Collective storytelling to improve freshwater ecosystem health through catchment community knowledge sharing

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To my children, Flint and Sophia

Our future generation

Ma te whakapono

Ma te tumanako

Ma te titiro

Ma te whakarongo

Ma te mahitahi

Ma te manawanui

Ma te aroha

Ka taea e mātou

By believing and trusting

By having faith and hope

By looking and searching

By listening and hearing

By patience and perseverance

By doing this with love and compassion

We can succeed

Abstract

Water, the lifeblood of Aotearoa New Zealand, sustains our identity and wellbeing; nonetheless, freshwater environments (lakes, rivers, wetlands and aquifers) are significantly impacted by humans. Aotearoa New Zealand has experienced one of the highest rates of agricultural land intensification internationally over recent decades, with almost 60,000 hectares of agricultural land converted from low producing to high producing between 1996 and 2018. With this rapid land use change, the pressures on freshwater quality are widespread and severe, resulting, for example, in only ten percent of Aotearoa New Zealand's wetlands remaining, 76 percent of indigenous freshwater fish species threatened with extinction or at risk of becoming extinct, and 46 percent of lakes larger than one hectare having poor to very poor ecosystem health due to excessive nutrients and contamination.

Many rural communities are actively working to restore Aotearoa New Zealand's freshwaters, demonstrated by the estimated 250 catchment care groups that operate across the country. Yet, a considerable barrier to widespread restoration remains - effective communication and knowledge sharing of freshwater restoration learnings between catchment communities. I identified four knowledge gaps relating to the communication of restoration activities which hinder progress: 1) *what* freshwater restoration knowledge is shared (e.g., inconsistent recording and reporting means that it has been difficult to accurately relate specific land management actions to improvements in freshwater ecosystem health), 2) *why* sharing is important and *why* catchment communities are compelled to share, 3) *how* freshwater restoration knowledge is shared (e.g., available tools for sharing restoration knowledge have been under-explored), and 4) *who* is best placed to share freshwater restoration knowledge (e.g., exploring the potential that stories and trusted storytellers can have in motivating catchment restoration). To bridge these gaps, I adopted a pragmatic, mixed methods approach between 2019 and 2023, to explore and test how freshwater restoration activities could be more effectively communicated.

To address knowledge gaps 1) and 2), I studied the willingness of land managers to share water quality improvement actions and identified motivators for recording and reporting of those actions. I conducted 23 face-to-face semi-structured interviews with food and fibre producers, tangata whenua, community members, government and industry representatives. Thematic coding identified three key themes that described motivators of these land managers to record and report land management actions: 1) collective engagement through collaboration with catchment care groups, 2) the importance of identity and social norms which related to land

managers being a 'socially approved' farmer by their peers, and 3) efficient farm management, whereby land managers could record and report their land management actions using a single, simple recording tool for multiple purposes.

To address knowledge gap 3), I consulted five freshwater restoration catchment groups using focus groups (N = 30) to explore how storytelling could be a tool for inspiring freshwater restoration action within and beyond their communities. Each group crafted a ‘Catchment Journey’, a graphical narrative depicting their land, people, and restoration efforts. While each Catchment Journey was unique, my thematic coding analysis revealed three common elements to be important in freshwater restoration knowledge sharing: 1) respected storytellers (or community champions) influence restoration in their community, 2) the responsibility to act is driven by concerns for future generations, land stewardship, prosperity, and community cohesion, and 3) authenticity, with genuine and honest stories that include weaknesses, threats, and hardship as well as successes.

To address knowledge gap 4), I used storytelling to explore the messenger's role in promoting freshwater restoration in rural catchment communities, tracking some of the processes involved in peer-to-peer knowledge exchange. I crafted two restoration stories—one voiced by a respected individual leader and the other by a collective catchment group and tested the effects of these stories through an online survey with rural community members (N = 82). Results were analysed using descriptive statistics and general linear models. Participants accepted both stories as trusted sources, with no differences between the individual and the collective voices. Participants considered both to be informative, containing new details.

Communities expressed the view that sharing their catchment stories could be a meaningful catalyst in inspiring large-scale restoration, emphasising the pivotal role of respected storytellers and authentic narratives, giving rural communities a ‘voice’ to share their extensive knowledge on sustainable land management. My study serves as a call to action, encouraging freshwater scientists, policy makers and implementors alike to place specific emphasis on the role collective engagement, social norms and effective farm management play in reporting land management actions (the *what* and *why*), while considering storytelling as a tool for sharing that knowledge (the *how*), through trusted messengers (the *who*). My research advocates for bottom-up engagement to improve the health of Aotearoa New Zealand's freshwater environments.

Co-authorship contributions – details of publications included in this thesis

Chapter	Paper title	Authors	Contribution of candidate and co-authors – please detail the nature and extent (%)	Journal	Status
FOUR	A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?	Doehring K.	Conceptualisation, Methodology – Development of interview schedule, Interviewing, Formal analysis, Writing – original drafts and revisions (85%)	Ecology & Society	published
		Longnecker N.	Supervision, Conceptualisation, Methodology – review and editing of interview schedule, Guidance on theoretical considerations, Writing – review and editing (6%)		
		Cole C.	Supervision, Conceptualisation, Methodology – review and editing of interview schedule, Guidance on theoretical considerations, Writing – review and editing (5%)		
		Young R.G.	Writing – review (2%)		
		Robb C.	Writing – review (2%)		

Chapter	Paper title	Authors	Contribution of candidate and co-authors – please detail the nature and extent (%)	Journal	Status
FIVE	Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change	Doehring K.	Conceptualisation, Methodology – Development of focus group schedule, Preparation and running of focus groups, Formal analysis, Writing – original drafts and revisions (85%)	Frontiers in Communication	published
		Cole C.	Supervision, Conceptualisation, Methodology – review and editing of focus group schedule, Guidance on theoretical considerations, Writing – review and editing (7%)		
		Young R.G.	Writing – review (2%)		
		Longnecker N.	Supervision, Conceptualisation, Methodology – review and editing of focus group schedule, Guidance on theoretical considerations, Writing – review and editing (6%)		

Chapter	Paper title	Authors	Contribution of candidate and co-authors – please detail the nature and extent (%)	Journal	Status
SIX	Trusted storytellers as freshwater knowledge brokers: individual and collective voices can both be effective	Doehring K.	Conceptualisation, Methodology – Development of focus group schedule, Preparation and running of focus groups, Data analysis cleaning, interpretation and application, Writing – original drafts and revisions (85%)	Kōtuitui: New Zealand Journal of Social Sciences Online	published
		Cole C.	Supervision, Conceptualisation, Methodology – review and editing of focus group schedule, Guidance on theoretical considerations, Writing – review and editing (6%)		
		Casanovas P.	Data analysis (4%)		
		Young R.G.	Writing – review (1%)		
		Longnecker N.	Supervision, Conceptualisation, Methodology – review and editing of focus group schedule, Guidance on theoretical considerations, Writing – review and editing (4%)		

Certification by Primary Supervisor:

The undersigned certifies that the above table correctly reflects the nature and extent of the candidate's contribution to this co-authored work.

Name: Nancy Longnecker Signature: Date: 26 February, 2024

Acknowledgements

Composing a PhD thesis is like embarking on a journey – similar to a water molecule morphing to be a river that travels from the mountains to the sea. Along this path, it encounters many different influences which shape its form and course. The rocks, trees and critters that live in and around the river turn that molecule into something more than a waterway. Together, they create an ecosystem where the whole is bigger than the sum of its parts. Throughout my PhD voyage, I've been nurtured by my own ecosystem of support which I would like to thank sincerely.

Firstly, to my supervisors, Professor Dr. Nancy Longnecker and Dr. Cathy Cole. Nancy, for introducing me to the world of science communication and making it such a rewarding experience. You always gave me the space and independence to take my research in the directions I chose, like a river meander, but kept me on track if I was at risk of overflowing my banks. Cathy, for your selfless support over the last three years. Standing by my side, despite moving to the other side of the world and growing your own family meant a lot to me. Both of you are beacons of inspiration, and I can't wait to see what science communication meanders we may create and travel together in the future.

I feel fortunate that I have such a large support network of brilliant minds that I could fall back on, regardless of whether I needed theoretical or ecological guidance. Within the Department for Science Communication, I would like to thank the Longnecker Lab for their support, friendship, scientific and life advice over the last four years, and Prof. Dr Hugh Campbell for your support early on. My Cawthron Institute colleagues, Mark Tadaki, Jim Sinner, Alaric McCarthy and Kiely McFarlane for their insights into the world of social sciences and critically questioning my research ideas. Joanne Clapcott and Roger Young for your guidance and discussions and for clearing my back from 'other' jobs so that I could finish this thesis on time. Thank you, Louisa Fisher and Susi Bailey for editorial support. I also would like to thank the Freshwater Team and my science communication colleagues Jonathan Puddick and McKayla Holloway for reminding me why science communication is so important.

I am grateful for the support that the National Science Challenge Our Land and Water has given me – not just financially. I thank my Healthy Waterways whānau (Aneika Young, Corey Ruha, Sylvia Tapuke, Christina Robb, Jonathon Alsop, Lesley Walls, Jamie Barter, Marie McCarthy) who helped shape the National Register of Land Management Actions platform so that it blossomed into something more than just a data compilation, but a knowledge sharing platform.

Without your mahi, my research would not have been possible. Thank you, Dr. Vicki Compton, for your insights from a Ministry of Primary Industry perspective and inspirational discussions about theoretical concepts throughout. Thank you also for the MPI Postgraduate Science Scholarship office for the financial support. I would also like to express my heartfelt gratitude to all participants in my studies who generously shared their expertise with me. Your trust towards me and willingness to open up your hearts and minds, and share your intricate and profound wisdom with me, is deeply appreciated.

The bedrock of my support lies within my friends and family. No water molecule would be channelled into a river without a riverbed guiding its way. Thank you, Mama and Papa, for nurturing my love for nature and fostering a mindset unafraid to think outside the square. Thank you to my New Zealand family, Yvonne, Donald, Amanda, Matt, Louis and Farrah for your constant support, teaching me to see the positive in challenges and your love. Thank you also to my friends, near and far, who reminded me that there are also other important parts to life than studying.

In every river ecosystem, there is one boulder that never shifts regardless of how forceful a flood may be. Blair, this is you – the rock I knew that was, and always will be there. Thank you for keeping me ’submerged’ when I was in fear to evaporate. Because of you believing in me (and your very pragmatic outlook to life), the water molecule has reached the estuary, morphing into something new, yet again. I look forward to exploring this next chapter with you.

To my children, Flint and Sophia, to whom I dedicate this thesis. Flint – thank you for your back- and head-rubs, for making me laugh with your wicked sense of humour, and for being ‘mein Grosser’. Sophia – thank you for the cups of tea, beautifully embellished with flowers and treats, for reminding me about how dancing and singing can help when in doubt. Thank you both for carrying on my curiosity in everything nature. I can’t wait to see how you will create your own ecosystems.

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Outputs from my work

As a science communicator, it was important for me to increase the reach of research beyond the scientific community, and to make it accessible for many audiences, including land managers, community groups, and local and national government. It's all about making sure research is seen, understood, and useful to different groups, helping to maximise its impact and practical application. During my PhD studies, I have used a mix of approaches to share my research findings to both academic audiences through publications and a wider community through conference interactions which I share below.

Scientific journal publications

Publishing in journals helped me share and validate my research with experts in my field, ensuring global reach. Chapters FOUR, FIVE and SIX have been published in peer-reviewed journals. All co-authors have agreed to the inclusion of the work in the thesis and their bibliographical details and contributions are outlined in the co-authorship form (p. v-vii). 'We' instead of 'I' has been used in the manuscripts to recognise the contributions of my co-authors.

Doehring, K., Longnecker, N., Cole, C., Young, R. G., & Robb, C. (2022). A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions? *Ecology and Society, 27*(4). https://doi.org/doi:10.5751/ES-13562-270425 (Chapter FOUR)

Doehring, K., Cole, C., Young, R. G. & Longnecker, N. (2023). Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change. *Frontiers in Communication, 7*. https://doi.org/10.3389/fcomm.2022.1061634 (Chapter FIVE)

Doehring, K., Cole, C., Casanovas, P., Young, R., & Longnecker, N. (2024). Trusted storytellers as freshwater restoration knowledge brokers: individual and collective voices can both be effective. *Kōtuitui:New Zealand Journal of Social Sciences Online*. https://doi.org/10.1080/1177083X.2023.2298914 (Chapter SIX)

Conference presentations

Presenting my research at conferences allowed me to share my findings to my fellow researchers as well as to science and policy implementors, enabling them to use the information in real-world situations. In the past, I have primarily attended and presented at the New Zealand Freshwater Sciences Society (NZFSS) Conferences, but I was eager to expand my audience to non-freshwater scientists and receive feedback for my work from fellow science communicators. Since 2021, I have therefore also attended the conferences by the Science Communication Association of New Zealand (SCANZ). All but one of these conferences were held in-person which allowed me to build new and foster existing relationships across both disciplines.

2023 | Doehring, K., Cole, C., Young, R., & Longnecker, N. (2023, June 3-7). *Restoring New Zealand's freshwaters through collective storytelling: inspiring catchment communities to make change from the bottom-up for our future generations* [Paper presentation]. Freshwater Sciences 2023 Conference, Brisbane, QLD, Australia.

2022 | Doehring, K., Cole, C., Young, R., & Longnecker, N. (2022, November 16-18). *Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change* [Paper presentation]. Science Communicators Association of New Zealand 2022 Conference, Dunedin, Aotearoa New Zealand.

2021 | Doehring, K, Cole, C., & Longnecker, N. (2021, November 11-19). *Restoring rivers at large scales: the power of storytelling as a tool to weave together catchment communities* [Paper presentation]. Science Communicators Association of New Zealand 2021 Conference, Virtual, Aotearoa New Zealand.

2020 | Doehring, K., Young, R., Tapuke, S., Alsop, J., & Longnecker, N. (2020, December 1-4). *Listen-up! What do rural communities have on their minds when discussing land management actions that help improve water quality?* [Paper presentation]. Aotearoa New Zealand Hydrological Society, New Zealand Rivers Group & New Zealand Freshwater Sciences Society Joint Conference 2020, Invercargill, Aotearoa New Zealand.

2019 | Doehring, K., Young, R., & Robb, C. (2019, December 1-4). *How can we quantify sustainable land use actions that improve water quality?* [Paper presentation]. New Zealand Freshwater Sciences Society & Australian Freshwater Sciences Society Joint Conference 2019, Geelong, Australia.

Mixed media

Driven by a commitment to democratise access to knowledge, promote transparency in science, and encourage public understanding of and involvement in freshwater restoration sciences, I use a range of communication techniques to talk about my research and share my findings. By engaging with the media, I aim to distil complex ideas into easily understandable messages, ensuring that the significance of my work reaches beyond the academic realm. Opinion pieces allow me to share my perspective and insights in a more personal and direct way, fostering a connection with readers who may not be familiar with freshwater science communication. Webinars provide an interactive platform for me to discuss my research, answer questions, and build a dialogue with diverse audiences. I especially enjoy meeting people face-to-face as part of public outreach activities. Being able to talk to people about my work in a space considered safe by the interested party (such as field days) has resulted in honest and real conversations. Insights through this type of communication have been incorporated into my research.

StoryMaps, online articles and opinion piece

2023 | StoryMap© – Rangitīkei Rivers Catchment Collective –
Collective voice: https://arcg.is/GOC4D; Individual voice: https://arcg.is/0L8Lmj

2023 | Our Land and Water website – New website will grow understanding of farmer and catchment group efforts – https://ourlandandwater.nz/news/new-website-will-grow-understanding-of-farmer-and-catchment-group-efforts/

2023 | Our Land and Water website – The power of storytelling: restoring rivers through knowledge sharing – https://ourlandandwater.nz/news/the-power-of-storytelling-restoring-rivers-through-knowledge-sharing/

2023 | FedsNews – https://www.fedsnews.co.nz/sharing-the-good-the-bad-and-the-ugly-is-key-to-ongoing-momentum-on-freshwater-quality/

2022 | Our Land and Water website – Solving one piece of the freshwater restoration puzzle at a time – https://ourlandandwater.nz/news/solving-one-piece-of-the-freshwater-restoration-puzzle-at-a-time/

2021 | Opinion piece: science communication must play a leading role in New Zealand's freshwater future – https://www.cawthron.org.nz/our-news/opinion-science-communication-freshwater/

Radio

2023 | Podcast – Farmers Weekly – https://www.farmersweekly.co.nz/people/champion-catchments-share-stories/

2021 | Doehring, K.: sci comms, Cawthron Radio

Webinars

2023 | Healthy Waterways Register webinar (https://vimeo.com/850792495)

2023 | Freshwater Science in Aotearoa New Zealand (https://vimeo.com/812944833); Webinar as part of the Freshwater Sciences 2023 Conference, Brisbane, QLD, Australia, 3-7 June 2023

2022 | Ministry for Primary Industries Science Seminar: National Register of Land Management Actions; 140 attendees (Chapter 2 and 3)

2021 | Connecting communities for effective farm plans (https://vimeo.com/490597240); Webinar for the National Science Challenge Our Land and Water covering results from farmer interviews.

Public outreach

2023 | 'Meet a freshwater scientist'; South Island Field Days; Kirwee; Freshwater Catchment Restoration, Wellington, Aotearoa New Zealand

2022 | 'Science communicator in action', National Catchment Forum, Wellington, Aotearoa New Zealand

Awards and scholarships

2023 | Science Communicators Association of New Zealand (SCANZ) Emerging Science Communicator Award – First place (https://www.scanz.co.nz/award)

2020 | Our Land and Water National Science Challenge – PhD Scholarship

2020 | Ministry for Primary Industries Postgraduate Science Scholarship

2020 | People's Choice Award – New Zealand Hydrological Society, New Zealand Rivers Group & New Zealand Freshwater Sciences Society Joint Conference 2020, Invercargill, Aotearoa New Zealand.

Online resources and platforms for knowledge recording and sharing

2024 | To be launched – Healthy Waterways Data Module on the Land Air Water Aotearoa website https://lawa.org.nz

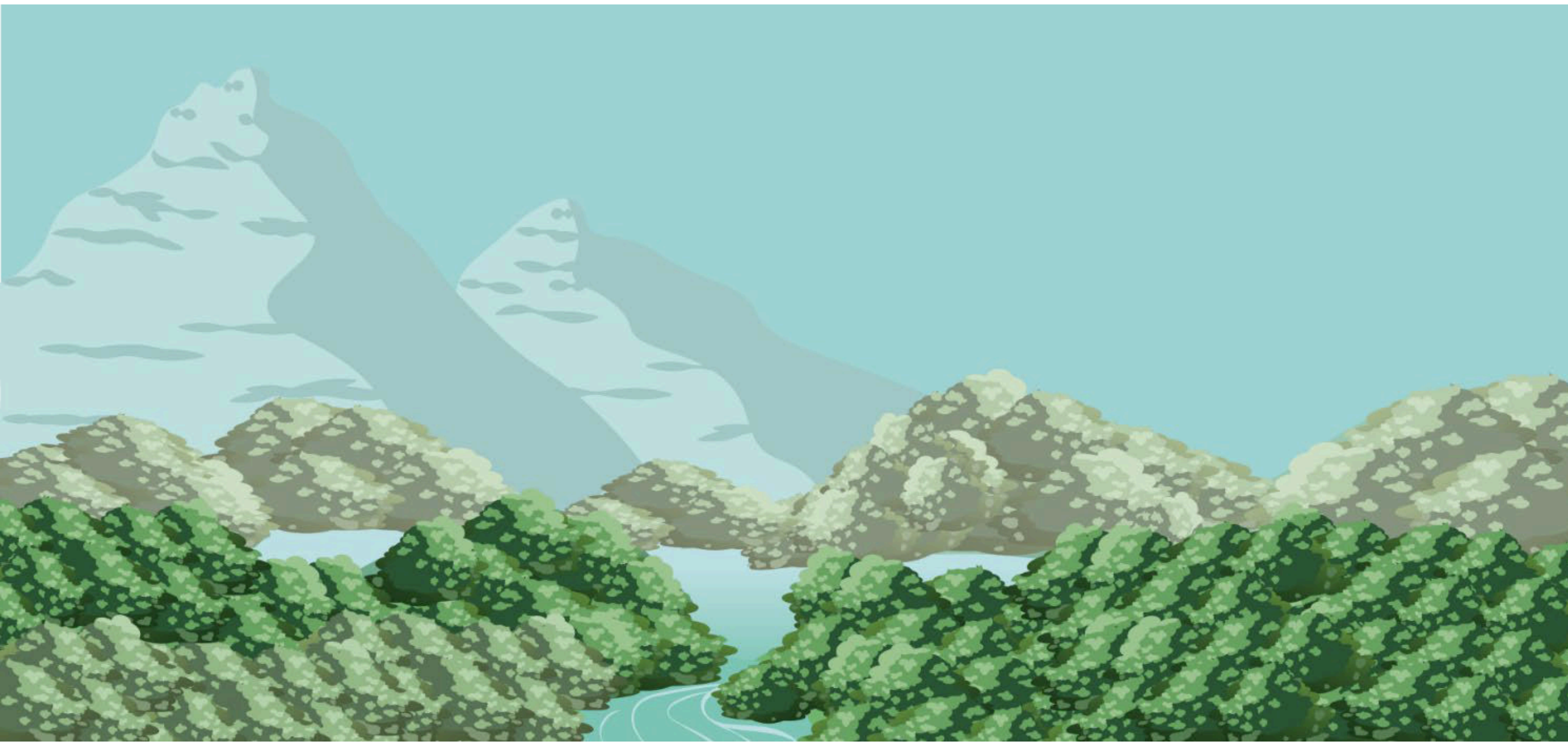
2023 | Catchment Journey Template – Infographic
https://ourlandandwater.nz/outputs/catchment-journey-template/

2023 | Healthy Waterways – Land Management Actions Register
https://ourlandandwater.nz/project/register-of-land-management-actions/

Whakapūpūtia mai ō mānuka,
kia kore ai e whati

Cluster the branches of the mānuka,
so they will not break
(Together with a shared vision,
we know which direction to go)

ONE | Research strategy and motivations



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Globally, pressures have never been greater for land managers to practice integrated land management that supports healthy people, a healthy environment, and a healthy return on investment. The impacts of agricultural production on the health of freshwater environments are well recognised, especially high concentrations of nutrients and sediment (Allan, 2004; Clark & Tilman, 2017; Food and Agriculture Organization of the United Nations, 2016; Mateo-Sagasta et al., 2017). Freshwater ecosystem health degradation is a highly intricate issue and improving them is equally complex. It requires contributions of many and hence a variety of communication strategies. This will allow a diverse range of people to make meaning from new information and act on it. The array of communication tools available to today's scientists is vast, ranging from traditional approaches like publishing scientific articles in print and digital publications, to more direct engagement either online or in person. On any given day people are learning about science while scrolling on their phones, watching TV, or attending events in their communities. But it's not just where people are learning about science that matters – it's also how they are learning. Storytelling is one tool that can help with communicating complex issues and sharing information between diverse audiences (Dahlstrom, 2014; Rose, 2012). Although the forms in which stories are being told have changed significantly over time (i.e., from cave paintings to social media), the desire to tell and hear stories has remained unchanged, profoundly impacting the way we look at life.

