lizards are omnivores, eating a variety of insects such as moths and flies, as well as fruit (from, e.g., *Coprosma* spp.) and nectar from flowers. Lizards, like other invertebrates, also help disperse seeds and pollinate some species of native wetland plants. Simple shelters for lizards can be made from stacking 2–3 sheets of corrugated roofing material, using small stones as spacers between the layers (see photo). Shelters can be placed around the edges of a wetland in dry sunny areas with good shrub or tussock cover. Lizards are extremely sensitive to disturbance so minimise any intrusions. While providing a safe haven from predators, the lizard shelters can also help track of lizard populations in the wetland – see the monitoring section at the end of the chapter for further information.

In most cases, frogs found in/near wetlands are likely to be exotic – only one native frog is found in damp areas such as alongside streams. Hochstetter's frog (*Leiopelma hochstetteri*) is widely distributed in the northern half of the North Island; at least 10 fragmented and isolated populations have been documented. The frog, however, is listed as vulnerable and this is due to the ongoing destruction and modification of its habitat both directly (e.g., afforestation, gold mining, storm water discharge) and indirectly (e.g., erosion caused by feral goats and pigs leading to waterway siltation). The frogs are nocturnal. The 3 introduced frogs, namely the green and golden bell frog (*Litoria aurea*), southern bell frog (*Litoria raniformis*), and brown tree frog (*Litoria ewingii*), are all found in wetland habitats, though their distributions vary.

ENCOURAGE INVERTEBRATES, LIZARDS AND OTHER FAUNA BY:

- controlling pest animals that are predators and competitors (see Chapter 11 – Pests)
- providing dead logs for terrestrial invertebrate habitat
- providing native vegetation for native insects, lizards and frogs to feed on and shelter in
- creating lizard refuges using corrugated materials
- linking wetlands near native bush areas or other wetlands with a 'green corridor' of native plants where possible

Te Hapua wetland (Wellington) is a fragmented wetland being restored by local landowners. With increasing pressure on coastal areas for development, these sites provide valuable refuges for native fauna. Photo: Monica Peters, NZ Landcare Trust



An artificial retreat made of two layers of Onduline, which attracts lizards because it absorbs heat and provides shelter and protection from predators. Photo: Marieke Lettink, Fauna Finders

In the 19th century at least 8 species of frogs were imported into New Zealand, though only three, including the green and golden bell frog, established populations that still exist today. Photo: D. Garrick. Crown Copyright, Department of Conservation

The green skink (*Oligosoma chloronoton*) is a large diurnal skink known from wetlands and other habitats in the southern South Island. Photo: Marieke Lettink, Fauna Finders

As ground dwelling predators, Carabid beetles are commonly found in drier fens and bogs. They “stink” when disturbed and are not palatable to mammals. Photo: Danny Thornburrow, Landcare Research

The larva of the native chafer beetle (*Odontria* sp.) eats the roots of wetland plants and is readily identified by its “c”-shaped body. Photo: Danny Thornburrow, Landcare Research

Hochstetter’s frogs are hard to locate as they are well camouflaged and nocturnal. Coromandel. Photo: Gregory Sherley. Crown Copyright, Department of Conservation

CASE STUDY

RANGITATA RIVER: CONSERVATION ACTION FOR THE UNIQUE WRYBILL

Maintaining and enhancing (restoring) the values of the wetlands, rivers and lakes of the upper Rangitata River and Ashburton Basin (O Tū Wharekai) is being undertaken by the Department of Conservation (DOC) as part of the Arawai Kākāriki Wetland Restoration Programme. One of the main objectives of this work is to protect threatened wetland fauna.

A species in decline

The wrybill (*Anarhynchus frontalis*) population is in decline, with less than 5000 remaining. Wrybills nest almost exclusively on braided rivers on the east coast of the South Island, and the upper Rangitata River (part of the O Tū Wharekai wetland restoration project) is recognised as a national stronghold for breeding wrybill.

Nest selection – adapting to the environment

Wrybill nesting requirements on the upper Rangitata River were studied over the 2008/09 breeding season. Wrybills showed a preference for a specific habitat type: fine gravels with no significant vegetation, on elevated gravel beds, and situated on spits or islands. This allows incubating birds a clear view of the surrounding environment allowing them to react to approaching predators.

Concerns for conservation

Only a small proportion of the study area matched these habitat criteria – large sections of river had no breeding birds. Finer gravels are close to the channels and are highly vulnerable to large flood events. The 2008 wrybill breeding season was characterised by two major flood events that effectively removed a high proportion of the first and second breeding attempts. Broom (*Cytisus* spp., an invasive exotic species) appears to displace wrybill from potential breeding habitat due to the threat of predation. Wrybills choose well-elevated parts of the river to nest, often on gravel spits. These areas are often used for vehicle access, increasing the potential for nests to be run over. Feral cats, ferrets and hedgehogs are frequently detected on the riverbed. Norway rats, possums, stoats and weasels are also detected, and all prey on wrybill nests. Large plants like broom provide cover for predators, which gives wrybills little opportunity to distract predators away from the nest. Black-backed gulls are a native predator of wrybills. This study showed wrybills avoiding nesting near a black-backed gull colony, despite being situated in ideal wrybill habitat.

Targeted management

The location of wrybill nests appears to be quite predictable. Understanding habitat requirements has assisted with targeted monitoring and management, with extensive control programs for broom and lupin by DOC and local landcare groups to maintain the mobile shingles, braids and lack of cover that are characteristic of their habitat. Ultimately, this increased knowledge ensures resources for weed and predator control are allocated where they are most effective.

– *Peter Langlands and Wendy Sullivan, Department of Conservation*

REF: www.doc.govt.nz/documents/conservation/land-and-freshwater/wetlands/Otuwharekai/o-tu-wharekai-outcomes-report-web.pdf

Female wrybill incubating with good vision around the nest . Photo: P. Langlands. Crown Copyright, Department of Conservation

Ideal wrybill habitat with 4WD tracks within metres of a nest. Photo: P. Langlands. Crown Copyright, Department of Conservation

3 Monitoring

Encouraging native fauna into your wetland is an ongoing project and requires a long-term commitment. This chapter outlines several commonly used approaches for recording increases in native fauna. Being able to quantify increases will help with designing appropriate pest animal control programmes – once a resident native bird population has been established pest control may be intensified before and during the breeding season (see Chapter 11 – Pests, for possible methods). In addition, monitoring will help you develop a general understanding of the site and how it responds to restoration efforts. Knowing, for example, what types of food resources are available at the restoration site can provide valuable insights on factors influencing the success of any species translocations.

Setting up a monitoring programme will require input from experts. Scientists from DOC, Landcare Research and Regional Councils can assist with information on the most up-to-date and appropriate methods and equipment to use, as well as which permits you may require. Established community groups may also be able to pass on valuable advice based on practical on-ground experience. A number of web-based identification guides in addition to books are available and are listed at the end of the chapter. For additional information on monitoring overall wetland restoration success, see also Chapter 13 – Monitoring).

3.1 5-minute bird count

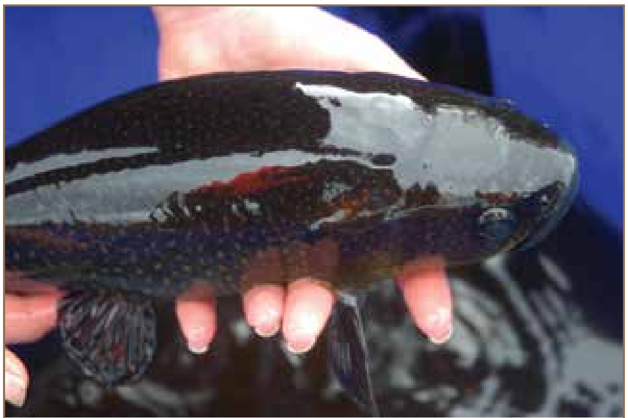
In a 5-minute bird count the observer records the number and species of all birds seen and heard. Each bird is only counted once. As with other index counts, it is important to remember that a 5-minute bird count does NOT result in an accurate count of all birds present. The numbers recorded are used to indicate the number of birds present, though many factors need to be taken into account including observer skill levels and hearing ability, bird habitat preferences and bird visibility.

Bird counting stations can be set up throughout the wetland. These should be at least 200 m apart to avoid duplication of bird calls from one station to another. Small wetlands therefore may only have one station. In larger wetlands, stations should be distributed so that they cover all vegetation types. In the original method (Dawson & Bull 1975) 200 m was specified as the cut off distance for recording birds. Though many current studies don't stipulate an actual cut off distance, it is recommended not to record birds that are obviously very far away (e.g., on the other side of the valley). The number and species of all birds seen and heard should be documented along with the station location, name of person doing the bird count, date, start time, temperature, wind, other noises, sun, and precipitation. The DOC website listed at the end of the chapter details the method more fully and includes field sheets and digital data entry sheet.