My thesis contributes to a growing body of work on cross-disciplinary knowledge co-production and knowledge sharing (e.g., De Groot & Zwaal, 2007; Norström et al., 2020; Raymond et al., 2010; Sundin et al., 2018; Thomas et al., 2020) specifically aimed at increasing dialogue between policy makers, industry and catchment groups to encourage sustainable land management for freshwater ecosystem health improvement into the future (e.g., Newig et al., 2023; Reed, 2008; Tadaki et al., 2020). If cross-disciplinary, multi-directional knowledge sharing is embraced, I hope that my children will be able to gaze at rivers in Aotearoa New Zealand, observing healthy freshwater ecosystems.

1.1 Personal context

When I was a young girl in Germany, I would sneak upstairs into my parents' bed which was next to a large window overlooking the River Inn. From the warmth of that special space, I observed the life surrounding and depending on the river. There were the ducks that munched on the algae, kingfishers that hunted for small fish and beavers that provided nutrients to the river by felling half of our orchard. This place taught me the importance of functioning ecosystems and how everything is connected.

Over thirty-five years later – at the other end of the world – my childhood passion has become my profession. I am now a freshwater ecologist playing a role in the journey to restore Aotearoa New Zealand's freshwater ecosystems, guided by a picture that formed when I was a little girl peeking out of my parent's bay window.

I started my formal training to become a freshwater ecologist more than 15 years ago, following what I would call a traditional path of becoming a natural scientist. As well as learning the core scientific methods of conducting bio-physical sciences, I was taught how to communicate them in an academic context which mostly involved publishing articles in scientific journals, presenting at scientific conferences, and collaborating with my freshwater science peers. However, for some time now, I've noticed researchers expanding their approaches to communicating science in the hope that they could enhance the value of science to society, and I have been inspired to do the same.

Particularly over the last decade, I realised that my attempts to communicate my freshwater research weren't having the impact I had hoped for. I found myself frustrated that freshwater quality continued to decline, even though there is plenty of evidence that justifies change and people know about the seriousness of the problem. I know that change can be hard at any level – whether it is personal lifestyle changes or broad societal challenges – which is why it is more important than ever to gain new perspectives and come up with new solutions.

In 2019, I took the leap and began a PhD in Science Communication through the University of Otago. I wanted to learn the skills required to communicate the great mahi (work) that my colleagues and I do in more meaningful and relatable ways without compromising the quality of the scientific content. I am excited to see many within the science system embracing transdisciplinary and collaborative approaches. There is much to be gained from taking a more holistic view of, and approach to, scientific research. In freshwater sciences we often talk about 'from the mountains to the sea' or 'ki uta ki tai' systems thinking, which acknowledges the inter-connectedness and inter-dependency of ecosystems. In addition, cross-fertilisation of scientific ideas amongst inter-disciplinary organisations and themes has become more relevant than ever before – in 2023 I was part of a national working group that contained 25 team members from 25 different organisations, acknowledging the value of multiple knowledge systems including mātauranga Māori (knowledge handed down).

With regards to the latter, I acknowledge a low number of Māori participants in my research. Although I was interested to learn about the motivations and barriers to recording and reporting actions, and the concept of storytelling to share mātauranga from a te ao Māori perspective, I recognise that mātauranga should be recorded and shared by tangata whenua (Indigenous people of the land) themselves. It is not my place to share that story, and I've chosen to honour that. Tangata whenua researchers are conducting research as part of the National Register of Land Management Actions project to tell their story (see Ruha et al., 2021). Nonetheless, the principles and outcomes of knowledge sharing through storytelling to preserve and foster ecosystem health have many commonalities between the Pākeha (non-Māori) and Māori knowledge systems. Based on this, my research may be useful for future studies that employ a collaborative freshwater restoration approach across multiple knowledge systems.

1.2 Rationale of research

The motivation behind my research stems from the evolving landscape of science communication, which emphasises multidirectional and interactive approaches, fostering collaboration between scientists and communities (Clarke, 2003; Fleming et al., 2020; Ison & Russel, 2007; Leach et al., 2023; Loroño-Leturiondo et al., 2018; Metcalfe, 2019). Despite calls for a more critical and strategic approach to science communication in Aotearoa New Zealand (Gluckman, 2013), progress on advancing science communication approaches have been stagnant, adhering to a unidirectional or deficit communication model (Ahteensuu, 2012; Fleming & Star, 2017): knowledge flows from scientists to implementors. Even with world-class research, communication of freshwater sciences as it is currently practiced has not helped stem the tide of ongoing decline of Aotearoa New Zealand's freshwater ecosystem health (Land Air Water Aotearoa, 2022; NZ Ministry for the Environment & Stats NZ, 2023).

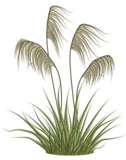
To ensure the impact of scientific communication, two critical aspects must be considered. Firstly, scientific findings should be communicated in an understandable manner using accessible tools to facilitate two-way knowledge exchange. A range of suitable tools exist, fostered through the ongoing expansion of online communication tools. Secondly, it is crucial to acknowledge that scientific knowledge is generated by diverse players across communities, both spatially and temporally. Sharing knowledge from different sources is vital. In the context of this project, integrating new information with existing knowledge sharing platforms such as the Land Air Water Aotearoa website (lawa.org.nz) and the Healthy Waterways Land

Management Actions Register (healthywaterways.nz), will increase the broader spatial and social reach of freshwater restoration knowledge.

Based on these considerations, my PhD thesis aims to improve and accelerate the sharing of the vast freshwater science knowledge that exists across the many knowledge holders. I explored the content and mechanisms of catchment community storytelling as a tool to increase awareness and catalyse on-the-ground actions for restoring freshwater quality in Aotearoa New Zealand. By delving into the content and mechanisms of restoration narratives, I uncovered insights that contribute to the development of effective science communication strategies capable of fostering behavioural change within catchment communities.

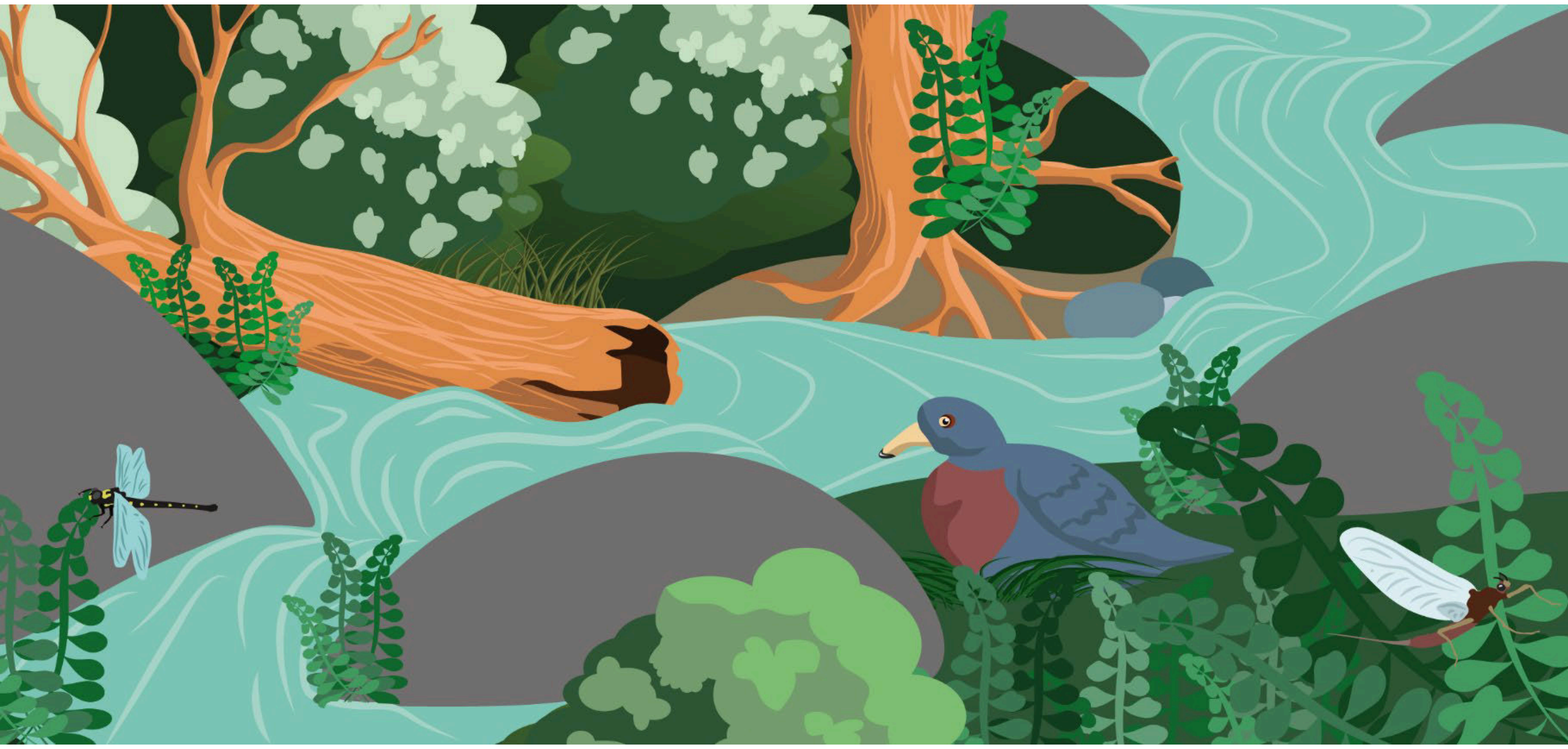
My research aligns with the evolving landscape of science communication in Aotearoa New Zealand (Fleming & Star, 2017), emphasising the need for transformative approaches that transcend traditional boundaries and actively engage communities in the restoration of our vital freshwater ecosystems, for decades to come. While this shift aims to increase awareness and ultimately drive the behavioural changes needed to halt and reverse the decline of Aotearoa New Zealand's freshwater ecosystems at the catchment level, achieving such changes is challenging and cannot be accomplished through a single approach alone, such as science communication through storytelling. Historically, Aotearoa New Zealand’s agricultural sector has demonstrated a high degree of responsiveness and adaptability, evident in the transition from a robust wool industry based on sheep and beef farming in the early 20th century to the rise of the dairy industry from the mid-1990s, and the subsequent growth of the kiwifruit and wine industries in the early 2000s. However, the current focus on environmental impacts—such as water quality and usage, greenhouse gas emissions, and land management—requires different adjustments than those experienced over the past 150 years. Today's changes in land management practices are designed primarily to benefit the environment, rather than directly benefiting the land managers and their businesses. Furthermore, the results of these changes will not be apparent in the short term but will emerge as long-term, intergenerational outcomes. This delay and the shift in focus to environmental benefits could present barriers to the necessary systemic changes in agricultural land management unless land managers and rural communities understand the critical importance of these changes. Effective science communication can play a key role in raising awareness and driving change, however, it is only one part of the broader strategy needed to address the degradation of freshwater ecosystems. Halting and reversing the decline of these vital systems involves a multi-faceted approach that extends beyond merely sharing knowledge. Additional components that are essential for achieving meaningful environmental change include amongst many others, policy and regulation, innovation and technology, and funding and resources. Only through the integration of these components can we hope to effectively halt and reverse the degradation of freshwater ecosystems and ensure their long-term health and sustainability. My research is one step towards demonstrating the potential of science communication, and storytelling in particular, for integrating those components and shifting conversations towards the much-needed holistic land management.

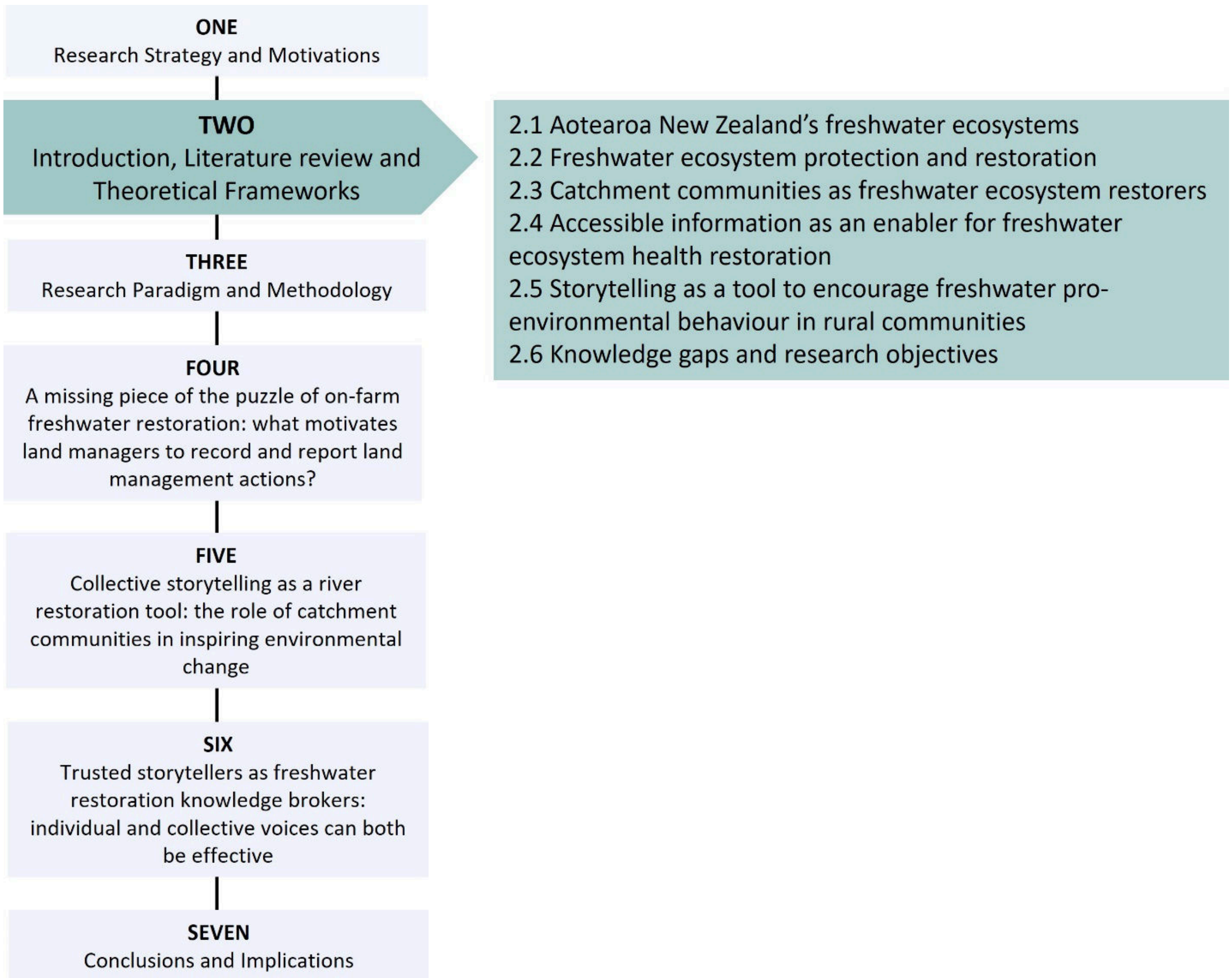
Ka ora te wai, ka ora te tangata



If the water is well, we are well

TWO | Introduction, literature review and theoretical frameworks





2.1 Aotearoa New Zealand's freshwater ecosystems

Functioning freshwater ecosystems are essential to wellbeing in Aotearoa New Zealand – they are where we learn, work, play and socialise. They support how we live and how we make a living. Rivers, lakes and wetlands are our home and our identity, and the foundation of our culture and tradition.

The freshwaters of Aotearoa New Zealand are diverse – they appear in many forms, from minute alpine streams and springs to large lakes and wetlands, they are highly variable in flow and have very large floods in proportion to their catchment[1] area due to the country's latitude, climate and mountainous relief (New Zealand Conservation Authority, 2011). They are home to many unique freshwater species such as the world's largest freshwater eel, the longfin eel (*Anguilla dieffenbachii*), which is endemic to Aotearoa New Zealand and a tāonga (treasured) fish species for Māori. This diversity makes freshwaters of Aotearoa New Zealand unique and an inherent part of the national identity.

When a reciprocal relationship between humans and the natural world exists, healthy ecosystems provide important services and functions that benefit us and our society (Bradley et al., 2012). Wetlands, for example, store carbon as peat, regulate water flow during storms, and purify water by filtering out nutrients and sediments (Clarkson et al., 2013; De Groot et al., 2018). Freshwater fish move nutrients by feeding and migrating between habitats (Vander Zanden & Vadeboncoeur, 2002). However, our relationship and connection with the environment goes well beyond the goods and services we receive from it, like food, fuel, and clean water. Intact lake and river ecosystems allow people of Aotearoa New Zealand to experience various cultural practices and the sharing of traditional knowledge such as mahinga kai (food provisioning), as well as the provision of materials for purposes such as raranga (weaving) and rongoā (medicinal uses). For Māori, water is a taonga (treasure) which has been, and still is, an integral political, economic and spiritual resource (The Waitangi Tribunal, 2019). In a world first, the Whanganui River, Te Awa Tupua and all its physical and metaphysical elements was recognised in law as an indivisible, living whole, that possesses 'all the rights, powers, duties, and liabilities' of a legal person in 2017.

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[1] A catchment (also commonly referred to as watershed) is defined as the natural drainage area of rainwater where it gets collected and transported from the source to the sea.

Freshwater ecosystem health and its pressures

The ecosystem health of waterways must be diagnosed and upheld (NZ Ministry for the Environment, 2020d). Measuring the overall condition of ecosystems is far more than counting the number of different species. Freshwater ecosystems are complex and made of many interacting biological and physical components that can all be affected by environmental changes (NZ Ministry for the Environment, 2019). A recognised definition of river ecosystem health describes 'a complete assessment of a river's physical habitat structure (e.g., instream cover, substrate, riparian vegetation), its water flow (e.g., velocity, rainfall and runoff, abstraction), biological community composition (e.g., exotic species, algae, microorganisms), energy and nutrient dynamics (e.g., seasonal cycles, algal growth, sunlight and shading) and water quality parameters (e.g., pesticides, suspended sediment, temperature, nutrients)' (Young et al., 2018).

Most river catchments in Aotearoa New Zealand are now a mosaic of land uses including cities, towns, plantation forests, farms and native vegetation. Activities in a catchment often interact and have compounding or cumulative effects on freshwater ecosystems – and the environmental, economic and social impacts of water quality decline are widely recognised (Julian et al., 2017; NZ Ministry for the Environment & StatsNZ, 2022). For example, water related issues (i.e., amount of freshwater in rivers and lakes, availability of groundwater for human use, area of wetlands) were rated by the public as the most important environmental issue between 2010 and 2019, demonstrating just how important freshwaters are (Hughey et al., 2019). In 2022, freshwater quality was the second most important issue to Aotearoa New Zealanders, after climate change (Booth et al., 2022). Similarly, a survey conducted by Fish & Game New Zealand in 2018 showed that over 80% of the 1000 participants were most concerned about the pollution of lakes and rivers (Fish & Game New Zealand, 2017) and StatsNZ – Tatauranga Aotearoa (2018) showed that four out of five New Zealanders (80%) are concerned about the state of rivers, lakes, streams and wetlands. Disturbing the services and functions healthy freshwater ecosystems provide through the expansion of human induced pressures affects people's wellbeing, sense of belonging and connection, and impacts our ability to use the environment for social and economic opportunities.

Farming as a key stressor for freshwater ecosystem health

Aotearoa New Zealand's freshwater ecosystems are and have been under pressure for decades, the largest and most widely distributed pressure being the physical change to landscapes due to anthropogenic land use practices. Water pollution in urban, farming and forestry areas are due to increased levels of deposited sediment and emerging contaminants (such as pesticides), changing water flows due to increased consented freshwater allocation and alteration of natural flow regimes through dams, channels, stop banks and culverts. Additionally, climate change impacts include more severe localised droughts and flooding (NZ Ministry for the Environment & Stats NZ, 2023). These large-scale alterations have had significant impacts on the health of our freshwater ecosystems. For example, before human arrival in Aotearoa New Zealand, forests covered about 80 % of our land, but in 800 years humans have changed landscapes by clearing vast areas of these forests and draining wetlands to make way for farming and settlements (Gluckman, 2017). Today, there are only about a third of original forest and 10% of wetlands remaining. Of those remaining wetlands, 60% are estimated to be in a moderately to severely degraded state (NZ Ministry for the Environment & Stats NZ, 2023).

High intensity agriculture is one of the largest and most widely spread pressures on freshwaters in Aotearoa New Zealand. The country has experienced one of the highest rates of agricultural land intensification over recent decades internationally. Between 1996 and 2018, almost 60,000 hectares of exotic grassland were converted from low producing to high producing, compared with only 3,500 hectares of exotic grassland converted from high to low producing (NZ Ministry for the Environment & Stats NZ, 2023). This increase in intensity was mainly due to a switch from sheep to dairy farming, resulting in a 61 percent increase in dairy cattle numbers between 1996 and 2014. Related to this land use change is land irrigation which almost doubled between 2002 and 2019, with 73 percent of the increase related to dairy farming, 18 percent to grain, fruit and berry, and vegetable growing, and 9 percent to sheep and beef. (NZ Ministry for the Environment & Stats NZ, 2023)

The impacts of poor agricultural land use management practices are vast, causing ecological (Basher et al., 2011), cultural (Awatere et al., 2023; Harmsworth et al., 2014), socio-economic and recreational harm (Campbell, 2020; Larned et al., 2020). For example, nitrate leaching from livestock urine and overuse of artificial fertilisers (i.e., nitrogen and phosphorus) lead to surplus nutrients on land that cannot be absorbed by plants, resulting in groundwater pollution and run-off into waterways causing ecological harm, such as excessive algal growth (Wilcock et al., 2007), of which some species can be toxic to organisms (Wood et al., 2007). Pasture irrigation can lead to soil compaction, reducing soil water capacity which exacerbates nutrient leaching and run-off to waterways (Drewry et al., 2022). Production on steep, erosion-prone land increases sediment run off into waterways which has large environmental effects on stream environments (Ryan, 1991). These include, for example, reduced visual clarity (Davies-Colley et al., 2015) and reduced habitat availability for the biota living in the waterway (Richardson & Jowett, 2002), affecting culturally significant species, such as the longfin eel.

Agriculture is a significant part of the cultural and aesthetic landscape of Aotearoa New Zealand. This causes tensions between the need for environmental protection, the desire to protect the interests of primary industries, and redress to Māori for colonial appropriation of their lands (Campbell, 2020; Harcourt et al., 2022). Through an economic lens, the role of agriculture is atypically large for a developed country (Campbell, 2020). In fact, for the first time since June 2015, export of dairy products overtook travel services as the top export earner in June 2020, due to COVID-19 introduced travel restrictions (StatsNZ - Tatauranga Aotearoa, 2020). So, Aotearoa New Zealand's primary industries are not only the backbone of the country's economy, but are also among its largest employers, making this sector woven into the economic and social fabric of rural communities, districts and regions.

2.2 Freshwater ecosystem protection and restoration

Freshwater restoration, including similar concepts like river rehabilitation or mitigation, aims to reverse the negative consequences of anthropogenic impacts and improve environmental outcomes. Restoration can include physical actions (such as the re-establishment of natural flow regimes through expanding floodplains or sustainable management of the land surrounding a waterway; Gann et al., 2019; Sayer et al., 2018) as well as social-ecological interventions (such as stakeholder participation in decision-making; Newig et al., 2023; Reed, 2008; Scott, 2015). The term 'freshwater restoration' encompasses the concept of restoring in-stream (e.g., water quality, habitat, water quantity, biological processes) and on-land ecosystems (e.g., riparian forest establishment). In contrast, 'sustainable land management actions' or 'freshwater restoration actions' typically refer to on-land farming practices designed to enhance freshwater ecosystems, with a particular emphasis on improving water quality. A review of land management strategies aimed at improving water quality in Aotearoa New Zealand identified 58 distinct methods. Among these, the most frequently employed strategies include fencing around waterways, excluding stock from waterways, creating vegetated buffer strips or plantings, developing riparian management plans, and constructing both artificial and natural seepage wetlands(Doehring et al., 2020).

Addressing the impact of the agricultural sector on Aotearoa New Zealand's freshwater environment comes at considerable costs, including environmental, economic and social. For example, the Taranaki Regional Council anticipates spending €52 million between 1992 and 2026 to develop individual riparian management plans for rural properties throughout their region, assessing the extent of riparian vegetation, type of fence, and farm numbers with riparian management plans (Bedford, 2017). Similarly, vast amounts of resources are being spent (economic and social) to restore freshwater ecosystems in other parts of the world. For example, Bernhardt et al. (2005) estimated that at least US$14 - $15 billion were spent on the restoration of streams and rivers within the continental United States between 1990 and 2005, an average of >US$ 1 billion a year, not including in-kind contributions such as labour by agencies or catchment communities.

To mitigate some of the environmental and economic expenses associated with freshwater ecosystem degradation, a range of protection and restoration measures exist which I discuss below.

Legislation as freshwater protection

The effects of human-induced stress on Aotearoa New Zealand's freshwater ecosystems became evident in the 1960s, marked by excessive algal growth and eutrophication in the country's lakes (Fish, 1963). This prompted a growing awareness of the decline in freshwater quality, leading to legal protection measures for these ecosystems. The initial safeguard was established through the Salmon and Trout Act of 1867 (New Zealand Government, 1867; Figure 1), an (indirect) first legislation aimed at the preservation and propagation of salmon and trout. After this, the Soil and Rivers Control Act (1941) was enacted as the first environmental protection law in Aotearoa New Zealand. This legislation addressed the effects of agricultural land use on freshwater ecosystems, with a primary goal of preventing and reducing soil erosion (Figure 1).

Between 1941 and the early 2000's, a suite of environmental protection acts were introduced, including the Water and Soil Conservation Act (1967), Environmental Act (1987) and the Resource Management Act (1991). Combined they raised awareness on environmental issues and called for more sustainable agricultural practices. The implementation of sustainable land management actions was subject to a range of national discussions in the early 2000's through the launch of the National Policy Statement for Freshwater Management (NPS-FM) in 2011, with various amendments since its release (NZ Ministry for the Environment, 2020d). It was closely followed by the Sustainable Dairying: Water Accord in 2013 (Dairy Environment Leadership Group (DELG), 2015), an agreement that set out the dairy industry's commitment to improving water quality.

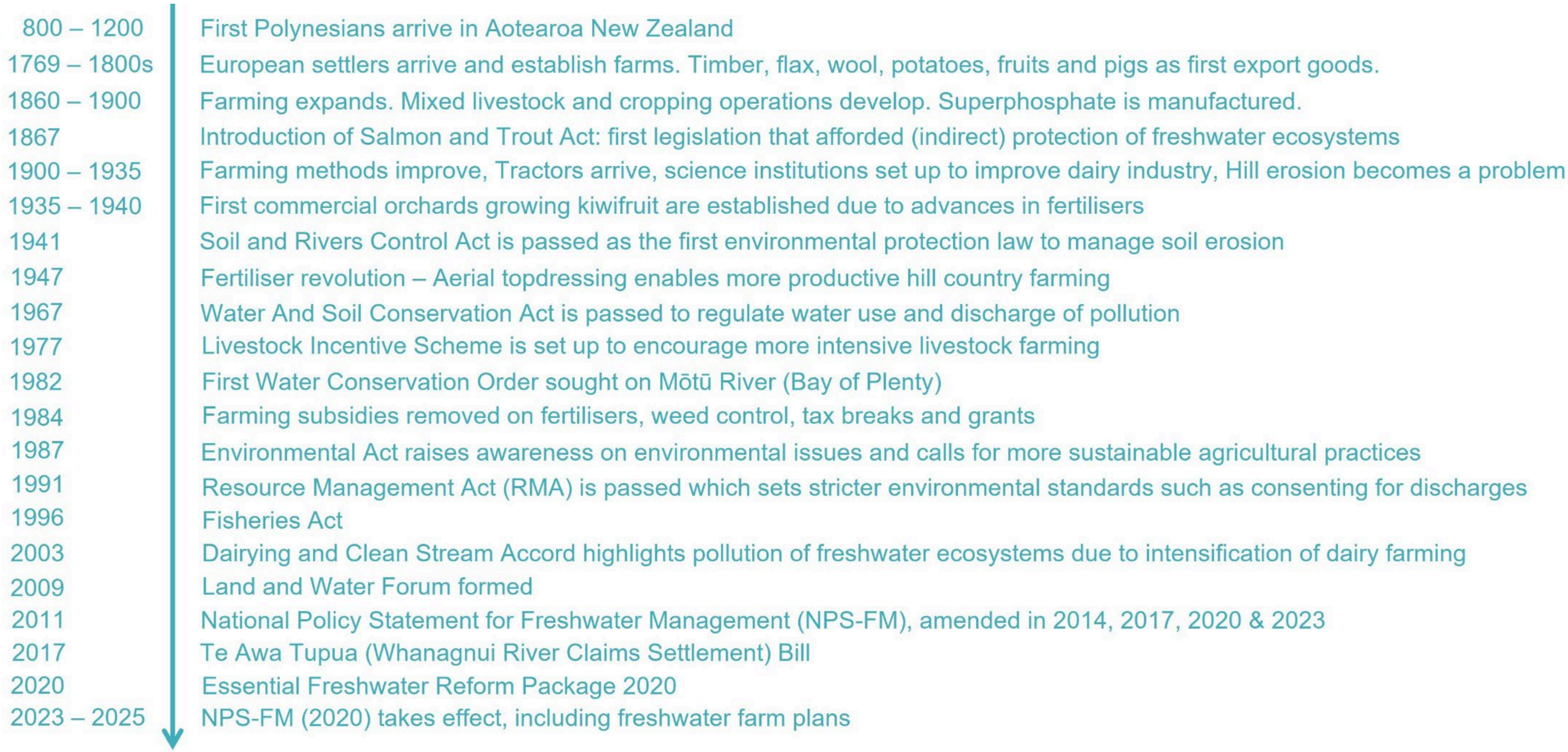


Figure 1: *Timeline of key agricultural milestones and associated freshwater ecosystem health legislations in Aotearoa New Zealand.(modified from Collins, 2018)*

The focus on the improvement of water quality has continued to grow with increasing pressure on improving agricultural land use practices, as outlined in the 2015 established Environmental Reporting Act (New Zealand Government, 2015) and the subsequent launch of the Essential Freshwater and the Action for Healthy Waterways packages (NZ Ministry for the Environment, 2020b). This Action for Healthy Waterways package outlines three government objectives[2]: 1) to stop further degradation of Aotearoa New Zealand's freshwater resources and to start making immediate improvements so that water quality is materially improving within five years, 2) to reverse past damage and bring Aotearoa New Zealand's freshwater resources, waterways and ecosystems to a healthy state within a generation, and 3) to address water allocation issues having regard to all interests including Māori and existing and potential new users (NZ Ministry for the Environment, 2020a). Overall, this package 'strengthens the obligations on all New Zealanders to protect and restore our waterways' while upholding Te Mana o te Wai – the health and wellbeing of the water. Te Mana o te Wai is a concept for all New Zealanders and "*refers to the essential value of water, and the importance of firstly sustaining its integrity and health, before providing for essential human health needs and then for other consumption*." (p.9; NZ Ministry for the Environment, 2020a)

Despite this large portfolio of legislative means and extensive implementation of best management practices to maintain and improve freshwater ecosystem health in Aotearoa New Zealand and across the globe, many restoration efforts have reported little or no improvements (Bond & Lake, 2003; NZ Ministry for the Environment & Stats NZ, 2023; Palmer et al., 2005; Roni et al., 2008). This is due to a range of challenges which I will further discuss below.

Challenges of freshwater ecosystem restoration

Firstly, freshwater ecosystems are complex and are comprised of a range of geomorphic processes, vegetation characteristics, climate, and anthropogenic land uses (Brierley, 2010). Because all these factors interact both over time and space, sustainably managing these complex characteristics is both complicated and difficult (Larned et al., 2018; NZ Ministry for the Environment & Stats NZ, 2020). For example, grazing livestock near fenced waterways on the flat Canterbury Plains might be an acceptable management practice to avoid increased turbidity

[2] In November 2023 a new government has been elected in Aotearoa New Zealand which indicated a departure from numerous environmentally responsible policies implemented by the preceding government. Changes are likely to include partial replacement of the National Policy Statement for Freshwater Management in its current form, including the removal of Te mana o te wai. (https://environment.govt.nz/acts-and-regulations/national-policy-statements/national-policy-statement-freshwater-management/; accessed 31.01.2024)

due to sediment runoff into adjacent waterways. However, the outcomes of this same practice might be significantly different when done on steep hill-country where sediment runoff is aggravated due to the land's topography, causing a rise in turbidity levels in adjacent waterways. Similarly, the application of fertilisers needs to be managed based on soil characteristics; while it might be effective to apply a certain amount of fertiliser on clay-rich, non-permeable soils where the nutrients will reside to be slowly absorbed by the crop, the same amount of fertilisers applied to sandy soils might readily leach and cause severe pollution of waterways. To effectively address land management actions that help improve water quality, an array of solutions is required that cover diverse issues at temporal, spatial and social scales.

Secondly, freshwater restoration is commonly implemented in the form of small-scale and isolated projects, narrowing down the implementation area to targeted sections within a catchment instead of entire catchments or ecosystems (Louhi et al., 2011; Parkyn et al., 2003). However, land degradation happens at all scales - from farm to catchment - (Allan, 2004) and any restoration planning should, thus, be done at spatial scales equivalent to the area where damage has occurred. But catchment-scale sustainable land management is often not an option, due to budget constraints, difficulties in obtaining legal mandates, uninformed project management, or the large amount of effort required to coordinate land managers.

Thirdly, closely linked to the implementation of restoration actions at large scales is the evaluation of those actions and the impact they have on ecosystem health at those large scales. For land managers to be confident that their investment in restoration actions will be returned, implementors need to find a way to measure actions, report these at catchment scale, and learn about impacts at the catchment level. Failure to record and subsequently advise on the performance of mitigation actions is likely to lead to misallocation of resources and false expectations with regards to treatment speeds and expected positive outcomes (Daigneault et al., 2017; Parliamentary Commissioner for the Environment, 2019). However, a lack of standardised recording and reporting methods for large scale restoration make it difficult for land managers to assess the effectiveness of their management practices (Doehring et al., 2020). Monitoring programmes are often designed to run over short to medium time frames (i.e., 5–10 years) which are too short to demonstrate water quality or ecosystem health improvements. This is because there is usually a substantial lag in time before a response to land management actions can be seen (Hamilton, 2012; Viaud et al., 2004), ranging from <1 year (for faecal bacteria waste management) to over 50 years (for sediment erosion control at a catchment scale) (Meals et al., 2010). This means that envisaged improvements may not occur as quickly as hoped and cannot be clearly linked to specific land management efforts. So, to detect shifts in freshwater ecosystem health, environmental monitoring programmes need to span over extensive periods of time (e.g., ten years or more) accounting for the natural variability in some water quality parameters (e.g., water temperature and nitrate concentrations), global climate cycles (e.g., El Niño, La Niña) and broader climatic conditions (e.g., climate change).

Lastly, changing land use to improve freshwater ecosystem health involves a spectrum; at one end there is change to management practices within the same farm system, such as changing land management actions to more sustainable ones aimed at improving water quality (e.g., stock exclusion, riparian planting, reduction of stock numbers). At the other end of the spectrum, there is wholesale land use change which involves changes of one specific type of land use to another (e.g., from less intensive sheep and beef farming to high intensity dairy farming). How much freshwater ecosystem degradation can be mitigated through changes of practice and how much through whole system change depends on a diverse range of factors, including topographical location (e.g., lowland versus high land), historical land use (duration of intensive farming) or climatic influences (e.g., high rainfall). In addition, fossil fuel emission mitigation will also need to be considered before a farm business can be considered truly sustainable (Parliamentary Commissioner for the Environment, 2023). However, while there are different views on future land use change in Aotearoa New Zealand, the vast majority of Aotearoa New Zealander's want the same outcomes, namely '*resilient landscapes that can be passed on to future generations, land that is rich in biodiversity and waterways that are healthy, and improvements to the environmental footprint of our land-based industries*'. (Parliamentary Commissioner for the Environment, 2024)

To effectively restore freshwater ecosystem health through sustainable land management, we thus not only have to ask ourselves 'at what scale do we need to restore freshwaters?', but also 'how long will it take before we see any improvements in water quality?', and 'will I need to consider a change in wholesale land use?'. Given these complexities and that the National Policy Statement for Freshwater Management has only come into effect in 2020, it is not surprising that water quality improvements have not been detected at rates as quickly and as widespread as hoped. A shift from passive land management to active environmental recording and reporting of land management actions is one approach towards addressing the challenges of freshwater ecosystem restoration within the same farm system. Currently, land managers are unable to consistently record and report land management actions, however "[w]*ithout the necessary information to assess the effectiveness of management practices and determine* *whether or not we are sustainably managing this precious resource, we risk losing it altogether"* (Parliamentary Commissioner for the Environment, 2019, p. 25).

Adding freshwater modules to Farm Environment Plans is one approach that has recently gained recognition as a way to record and measure what land management actions have been done, where, and to what extent. While the concept of Freshwater Farm Plans is not new, discussions on making it compulsory have only been officially introduced in Aotearoa New Zealand in early 2020 (NZ Ministry for the Environment, 2020a, 2020c). Farm Environment Plans will allow stakeholders to collect information at large scales, merge the vast mosaic of land management interventions, and enable land managers to quantify in a consistent way how much of each intervention has occurred. This would not only inform land managers on the most cost-effective management practices on water quality outcomes but would also provide policy makers with the evidence they need to make informed decisions.

Designing good policies is one step towards improved freshwater ecosystem health. Getting policies understood, then adopted and implemented is another complex step which requires the commitment from the people that live and work on the land surrounding the rivers, lakes and wetlands. But who are the key players in freshwater catchments that may need to be persuaded to act environmentally responsible? And how can they be motivated to do so? The following chapters will provide insights into those questions.

2.3 Catchment communities as freshwater ecosystem restorers

To generate positive social and environmental outcomes (Bodin, 2017; Gunningham & Holley, 2016; Innes & Booher, 2018), community-based catchment, or watershed, management (also often referred to collective management or collaborative governance) is prevalent across the globe (e.g., Da Costa Silva, 2011; Mekuriaw & Amsalu, 2023; Pumicestone Region Catchment Coordination Association Inc, 2017; Scott, 2015; Tadaki et al., 2020).

Catchment communities are groups of people who build from existing connections of those who share an attachment to the land and people in their catchment. They share common interests in freshwater restoration, residing in the same locality (Mannarini & Fedi, 2009), often close to the waterway of concern. They involve collaborations of people who take ownership of a problem, jointly addressing the most pressing issues at local scales. Together, these catchment communities bring about on-the-ground change by working collectively and contributing to decision-making, a principle commonly termed 'grassroot' community engagement

(McDonnell & Buswell, 2018; O'Meara et al., 2007). They foster governance and responsibilities grounded in local culture and social and community values (Wakefield et al., 2006), as opposed to regulatory standards imposed from above, which can result in erosion of social capital and trust (McIntyre et al., 2022).

To sufficiently address the growing pressures on freshwaters, Aotearoa New Zealand's government has recognised that successful restoration efforts require the support of the communities who live and work in these catchments, in the form of community-led freshwater collectives. In May 2023, it committed NZ$56 million of funding over three years for eleven projects as part of their Essential Freshwater Fund. The programme is aimed to "*help upskill, train and provide information and tools for people in community groups, tangata whenua, regional and unitary councils, rural advisory businesses and other organisations*" that support waterway restoration and protection (https://environment.govt.nz/news/56-million-for-projects-supporting-waterway-restoration-and-protection/; accessed 27.02.2024, para. 1).