Additionally, keep an annual list of bird sightings and observations throughout the year. Information on specific monitoring of bird populations, e.g., threatened species, can also be accessed via the DOC website.

A careful investigation around the base of dense wetland vegetation may yield whitebait/inanga eggs. Canterbury.
Photo: Sjaan Charteris. Crown Copyright, Department of Conservation

Inanga eggs. Canterbury.
Photo: Sjaan Charteris. Crown Copyright, Department of Conservation



The giant kokopu usually waits for its prey (e.g., koura, spiders and cicadas) in sheltered places with overhanging vegetation, logs, or debris clusters. Photo: Crown Copyright, Department of Conservation

3.2 Fish trapping

Many wetlands contain populations of native fish and restoration should encourage these populations to thrive. To detect whether fish are present in your wetland simply shine a flashlight into the water at night as this is when many native freshwater fish species are most active. Contact DOC for standard methods for monitoring fish, especially if threatened species such as mudfish are involved.

A basic monitoring method is to use traps or fyke nets. It is, however, worth noting that each type of sampling gear has a bias toward different fish species so it pays to use a range of methods to get a full picture of the fish community. The traps and nets are easy to use and if set properly are unlikely to kill fish. Set up in a secure place overnight, for example, under overhanging stream banks or vegetation. Mark the spot with flagging tape so the traps can easily be found the next morning. It is important to leave an air gap at the top of the traps and nets because water in wetlands can become de-oxygenated overnight. Care should also be taken to avoid setting gear during floods when water levels can drop and expose fish. As well as trapping native fish, you may also trap unwanted introduced fish such as Gambusia/mosquito fish, koi carp or catfish. In this case you should contact DOC as this information could help the Department and other interested parties keep track of the spread of these species. See also Chapter 11 for information on pest fish.

Populations of the threatened mudfish can be monitored by setting unbaited traps overnight and counting, measuring and releasing the fish the next morning. Using a permanent station, traps can be set once a month for several months, avoiding the mid-summer to early autumn period if water becomes scarce. Alternately, mudfish fry can be observed in pools during the day. The case study on Fensham wetland in Chapter 13 – Monitoring, demonstrates how mudfish monitoring has been integrated into a wider programme of wetland restoration monitoring. The group received guidance from both the Regional Council and DOC.

3.3 Lizard and frog counts

Lizard retreats as described in Section 2.3 can also be used to gain a snapshot of presence/absence without any handling. Handling hazards requires a permit (see Section 1.4.1 – Keeping it legal). Another basic method that doesn't involve any handling is tracking tunnels. These are made from light-weight plastic and contain a pre-inked tracking card. U-shaped pins secure the tunnel to the ground. Food, e.g. banana, honey or tinned pear, is placed on the ink free section in the centre of the card. The lizard stands on the inked section while eating, and the ink is then transferred from the lizard's feet to the ink-free ends of the card. This method provides a useful record of presence/absence and can help estimate abundance. Footprint guides (see Useful websites section at the end of the chapter) will highlight the difference between gecko and skink tracks, though not between species. Tracking tunnels can also be used for frogs and some invertebrates as well as for pests (see Chapter 11).

Gecko tracks showing front and hind foot tracks and tail drag.
Image: www.gotchatraps.co.nz

3.4 Terrestrial invertebrate trapping

Invertebrate communities often change as a result of restoration activities. The success of restoration activities can be measured by comparing invertebrate communities in the restored wetland with those in similar but natural wetlands. If the communities become similar, the restoration could be considered successful.

Tracking tunnels (see previous section) can be used for larger invertebrates such as weta. Pitfall traps are small containers filled with a preservative solution (e.g., antifreeze), which are dug into soil. Invertebrates that fall into them are preserved for collection, identification and counting. The containers are shielded from the rain (e.g., with a plastic plate wired to the cup). A small amount of detergent is added to break the surface tension on the liquid contents, preventing insects from escaping.

Malaise traps are designed to capture low-level flying invertebrates, guiding them into a container for later identification and counting. A structure shaped like a small tent traps invertebrates emerging from the ground as well as those flying within about a metre of the ground. Though more time consuming to set up than pitfall traps, malaise traps sample a greater range of invertebrates.

3.5 Aquatic invertebrate trapping

Monitoring aquatic invertebrates as part of wetland restoration projects is relatively easy – it just takes time and a bit of practice. Collecting invertebrates is best done with a small, fine-meshed net that is swept through the different habitats within the wetland, for example, in the water column, along the bottom, and among any submerged plants. The contents of the net are then examined to search for the many different types of invertebrates. It helps to spread some of the sample evenly across a white tray with bit of water in it, and then search for the swimming and crawling invertebrates. Some, such as beetles, dragon flies and midges, are relatively easy to see, while others are much smaller and are best seen with a magnifying glass or a small microscope.

Malaise trap set up in the Ramsar listed Kopuatai peat dome, Waikato. Photo: Danny Thornburrow, Landcare Research

Although setting up a pitfall trap is relatively straightforward, analysing the results, i.e. identifying the insects and counting them, can be very time consuming. Photo: Danny Thornburrow, Landcare Research

A hand-held net with fine mesh (usually 0.5 mm) will greatly assist in the collection of freshwater invertebrates from wetlands. South Westland. Photo: Brian Sorrell, NIWA

6 References and further reading

Crowe, A. 2002. *Which New Zealand insect?* Penguin Books, New Zealand.

Dawson, D.G. and Bull, P.C. 1975. *Counting birds in New Zealand forests*. Notornis 22: 101–109.

Moon, G. 2009. *New Zealand wetland birds and their world.* New Holland, New Zealand.

Winterbourn, M. J., Gregson, K. L. D. and Dolphin, C. H. 2006. *Guide to the aquatic insects of New Zealand*. Bulletin of the Entomological Society of New Zealand 14: 1–108.

Suren, A.M. and Sorrell, B. K. 2009. *Aquatic invertebrate communities within New Zealand wetlands: characterising spatial, temporal, and distribution patterns.* Department of ConservationScience for Conservation Report, New Zealand.

6.1 Useful websites

Wetland restoration templates

Waikato Regional Council Wetland Restoration Plan templates

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate1.pdf

www.waikatoregion.govt.nz/PageFiles/5799/Wetlandtemplate2.pdf

Wetland restoration guides and factsheets (New Zealand)

Northland Regional Council

www.nrc.govt.nz/upload/2217/Wetland%20Restoration%20Guide%20(second%20edition%20Feb%2009).pdf

Auckland Regional Council

www.arc.govt.nz/albany/fms/main/Documents/Environment/Plants%20and%20animals/wetlandsfacts2.pdf

Waikato Regional Council

www.waikatoregion.govt.nz/Environment/Natural-resources/Water/Freshwater-wetlands/

Hamilton City Council

www.gullyguide.co.nz/index.asp?pageID=2145821537

Bay of Plenty Wetlands Forum

www.doc.govt.nz/upload/documents/conservation/land-and-freshwater/wetlands/wetland-restoration-guide.pdf

Greater Wellington

www.gw.govt.nz/a-beginner-s-guide-to-wetland-restoration/

Department of Conservation Protecting Natural Areas Design Guide

www.doc.govt.nz/publications/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project-/nature-heritage-fund/protecting-natural-areas-design-guide/

Wetland restoration guides (International)

USA Environmental Protection Agency

www.epa.gov/owow/wetlands/pdf/restdocfinal.pdf

Native fauna fact sheets and identification guides

Birds

www.whatbird.co.nz

www.nzbirds.com

www.brownteal.com/

Freshwater Fish

www.doc.govt.nz/conservation/native-animals/fish/facts/

www.niwa.co.nz/our-science/freshwater/tools/fishatlas?a=26663

www.doc.govt.nz/upload/documents/about-doc/concessions-and-permits/conservation-revealed/nz-native-freshwater-fish-lowres.pdf

www.nhc.net.nz/index/fresh-water-fish-new-zealand/freshwater-fish.htm

www.mudfish.org.nz/mudfishInfo.html

www.igrin.co.nz/trisha/black%20mudfish.htm

Invertebrates (terrestrial and aquatic)

www.landcareresearch.co.nz/research/biosystematics/invertebrates/invertid/

Reptiles and Frogs

www.doc.govt.nz/conservation/native-animals/reptiles-and-frogs

www.nzfrogs.org

www.reptiles.org.nz

Monitoring native and introduced fauna

5 minute bird count methods, field sheets and digital data entry sheet

www.doc.govt.nz/conservation/native-animals/birds/five-minute-bird-counts/

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=54:5minbird&catid=52:landmethods&Itemid=74

Footprint Identification Guide for tracking tunnels

www.rimutakatrust.org.nz/downloads/download.htm

www.gotchatraps.co.nz/html/photo_gallery.html

Protocols for using wax tags

www.pestcontrolresearch.co.nz/docs-monitoring/waxtagprotocol.pdf

Bird counts, setting up photopoints, pest animal transects

www.formak.co.nz

Foliar browse index

nvs.landcareresearch.co.nz/html/FOLIAR_BROWSE_INDEX.pdf

Freshwater Fish

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=53:fish-surveying&catid=51:watermethods&Itemid=75