While the central government only acted to put legislation into place to formally recognise and address the decline in freshwater ecosystem health in 2020 (and support communities to step-up and help with the restoration the country's degraded freshwaters in 2023), this issue has been on the mind of Aotearoa New Zealanders for much longer. Many rural communities (often in collaboration with local authorities) have worked towards restoring their rivers, lakes, and wetlands for decades. For example, Taranaki Regional Council has been collaborating with farmers to develop individual riparian management plans for their properties since 1992, assessing the extent of riparian vegetation, type of fence, and farm numbers with riparian management plans. The programme has been widely adopted and 2587 (99.5%) Taranaki dairy farms now have riparian management plans in place, 12,200 km (85%) of waterways are mapped and fenced and 7700 km (70%) of streambanks are protected with riparian vegetation (Bedford, 2017). However, despite the time and cost intensive efforts by the Taranaki Council over the last two decades, water quality improvements are inconclusive across the region (https://www.lawa.org.nz/explore-data/river-quality/; accessed 27.02.2024), confirming the complexity of freshwater ecosystem health restoration over long time frames at catchment scales. If catchment care groups are highly visible and well-intentioned but fall short of addressing the underlying problems, it poses the risk of catchment groups potentially being perceived as 'successful failures'. For example, despite many restoration communities having come together over the last ten years to address water quality degradation in their local waterways, their efforts often only address local, small-scale challenges (e.g., wastewater treatment upgrades), rather than landscape-scale, systematic challenges (e.g., land-use change). "Scaling" has emerged as a key concept in conservation and restoration literature, capturing the prevailing view that restoration practices must evolve to effectively reverse the decline of freshwater ecosystem health on both national and global levels. Scaling up regeneration involves more than simply expanding the geographic scope or frequency of restoration efforts; it also encompasses enhancing the efficiency and resilience of these initiatives, as well as altering broader systemic rules and values (McFarlane et al., 2021).

Currently, there is a surge in community-led freshwater restoration communities in Aotearoa New Zealand (>1900 groups), which means that a large and growing proportion of citizens now participate in freshwater ecosystem restoration activities across the country (McFarlane et al., 2021; Peters et al., 2015; Tadaki et al., 2020). For example, the Southland region has established 35 community catchment groups since 2013, forming a network covering over 90% of the Southland region. Their vision is to "*create a prosperous Southland, healthy people, healthy environment from the mountain to the sea.*" (https://www.thrivingsouthland.co.nz/about-us/; accessed 27.02.2024, para. 1). Their catchment groups support farmers to navigate regulation changes and future challenges such as climate change and help them to get ahead of issues by participating in events and projects to develop localised responses that reflect their expertise and experience. In 2021/22 the Southland Region groups held 156 catchment meetings and events with 2,657 attendees, identifying and obtaining funding for 41 projects, valued at NZ$ 623,015.

While it is encouraging to see this increase of communities of action, freshwater restoration will need to be maintained and further expanded into those communities that may not have had the same financial and moral support by their local authorities or their community. Many, but not all, catchment care groups formed based on financial support provided by the Aotearoa New Zealand Government. Although ongoing financial support has been allocated for specific catchment groups across the country (NZ$ 7 million for up to five years; https://www.beehive.govt.nz/release/36-million-commitment-local-catchment-groups; accessed 14.08.2024), funding will cease for many, often more established groups, by June 2025. It remains to be seen how many of these groups will maintain their efforts once funding ends. However, given that many of these groups have emerged organically from shared interests in freshwater restoration, it is likely that many will find ways to continue their work even in the face of financial constraints.

Moreover, the significance of these catchment care groups extends beyond their immediate goal of improving freshwater ecosystems. By fostering 'communities of practice,' these groups build strong, collaborative networks that enhance their collective resilience and problem-solving capabilities. This cohesion not only strengthens their ongoing efforts in freshwater restoration but also equips them to address broader, large-scale challenges that may emerge in the future, such as climate change. The bonds created through their shared commitment can serve as a foundation for tackling other environmental and community issues, ensuring their relevance and effectiveness in the long term.

For change to happen, land managers need to not only understand restoration actions, but need to be motivated to undertake them for sustained periods of time (Aronson et al., 2006; Society for Ecological Restoration International (SER), 2004). For example, instilling a positive attitude about managing sediment input into waterways through retiring waterway margins and steep hill country is only a first step in addressing the sediment contamination in Aotearoa New Zealand's waterways. Unless land managers actively implement the actions required on their properties, outcome-based measurements are unlikely. But how can restoration communities be motivated to act, and to sustain the work for generations to come?

How to motivate catchment communities to act?

Motivation to act can be triggered, and sustained, if information is provided from the 'bottom-up', as opposed to a 'top-down', deficit model approach, with limited consultation or regard for lay knowledge or experience (Manyweathers et al., 2020; Society for Ecological Restoration International (SER), 2004; Wynne, 1982). But it is less well understood how the information should be provided in a large-scale restoration context. Because catchment communities consist of a multitude of players (including indigenous people, residents, farmers, land stewards, environmental groups, businesses, national and local government agencies, and visitors), their interplay and impact on the catchment can be varied, as can their aspirations, knowledge, perspectives, needs, and priorities. Because of this diversity, restoration actions may be done in isolation (Morresey & Hellberg, 2015), missing opportunities for more effective collaboration.

In addition, obligations for catchment communities to operate in accordance with their 'social license' have become more relevant, meaning that rural communities consider the expectations of society and avoid activities that societies deem environmentally unacceptable (Clark-Hall, 2018; Gunningham et al., 2004). The concept of social license to operate refers to a community's acceptance or approval of a company or industry and its operations. This can mean that even if an industry holds the appropriate legal permits, its operations are at risk if local communities have a low opinion of the company and its actions (Boutilier & Thomson, 2011; Gunningham et al., 2004; Moffat & Zhang, 2014; Woodward, 2017). One well known example of damage to a company's social license to operate resulted from Monsanto's failure to respond to the concerns of European consumers about the introduction of genetically modified food. This led to a consumer backlash and breakdown of public trust sufficient to cause a restructuring and re-branding of the corporation itself (Moore, 2001).

There is no one set social licence, meaning that a social license to operate is a dynamic and an evolving concept; once it is obtained, that does not mean it is held forever. For a social license to be granted or improved, industry groups need to have worked towards and created social capital within the community. In the context of the Aotearoa New Zealand agricultural industry, this means that when the community believes farmers are not living up to the community's values, that the social license can be lost.

Social license to operate has become increasingly relevant in relation to farmers' decision-making over the past ten years as the primary sector grapples with public discontent about its environmental performance (Clark-Hall, 2018). Farming is perceived as a major cause of damage to our freshwater ecosystems, with management of farm effluent and runoff perceived very negatively (49.3% of New Zealanders think farming activities were the main cause of water quality degradation (StatsNZ - Tatauranga Aotearoa, 2019)). These perceptions are backed-up with data, showing that rivers in areas of pastoral farming have between 2- and 15-times higher nutrients, pathogens, and sediment than natural conditions (Land Air Water Aotearoa, 2022; StatsNZ - Tatauranga Aotearoa, 2019). The ongoing concerns over the effects primary industry has on freshwater ecosystem health has decreased the trust and understanding that the public had in the agricultural sector in the 1980's. It is not surprising, therefore, that farmer's social license to operate is under continous pressure with some believing that the primary sector has already lost its social license to operate with the public (Woodward, 2017). For the primary sector to earn back the appreciation, respect and trust of those that question it, it will have to prove that farmers are doing their best to address water quality decline.

Effectively communicating the restoration efforts done by farmers within rural communities, as well as with the public, will play a key role in proving farmer's responsible environmental behaviour. This will likely address the alleged negative impact of farming on freshwater ecosystems which has dominated public perceptions over the last twenty years (Hughey et al., 2019; StatsNZ - Tatauranga Aotearoa, 2019), reinstating their social license.

Model of responsible environmental behaviour

Any actions that improve water quality, including systematic recording and reporting, can be regarded as pro-environmental behaviour, which is commonly defined to as any behaviour that "*harms the environment as little as possible, or even benefits the environment*" (Steg & Vlek, 2009, p. 309). Pro-environmental behaviour is directed toward and performed with the intention of promoting the welfare of others (Ramus & Killmer, 2007). Acting for the benefit of others contributes to intrinsic satisfaction, which drives pro-social motivation and behaviour (Caprara & Steca, 2007; Grant, 2008; Greiner & Gregg, 2011). Which variables are most influential in motivating individuals or groups to take responsible environmental action is not well understood (Tabernero & Hernández, 2012).

One model that describes factors impacting pro-environmental behaviour is the Model of Responsible Environmental Behaviour (Hines et al., 1987). Development of this model was based on an analysis of 128 empirical studies in environmental behaviour that found that an individual's intention to act in an environmentally responsible manner depends on a combination of six cognitive and personality variables (Figure 2).

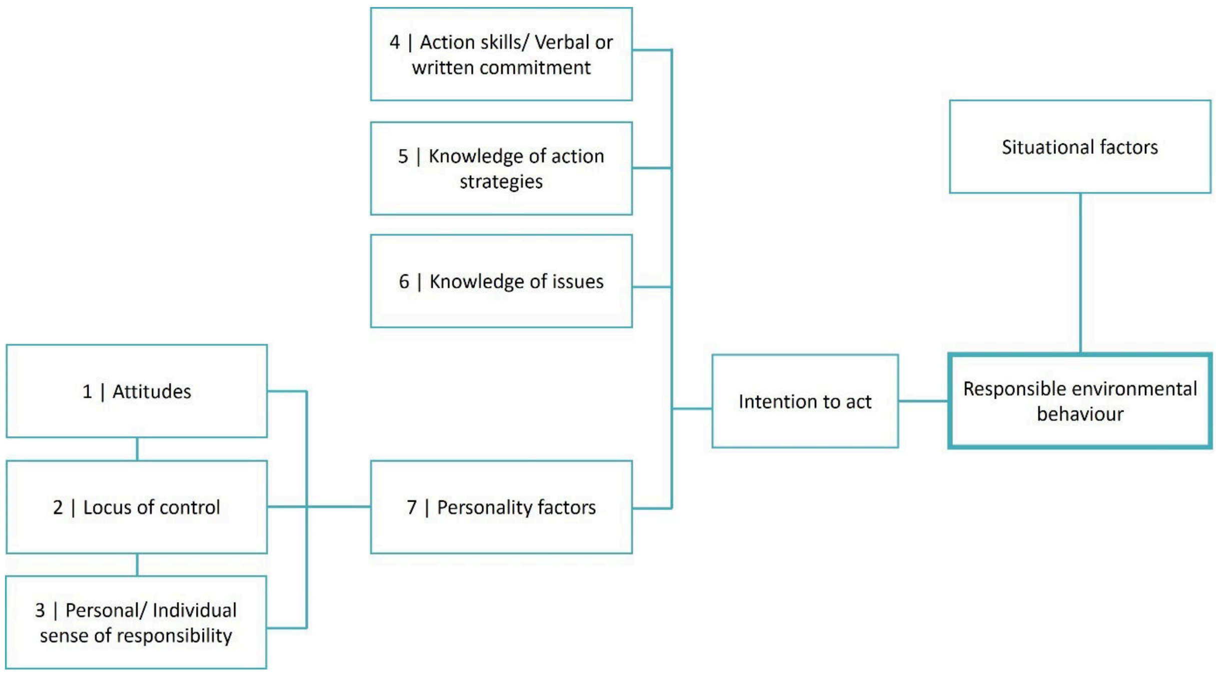


Figure 2: The Model of Responsible Environmental Behaviour (Hines et al. 1987) *showing six cognitive and personality variables that describe an individual's intention to act in an environmentally responsible manner.*

The six cognitive and personality variables are described below, in the context of this thesis.

1. Attitudes: The general attitude of an individual, and an individual's feelings toward recording and reporting land management actions, whereby land managers with more positive attitudes toward recording and reporting are more likely to engage in the process.

2. Locus of control: Represents an individual's perception of whether he or she can bring about change through his or her own behaviour (internal locus of control), as opposed to the belief that change occurs through chance or powerful others such as government (external locus of control). In the context of Aotearoa New Zealand, land managers who have an internal locus of control would be more likely to record and report land management actions.

3. Personal/Individual sense of responsibility: An individual's feelings of duty or obligation to portray pro-environmental behaviour. Land managers who feel some degree of personal responsibility toward the environment are more likely to engage in pro-environmental behaviour than land managers who hold no such feelings.

4. Action skills / Verbal or written commitment: An expressed intention to act upon a pro-environmental action. Thus, land managers who commit to recording and reporting land management actions, either verbally or in written form, are more likely to do so than land managers who do not commit.

5. Knowledge of action strategies: This variable is closely linked to variable 1, whereby land managers with knowledge on how to take action on freshwater degradation are more likely to record and report land management actions. This is because they are more likely to understand the connections between recording and reporting and freshwater restoration.

6. Knowledge of issues: Any factors pertaining to knowledge of the environment or aspects of environmental problems and their consequences. In an Aotearoa New Zealand context, this variable means that land managers with greater knowledge of environmental issues would be more likely to record and report land management actions than land managers who are not aware of any issues.

These variables may be applied as determinants of increasing land manager's intentions to record and report land management actions to improve freshwater ecosystem health.

However, while the efforts spent by restoration communities to reverse freshwater ecosystem decline is encouraging to see, the lag-effects between restoration action and water quality outcomes mean that their efforts need to be sustained for substantial periods to have a meaningful impact on the country's freshwater health. The degradation of freshwater in Aotearoa New Zealand has occurred for over a century, and maintaining or improving these systems is expected to take as long, if not longer. Maintaining restoration momentum that will span across centuries is, therefore, paramount. Accessibility of information that is "*clear, complete, up to date, consistent, accessible, and readily available*" is essential for progress to be assessed by different stakeholders across different spatial scales to keep up the required momentum (Controller and Auditor-General - Tumuaki o te Mana Arotake, 2019, p. 6).

2.4 Accessible information as an enabler for freshwater ecosystem health restoration

Freshwater ecosystems are complex, and so is their restoration management. As freshwater ecosystems deteriorate globally, guidance on how to sustainably manage the lands surrounding rivers, lakes and wetlands is widely available to counter these trends. However, the abundance of information can lead to overload, blurring the distinction between valuable and subpar content. Assisting land managers to comprehend, filter and implement what is required from them is more important than ever. In a meta-analysis of adoption literature, Baumgart-Getz et al. (2012) concluded that quality information – not quantity – drove successful adoption of agricultural best practices in the United States.

Demands on land managers to adapt to and implement legislative changes in freshwater management have been a constant since the implementation of the NPS-FM 2020 (NZ Ministry for the Environment, 2020d). The policy requires all proposed regional plan changes to be in place by the end of 2025, listing 22 standards for which the primary mechanism to achieve improvement is individual Freshwater Farm Plans. Not only do these plan alterations require land managers to understand what changes they will have to implement to comply with the law, they will then also have to adapt land management practices within a given timeframe.[3]

[3] As mentioned earlier, there is a high probability of substantial revisions to these objectives in 2024 following the election of a new national government in Aotearoa New Zealand in October 2023. At present, the specific nature of these revisions remains unclear. Therefore, the objectives outlined here are aligned with the National Policy Statement for Freshwater Management 2020. (amended January 2024; https://environment.govt.nz/publications/national-policy-statement-for-freshwater-management-2020-amended-january-2024/)

In general, people by nature impose coherence onto new information that they receive, incorporating it into their existing knowledge in an effort to interpret it (Kahneman & Frederick, 2005). Limited understanding of a problem can lead people to make inaccurate assumptions or draw unwarranted conclusions in making sense of new information. To empower rural land managers across Aotearoa New Zealand to filter and prioritise information that comes their way, that information should be communicated in an understandable, relatable manner (McKitterick et al., 2019). Access to high-quality environmental information is a 'public good' that needs to be available to everyone, free of charge, which if shared effectively may yield economic and environmental benefits. (Parliamentary Commissioner for the Environment, 2024) This critical consideration is currently underdeveloped in Aotearoa New Zealand's resource management strategies, resulting in (scientific) knowledge about sustainable land management being produced and disseminated from the government to those implementing this knowledge through a top-down approach (Parliamentary Commissioner for the Environment, 2024). However, this one-way approach to information transfer has been shown to be outdated and inefficient (Ahteensuu, 2012; Miller, 2001; Sturgis & Allum, 2004). There is now a growing call for recognising and supporting knowledge production and distribution through a variety of sources, particularly from the bottom-up. Newer models of science communication champion a holistic understanding of how individuals interact with (scientific) information, rather than solely being concerned about what people know or not know.

How do people engage with information? – Koru Model of Science Communication

To implement freshwater restoration, it is necessary to share information about the problem and inspire action. One model that accounts for a more holistic understanding of the factors impacting engagement with information and the use of information is Longnecker's Koru Model of Science Communication (Longnecker, 2016). Using the metaphor of an unfurling fern frond (Figure 3), the Koru Model describes that these factors are both internal (based on existing values, beliefs, attitudes, awareness, affect, understanding and skills), and external (based on social norms, support and control) and build an ecosystem around us that helps us decide whether we believe information is trustworthy and well-grounded, or not. For example, the environment in which individuals are embedded is one such external factor that is a critical determinant of how information is used. The norms that govern communities influence our behaviour (Ajzen, 1991; Cacciatore et al., 2016; Longnecker, 2016; Priest, 2016). Social norms are unwritten rules that reflect society's shared beliefs and ideas about how people should behave (Eggertsson, 2001) and what behaviour is or isn't acceptable (Hechter & Opp, 2001). They are also a key factor in adoption of pro-environmental management practices in rural communities (Collins, 2018). For example, Brown & Roper (2017) found that environmental norms within the family are strongly associated with innovativeness. Others identified that social pressures from consumers, public or regulatory boards can be effective in motivating adoption of environmental management practices (Anton et al., 2004; Horbach, 2008).

Enabling clear communication of new information from trusted sources is also critical to avoid cognitive dissonance which can occur when new information does not fit with existing knowledge (e.g., ignoring new information or holding onto faulty knowledge in preference to no explanation whatsoever; Festinger, 1957; Kahneman & Frederick, 2005; Lewandowsky et al., 2012).

In the restoration sciences, where new knowledge is constantly being created, cognitive dissonance is a risk, potentially causing delays in adoption of best land management practices. For example, while some land management actions may provide positive outcomes in some agricultural settings, the magnitude of any benefit associated with the action may be very much context-, and action-type-dependent, and the rate of change slow (Hamilton, 2012). Here, Parkyn et al. (2003) discovered that streams with planted riparian buffer vegetation showed rapid improvements in clarity, bank stability, and nutrient contamination, but not in macroinvertebrate (small animals without backbones) communities typical for 'clean water' or 'native' communities. Their findings highlight the complexity of freshwater restoration, but also emphasise that one land management action alone may not be sufficient to drive ecosystem-wide improvements. Instead, a combination of restoration actions may need to be implemented to address water quality issues in any given place, such as planting riparian vegetation for shading to cool water temperatures, fencing for keeping stock out to reduce faecal coliform contamination and retiring of steep hill country to reduce surface sediment run-off (Doehring et al., 2020).

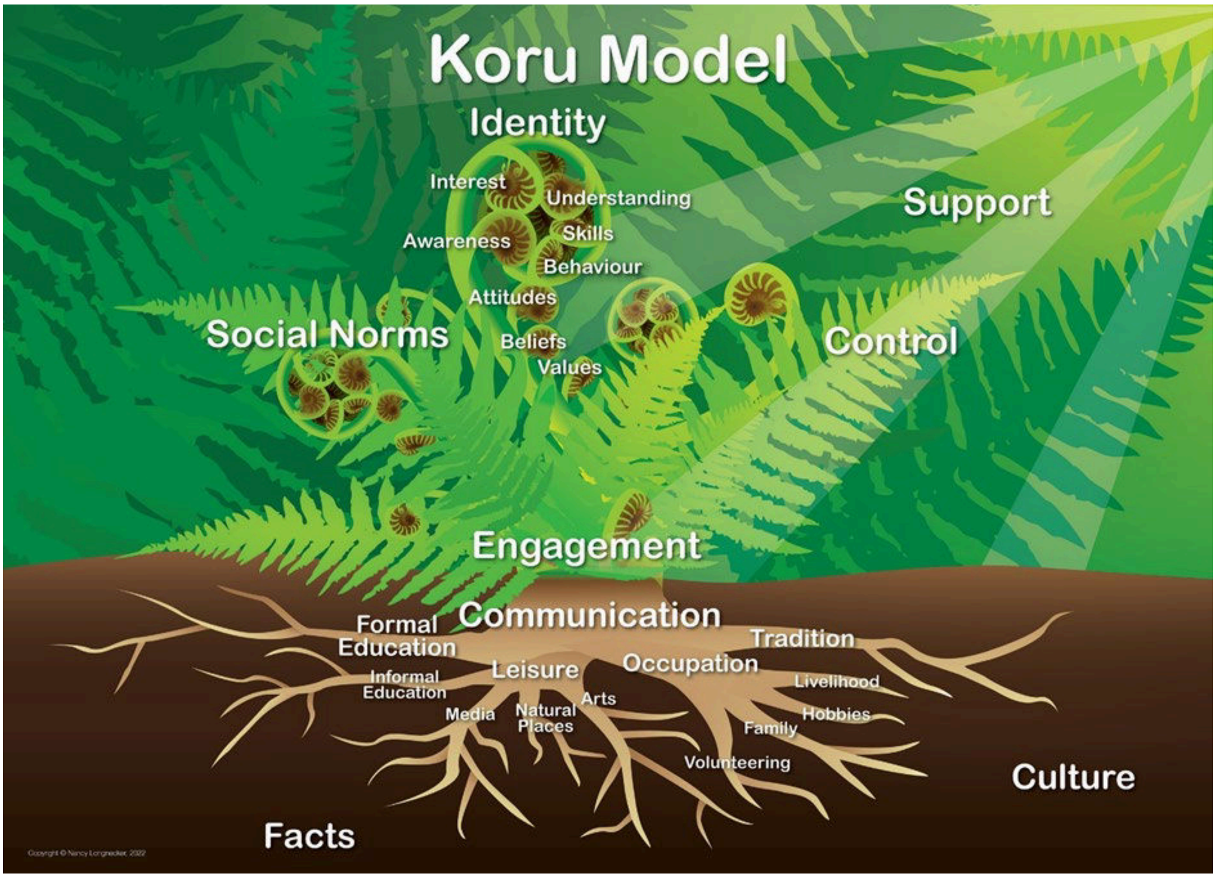


Figure 3: *The Koru Model of Science Communication. (Longnecker, 2023). Individual learners (symbolised by a koru or unfurling fern frond) obtain information from a wide range of communication avenues (roots in this visual metaphor). Learners are more likely to engage with information when it is relevant to them and aligns with their self-perceived identity. Whether and how learners make use of new knowledge is impacted by external factors, including perceived social norms, support, and control. Individual learners use new information to confirm existing schema or to construct new knowledge. The koru is a Māori symbol for growth and new beginnings and is used as a sign of respect for mātauranga Māori/ Māori knowledge, culture and values.*

Unfortunately, these complexities are often not clearly communicated to those that are implementing the actions on the ground, despite the sciences being clear. This lack of sharing of critically relevant restoration knowledge can lead to disappointment amongst implementers when the environmental benefits are not of the magnitude or within the timeframes expected. (Controller and Auditor-General - Tumuaki o te Mana Arotake, 2019)

To overcome some of these challenges and to trigger transformative environmental behaviour change (Díaz et al., 2019; United Nations, 2015), researchers and restoration practitioners are calling for more novel and accessible forms of scientific communication about the environment. Director of New Zealand's National Science Challenge Our Land and Water and Professor at the University of Canterbury, Jenny Webster-Brown, emphasises this knowledge-action gap and calls for 'a bridge across the chasm of doom': *"There have been too many instances in the past of scientists working in their labs, generating ideas that have never been applied in practice and have instead been dropped into the chasm of doom. There needs to be a bridge across the chasm to ensure solutions are practical and understandable so new practices can be adopted, and changes made. For that to happen there needs to be a real understanding of different perspectives and collaboration to find consensual solutions. Interdisciplinary science and research will play a key role but effective communication of science using language and ideas non-scientists can understand will be critical."* (https://www.farmersweekly.co.nz/news/bridging-the-chasm-of-doom/; accessed 27.02.2024).

A shift is needed in how freshwater restoration is recorded and communicated. Freshwater restoration may be more effective if science ambassadors facilitated knowledge exchange, sharing new information across rural communities while acknowledging the variables that could potentially impact how information is perceived, processed and integrated, namely relatable and trustworthy knowledge exchange.

2.5 Storytelling as a tool to encourage freshwater pro-environmental behaviour in rural communities

An introduction to storytelling

Most of us have been exposed to stories since we were born. Whether it was a song we listened to or a story read to us as a baby, storytelling is "*...central to human existence"* (Rose, 2012, p. 1). Storytelling is a universal practice that everyone, regardless of dialect, hometown, or heritage, can recognise. Storytelling is common to every known culture and its practice can be considered a successful way of meaning-making (Davies et al., 2019). Stories have always fascinated mankind.

Although the forms in which stories are being told have changed significantly over time (i.e., from cave paintings to social media), the desire to tell and hear stories has remained unchanged, profoundly impacting the way we look at life. Some of the earliest forms of storytelling were found as murals in the Lascaux Caves in the Pyrenees Mountains in southern France. These murals tell stories of early rituals and hunting practices performed and date back 400 000 years. (https://whc.unesco.org/en/soc/930/; accessed 27.02.2024). This example of early storytelling confirms current understanding of how the human brain is conditioned for stories (Haven, 2007), acknowledging the potential of stories as a tool to communicate complex phenomena (Dahlstrom, 2014; Negrete & Lartigue, 2010), such as freshwater ecosystem restoration.

Stories are easier to process and generate more attention and engagement than traditional logical-scientific communication (Dahlstrom, 2014). Information conveyed via stories can also be remembered better than traditional information communication (Negrete & Lartigue 2020). Traditionally, storytelling is a two-way interaction between someone telling a story, written or oral, and one or more listeners. *"It involves a symbiotic exchange between teller and listener – an exchange we learn to negotiate in infancy. The brain detects patterns in information. Stories are recognisable patterns and in those patterns, we find meaning"* (Rose, 2012, p. 1).

More recently, the potential of narratives, or fictional written text, in science education has been explored as a way to make science meaningful, relevant, and accessible to the public (Avraamidou & Osborne, 2009; Dahlstrom, 2014; Klassen, 2009; Negrete & Lartigue, 2010). For example, health communication developers are turning to narrative forms of communication including storytelling and testimonials to persuade and motivate people to adopt behavioural changes (Hinyard & Kreuter, 2007). Narratives are typically characterized by a structure that centres on a sequence of events and the actions of one or more characters.

They are a representation or specific manifestation of a story - a new event order means a new narrative of the same story. (Dahlstrom & Ho, 2012; Graaf et al., 2016). They often feature a clear beginning, middle, and end, incorporating elements of conflict and resolution or a 'cause-and-effect' framework (Dahlstrom, 2014; Hinyard & Kreuter, 2007). In this thesis, the terms story and storytelling will be used as overarching concepts, allowing for a range of narratives to unfold within each story.

Storytelling and its role in science communication

Stories offer distinctive ways to convey how science intersects with human experience, something that the entertainment industry, in particular, effectively uses as an approach to capture attention and foster a love for science (Kaplan & Dahlstrom, 2017). Stories can engage audiences with most scientific disciplines (Olson, 2013, 2015), and science communication practitioners increasingly use storytelling to explain complex processes, often inherent in scientific phenomena, to raise awareness, spark interest, and encourage critical discussion about science and its societal implications (Riedlinger et al., 2019).

When (new) scientific findings are presented as stories, communicators are required to place these findings within a broader societal context, which aids audiences in organising and processing new information (Downs, 2014). Consequently, stories help people grasp complex concepts and make science more relevant to their everyday lives. Scientists are increasingly recognising the need to find new ways to effectively engage with a diversity of audiences (Fiske & Dupree, 2014; Lubchenco, 1998), which is why storytelling as a science communication tool is so powerful.

However, because stories are so compelling, they must be considered carefully. For example, simple, appealing narratives can be misleading and result in the rejection of empirical reality (as can be seen in climate change discussions). Further concerns about the ethics of privileging storytelling over science-based reasoning in science communication include 1) the perception of stories to be subjective and thus their potential to taint or distort the objective nature of science, 2) their association with imaginary tales, fabrications and fiction, and 3) their potential to be persuasive without having to provide evidence to back up claims (Dahlstrom & Ho, 2012; Kaplan & Dahlstrom, 2017). This is why storytelling as a form of science communication has been criticised as manipulative and inappropriate (Katz, 2013; Redford et al., 2012), highlighting the continued need for rigor and accurate representation of reality within science narratives (Leslie et al., 2013).

Nonetheless, communication focuses on fostering understanding among differing viewpoints. To achieve this, we must recognise that objectivity alone may not be engaging (Fiske & Dupree, 2014), and scientific evidence does not necessarily convey its message on its own (Baron, 2010; Dean, 2009; Fischhoff & Scheufele, 2014; Schimel, 2012). Broad audiences understand science when we make it meaningful to them (Baron, 2010; Dean, 2009; Olson et al., 2013). Storytelling can be a powerful way to nurture engagement with science (Dahlstrom, 2014) and stories particularly can help people to understand, process and recall science-related information (ElShafie, 2018).

Digital storytelling through visuals for improved restoration knowledge exchange

Today, technical tools for communication such as PC's, laptops, smartphones, e-readers, tablets or wearable tech (such as attachable trackers for livestock) are commonly used by 'modern-day' land managers. Due to the ability of digital tools to engage a wide range of audiences, independently of the user's computer and digital skills, digital tools are becoming increasingly popular to share information in the form of stories (Cortes-Arevalo et al., 2020). Worldwide, land managers and catchment care groups connect online to build 'digital relationships' with their peers to form communities of practice (Rust et al., 2022) and to communicate land management knowledge between stakeholders (Carmona et al., 2013; van Delden et al., 2011; Volk et al., 2010).

Digital storytelling is based on similar principles as 'traditional' storytelling, however, the major difference being the 'many-to-many' approach to communication, rather than the approach of 'one-to-many'. Since the early 2000s, storytelling through digital platforms has emerged as a powerful teaching and learning tool which engages the storyteller, the anticipated recipient, as well as broader audiences (Robin, 2008). To encourage knowledge sharing of freshwater restoration information at larger than catchment scales and to monitor restoration actions across time and space in Aotearoa New Zealand, the government funded a four-year research project to establish a digital on-land management actions data repository (National Science Challenge Our Land and Water - Toitū te Whenua Toiora te Wai, 2023b). The first aim of the 'National Register of Land Management Actions' was to enable catchment-scale on-land freshwater restoration information to be recorded and reported in a systematic way (e.g., kilometres of fences built, number of trees planted, area of wetlands protected). The second aim was to connect land managers and catchment care groups through sharing their freshwater restoration knowledge in the form of stories, allowing them to exchange restoration-based insights across the country. The 'Healthy Waterways' platform was launched in November 2023 (https://healthywaterways.nz/dashboard/; accessed 25.01.24) and several catchment groups and industry bodies have since registered, confirming the need for systematic recording and reporting of land management actions and the sharing of restoration knowledge in the form of storytelling.

Making information accessible also involves adapting available knowledge into formats that practitioners can easily engage with, helping them identify what is most relevant and useful for their work (McInerny et al., 2014). 'Modern-day' storytelling allows restoration stories to be told using multi-modal storytelling agents, including photographs and videos, written text, and links to social media and websites. This diverse range of media, enabled through digital storytelling, ensures a lively experience for the reader and provides a break from written content. Using visuals to communicate scientific information to improve a story's content and design has increasingly gained attention to bridge the science-practice interface (Cortes-Arevalo et al., 2020). Visual storytelling includes a single or a collection of visuals (i.e. images, visualisations, or any combination thereof) that are either part of a larger text or have little or non-accompanying text (Figueiras, 2014; Figueiras, 2016). Depending on the visuals used as part of a story or as narrative elements, they can influence the affective and cognitive involvement by sparking the interest of the audience in a way that they can identify, recall, remember, or contextualize the content (Negrete & Lartigue, 2010).

Narrative and storytelling have garnered substantial research attention at the intersection of cartography, geography, and GIS - science (e.g., Elwood, 2006; Phillips, 2012). Recent trends and research have underscored the potential of StoryMaps in science communication for non-expert audiences (Cortes-Arevalo et al., 2020; Patterson & Bickel, 2016), in integrating new technologies into educational settings (Hong, 2014), and in involving citizens in community issues (Santo et al., 2010). Story maps are web applications that enable scientists, educators, and others to enhance interactive maps with text, figures, and multimedia content. In 2023, for example, the New Zealand Ministry for the Environment - Manatū Mō Te Taiao has used a StoryMap to convey the health of Aotearoa New Zealand's freshwater ecosystems (NZ Ministry for the Environment, 2023). The story is creatively told from the perspective of a longfin eel (tuna), one of Aotearoa New Zealand's taonga (treasured) species, communicating the challenges associated with the protection of this species in a story format.

Knowledge sharing via digital tools, such as StoryMaps has also become a key concept for catchment restoration groups across the globe whereby land managers and catchment care groups build 'digital relationships' online with their peers, communicating with each other and potentially forming communities of practice (Rust et al., 2022). In fact, many of these groups have active Facebook pages where they publish scientific information about freshwater restoration, inform about upcoming community engagements and link to other restoration related knowledge and/or activities (e.g., Brisbane Catchments Network Australia, 2200 followers; Friends of the River Roding UK, 2700 members; Pomahaka Catchment Project, Aotearoa New Zealand, 1200 followers).

To effectively raise awareness in rural communities about land management actions that help improve water quality and lead to implementation of those actions, a detailed understanding of what influences reception and use of information is needed. Based on the strengths of peer-to-peer information exchange, digital storytelling may be a suitable mode of communication to convey restoration knowledge between catchment care groups in Aotearoa New Zealand.

Telling stories is an art as it requires creativity, vision, skill, and patience. It has been a method for humanity to make sense of their environment, organise and experience ideas, as well as to create shared understanding within communities (Wyer et al., 1995). Exploring ways in which catchment communities can use storytelling to communicate their knowledge about freshwater restoration could hence make a significant contribution to constructing sustainable futures (Gearey, 2018), including not only the sustainability of ecosystems, but also of catchment communities. But which instruments should be used to tell and share a story, and what should their content include? What inspires catchment groups to share their restoration story in the first place, and who would be a suitable narrator? The following sections elaborate context for these questions.

Peer-to-peer freshwater restoration knowledge exchange and why it is needed in Aotearoa New Zealand

To successfully increase (and maintain) the intention of rural communities to manage their lands sustainably, restoration knowledge needs to be discussed with the envisaged outcomes. People are more likely to engage with information that resonates with their identity and cultural background (Longnecker, 2016). However, with the ongoing expansion of information and advice about how to sustainably manage their land, it has become more challenging for rural communities to navigate through the complex and often messy information network (Klerkx & Proctor, 2013). These challenges create a significant cognitive load on information seekers, which can lead to inefficient use of time and resources, as well as ineffective management practices (Bawden & Robinson, 2020).

To account for these challenges, rural land managers often turn to their peers for information exchange, rather than regional councils, external agricultural advisors or scientists, since the latter are commonly known to provide information that is too technical to understand (Halabi & Carroll, 2015). For example, Small et al. (2016) showed that farmers in Aotearoa New Zealand ranked regional councils poorly in terms of trustworthiness of farming advice that they provided. In comparison, communication from a (trusted) restoration community member enabled cognitive short-cuts and minimised the risk of information overload, which resulted in meaningful information uptake (Rust et al., 2022; Small et al., 2016).

Peer-to-peer information exchange enables rural communities to engage and learn from each other (Chambers et al., 1989). Farmers, for example, believe that information conveyed from someone in their own profession is more useful than from others, especially where this information already has demonstrated value and benefits to other farmers in their network (Blackstock et al., 2010). Rust et al. (2022) documented farmers' preference for learning about restoration actions from other farmers through in-person events such as farm visits. Further research confirms the critical role of peers as advisors and support, suggesting successful sharing occurs when the farmer who shares the knowledge does not have a conflicting agenda but has applied, practical experience relevant to the farmer seeking information (McKitterick et al., 2019; Rust et al., 2021; Wood et al., 2014). This means that farmers see themselves and other farmers as experts (Palmer et al., 2009), acknowledging the many different sources from which knowledge is generated, notably by the farming community themselves (Chambers et al., 1989).

For land managers to convert information into actionable knowledge that changes their land management practices, the message not only needs to be shared in a way that is understandable, but needs to be relatable and trusted (McKitterick et al., 2019; Rust et al., 2022). Essential here is the element of trust, a heuristic used to evaluate information which is based, amongst other factors, on whether new information comes from credible sources that are also trusted by peers (Lewandowsky et al., 2012). For example, Joffre et al. (2020) and Mills et al. (2017) found that a farmer's likelihood of adopting sustainable management practices and technologies were determined by the access to good quality information and the level of trust perceived from the information source. Similarly, Brown and Roper (2017) showed that farmers are more likely to adopt new practices and technologies when that demonstration was undertaken within farmer networks, because these networks already provided that interpersonal trust. Farmers in another study did not tend to trust information that came from people with limited farming experience (Mauro et al., 2009; Rust et al., 2020; Skaalsveen et al., 2020). So, social similarity to an audience allows them to identify with the storyteller and is key in building trust (Neef & Neubert, 2011).

To encourage pro-environmental behaviour change, it is important to identify effective intervention strategies and determine the circumstances under which they are most effective for specific groups of people. For bottom-up collaboration to be successful, communities need to define a common vocabulary by discussing goals, motivation, and desired outcomes which encourages open dialogue for knowledge sharing (Mamykina et al., 2002). Peer-to-peer knowledge exchange could help build collective identity using the existing common vocabulary of those communities that rely on functioning freshwater ecosystems.

For long-term benefits and effectiveness of the information communicated, local restoration knowledge then needs to be integrated into other local, regional and national restoration communities. This will facilitate the acquired information making a difference on the ground at larger scales. However, local knowledge integration is challenging as the process needs to accommodate different views and methodologies in a robust manner (Raymond et al., 2010).

One solution for knowledge integration that has become increasingly popular is the co-production of knowledge by researchers, policy makers and practitioners, defined as an 'iterative and collaborative process(es) involving diverse types of expertise, knowledge and actors to produce context-specific knowledge and pathways towards a sustainable future' (Norström et al., 2020). This co-production (also commonly termed 'participatory monitoring and evaluation') creates a learning process which strengthens knowledge acquisition and sharing amongst the various stakeholders which in turn builds trust (Raymond et al., 2010). Multiple stakeholders are then more likely to use the products if they understand the participatory processes involved and how the different forms of knowledge were integrated and can be applied within an environmental management context (Reed & Dougill, 2010).

A key indicator of project success is the extent to which the integrated knowledge outputs are used by those who input their knowledge. For example, Living Water (www.livingwater.net.nz; accessed 27.02.2024) is a ten-year long collaboration between Fonterra (a global dairy nutrition co-operative owned by farmers and their families) and the Department of Conservation / Te Papa Atawhai that formed in 2013 to jointly address lowland freshwater ecosystem degradation.

This flagship programme used an integrated approach to understand linkages and interactions between components of a system, called 'system thinking', whereby they made purposeful connections with everyone involved in freshwater restoration at small, farm and catchment scales, including farmers, scientists, tangata whenua (Indigenous people of the land), councils, and communities. Over a ten-year period, Living Water has trialled and tested the concept of restoration knowledge co-creation, and peer-to-peer knowledge exchange, proving the validity of this approach in the freshwater restoration space. At the conclusion of their ten-year programme in 2023, they were championing change by working with 60 partners and groups to improve freshwater ecosystem health across 35,000ha in five catchments (Living Water, 2023). They summarise their work, stating that "*Innovation and success is more likely with collective knowledge and shared understanding. The sharing of knowledge is about the process of sharing as much as the knowledge itself.*" (https://www.livingwater.net.nz/catchment/national-projects/maori-engagement-and-collaboration-1/; accessed 27.02.2024; para. 13).

Co-production of freshwater restoration knowledge and its exchange amongst peers is critical to encourage lasting pro-environmental behaviour change. Apart from what restoration knowledge should be shared, and by whom, considerations also need to be given to how rural communities accrue and retain new knowledge.

How do people learn? – Social Cognitive Theory

Social learning through modelling the behaviour of peers is a recognised concept in Social Cognitive Theory (Bandura, 1989), and relevant for the study of restoration knowledge sharing. Learning among farmers is inherently social but social learning does not necessarily lead to better environmental governance, such as the adoption of sustainable land management actions (Nykvist, 2014). Bandura's theory is based on the idea of 'observational learning', a relevant concept for effective restoration knowledge communication.

Observational learning considers in detail the unique way in which individuals acquire and maintain behaviour, while also considering the social environment in which individuals perform the behaviour, based on a person's past experiences (Bandura, 1989). It postulates that learning can occur by observation and/or interaction with others in communities through the process of behaviour modelling, in addition to individual cognitive learning. In the field of environmental management, it has been recognised that observational learning can help avoid repetition of past management failures in complex social-ecological systems (Armitage et al., 2008; Blackmore, 2007). In rural catchment community terms, this could be 'looking over the fence to see what my neighbour has done', rather than solely 'learning by doing' (Figure 4). The land manager over the fence then acts as a 'model' or an 'influencer', a critical source of learning within farming communities (Burton, 2004; Zeng et al., 2022).

Social Cognitive Theory provides a framework for understanding psycho-social mechanisms that influence human thought, and for predicting and changing human behaviour (Bandura, 1989). Story parts or narrative elements influence cognitive involvement by sparking the interest of the audience in a way that they can identify, recall, remember, and contextualise the content (Dahlstrom, 2014). Based on Social Cognitive Theory, the following four cognitive processes impact restoration knowledge sharing and pro-environmental behaviour change following a modelled event (e.g., freshwater restoration and restoration knowledge sharing): retention and extraction of information, motivation to reproduce modelled behaviour, reproduction of modelled event, and recall of modelled event (Figure 4).

Exploring ways in which catchment communities can use storytelling to communicate could make a significant contribution to constructing sustainable futures (Gearey, 2018), including the sustainability of ecosystems and catchment communities, and reinstating social license to operate. Equally important to the accrual of new knowledge through observational learning are the mechanisms that can be used to share the learnings. I discuss mechanisms for sharing knowledge in the following section.