Lizards and frogs

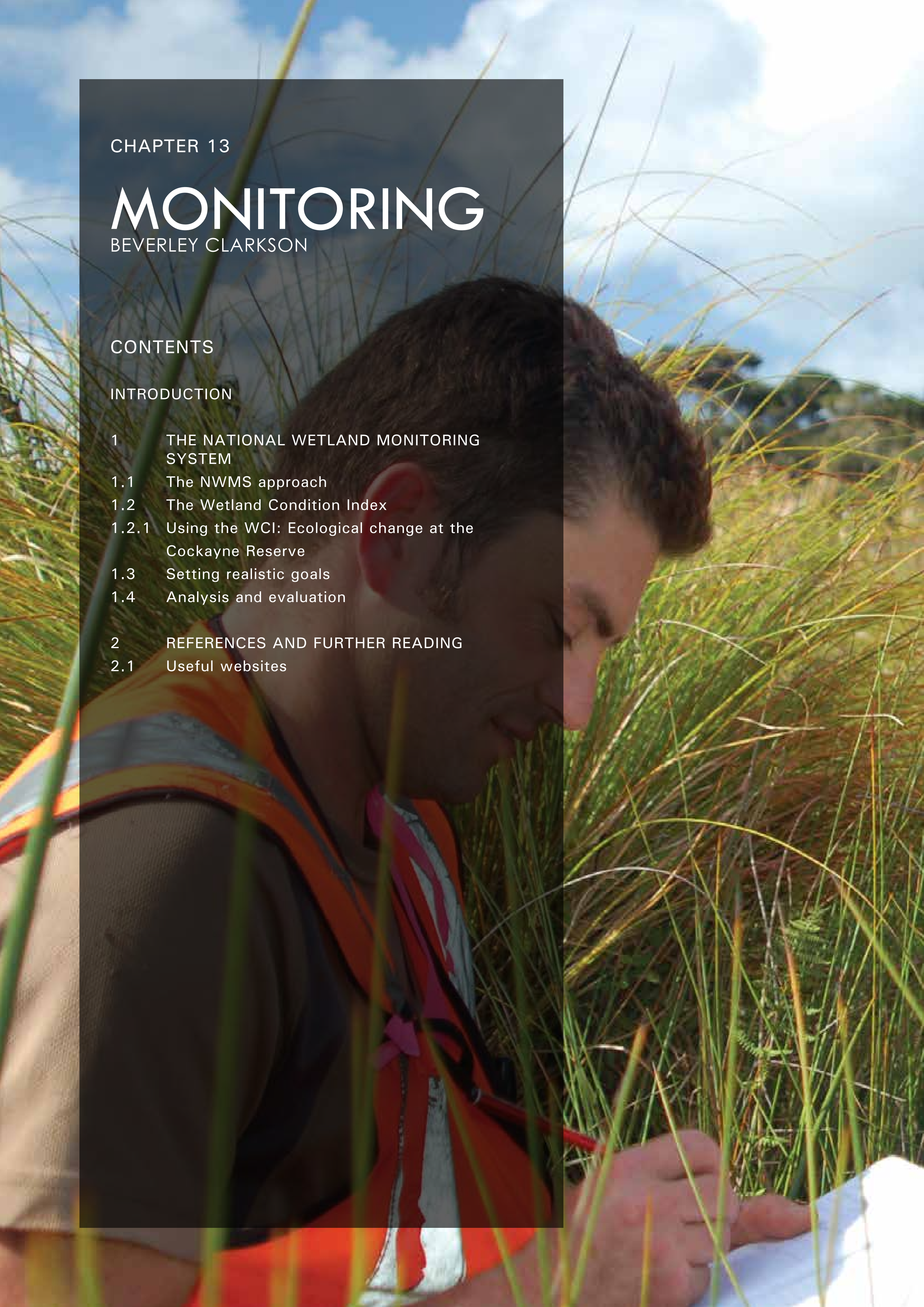
www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=90:tracking&catid=52:landmethods&Itemid=74

www.gotchatraps.co.nz/html/photo_gallery.html

Invertebrates (terrestrial and aquatic)

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=55:inverts&catid=52:landmethods&Itemid=74

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.



CHAPTER 13

MONITORING

BEVERLEY CLARKSON

CONTENTS


MONITORING

MONITORING

BEVERLEY CLARKSON

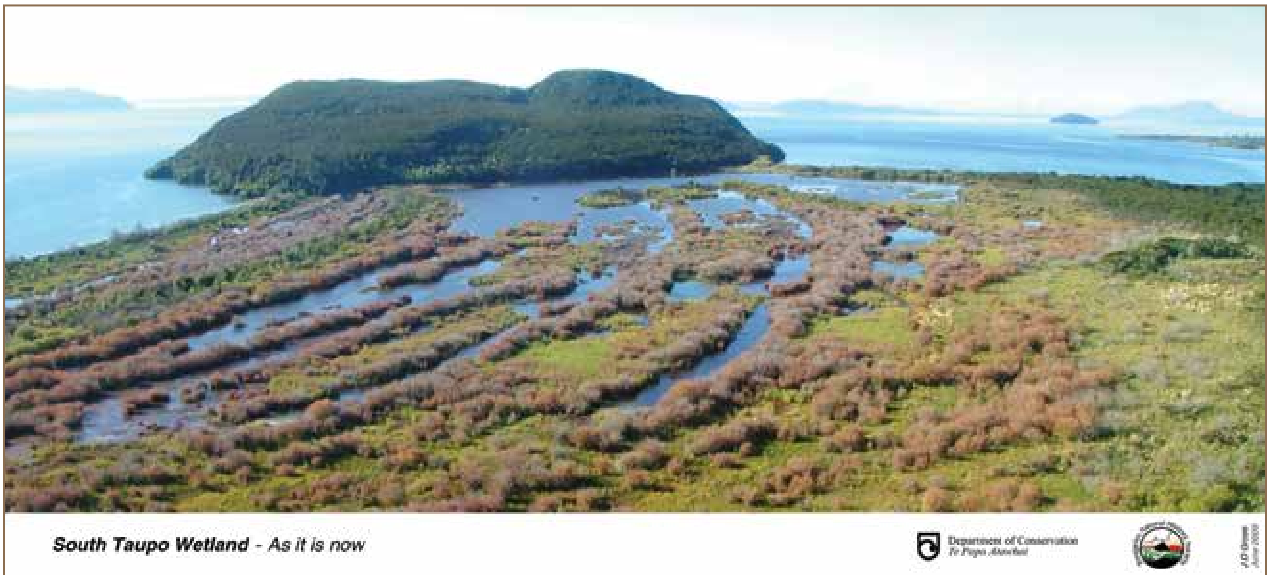
Monitoring is more than just collecting data. It is about gaining an insight into how the wetland functions (reflected as ecological condition) and how these functions change over the course of the restoration. Developing a robust monitoring system is essential for measuring the direction of change over time and assessing the effectiveness of restoration efforts. Changes can be either positive, reflecting improvement, or negative, thus triggering the need for remedial action.

Data alone, for example, from bird monitoring or native plant establishment though valuable, only represent one aspect of how successful the restoration has been. To determine the overall success of the restoration a wide range of data is required, from small plot or sampling station scale, to broad whole-wetland or catchment scale. It involves regular field reconnaissance (recce) and survey, ground-truthing and collection of data. This chapter brings together the methods outlined in previous chapters (Chapters 7–12) for monitoring key components of wetland ecological condition, namely hydrology, nutrients, weeds, native flora, pest species and native fauna. Key indicators linked to these components form the basis of the New Zealand National Wetland Monitoring System, which will enable you to answer the ultimate question: "How has the condition of the wetland changed due to restoration efforts?"

Although developing a monitoring programme and collecting data may seem complex to non-scientists, the two case studies in this chapter show how strong partnerships were used to provide the expertise for designing the restoration programme as well as measuring overall restoration success. The methods used in the case studies are also included in the monitoring sections of previous chapters.

Previous page: Vegetation and hydrological monitoring at Lake Rotopouka, Northland. Photo: Danny Thornburrow, Landcare Research

Carrying out a recce by kayak at Waimarino, Lake Taupo.
Photo: Department of Conservation and Tongariro Natural History Society



Waimarino Before. Photo: Department of Conservation and Tongariro Natural History Society

Long-term vegetation monitoring will determine whether on-going willow and weed control have resulted in returning Waimarino swamp to a system dominated by native species. Lake Taupo. Digitally enhanced. Photo: Department of Conservation and Tongariro Natural History Society

1 The National Wetland Monitoring System

The National Wetland Monitoring System (NWMS) was developed specifically for New Zealand wetlands (Clarkson et al. 2003). It provides a useful framework for restoration projects to assess changes in the ecological condition or health of your wetland. The system includes assessment before restoration, setting realistic short-term and long-term goals, scoring restoration components, and evaluating overall restoration success.