Social Cognitive Theory	**MODELLED EVENT**	**RETENTION & EXTRACTION**	**MOTIVATION TO REPRODUCE BEHAVIOUR**	**REPRODUCTION**	**RECALL**
“Learning by observing others”	Influencers share restoration knowledge and experiences.	Others observe and attend knowledge and accurately perceive the model’s behaviour.	A change in behaviour is triggered.	Modelled behaviour is reproduced.	Emotional memory of the catchment story is triggered by empathy, sympathy, surprise, curiosity and suspense.
Social Cognitive Theory applied through restoration stories	A rural community member/ catchment group restores a catchment and shares restoration knowledge through a story.	Story audience accurately observes and attends the act of knowledge sharing through stories as well as the content of the information shared.	Story audiences understand the relevance the modelled behaviour and are motivated to reproduce it.	Story audiences reproduce restoration behaviour.	Story audience remembers both, the act of knowledge-sharing through stories as well as details of the information shared.
“Looking over the fence”					

Figure 4: *Four cognitive processes (retention and extraction of information, motivation to reproduce behaviour, reproduction and recall of information) which impact restoration knowledge sharing and pro-environmental behaviour change informed by Social Cognitive Theory (Bandura, 1989).*

2.6 Knowledge gaps and research objectives

Encouraging pro-environmental behaviour and sustaining it over time is difficult. Solely educating stakeholders about potential positive outcomes on freshwater ecosystems through sustainable land management practices is unlikely to be sufficient to maintain and improve the health of Aotearoa New Zealand's rivers, lakes and wetlands. '*Clear, complete, up to date, consistent, accessible, and readily available information'* (Controller and Auditor-General - Tumuaki o te Mana Arotake, 2019) needs to be effectively communicated for behaviour change to be triggered and implemented. Communication strategies that are driven from the bottom-up are likely to allow the implementors of freshwater restoration, such as policy makers, scientists and rural communities to connect more effectively with each other, enabling a successful shift in thinking. To facilitate this shift in thinking, four knowledge gaps and needs were addressed in this thesis:

1) poor understanding of **what** restoration knowledge should be shared amongst catchment communities to engage and encourage best practice.
2) limited comprehension of **why** restoration knowledge sharing is important, and what principles motivate land managers to record and report their freshwater restoration actions,
3) a need to understand **how** communication tools could be appropriately harnessed for sharing freshwater restoration knowledge to encourage ongoing restoration action, and
4) underdeveloped understanding of **who** may be suitable messenger(s) to motivate lasting catchment restoration in restoration communities.

Based on the review of the literature and the knowledge gaps identified, I conducted research to help understand the role collective storytelling may play as a tool to share freshwater restoration knowledge between rural communities. The following research questions guided my work (Figure 5).

1) *What motivates land managers to record and report land management actions?*
    a. *WHAT restoration knowledge should be shared?*
    b. *WHY is restoration knowledge sharing important?*
    c. *WHY are catchment communities compelled to share?*

These questions were posed to determine key motivators for Aotearoa New Zealand land managers to record and report sustainable land management actions on their land

and explore reasons as to why knowledge sharing is important for these communities and their freshwater catchments. (Chapter FOUR)

2) *HOW is restoration knowledge shared within and across catchment restoration communities?*

    a. *What role do catchment restoration stories play in inspiring environmental change?*

Once I had a better understanding of what triggers land managers to record and share their knowledge, I explored the mechanisms and content of restoration knowledge sharing. (Chapter FIVE)

3) *WHO is best placed to share restoration knowledge?*

    a. *What role do storytellers play in motivating collective restoration action?*

With the knowledge gained from my research addressing the previous two research questions, I tested for differences in cognitive processing of restoration story content depending on whether a story was told by a respected individual or a collective voice. (Chapter SIX)

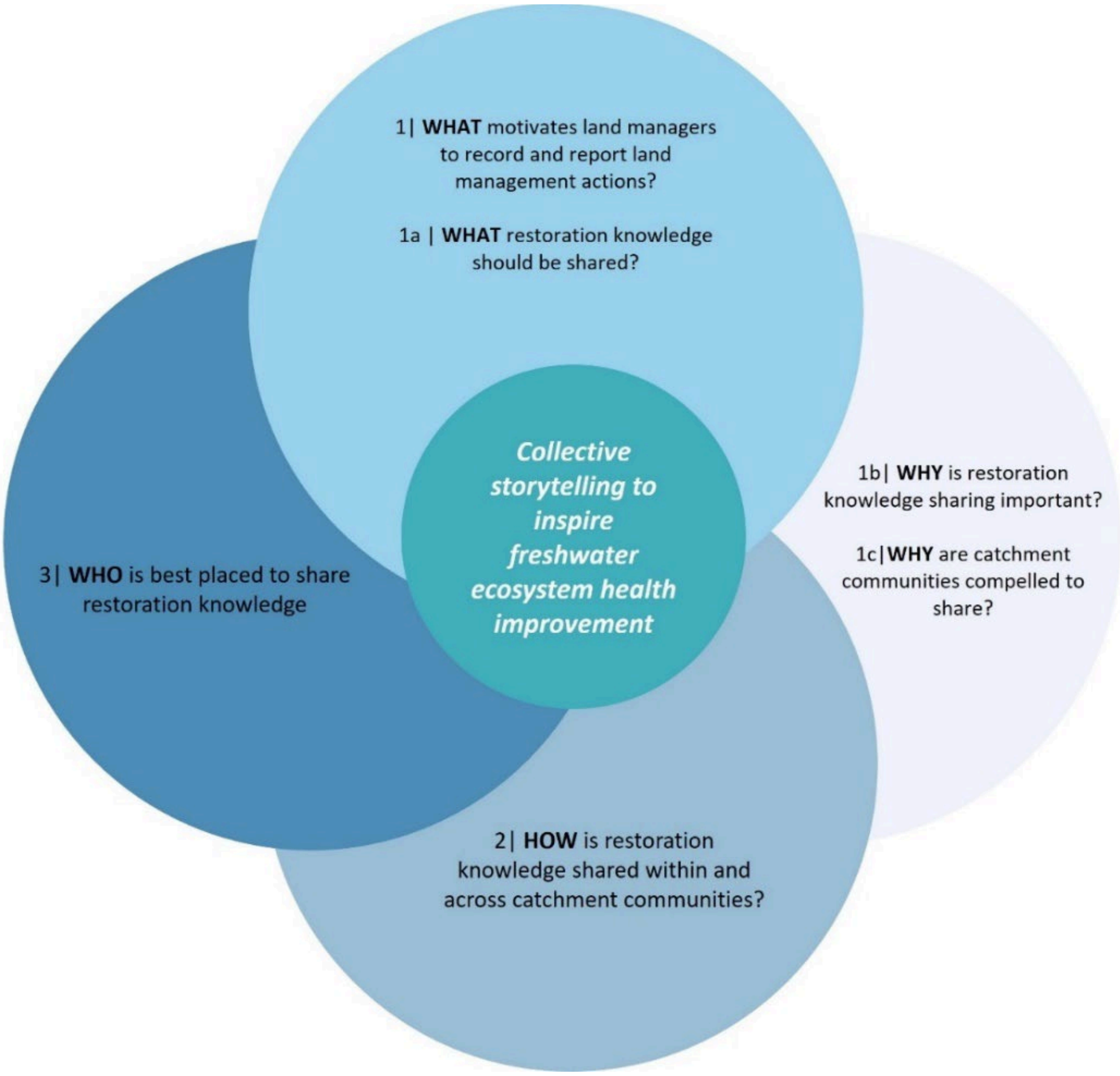


Figure 5: *To increase understanding about the role collective storytelling plays as a freshwater restoration tool, the WHAT, WHY, HOW and WHO of freshwater restoration knowledge sharing needs to be explored.*

Mā te kōrero, ka mōhio,

Mā te mōhio, ka mārama,

Mā te mārama, ka matau,

Mā te matau, ka ora

Through discussion comes awareness,

Through awareness comes understanding,

Through understanding comes knowledge,

Through knowledge comes wellbeing

THREE | Research paradigm and methodology

ONE
Research Strategy and Motivations

TWO
Introduction, Literature review and Theoretical Frameworks

THREE
Research Paradigm and Methodology

- 3.1 Pragmatic worldview as a research paradigm
- 3.2 Exploratory sequential mixed methods as a methodological approach
- 3.3 Structure of thesis

FOUR
A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?

FIVE
Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change

SIX
Trusted storytellers as freshwater restoration knowledge brokers: individual and collective voices can both be effective

SEVEN
Conclusions and Implications

3.1 Pragmatic worldview as a research paradigm

'Worldview', as a synonym for paradigm, can be defined as "*a basic set of beliefs that guide action*" (Guba, 1990, p. 17) or "*a way of thinking about and making sense of the complexities of the real world*" (Patton, 2002, p. 69). This set of beliefs encompasses the philosophical orientation with regards to the world and the way in which a researcher interprets their study (Creswell & Creswell, 2023). My worldview is shaped by my discipline as a freshwater ecologist. It arises out of actions, situations, and consequences, as well as the research I have been part of over the last 15 years. I have adopted a *pragmatic worldview* (Creswell & Creswell, 2023) which is not committed to any one system of philosophy and reality, but opens the doors to multiple methods, different worldviews and assumptions, and different forms of data collection and analysis. Pragmatism emphasises the practical implications and applications of knowledge, suggesting that the meaning and truth of ideas should be judged by their practical consequences. Rather than relying solely on abstract principles or theoretical frameworks, pragmatists prioritise the usefulness and effectiveness of ideas in guiding action and solving problems. This worldview harmonises with my experiences as a freshwater ecologist and aligns with my approach to research.

Because a pragmatic worldview research philosophy embraces more than one research approach and strategy within the same study, the use of mixed methods is used to provide the best understanding of a research problem (Creswell & Plano Clark, 2011). My research questions, therefore, were addressed through a mixed method approach, drawing from both quantitative and qualitative methodologies, valuing both objective and subjective knowledge.

3.2 Exploratory sequential mixed methods as a methodological approach

A combination of qualitative and quantitative methods (mixed methods approach) (Creswell, 2014) enabled me to robustly explore my research questions and to gain a more holistic understanding and interpretation about communication and storytelling in the context of motivating pro-environmental behaviour.

In general, mixed methods research allows statistical trends obtained from close-ended quantitative data to be integrated with qualitative information in the form of stories and personal experiences. Quantitative methods are weak for investigating personal stories, meanings and deeper explorations of individual perspectives and experiences, while qualitative methods fall short in generalising results from small samples to bigger populations (Creswell, 2014). By applying mixed-methods, the shortcomings of one methodology can be compensated for by using the other (Johnson & Onwuegbuzie, 2004; O'Leary, 2010), allowing a more holistic understanding of a phenomenon to be obtained (Yvonne Feilzer, 2010). Through incorporating mixed methods, I was able to gain a more comprehensive understanding of rural community social dynamics and was able to deeper explore the issues that may not be fully captured by one method alone.

A mixed methods approach also gave me flexibility in using sequential design, whereby one phase of my study informed the next (Figure 6). Following an exploratory sequential approach, I began my work with a qualitative research phase which allowed me to first explore a problem (i.e., is collective storytelling a suitable tool for enhancing freshwater restoration actions?) and then develop an intervention which tested this problem through quantitative methods (i.e., how suitable a tool is collective storytelling for motivating freshwater restoration?).

My project was designed as a multistage process (Figure 6). First, semi- structured face-to-face interviews (Appendices A, B and C) were used to collect data from stakeholders who exhibited the 'personal factor', a trait recognizable in "*people who personally care about the findings it generates*" (Patton, 2008; p.66). I identified participants who were knowledgeable about sustainable land management to provide useful practice-based knowledge. This ensured that the sampling process uncovered a range of perspectives, encouraged knowledge generation, and provided useful information that could be invested immediately into practice. I collected data from national sector representatives (e.g., Dairy NZ, Horticulture NZ), governmental and non-governmental organisations (e.g., Department of Conservation, Ministry for the Environment, Forest & Bird) and land managers (e.g., farmers) to examine their responses to the overall recording and reporting of land management action data. Qualitative analysis involved thematic coding (Appendix B), using an inductive approach (Creswell, 2014). These data are presented in Chapter FOUR.

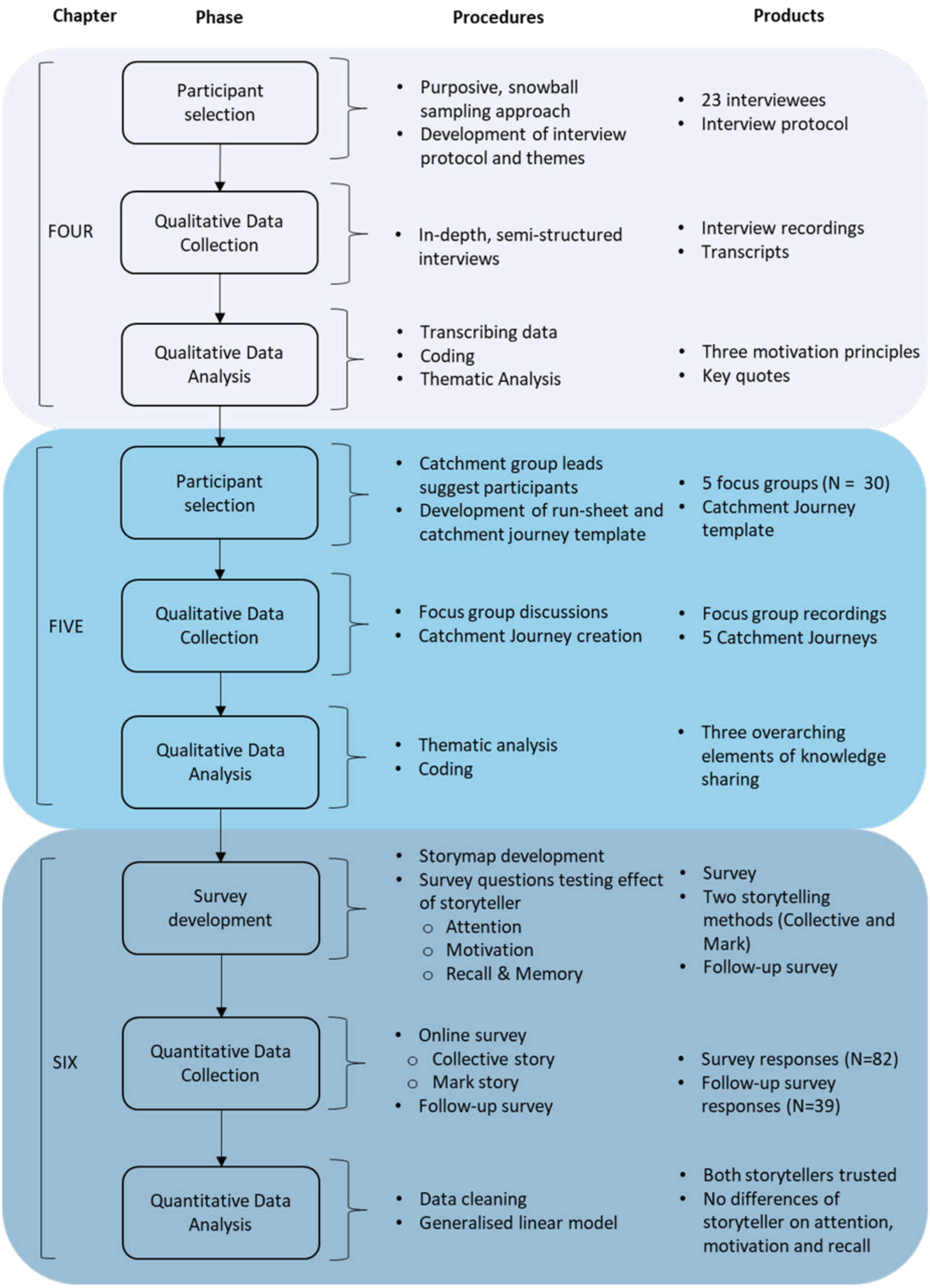


Figure 6: *Procedural diagram for mixed methods research design.*

For Chapter FIVE, I conceptualised and defined how knowledge sharing through storytelling could be used as a tool to inspire large scale freshwater restoration action amongst catchment care groups. Data were collected through focus-group discussions (Appendix D and F). Qualitative analysis involved thematic coding (Figure 6; Appendix E), using an inductive approach (Creswell, 2014). This allowed me to systematically develop frameworks of the underlying structure of experiences and processes that became evident in the raw data, producing meaningful, reliable, and valid results.

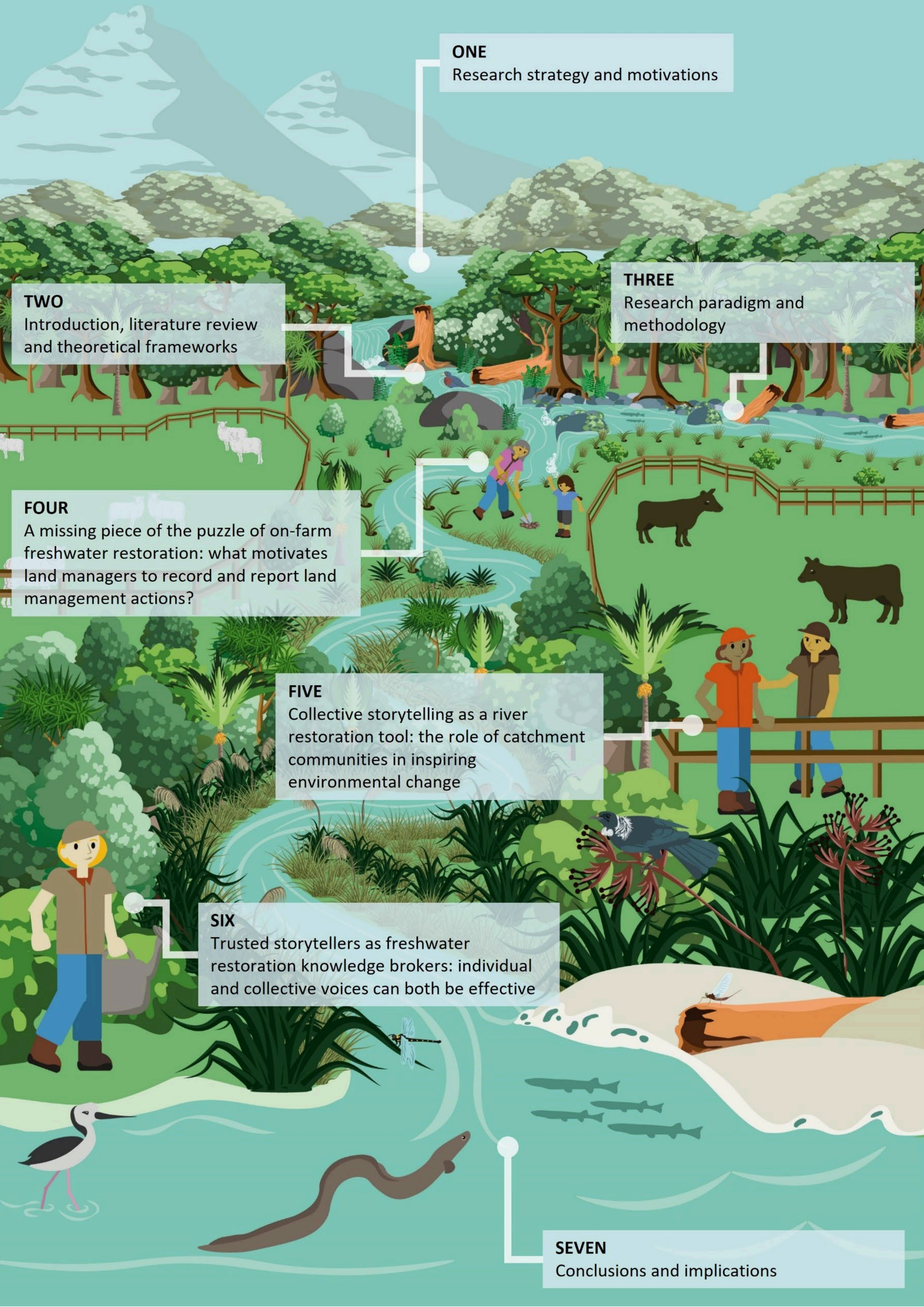
Chapter SIX (Figure 6) involved a quantitative pre-post intervention survey. This survey was set up as a two-part process; part one tested the effects of storytelling on extraction of new information in the reader, and part two tested the effects of replication of actions based on observing a model (Appendix H and I). Quantitative survey methods tested four hypotheses. Results were statistically analysed using descriptive statistics for demographics data (e.g., age, region) and generalised linear models to explore if the responses to the survey were different between treatments and among categories of the demographic variables. This research approach followed a deductive methodology whereby Social Cognitive Theory was tested to see whether it was valid in my study. Detailed descriptions of methods and analyses used for each study are provided in the methods sections of Chapters FOUR, FIVE and SIX.

3.3 Structure of thesis

Chapter ONE provides insights into the research strategy, my personal background and the motivation behind my research. In Chapter TWO, I offer an overview of Aotearoa New Zealand's freshwater ecosystems (2.1), highlighting the challenges these systems face and the integral role of farming in the country. I also review existing literature on the protection and restoration of freshwater ecosystems and the challenges associated with restoration (2.2). I then describe the importance of catchment communities as freshwater restorers and introduce the Model of Responsible Environmental Behaviour (Hines et al., 1987) as a theoretical framework that informed my research (2.3). I review literature on how accessible information can enable freshwater restoration and how the Koru Model of Science Communication (Longnecker, 2016) guided my theoretical thinking (2.4). I introduce the concept of knowledge sharing in the form of storytelling, specifically digital storytelling as a means of transferring peer-to-peer restoration knowledge (2.5). I conclude by outlining four knowledge gaps within the field of the freshwater restoration social-ecological sciences (2.6). Chapter THREE delves into my research paradigm (3.1), the methods used, and the methodological approaches applied (3.2), before concluding with this sub-chapter outlining the structure of my thesis (3.3). Chapter FOUR explores WHAT restoration knowledge should be shared amongst catchment communities, WHY restoration knowledge sharing is important and WHY catchment communities feel compelled to share restoration knowledge in the context of a Model of Responsible Environmental Behaviour. Chapter FIVE places my research findings into context with the Koru Model to help answer HOW freshwater restoration knowledge can be transferred through storytelling in the context of internal and external factors that impact a farmer's engagement with information. Following on from the WHAT, WHY and HOW of restoration knowledge sharing, Chapter SIX explores WHO may be a suitable messenger of restoration knowledge, using Bandura's Social Cognitive Theory to guide my thinking (Bandura, 1989). An overarching conclusions chapter (SEVEN) then outlines key findings, placing them into the context of freshwater ecosystem health restoration in Aotearoa New Zealand and discussing potential implications for advancing restoration. Supplementary materials that either informed my work, ensured robust research procedures were followed, or present content produced as part of my research are appended.

Rather than presenting all methods used in one chapter, my thesis adopts a hybrid format. Because articles about Studies 1- 3 have already been published in the peer-reviewed academic literature, Chapters FOUR, FIVE and SIX include the introduction, methods, results, and discussion sections of the articles. The references for the articles have been shifted and compiled into one complete list of cited literature at the end of the thesis. While Chapters FOUR – SIX report about distinct studies, some concepts are repeated to ensure adequate context for their research results and discussion.

Prior to each chapter, I incorporated a whakataukī, a traditional Māori proverb or saying that encapsulates significant aspects of Māori culture, wisdom, values, and teachings. These proverbs are often passed down through generations and are used to provide guidance, convey moral lessons, or illustrate a point. The whakataukī I have used are rich in metaphor and symbolism that align with my research topic and worldview. They reflect the interconnectedness of nature, spiritual, and human experience, three realms that played an integral part during my study. Citing the proverbs allows me to set the scene for each chapter and reminds me that many belief systems worldwide share more commonalities than differences.


ONE
Research strategy and motivations
TWO
Introduction, literature review and theoretical frameworks
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FOUR
A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?
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Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change
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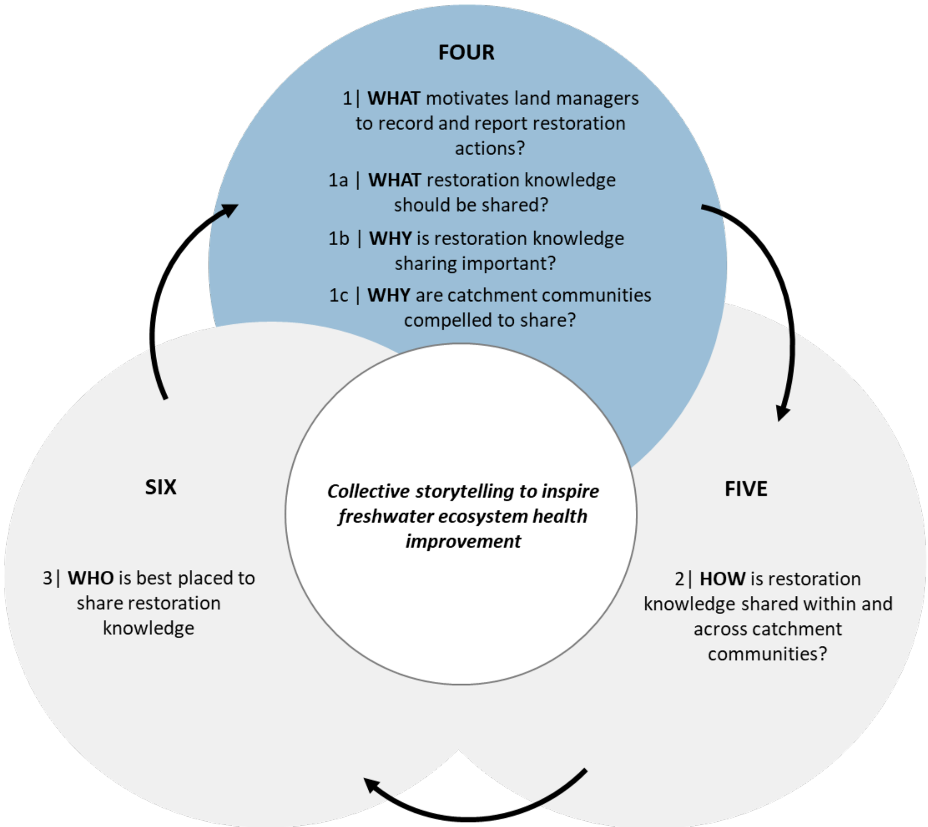
SEVEN
Conclusions and implications

Ko te pae tawhiti whāia kia tata,

Ko te pae tata whakamaua kia tina

Seek out the distant horizons,

while cherishing those achievements at hand



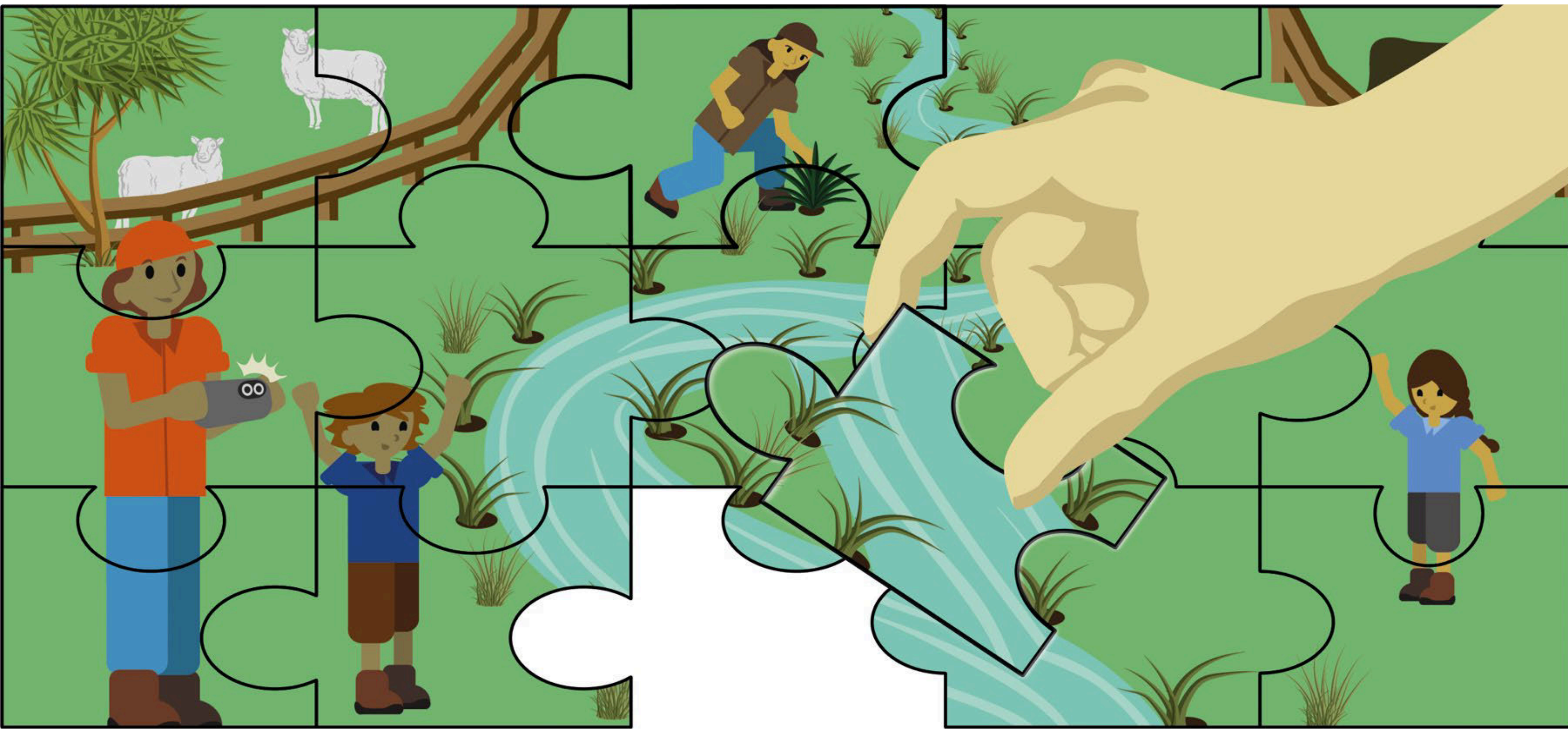
In a rapidly changing world, the pressure on agricultural land managers to balance human wellbeing, environmental health, and financial sustainability is intense. A significant part of this challenge involves understanding the impact land management practices have on freshwater ecosystems and whether environmental bottom-lines can be met through changes within the same farm system, or whether wider, whole-system land use is required. Public awareness of these issues (Booth et al., 2022) has led to heightened expectations for land managers to adopt sustainable land management, or restoration, practices, including the creation of buffer strips, construction of wetlands, and excluding stock from waterways through fencing. However, a critical obstacle remains for the implementation of land management actions that help improve water quality within the same farm system: the absence of standardised methods for recording and reporting these actions. This inconsistency hampers the accurate assessment of their impact on water quality.

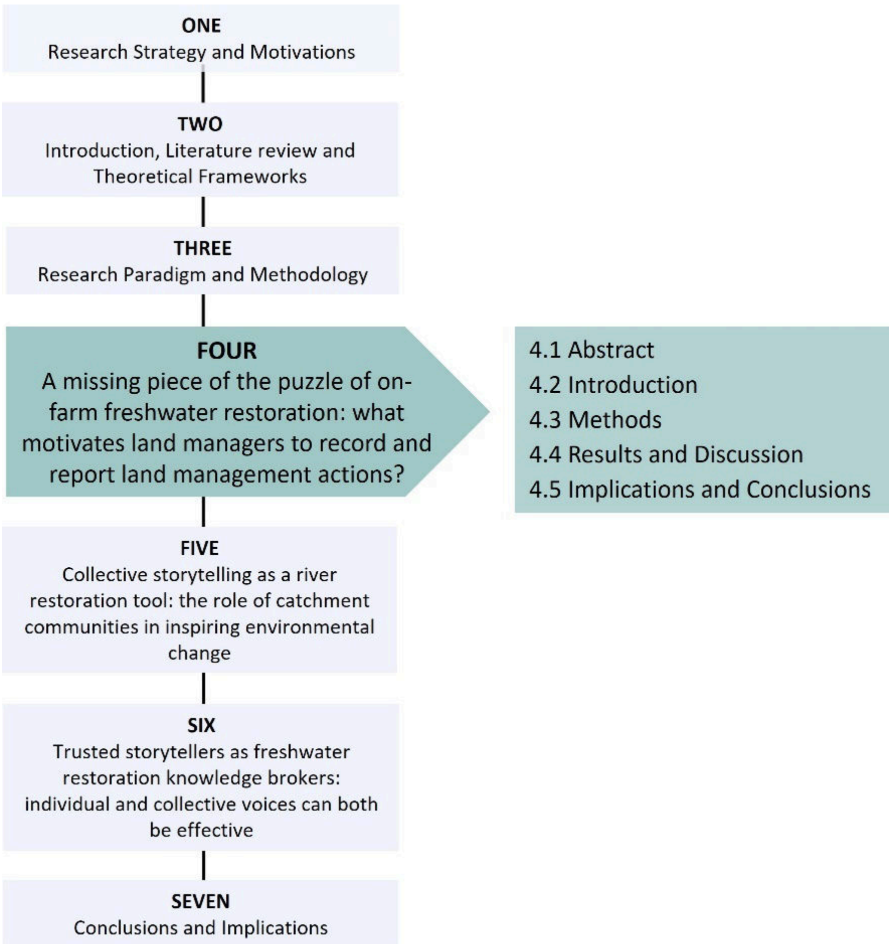
In the following chapter, this situation is compared to a jigsaw puzzle, with a crucial piece missing—systematic documentation of sustainable land management actions. The terms ‘sustainable land management actions’, ‘holistic land management actions’ and ‘restoration actions’ are used interchangeably throughout my research and describe the same principle - the application of on-land farming practices that help improve water quality.

This chapter is the first of three data chapters and investigates WHAT motivates land managers to record and report restoration knowledge, WHAT restoration knowledge should be shared amongst catchment communities, WHY restoration knowledge sharing is important, and WHY catchment communities feel compelled to share restoration knowledge in the context of a Model of Responsible Environmental Behaviour.

My research addresses the complexities and challenges of quantifying land management actions and explores the socio-psychological factors influencing land managers' decisions. My research aims to bridge this critical knowledge gap and inform the development of a National Register of Land Management Actions in Aotearoa New Zealand, with broader implications for international contexts. An aim of this work is to illuminate the essential role of systematic recording and reporting in advancing the sustainability of freshwater ecosystems and fostering healthier communities.

FOUR | A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?





4.1 Abstract[4]

Worldwide, progress has been made toward managing productive lands more sustainably to improve freshwater health. However, a lack of national guidance for environmental reporting and recording means that it is not possible to quantify consistently which land management actions that help improve water quality have been implemented, where, when, and to what extent. This situation suggests that information on the effectiveness of these actions is missing or fragmented. Systematic recording and reporting of land management actions is an important piece of a large freshwater restoration puzzle. We investigated what motivates Aotearoa New Zealand land managers to record their actions and report them to their networks by conducting 23 semi-structured interviews. Between February and November 2020, we spoke with food and fibre producers, Aotearoa New Zealand Indigenous people of the land tangata whenua community members, and government and industry representatives. The key themes that described motivators for these land managers to record and report land management actions were collective engagement (e.g., working with catchment care groups), identity and social norms (e.g., being a 'socially approved' farmer), and efficient farm management (e.g., using one simple recording tool for multiple purposes to save time). While these findings will be broadly germane to international contexts, they are being used specifically to inform the development of a proposed National Register of Land Management Actions in Aotearoa New Zealand.

Keywords: agriculture; catchment groups; ecosystem; freshwater; land management; land use actions; monitoring; motivations; recording; reporting; restoration

4.2 Introduction

Globally, pressures have never been greater for land managers to practice integrated land management that supports healthy people, a healthy environment, and a healthy return on investment. The impacts of agricultural production on the health of freshwater environments are well recognised, especially high concentrations of nutrients and sediment (Allan, 2004; Clark & Tilman, 2017; Food and Agriculture Organization of the United Nations, 2016; Mateo-Sagasta et al., 2017). Changes to environmental legislation such as Aotearoa New Zealand's

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[4] Doehring, K., Longnecker, N., Cole, C., Young, R. G., & Robb, C. (2022). A missing piece of the puzzle of on-farm freshwater restoration: What motivates land managers to record and report land management actions? *Ecology and Society 27*. https://doi.org/10.5751/ES-13562-270425

National Policy Statement for Freshwater Management (NZ Ministry for the Environment & Stats NZ, 2020), Australia's Queensland Government's Reef 2050 Water Quality Improvement Plan (https://www.reefplan.qld.gov.au/; accessed 27.02.2024), and the UK's Environment Bill 2020 (Department for Environment Food & Rural Affairs, 2022) reflect the impacts that agricultural production has had globally on freshwater ecosystem health. These legislative changes, along with increasing public awareness (e.g., Doehring et al., 2020; Rousseau & Deschacht, 2020; StatsNZ - Tatauranga Aotearoa, 2018), have created significant expectations for land managers to move toward holistic land management actions. These actions most commonly include fencing of land adjacent to waterways, stock exclusion from waterways, vegetated buffer strips or plantings, riparian management plans, and construction of artificial and natural seepage wetlands (Doehring et al., 2020).

Although recognised techniques exist to record and report some of these actions (e.g., decision support tools for the management of grazing and crop practices), an overall lack of standardised recording methods means that there are large inconsistencies in how actions are recorded (e.g., ranging from paper records to photographs and digital recording). These inconsistencies result in the inability to determine accurately which land management actions have the greatest effect on water quality outcomes (Filoso & Palmer, 2011; Pander & Geist, 2013), making the effectiveness of freshwater restoration efforts difficult to assess (Doehring et al., 2020). This situation is particularly the case where many different yet contributing actions need to be evaluated, all while separating impacts caused by climate change and natural influences.

The jigsaw puzzle of improving water quality

The process of improving water quality is comparable to completing a jigsaw puzzle with critical pieces of knowledge missing (Figure 7). There are three pieces of information to the puzzle, two of which are commonly done and reasonably well understood: the type of water quality actions that land managers implement, and the state and trends of water quality. Freshwater quality information, in particular, is commonly recorded and reported, contributing detailed pieces of information to the complex restoration puzzle. For example, water quality is collected at > 1500 river monitoring sites in Aotearoa New Zealand (https:// www.lawa.org.nz; accessed 27.02.2024) and at > 13,000 sites in Germany (Arle et al., 2016).

However, although the state and trends of freshwater quality are generally well understood, just measuring outcomes (e.g., water quality) without simultaneously quantifying actions (e.g., 98% of stock excluded from riverbanks) leads to an inability to evaluate accurately which actions are most effective and why (Figure 7). This situation describes the third (missing) piece of the puzzle: the systematic recording and reporting of what type of land management actions have been done, where, and to what extent. Although multiple open access databases exist that allow the recording and reporting of a variety of restoration action data worldwide (e.g., Atlas of Living Australia, https://www.ala.org. au/; The Global Restore Project, https://www.globalrestoreproject. com; Coral Restoration Database, https://www.icriforum.org/ restoration/coral-restoration-database/; all accessed 27.02.2024), these data depositories do not offer detailed enough frameworks to enable systematic recording and reporting of land management actions.

Without this critical (puzzle) piece of information, any type of freshwater restoration cannot be assessed for its effectiveness, inhibiting freshwater ecosystem-relevant change (Bernhardt et al., 2007; Parliamentary Commissioner for the Environment, 2019; Robert et al., 2005). The puzzle analogy is a useful conceptual framework for our research, and we refer to it throughout this article.

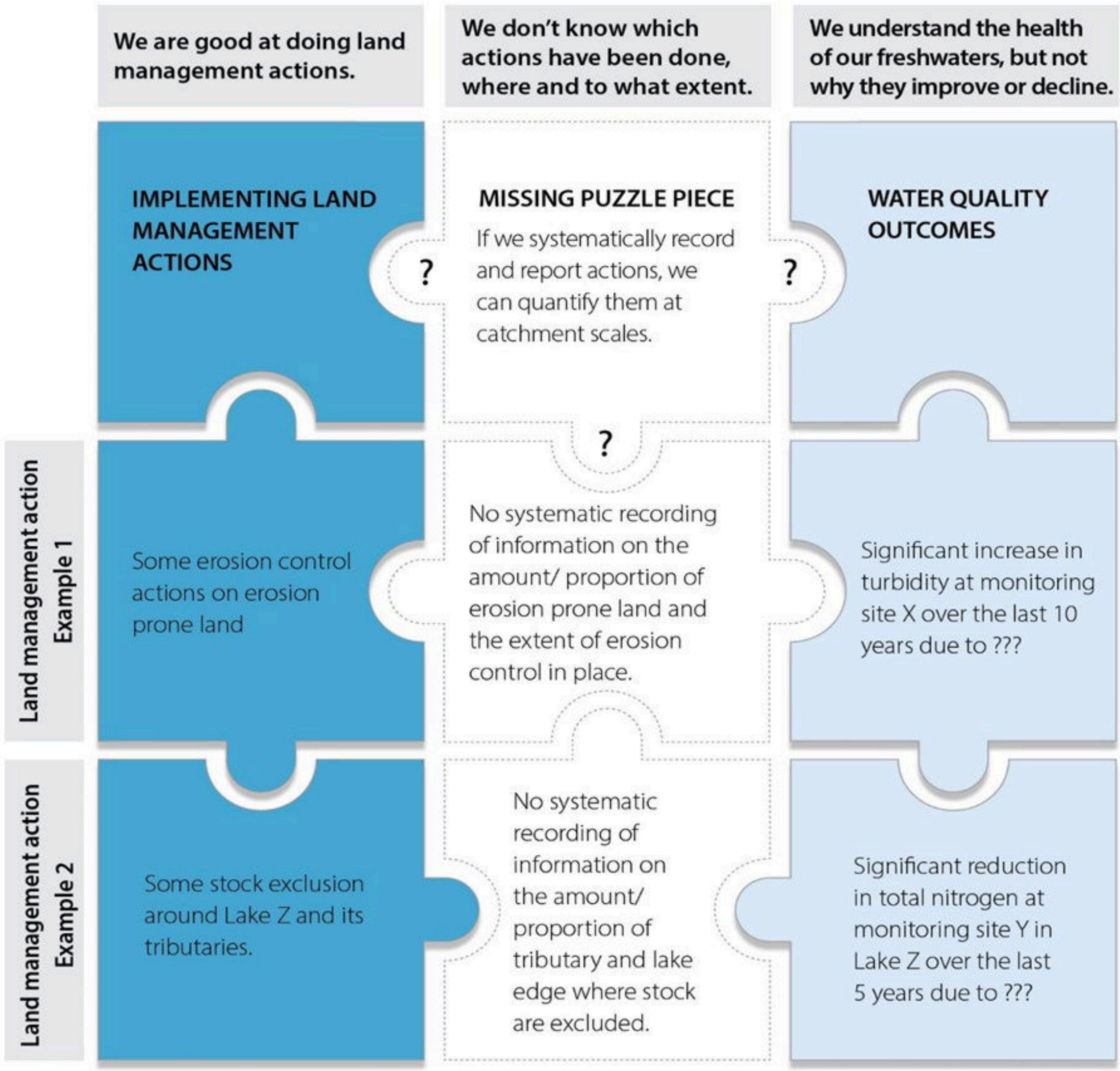

Figure 7: *The puzzle of freshwater restoration. We are good at implementing land management actions that help improve water quality (left column), and we understand the state and trends of water quality (right column). However, we do not understand why water quality is improving or declining because we do not systematically record and report land management actions that improve water quality (middle column). Once actions are systematically recorded and reported, their effectiveness can be assessed. This figure represents an illustrative concept, showcasing a subset of two potential land management actions relevant to on-farm water quality restoration, their indicators, and hypothetical water quality outcomes.*

The need for this research

There is a multitude of complexities associated with systematically quantifying actions, including high costs, privacy and confidentiality issues, lack of standardised methods, variability of data quality due to multiple spatial scales, and the lag effects of management actions (Doehring et al., 2020). To address some of these challenges, the Aotearoa New Zealand government funded a study to develop a National Register of Land Management Actions, which will provide a much-needed repository tool, capturing consistent information within a centralised 'data warehouse' that brings together data from various platforms (https://ourlandandwater.nz/incentives-forchange/national-register-of-actions/). Although our findings specifically inform the development of this National Register in Aotearoa New Zealand, the insights gained are widely applicable in international contexts.