The first stage of the NWMS is to undertake a detailed inventory of your wetland. This includes maps and descriptions of the main vegetation types and habitats, flora and fauna species lists, and other features of interest, e.g., presence and abundance of threatened species (see Chapter 2 – Restoration planning). Establishing permanent vegetation plots, and fauna and hydrological monitoring stations is recommended as these provide quantitative data to set baselines and to track changes over time. These data are very important in scoring the condition of the wetland as accurately as possible.

1.1 The NWMS approach

The NWMS approach involves a systematic comparison and evaluation process integrating data gathered from small-scale permanent plots, fauna stations, hydrological stations, etc., as well as whole wetland assessments, e.g., extent of willow coverage, proportion remaining of the original wetland area and species lists. The overall ecological condition of the wetland is compared against an assumed natural state, such as pre-settlement. It is scored using five indicators to reflect the extent and impact of the modification where a high degree of modification = low score. The indicators relate to the major threats known to damage wetlands and are based on changes in:

- Hydrology
- Soils/nutrients
- Ecosystem intactness
- Native animal dominance (‘pest-free’ measure)
- Native plant dominance (‘weed-free’ measure)

The sum of the indicator scores provides an “index” for the ecological condition of the wetland, known as the Wetland Condition Index (WCI). The table below shows how the monitoring methods outlined in Chapters 7 – 12 are linked to the NWMS. The quantitative data these methods provide contribute to calculating the WCI.

WHAT SKILLS ARE NEEDED?

Depending on the type of monitoring carried out, the main skills needed generally include basic data analysis; good data management (making sure information is recorded and data not lost); and specialist identification (flora, fauna) skills. While data can be presented in hand-written reports with diagrams on graph paper, it is quicker and easier to use computer programmes such as Word and Excel to draw graphs and write up results. The monitoring report can be a concise one page summary for circulation among key restoration stakeholders.

– *Adapted from the Fensham Wetland Monitoring Guidelines 2004*

Some tools of the trade for carrying out bird counts: map, (waterproof) notebook, pencil and bird identification guide. Photo: Nelson Mail

Table 1. Integrating Handbook monitoring methods with the National Wetland Monitoring System

Indicator	Indicator components	What to look for	Monitoring method	Relevant Handbook chapters
Change in hydrological integrity	Impact of man-made structures	Number/size/depth/effectiveness/ coverage of man-made structures (drains, stopbanks, tide gates, etc.) within wetland and in catchment. Extent of wetland affected by structures. Includes permanent flooding changes.	Dipwells and piezometers	7 – Hydrology
	Water table depth	Water table decline (need long-term data), loss/decline of species requiring high water table, e.g., aquatic and semiaquatic species such as bladderwort.	Dipwells and piezometers, permanent plots	7 – Hydrology
	Dryland plant invasion	As above, but presence/increase of dryland species/vegetation.	Permanent plots, transects, recce, survey	9 – Weeds 10 – Revegetation
Change in physico-chemical parameters	Fire damage	Recent fires evident from loss of late successional vegetation, (e.g., wirerushland replaced by sedgeland), sparse vegetation cover, charred trunks of woody species, visible ash deposits. Fires >2 years ago discernible from ash/charcoal layers in soil cores, absence/rarity of fire-sensitive species (e.g., *Carex secta* in swamps, *Sporadanthus* in bogs).	Recce, survey, aerial photos, photo points, permanent plots	4 – Site interpretation 1 8 – Nutrients
	Degree of sedimentation/ erosion	Recent earthworks or freshly dug drains in the catchment. Abrupt change in soil colour. Plants partially buried by sediment. Suspended sediments.	Recce, survey, sampling stations, soil/ water analyses, sediment cores	4 – Site interpretation 1 5 – Site interpretation 2
	Nutrient levels	Changes (mainly increases) in soil/ water N, P & pH, foliage N:P ratio (from plot data), loss/decline of species adapted to oligotrophic conditions (especially slow-growing stress tolerant plants, e.g., *Empodsima, Sporadanthus*), change in phytoplankton composition, e.g., from diatoms to large filamentous Cyanobacteria.	Recce, survey, sampling stations, soil/ water analyses	4 – Site interpretation 1 8 – Nutrients
	von Post Index	Squeeze technique – decomposition low if only water escapes through fingers, high if peat escapes. Loss of peat forming species, e.g., *Empodisma, Sphagnum*.	von Post Index, permanent plots	7 – Hydrology 9 – Weeds 10 – Revegetation

Indicator	Indicator components	What to look for	Monitoring method	Relevant Handbook chapters
Change in ecosystem intactness	Loss in area of original wetland	Usually monitored over time in databases by mapping exercises, often from aerial photography or historical information. Visual evidence at individual wetlands in the absence of any existing information can be observed in soil cores, presence of remnants of wetland vegetation in old wetland areas, topography or obvious reclamation.	Range of methods including comparison of extent with historical maps, historical records, topo maps (look for drains), aerial photos, catchment recce and survey	4 – Site interpretation 1
	Connectivity barriers	Presence of tide gates, stop banks, weirs isolating system from riverine connections to other wetlands. Ring drains and box culverts around margin isolate wetland from catchment groundwater. Loss of riparian vegetation and buffer vegetation connecting wetlands to native forests, lakes and rivers.	Recce, survey, aerial photos, maps	4 – Site interpretation 1
Change in browsing, predation and harvesting regimes	Damage by domestic or feral animals	Browse damage to foliage, branchlets; soft, herbaceous, palatable plant species absent or greatly reduced in number and stature. Animal tracks visible in wetland. Damage to bark, e.g., biting and scratching. Disturbance to substrate, e.g., deer wallows, pig rooting, pugging of soil. Adequacy and extent of fencing.	Foliar Browse Index, plot data, recce, survey	4 – Site interpretation 1 11 – Pests
	Introduced predator impacts on wildlife	Direct evidence from bird, fish, pest animal datasets. Indirect evidence from predator tracks, scat counts. Presence of sensitive species such as fernbird, bittern and banded rail would indicate low predator impacts.	5-minute bird counts, native fauna and pest trapping (aquatic and terrestrial), tracking tunnels, recce, survey, species lists	4 – Site interpretation 1 11 – Pests 12 – Native Fauna
	Harvesting levels	Recent vegetation harvesting readily observed; longer term effects may be evident in absence of key species from communities where they typically occur.	Foliar Browse Index, recce, survey	4 – Site interpretation 1 11 – Pests
Change in dominance of native plants	Introduced plant canopy cover	Cover of introduced plants in permanent plots and, especially, increase of introduced plants over time. Changes in extent of exotic plant coverage. Changes in number of exotic species recorded.	Permanent plots (e.g., along invasion gradients), transects, aerial photos, high vantage points, recce, survey, ground truthing, species lists	4 – Site interpretation 1 9 – Weeds 10 – Revegetation
	Introduced plant understorey cover	Canopy composition and historical information will give clues to understorey composition, e.g., long-established willow forest will likely have low native understorey.	Permanent plots, transects, recce, survey, species lists	4 – Site interpretation 1 9 – Weeds 10 – Revegetation

The invasive yellow flag iris, one of the many weeds found in the Cockayne Reserve.
Photo: Rohan Wells, NIWA

Yellow flag iris, detail of flower.
Photo: John Clayton, NIWA

Paul Champion (NIWA) assessing the condition of the highly modified Cockayne Reserve, Christchurch.
Photo: Kerry Bodmin, NIWA (with permission from DOC)

1.2 The Wetland Condition Index

The Wetland Condition Index (WCI) can be used for goal setting and evaluation by assessing the wetland before restoration, and identifying where improvements can be made. The WCI can provide a useful framework for restoration projects when applying for funds as goals can be clearly defined and evaluated for each phase. Hence, incorporating a national system of project reporting and evaluation in a Wetland Restoration Plan should add value to any funding application. Future plans include a website where WCI data can be entered to enable, e.g., comparisons between different projects or across regions.

Each of the five indicators (hydrology, soils/nutrients, ecosystem intactness, native animal dominance and native plant dominance) has several components, which are compared against an assumed natural state (e.g., pre-European) and scored out of 5 (5 ='natural' condition). Indicator component scores are averaged to produce a score out of 5 for the indicator, and summed to provide an overall WCI score out of a maximum of 25. Follow the guidelines provided in the Handbook for Monitoring Wetland Condition (Clarkson et al., 2003) for assessing and assigning the scores. The system is flexible enough to add any monitoring component to the basic model (as Table 1 shows). Alternatively, the system can be adapted to suit your own restoration project – the case studies included in this chapter are good examples of this.

The tables below show how the indicators were used to show changes in the wetland condition at the 3 ha Cockayne Reserve, an isolated wetland fragment within Christchurch City.

1.2.1 Using the WCI: Ecological change at the Cockayne Reserve

In pre-European time the Cockayne Reserve and surrounding land comprised a mosaic of swamp and estuarine vegetation. The area was fed by the extensive freshwater dune swales upstream and the brackish Avon River and Avon-Heathcote Estuary downstream. The Reserve is now highly modified by surrounding residential development, and has a history of fire, eutrophication, and altered hydrology. It is artificially divided into a freshwater area (approximately two-thirds of total area) and an estuarine area by a stopbank.

Table 2. Using the WCI to determine pre-restoration wetland condition: Cockayne Reserve 1982

Indicator	Indicator components	Specify and Comment	Score 0– 5[1]	Mean score
Change in hydrological integrity	Impact of man-made structures	Extreme: Stopbanks, roads, housing have completely modified original hydrology. One small connection to estuary remains	1	0.67
	Water table depth	No water supply	0	
	Dryland plant invasion	Dry soils have allowed extensive invasion.	1	
Change in physico-chemical parameters	Fire damage	Entire area repeatedly burnt due to vandalism	0	0.5
	Degree of sedimentation/erosion	Little wetland character now remains in soils	1	
	Nutrient levels	No data available	–	
	von Post index	N/A	–	
Change in ecosystem intactness	Loss in area of original wetland	Extreme – almost all natural character lost	0	0.5
	Connectivity barriers	Extreme – no connections upstream, many barriers downstream	1	
Change in browsing, predation and harvesting regimes	Damage by domestic or feral animals	No stock access. Potential access by small feral animals but no evidence of impacts	5	3.67
	Introduced predator impacts on wildlife	Little habitat remains for wildlife, and drying of wetland allows full access to predators	1	
	Harvesting levels	None	5	
Change in dominance of native plants	Introduced plant canopy cover	Tall fescue and yellow flag iris have almost replaced all native species	1	1
	Introduced plant understorey cover	Tall fescue and yellow flag iris have almost replaced all native species	1	
Total wetland condition index /25				6.34

[1] Assign degree of modification as follows: 0=extreme, 1=v high, 2=high, 3=medium, 4=low, 5=v low/none

Compare the condition of the Reserve in 1982, (after being degraded by repeated recent fires and the spread of weeds such as tall fescue and yellow flag iris) with the condition of the Reserve in 2000 once restoration had begun.

Table 3. Using the WCI to determine current wetland condition: Cockayne Reserve 2000

Indicator	Indicator components	Specify and Comment	Score 0– 5[1]	Mean score
Change in hydrological integrity	Impact of man-made structures	Very high: Stopbanks, roads, housing have completely modified original hydrology. Artificial bore supplies freshwater area, one artificial channel links estuarine area to river	1	2
	Water table depth	Highly modified: dry in some areas and stagnant in others	2	
	Dryland plant invasion	Dryland plants now a minor component	3	
Change in physico-chemical parameters	Fire damage	Entire area burned in the past but fire-sensitive species recovering over most of area	3	2
	Degree of sedimentation/ erosion	Very high: excessive Typha growth has been allowed to accumulate a deep layer of anaerobic sediment	1	
	Nutrient levels	Both N and P highly elevated in soils and vegetation	2	
	von Post index	Not applicable	–	
Change in ecosystem intactness	Loss in area of original wetland	Extreme – all natural original vegetation destroyed in the past and current system is artefact of management interventions	0	0.5
	Connectivity barriers	Very high – freshwater section isolated entirely from other waterways, estuarine connection limited	1	
Change in browsing, predation and harvesting regimes	Damage by domestic or feral animals	No stock access. Potential access by small feral animals but no evidence of impacts	5	4
	Introduced predator impacts on wildlife	Evidence of predator trails (stoats) in and around wetland, but some native birdlife remains	2	
	Harvesting levels	None	5	
Change in dominance of native plants	Introduced plant canopy cover	Low in estuarine area but tall fescue is co-dominant in freshwater area	4	3
	Introduced plant understorey cover	High in both areas, particularly freshwater where many adventive species are present. Purple loosestrife and yellow flag iris both common	2	
Total wetland condition index /25				11.5

[1] Assign degree of modification as follows: 0=extreme, 1=v high, 2=high, 3=medium, 4=low, 5=v low/none

By 2000, considerable recovery had occurred due to management interventions. Planting of native species and restoration of a water supply had restored some natural character, although weeds were still widespread. However, poor water exchange had allowed the raupo biomass to increase dramatically, leading to excessive sedimentation and in-filling. The score therefore reflects an overall improvement but identifies those issues still causing problems.

CASE STUDY

WORKING IN PARTNERSHIP: MONITORING FENSHAM WETLAND

Fensham Wetland (west of Carterton) contains one of the best lowland forest remnants on the Wairarapa Plains, as well as a small wetland that supports the nationally endangered brown mudfish (*Neochanna apoda*). The 3 ha wetland is being restored, the goal being to "Restore the wetland to sustainable natural state" (Fensham Wetland Restoration Plan 2001). The Fensham Group has received technical support and assistance from Greater Wellington under the 'Take Care – Environmental Programme'.

The comprehensive Fensham Wetland Monitoring Guidelines (2004) details methods on how to monitor wetland hydrology, water quality, the mudfish population, natural plant regeneration and survival. Additional information includes updating the plant species list, carrying out surveillance for pest species, and using photo points. Monitoring forms to record data are also included. Several examples from the Guidelines are highlighted below.

Mudfish population trends

Monitoring will show long-term trends in population numbers.

METHOD: Unbaited traps are set overnight at 6 sites (marked by posts). The following morning, the number of fish in the traps are counted and measured. Frequency: Check traps monthly July–Dec.

DATA MANAGEMENT: Present data in Annual Report and forward data to DOC Wairarapa Office. Contact DOC mudfish experts if mudfish numbers decline.

Brown mudfish. Photo: Stephen Moore, Landcare Research

Plant survival

Monitoring how many plants survive in areas with weed problems (e.g., sweet grass) will help determine which species work best and where, and will save on planting effort and numbers of plants used.

METHOD: Record number of plants planted, species, size (e.g., PB 2) and location. Record general comments (e.g., plant health and environmental conditions when planted including water depth, etc., who planted them). Record weed control method and frequency. Frequency: All plantings should be monitored when they are put in the ground; and in January for at least 3 years.

DATA MANAGEMENT: Summarise numbers of plants, species and size, where planted and how many survived annually. Make revised recommendations on species to use etc. for next year's planting programme if necessary.

Water quality

Fertility has a major influence on wetland plant communities. High nutrient conditions favour highly competitive, fast growing, wetland plants – often exotics. Nutrients enter the wetland from the catchment. Monitoring will pick up any changes to management of the catchment that signals changes in nutrient levels. Nitrate nitrogen and Dissolved Reactive Phosphorus are the key indicators measured.

METHOD: There are two water quality monitoring points. Either arrange with the water quality scientist based in Greater Wellington's Masterton Office to process the samples or contact a commercial laboratory at c.$40 per site. Frequency: Take samples twice per year (first week of Dec and last week of June).

DATA MANAGEMENT: Compare data with previous years, and between monitoring points.

REF: www.gw.govt.nz/assets/council-publications/Fensham_monitoring_guidelines.pdf

Young sedges are protected in order to become established amongst the rank grasses. Photo: Beverley Clarkson, Landcare Research

Sedges once established and with the plastic sleeves removed, easily overtop pasture grasses. Photo: Beverley Clarkson, Landcare Research

1.3 Setting realistic goals

It is important to aim for a realistic improvement and time frame. For example a wetland goal could be to achieve 50% increase in wetland condition in 10 years (Wetland Condition Index increases from 12 to 18) by implementing staged fencing, pest and weed control, and planting programmes. Some indicators will be easier to improve than others, e.g., removal of stock by fencing the wetland will increase the pest-free indicator, while others, such as increasing the area of the wetland within an urban setting (see intactness indicator), may prove impossible.

1.4 Analysis and evaluation

Analysis and evaluation is based on changes in both the total score, and the scores of the individual indicators (and components therein). Investigate the data at all levels – wetland condition index, indicator, indicator components as well as underlying data, as there can be hidden trip-ups. For example, an improvement in the pest-free indicator by fencing a wetland may be offset by a decrease in the weed-free indicator caused by a subsequent rampant spread of, e.g., reed sweetgrass, yet the WCI remains unchanged. Analysis at different levels is important for interpreting successes and failures, as well as for refining restoration and/or adaptive management approaches. Although there will inevitably be setbacks and challenges, particularly in the early stages of restoration, monitoring and perseverance will be rewarded by markedly enhanced environmental, social and other benefits.

Vegetation monitoring, Wahakari. Despite being in Northland, drysuits come in handy! Photo: Rohan Wells, NIWA

Table 4: Wetland condition index: pre-restoration condition, and 5 & 10 year restoration goals

Indicator	2006 (pre-restoration)	2011 (year 5)	2016 (year 10)
Changes in: Hydrology	3.5	3.5	3.5
Soils/nutrients	2.8	2.9	3.0
Intactness	2.5	2.5	2.5
Native animal dominance	2.2	4.1	4.5
Native plant dominance	1	2	4.5
Total wetland condition index /25	12.0	15.0	18.0

In the above example, the goal is a 50% improvement in wetland condition from pre-restoration (2006) to 10 years after the project was started. In this case, site hydrology and overall intactness will be unchanged, demonstrating that these factors were beyond the scope of the 10-year restoration. However, progress in other areas will be achieved by increases in both native plant and animal dominance over introduced species and an overall improvement in soils and nutrient levels.

Drilling willow in Waimarino, Lake Taupo.
Photo: Tongariro Natural History Society

Reed sweetgrass is an aggressive invader that displaces native plants. Mapara Reserve, Te Kuiti. Photo: Monica Peters, NZ Landcare Trust

CASE STUDY

WAIWHAKAREKE: MONITORING REVEGETATION SUCCESS

The 60 ha Waiwhakareke Natural Heritage Park (www.waiwhakareke.co.nz) lies on the outskirts of Hamilton. The Park comprises a peat lake with remnant wetland vegetation within a largely pastoral catchment. The overall restoration goal is to reconstruct native lowland and wetland ecosystems once widespread in the Waikato Region. The project is led by the Hamilton City Council in partnership with The University of Waikato, Wintec, Nga Mana Toopu o Kirikiriroa Limited Resource Management and Cultural Consultants and Tui 2000. Replanting with natives began in September 2004. Monitoring is undertaken by the staff of the Centre for Biodiversity and Ecology Research at the University of Waikato.

Monitoring

Baseline monitoring plots were established during the early stages of restoration plantings to assess:

- Canopy cover/closure in plantings
- Plant health and survivorship rates
- Animal browsing impacts on plants
- Reproductive output of plants
- Groundcover composition

Methods

In Nov 2005 – Jan 2006, five monitoring plots ranging from 90 to 290 m^2 were established in each of four plantings of varied ages. Plot size varied according to planting size. Plots were permanently marked with wooden stakes spray-painted orange. White metal labels indicate the plot number and corner. Photopoints were also established for each plot.

Measures for all plantings within plots: height, width (longest and shortest axis perpendicular to ground surface), health (dead/poor/good), browse (presence/absence), weeds at base (live/dead) and flowers and fruits (presence/absence). Canopy % cover was calculated for each plot using measures of width to calculate the surface area covered by each plant.

Ground cover was assessed in each plot using a point-height intercept method. At 25 cm intervals along transects the ground cover species was identified and height recorded, an assessment was also made of whether the ground had been recently sprayed (dead/dying plants) at each intercept. Data were gathered for at least 125 points within each plot.

Recommendations

- Carry out plot monitoring including photopoints, annually (in the same season) for the first five years, then at 5-yearly intervals
- Establish further monitoring plots in new plantings to gain adequate coverage of site variability and variation in planting or maintenance techniques
- Fully exclude stock from planted areas
- Reduce rabbit and hare damage to small leaved shrubs (e.g., *Coprosma tenuicaulis*) by using older plants, plant protection sleeves or by pest animal control
- Mulching around plantings instead of spraying to control weeds may be more effective for herbicide-sensitive species such as Carex sedges
- Consider staking young woody trees in exposed situations

REF: www.waiwhakareke.co.nz/file/citygreen_hamilton-ecosystems-2-.pdf

Waiwhakareke (Horseshoe Lake) lies on the outskirts of Hamilton City. Photo: Karen Denyer, National Wetland Trust

Successful plant establishment: returning indigenous vegetation cover to a former pasture grass-dominated zone.
Photo: Karen Denyer, National Wetland Trust

2 References and further reading

Clarkson, B.R., Sorrell, B.K., Reeves, P.N., Champion, P.D., Partridge, T.R, and Clarkson, B.D. 2003 (rev. 2004) *Handbook for Monitoring Wetland Condition.*

www.landcareresearch.co.nz/publications/researchpubs/handbook_wetland_condition.pdf

2.1 Useful websites

Monitoring native and introduced fauna

5 minute bird count methods, field sheets and digital data entry sheet

www.doc.govt.nz/conservation/native-animals/birds/five-minute-bird-counts/

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=54:5minbird&catid=52:landmethods&Itemid=74

Footprint Identification Guide for tracking tunnels

www.rimutakatrust.org.nz/downloads/download.htm

www.gotchatraps.co.nz/html/photo_gallery.html

Protocols for using wax tags

www.pestcontrolresearch.co.nz/docs-monitoring/waxtagprotocol.pdf

Bird counts, setting up photopoints, pest animal transects

www.formak.co.nz

Foliar browse index

nvs.landcareresearch.co.nz/html/FOLIAR_BROWSE_INDEX.pdf

Freshwater Fish

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=53:fish-surveying&catid=51:watermethods&Itemid=75

Lizards and frogs

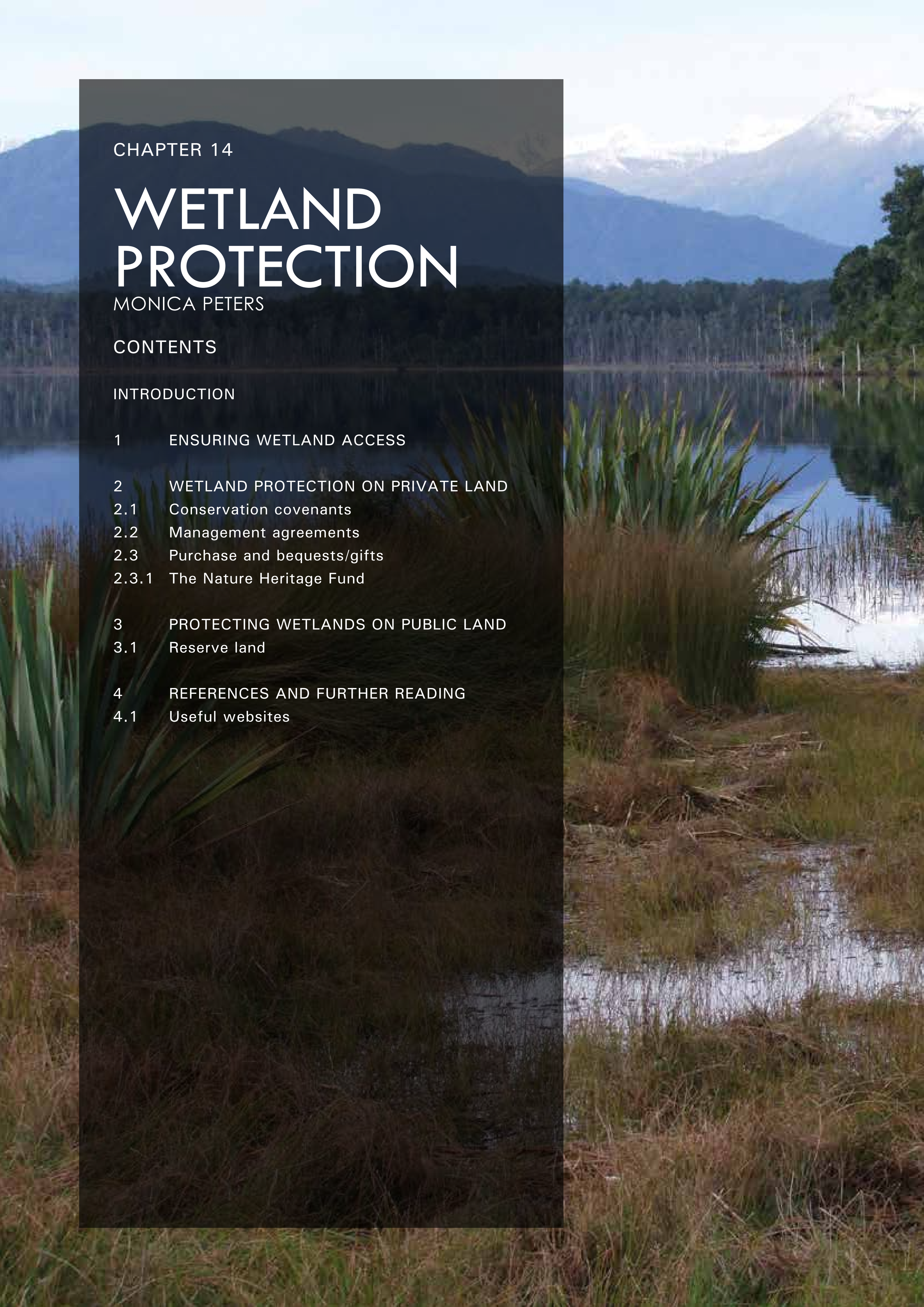
www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=90:tracking&catid=52:landmethods&Itemid=74

www.gotchatraps.co.nz/html/photo_gallery.html

Invertebrates (terrestrial and aquatic)

www.wildaboutnz.co.nz/index.php?option=com_content&view=article&id=55:inverts&catid=52:landmethods&Itemid=74

Note that many of the resources above are available as hard copy from the respective organisations. There is also a CD containing all above hyperlinks at the back of this Handbook. If you are using the online version of the Handbook and having problems with the hyperlinks above, try copying and pasting the web address into your browser search bar.

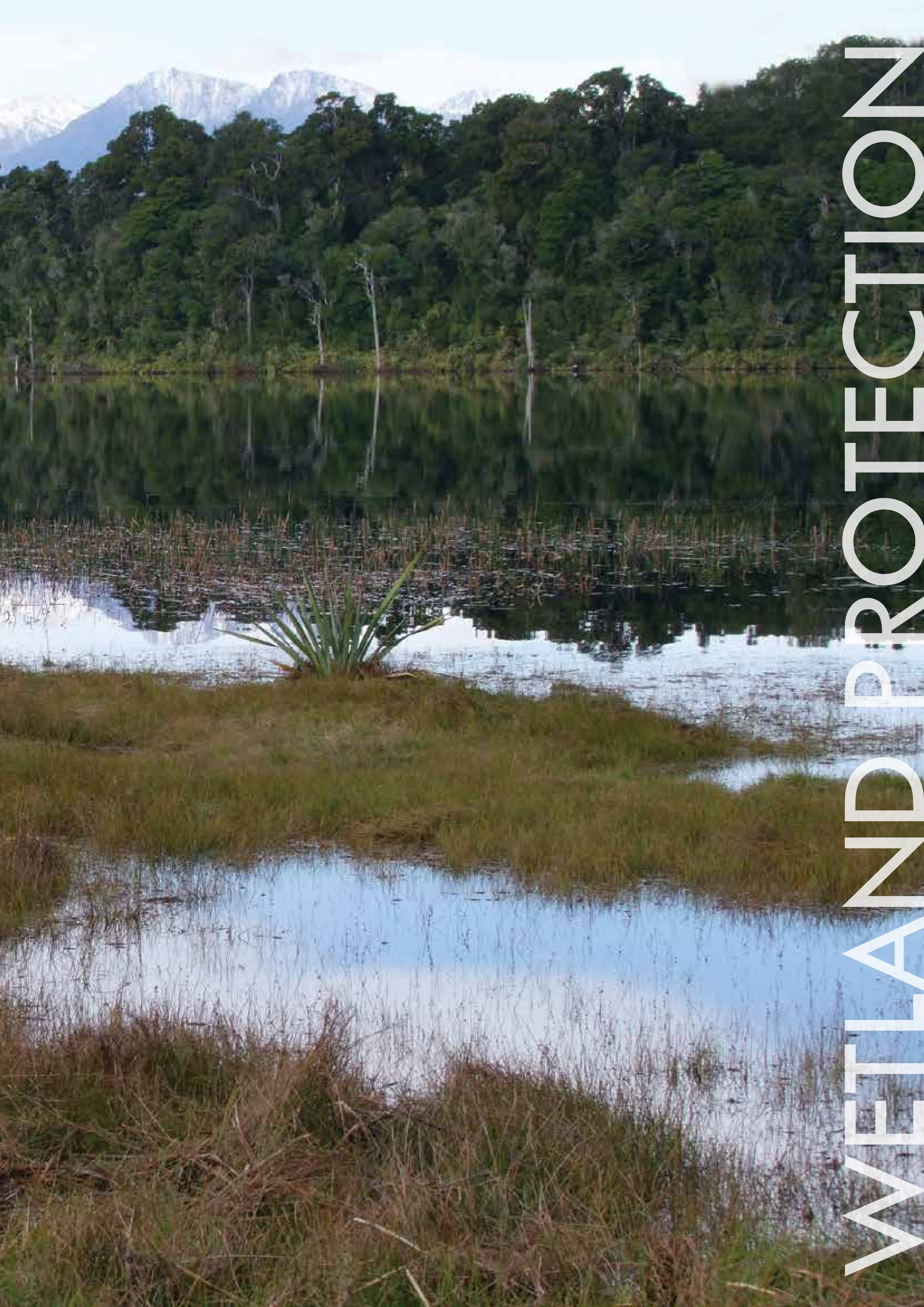


CHAPTER 14

WETLAND PROTECTION

MONICA PETERS

CONTENTS


WETLAND PROTECTION

WETLAND PROTECTION

MONICA PETERS

One third of the land across New Zealand is public land managed by the Department of Conservation. However, most of it is high country land, and our reserve network does not represent the full range of natural habitats or native species, particularly lowland ecosystems. Initiatives to restore and enhance habitats on privately owned land – and to protect them for the future – are therefore a valuable if not critical means toward preserving our unique natural heritage. Lowland wetlands have suffered enormously through urban and rural expansion, yet fewer than half of the 10% of wetlands that remain are legally protected, compared to 80% of remaining native forest areas.

There is a range of measures available to ensure the wetland (and the hard work that went into restoring it) remains protected for the longer term if not in perpetuity. Another consideration is securing access to the wetland if this entails crossing private land. This chapter outlines some of the main ways to protect wetlands on privately owned land in the intermediate and long term as well ensuring on-going access. A small section is also included on securing protection for projects on land owned by local authorities.

Previous page: The Lake Mahinapua Scenic Reserve was established in 1907 to protect the land around the Lake. West Coast.
Photo: Hugh Robertson. Crown Copyright, Department of Conservation

Baumea seed head.
Drawing: Monica Peters

While fences are a primary form of wetland protection, covenants can provide another level of protection altogether. Hikurangi swamp, Northland. Photo: Lisa Forester, Northland Regional Council

The privately owned wetland restoration is protected in perpetuity under a QEII National Trust "Open Space" covenant. Photo: Monica Peters, NZ Landcare Trust

1 Wetland protection on private land

1.1 Conservation covenants

A conservation covenant is a legally binding agreement between two or more parties to protect and manage a given site such as a wetland. A conservation covenant means the landowner will retain ownership and the site will be managed according to an agreement between you (or a future landowner) and the covenanting agency.

A starting point for considering a conservation covenant will depend on the goals and aspirations of landowners. Is the covenant a means toward gaining a resource consent or extra subdivision right? Protecting a unique part of the property? Enhancing the value of the property? Protecting an area, though not in perpetuity? Equally, the criteria for conservation covenants will differ according to a range of factors, such as:

- Geographical location, i.e. region or district council
- Ecological values (e.g., flora, fauna, representativeness within eco-region)
- Recreational or landscape values (e.g., gamebird hunting, fishing, sailing)
- Cultural values (e.g., mahinga kai)
- Nature of land tenure (e.g., public, private, Maori land)
- Funding available or achievable

Once agreed, the protected site (or sites) is noted on the title of the land. An advantage of covenanting is that you can ask for funding to assist with, e.g., surveys, and legal and fencing costs. Applications can also be made to local authorities for rates relief. Some examples of covenants follow:

QE II OPEN SPACE COVENANT

- Most common form of covenant on private land in New Zealand
- QEII National Trust is a non-government agency, an ideal option for those who prefer not to deal with local or central government
- Legally binding protection agreement for current and all subsequent landowners, registered on the title of the land
- Most QEII covenants are in perpetuity; however, covenants can be registered for a limited period of time depending on the status of the land to which the covenant applies
- Must meet minimum landscape or ecological value criteria
- QEII contributes funding towards fencing and legal costs
- There is no requirement to provide public access but conditions concerning things like fencing, pest and weed control, controls on vegetation or timber removal will be included in the agreement – the Trust works with landowners to ensure compliance and help with management
- In some cases land can be gifted to QEII

NGA WHENUA RAHUI KAWENATA

- Supports tangata whenua to retain ownership and control of their land, thus protecting cultural and spiritual values
- May be entered into in perpetuity; however, can be for a specified term or reviewed at intervals of not less than every 25 years, enabling tangata whenua to modify or extinguish the agreement

OTHER CONSERVATION COVENANTS

- Conservation covenants established under the Conservation Act (1987) run in perpetuity, i.e. apply to subsequent landowners
- Conservation covenants established under the Reserves Act (1977) run in perpetuity or for an agreed term
- A local council may place a condition on a resource consent requiring the applicant enter into a covenant, e.g., as a condition of a subdivision consent

Many of our lowland shallow lakes suffer from poor water quality; restoration and protection measures are the only way to halt further decline. Lake Kereta, South Kaipara Head.
Photo: Monica Peters, NZ Landcare Trust

1.2 Management agreements

Management agreements for conservation purposes are mostly entered into between landowners and a government agency, though in some circumstances they may be developed through other organisations such as the Waiau Fisheries and Wildlife Habitat Enhancement Trust. A significant advantage of management agreements is their flexibility – they can be negotiated to suit the nature of, and any special circumstances associated with, the site. They can also be negotiated around current land uses and landowner needs. The success of a management agreement will ultimately lie in how clearly the rights and obligations of each of the parties in the agreement are laid out, for example, who will be responsible for on-going site maintenance.

The rare fern, *Cyclosorus interruptus*. Matakana Island, Bay of Plenty. Photo: Monica Peters, NZ Landcare Trust

Opposite page: Originally privately owned, Seeley's gully was gifted to the Hamilton City Council and is well used as an education site for ecological restoration. Photo: Monica Peters, NZ Landcare Trust

1.3 Purchase and bequests/gifts

CONSERVATION ORGANISATIONS

- Bequests of land, or funds to buy land, can be made to groups such as Forest and Bird or the Native Forest Restoration Trust and are evaluated on a case-by-case basis
- A fund is often required or requested along with the bequest to assist with ongoing site management
- In some circumstances these organisations will raise funds to purchase areas of high ecological value from willing landowners
- These organisations will often secure the land with a QEII covenant or under the Reserves Act 1977
- Public access is usually anticipated

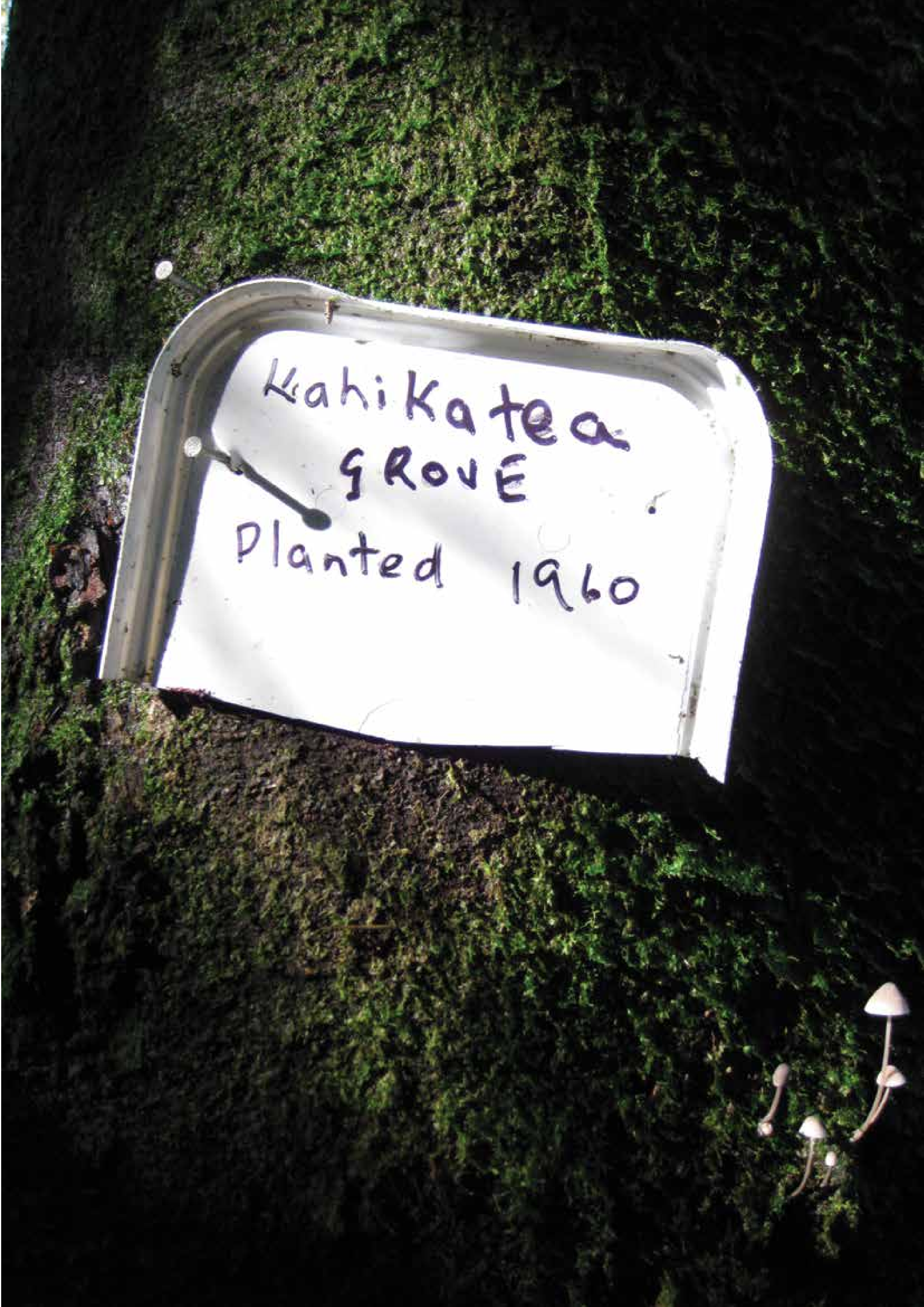
FISH & GAME NZ

- Local Fish & Game councils currently manage bequests and gifts
- Fish & Game NZ are currently developing a formalised process for gifting/bequeathing wetlands for sports fishing and game bird hunting
- The New Zealand Game Bird Habitat Trust also manages bequests and gifts

THE NATURE HERITAGE FUND

The Nature Heritage Fund provides contestable finance for projects that protect ecosystems. The Fund assists with direct purchase and with covenanting. It is administered by an independent committee and serviced by the Department of Conservation.

- Provides the finance and negotiates the purchase of areas in need of protection
- Contributes to purchases made by local authorities or other agencies prepared to manage protected areas as reserves under the Reserves Act 1977
- Provides assistance with funding for fencing, survey and legal costs associated with covenanting


Kahikatea
GROVE
Planted 1960

2 Protecting wetlands on public land

2.1 Reserve land

If the wetland restoration project is situated on City, District or Regional Council reserve land, one method of securing protection for ongoing works is to ensure it is included in the Long Term Council Community Plan (LTCCP). The LTCCP provides a long-term focus for the decisions and activities of the local authority. Consultation and submission processes provide an opportunity for the public to contribute to the decision-making about which activities should be prioritised. Raising the profile of a restoration project for potential incorporation into an LTCCP can be achieved in a number of ways, including:

- promoting the project to councillors and local politicians (e.g., inviting them to the restoration site in association with a community event or as a stand-alone visit)
- raising the profile of the project through media releases and coverage of events (e.g., community planting days)
- engaging the community (e.g., through educational programmes on or off site, planting days, pest control programmes, monitoring)

Don't assume that if a wetland is on council land its ecological values will be recognised and provided for. If the land is set aside for purposes such as recreation, for example, the council may seek to encroach on the wetland to build sports facilities. Ensure the wetland is identified in any reserve management plan for the site, and if the district or regional plan has a register of significant natural areas make submissions to the council to include the site in it. This will provide additional protection from development proposals such as roading or powerlines that may impact on the site.

Lake Ngaroto (Waikato) is a recreation reserve administered by Waipa District Council. Photo: Monica Peters, NZ Landcare Trust

Duck decoys. Photo: Abby Davidson, NZ Landcare Trust

One of the many reasons a landowner may choose to protect the wetland through formal means could be to ensure continued hunting opportunities. Lake Serpentine, Waikato. Photo: Monica Peters, NZ Landcare Trust

3 Ensuring wetland access

Access across privately owned land to the wetland restoration usually relies on the goodwill of landowners. If the wetland restoration site shares a boundary with privately owned land or is located within the boundaries of privately owned land, then an easement may be negotiated with the landowner. This formal agreement will help avoid any future access issues through, e.g., changes in land ownership. Survey and legal costs, however, can be quite significant even if the landowner grants an easement without requiring payment for the grant. Estimates of costs from professional advisers early in the process are highly recommended. Check with the district council first to find out if any easements or unformed 'paper roads' already exist.

Commnuity planting at Lake Serpentine, Waikato.
Photo: Abby Davidson, NZ Landcare Trust

4 References and further reading

Ewing, K. 2008. *Ecological Restoration and the Law: A Guide for Community Conservation Groups.* University of Waikato, Hamilton, New Zealand.cber.bio.waikato.ac.nz/images/URBAN_RESTORATION_Legal_Issues_Handbook_15_Dec_2008.pdf

4.1 Useful websites

Agencies

Department of Conservation

www.doc.govt.nz

Regional and District Councils

www.localcouncils.govt.nz/lgip.nsf

Non-government organizations

Fish & Game New Zealand

www.fishandgame.org.nz

NZ Landcare Trust

www.landcare.org.nz

Queen Elizabeth II National Trust

www.openspace.org.nz/

Royal Forest and Bird Protection Society

www.forestandbird.org.nz

National Wetland Trust

www.wetlandtrust.org.nz

Funding

www.doc.govt.nz/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project/funding/

www.asbcommunitytrust.org.nz/Links-resources-funders.html

Nga Whenua Rahui

www.doc.govt.nz/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project/funding/ngawhenua-rahui/nga-whenua-rahui-fund/

Native Forest Restoration Trust

www.nznfrt.org.nz/

Nature Heritage Fund

www.doc.govt.nz/getting-involved/volunteer-join-or-start-a-project/start-or-fund-a-project/funding/nature-heritage-fund/

Long Term Council Community Plan

www.lgnz.co.nz/library/files/store_011/LTCCP_Question_and_Answer_Fact_Sheet.pdf

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