Any data reporting platform is only as good as the information it contains. For the purposes of catchment management, that information must be available for sharing with others. We use the term 'recording' to refer to any collection of information on land management actions that influence water quality (e.g., written notes, photographs, existing databases) and the term 'reporting' to refer to any form of information and knowledge sharing (e.g., social media, any form of oral communication, industry-specific reporting platforms). For any data recording and reporting platform to be successful, land managers must be sufficiently motivated and empowered to participate in the platform. Substantial research efforts have assessed the efficacy of innovative smart technologies for farm management (e.g., decision-support tools, variable-rate irrigation; Grober & Grober, 2020), and the adoption of new management practices and tools (e.g., Ahnström et al., 2009; Brown & Roper, 2017; Heath, 2011; Rust et al., 2021). Substantial research has also been done on the social theoretical aspects of adoption of innovations in agriculture (Montes de Oca Munguia et al., 2021), including the 'model of contagion' whereby people adopt new practices when they come into contact with others who have already adopted the practices (Young, 2009). However, there are still considerable knowledge gaps around the roles of sociopsychological variables (e.g., attitudes; social pressures; behavioural, cultural, economic, and regulatory barriers) in motivating land managers to record and report their actions. Our research aims to address this gap by informing the implementation of an effective national register through exploring such sociopsychological aspects.

Responsible Environmental Behaviour as theoretical framework

We regard any actions that improve water quality, including systematic recording and reporting, as pro-environmental behaviour, which can be referred to as any behaviour that "*harms the environment as little as possible, or even benefits the environment*" (Steg & Vlek, 2009, p. 309). Pro-environmental behaviour is directed toward and performed with the intention of promoting the welfare of others (Ramus & Killmer, 2007). Acting for the benefit of others contributes to intrinsic satisfaction, which drives pro-social motivation and behaviour (Caprara & Steca, 2007; Grant, 2008; Greiner & Gregg, 2011). It is not well understood which variables are most influential in motivating individuals or groups to take responsible environmental action (Tabernero & Hernández, 2012). Our study addresses this gap by exploring motivational variables that affect pro-environmental behaviour in the Aotearoa New Zealand context, under the theoretical framework of the Model of Responsible Environmental Behaviour (Hines et al., 1987). This model was developed based on an analysis of 128 empirical studies in environmental behaviour that found that an individual's intention to act in an environmentally responsible manner depends on a composition of six cognitive and personality variables. Here, we list these variables in the context of landowners' intentions to record and report.

1. Knowledge of issues: Any factors pertaining to knowledge of the environment or aspects of environmental problems and their consequences. In our context, this variable means that land managers with greater knowledge of environmental issues would be more likely to record and report land management actions than land managers who are not aware of any issues.

2. Knowledge of action strategies: This variable is closely linked to variable 1, whereby land managers with knowledge on how to take action on freshwater degradation are more likely to record and report land management actions because they are more likely to understand the connections between recording and reporting and freshwater restoration.

3. Locus of control: Represents an individual's perception of whether he or she can bring about change through his or her own behaviour (internal locus of control), as opposed to the belief that change occurs through chance or powerful others such as government (external locus of control). In our context, land managers who have an internal locus of control would be more likely to record and report land management actions.

4. Attitude-behaviour relationship: The general attitude of an individual, and an individual's feelings toward recording and reporting land management actions, whereby land managers

with more positive attitudes toward recording and reporting are more likely to engage in the process.

5. Verbal or written commitment: An expressed intention to act upon a pro-environmental action. Thus, land managers who commit to recording and reporting land management actions, either verbally or in written form, are more likely to do so than land managers who do not commit.

6. Individual sense of responsibility: An individual's feelings of duty or obligation to portray pro-environmental behaviour. In our context, land managers who feel some degree of personal responsibility toward the environment are more likely to engage in pro-environmental behaviour than land managers who hold no such feelings.

We think that the empirical application of the Model of Responsible Environmental Behaviour is well suited for our research. We were interested to determine whether the six variables could be applied as determinants of increasing land manager's intentions to record and report land management actions in our context.

4.3 Methods

Twenty-three in-depth, semi-structured interviews were conducted between February and November 2020. Interviewees were targeted leaders whom we categorised into the following five stakeholder groups: 1) public or community, 2) Indigenous people of the land or tangata whenua, 3) government, 4) a range of primary industry sector bodies, and 5) food and fibre producers[5] (Table 1). Industry sector bodies and producers (including agricultural organizations and farmers) will be the primary data providers for the Register of Actions and therefore comprised 12 of the 23 interviewees. Members of the other three stakeholder groups are also likely to provide data or to use the register to inform their catchment management actions; these 11 interviewees were included to explore the perspectives of a range of potential register users. A purposive, snowball sampling approach (Corbett, 2005; Robson, 2011) was used to identify and select key individuals covering the range of stakeholder types. Participants were selected based on their leading roles in and extensive knowledge of agricultural knowledge extension. Their combined experience provided in-depth expert advice on the topic of recording and

[5] 'Food and fibre producers' is used in this context to describe a broader spectrum of actors involved in different stages of food production, from farming to processing, distribution, and retailing.

reporting land management actions. This study was approved by the University of Otago's Human Ethics Committee (D20/03; Appendix M and N) and adhered to Cawthron Institute's research ethics (Appendix P).

Interview protocol

Prior to the start of the interviews, participants were reminded that their participation was voluntary with the option to pull out any time (Appendix C). Two different sets of interview questions were developed to allow for targeted questioning of industry sector data providers and potential register users (Appendix A). The interview schedule was piloted with one rural community member and one national industry sector representative to test question wording, clarity, sequencing, and length of interviews. Semi-structured interviews provide consistency across interviews yet allow deviation from the plan to follow the natural flow of conversation and to explore other ideas (O'Leary, 2005). This form of interviewing allows a conversational approach with open-ended questions used as prompts (Brinkmann & Kvale, 2015). We used questions such as "*What are the advantages that you foresee with sharing management data*?" and "*How would you like to see your data shared?*" In addition, land managers were asked to show photographs of the land they own or manage where land management actions have been applied to help improve water quality (Appendix A). This method of photo elicitation, also known as 'photo voice' (Maclean & Woodward, 2013; Wang & Burris, 1997), is a participatory approach that assists with 'breaking the ice' between interviewer and participants and helps participants to talk about specific aspects of their land management actions.

Table 1: *Interviewees (*N *= 23) represented five stakeholder groups.*

Stakeholder	*N*	Identifier	Affiliation	Responsibility	Area of expertise
Public or community	3	Comm1	Non-governmental organisation	Managerial	Environment
		Comm2	Non-governmental organisation	Managerial	Environment and policy
		Comm3	River catchment care group	Active member	
Indigenous people of the land – tangata whenua	2	TW1	Māori agribusiness	Managerial	All areas
		TW2	Ngāi Te Ruahikihiki ki Taumutu, Te Taumutu Rūnanga	Governor and member	Mahinga kai practitioner
Government	6	Gov1	Regional council	Managerial	Environment and policy
		Gov2	New Zealand Department of Conservation	Managerial	Freshwater
		Gov3	New Zealand Department of Conservation	Leadership	Environment and extension
		Gov4	New Zealand Ministry for the Environment	Managerial	Policy
		Gov5	New Zealand Ministry for Primary Industries	Leadership	Environment
		Gov6	New Zealand Landcare Trust	Leadership	Environment and extension
Industry sector bodies	7	Ind1	New Zealand Beef and Lamb	Managerial	Environment and extension
		Ind2	Dairy NZ	Managerial	Environment and extension
		Ind3	Dairy NZ	Leadership	Environment and extension
		Ind4	Fertiliser association	Managerial	All areas
		Ind5	Forestry, regional	Managerial	Environment
		Ind6	Horticulture NZ	Leadership	Environment and policy
		Ind7	Forestry, national	Managerial	All areas
Producers	5	Prod1	Sheep and beef	Farmer	
		Prod2	Mixed (deer, sheep and beef)	Farmer	
		Prod3	Mixed (dairy, arable)	Farmer	
		Prod4	Sheep and beef	Farmer	
		Prod5	Dairy	Farmer	

Data collection and analysis

Interviews ranged from 38 to 80 min, with an average length of 61 min. Interviews were recorded using a handheld voice-recorder and transcribed verbatim, with a one-page summary of the interview sent back to participants to check the accuracy of the summary interpretation. Transcripts were coded using thematic content analysis following the six phases described by Braun and Clarke (2006): familiarising with data, generating initial codes, searching for themes, reviewing themes, defining and naming themes, and reporting. Based on the number of times a theme was mentioned in conjunction with motivation to record and report, themes were ranked from most to least frequently mentioned. Six themes were identified, coded, and analysed, reflecting the content of the entire data set. Of the six themes, detailed and nuanced analyses were conducted for the three most frequently mentioned themes across all stakeholder groups. This method applies the principle of 'thick description' (Holliday, 2002), which recognises the strength of 'going deeper' in the analysis to find the meaning and intentions of an interview, rather than reporting 'shallow' results from a large number of interviews. Also described as a 'latent' level of thematic analysis, we produced word trees from the interviews and used them to examine some of the underlying ideas, assumptions, and conceptualisations shaping the semantic content of these three themes.

The development of a validated and robust coding manual (Appendix B) involved an iterative process in which drafts were refined and then tested by an independent researcher (Lombard et al., 2002; Neuendorf, 2017). A total of 20% of the interview transcripts were tested for inter-rater agreement, calculated as Cohen's kappa and percentage agreement. The final agreement was Cohen's kappa of 0.523, with a percentage agreement of 97%, which was considered sufficient to validate the robustness of the coding manual (Lombard et al., 2002). All data handling was done in NVivo 12 (QSR International, 1999).

4.4 Results and discussion

Recording and sharing knowledge is not a new practice for land managers

Our participants agreed that sharing knowledge on farm management was important to them and within their communities: 22 of 23 interviewees stated that they were willing to report land management actions to the wider public and their communities.

> *If you're not willing to share, then you are usually not willing to learn.* - Prod1

I think for me, we've got nothing to hide and only lots to learn. - Prod3

In terms of recording, 20 of 23 participants indicated that they recorded actions for the overall management of their land. Such records included those for pest control (e.g., "*There is accurate data on the trapping. [We] keep good records of how many mice and stoats [we catch] and that's quite good.*" - Comm3), water quality monitoring ("*We are actually recording a lot of the stuff we're doing, particularly around water quality.*" - Prod2), and the monitoring of wider farm management processes ("*All our stock numbers are recorded through systems.*" - TW1). The importance of monitoring land management actions was generally well understood among land managers, highlighting that recording and reporting information is not new to them.

Producers and catchment community groups are already subject to a range of reporting requirements, resulting in complex workloads as part of their day-to-day land management.

Understanding this fact is critical for the successful adoption of new farm management requirements. To support the successful implementation of new recording and reporting platforms, the situation of land managers needs to be understood and respected, and thoughtful considerations need to be given about how new tasks can be incorporated into existing monitoring systems. The risks of monitoring for the 'sake of monitoring' are real, thereby losing sight of the overarching goal of sustainable land management.

> *You've got to really be careful you don't end up getting too side-tracked [with recording]. Who's going to use this stuff and what's the expected outcome? That's got to be in your mind the whole time, otherwise you could end up wasting your time.* - Comm3

> *To be fair, most farmers just want to get out in the sun and get on with it and enjoy themselves. We don't really like sitting around collating data.* - Prod4

When personal information is recorded and reported on public interfaces, the topic of privacy and confidentiality needs to be considered. All but one participant indicated that they agreed to share their information with the wider public, and another participant agreed to do so after data stewardship and confidentiality was ensured. Privacy concerns were raised by three governmental stakeholders, one industry sector body stakeholder, and one community stakeholder.

> *But I couldn't see companies releasing [private] information to your register because that would be contravening any privacy obligations.* - Ind4

> *[I]f they don't need to disclose [private] information, then people are more confident or comfortable [to record and report] because there's that balance of retaining their private information.* - Comm5

Concerns around disclosing financial information was mentioned as a barrier to recording and reporting by one producer ("*You wouldn't want financial data out there though*?" - Prod2). Understanding and responding to concerns about confidentiality and data stewardship is a fundamental part of this research. It needs to be upheld by clearly outlining and adhering to confidentiality requirements of those who produce the information. For example, although information might be collected at a farm level, it would be anonymised and summarised at a catchment level when publicly shared through potential data reporting platforms (e.g., Land Air Water Aotearoa, https://www. lawa.org.nz; accessed 27.02.2024).

Inconsistent measurement of land management actions

To measure the nature of change, direction, and rates of change in restoration, information on land management actions needs to be recorded and reported in a consistent way and on a recurring basis.

> *And like any business, you need to know your infrastructure, you need to know your foundations as a business. That will take some time. [T]o really be able [for farmers] to manage [their land], and then monitor it and collect data against it that is actually useful, is going to take a step change in how we do things, and we're going to have to really emphasise [...] that they must record, and they must report.* - Ind1

Although most land managers were willing to record and share their information on land management actions, our results showed large inconsistencies in the detail and type of recording. This variation was related to the different purposes of recording and reporting (i.e., water quality actions vs. broader ecosystem restoration), but also to specific monitoring requirements imposed by regulatory authorities or funding bodies.

> *We're accountable for delivering on outcomes, especially with regards to certain funding streams. We have certain KPI's [key performance indicators] that we're supposed to be delivering on, so it helps show progress towards those as well, and can show that they were worth investing in from the perspective of Treasury, for example.* - Gov2

Participants noted that specific programmes such as erosion control programmes (e.g., the Hawkes Bay Erosion Control Programme in Aotearoa New Zealand) require land managers to fill in very detailed information on project databases, such as the number of poplar poles planted, or the type of debris dams built. One interviewee is part of a catchment care group that records and reports information that is particularly relevant to them and their intended outcomes, such as volunteer hours spent in the field, number of field days in the catchment, and number of plants planted. Another interviewee who is part of a community group mentioned that they recorded length of planting done because it is more relevant for their restoration programme. This inconsistency in recording and reporting means that land managers are unable to compare their efforts with those of their peers, both within their own catchments or at a national scale. This situation makes it difficult to learn from their successes and, importantly, from their less successful actions.

> *We've got to [record] because otherwise you just lose control. [I]f you've got one farm doing this and another one doing that, there's just no way you can keep track. [...] So, we've got to have simple tools that actually collect the same data, otherwise you just go round and round in circles.* - TW1

Lack of tools for standardised recording and reporting of land management actions

Systematically recording and reporting land management actions that help to improve water quality are critical steps toward being able to link restoration actions with freshwater quality outcomes (Gilvear & Casas-Mulet, 2008; Parliamentary Commissioner for the Environment, 2019; Tomer et al., 2014). Consistent recording is more likely if information is either collected within one tool or the data collected across tools are the same. Our results showed, however, that land management action data in Aotearoa New Zealand are currently recorded and reported through a wide variety of tools by different stakeholders (Table 2), many of which do not collect the same type of information. These tools included: 1) holistic farm management apps for recording a wide range of information on farm management (e.g., mapping of paddocks retired for winter grazing), 2) farm assurance templates (e.g., for recording animal welfare), 3) industry-specific environmental planning tools (e.g., for recording erosion control measures), 4) nutrient or fertiliser management tools (e.g., for recording fertiliser applications), 5) financial reporting tools (e.g., for recording of monthly expenses), and 6) their own databases (e.g., spreadsheets; Table 2).

Table 2: *Types of recording systems and platforms used by the interviewed cohort. Numbers in brackets indicate the number of times a specific tool was used.*

Public or community	**Indigenous people of the land – tangata whenua**	**Government**	**Industry sector bodies**	**Producers**
Own databases (2)	Precision Farming Dashboard (1)	Specific evaluation frameworks of national programmes (1)	Own database (1)	Own databases, paper maps, digital portable devices (phone or tablet) (1)
Not required to record (1)	Unknown (1)	Regional monitoring programmes (e.g., Sediment Erosion Control) (1)	Farm management system targeted at specific risks such as nutrients or fertiliser (e.g., Minda Land and Feed, Overseer) (2)	Farm management system or app targeted at broad farm management (e.g., Resolution, Farm IQ, Tiaki [Fonterra]) (3)
		Spatial mapping (1)	Legislation or national environmental standards (2)	Specific farm assurance programmes (e.g., NZ Red Meat Profit Partnership) (1)
		Surveys at varying intervals (1)	Land and environment plans (e.g., farm environment plans) (2)	
		Do not record (2)		

The types of recording and reporting platforms used were largely dictated by the type of land use (i.e., dairy, red meat, horticulture), the region where the land managers were based, and the environmental programmes their council ran. Different recording tools were also used within the same industry. For example, dairy farmers who are Fonterra[6] shareholders used its sustainable dairying programme 'Tiaki' (https://www.fonterra.com/nz/en/ campaign/tiaki.html; accessed 27.02.2024), whereas dairy farmers who provide milk to Synlait Milk[7] used its best practice dairy farming programme 'Lead with Pride' (https://www.synlait.com/our-milk/; accessed 27.02.2024). While both programmes aim to maintain and improve on-farm water quality, the information that is required to be entered by land managers can differ greatly because it is specific to the companies that require the information.

Despite this large variety of recording and reporting tools and platforms, we found that photographs were the most used method for recording and reporting land management actions across interviewees. Imagery or photographs were mentioned by all 23 interviewees when discussing suitable methodology for recording and reporting land management actions. Photographs are an effective and efficient way to record land management actions, especially because most land managers have access to cameras as part of their day-to-day digital devices such as mobile phones.

> *Photos are the easiest and quickest way to record [actions]. It doesn't involve a whole lot of paperwork and it tells a big story.* - Comm3

Although it might be useful to assess progress based on a photograph taken on a farmer's device, the strength of any given photograph lies with the details that are recorded along with the image. For example, details could include the date and time the photograph was taken, GPS location, reason why the action was done (e.g., stock exclusion to reduce critical source areas), details about the land management action (e.g., length of fencing, number of plants planted), and any other metadata to add value to the information collected (e.g., name of the person who took the photo or details of materials used for stock exclusion). Without such information, a photograph loses value and suitability as a practical recording technique. We observed variability in the

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[6] Fonterra (https://www.fonterra.com) is an Aotearoa New Zealand multinational, publicly traded, dairy co-operative owned by approximately 10,500 New Zealand farmers. The company is responsible for approximately 30% of the world's dairy exports and is Aotearoa New Zealand's largest company in terms of revenue.

[7] Synlait Milk (https://www.synlait.com) is a dairy processing company in Aotearoa New Zealand that manufactures ingredient and nutritional milk powders.

quantity and quality of the photographs taken. Whereas some land managers, for example, captured a one-off community planting event, others took more detailed photographs of plant type, georeferenced the location of the plants planted, and applied an assessment method called 'fixed-point photo' whereby a photograph is taken at regular intervals from the same location to assess progress (e.g., Hall, 2002; https:// www.landcare.org.nz/file/module-2-photopoints/open; accessed 27.02.2024).

Being able to upload photographs or other land management indicators to document implementation progress of land management actions requires a suitable recording and reporting platform. Learning processes that incorporate interactive platforms and create collaborative partnerships have the potential to change behaviours by enabling people to learn continuously and collectively about the context in which they work within their wider networks (Coggan et al., 2021). Examples of such global collaborations include the SAI Platform, which enables > 150 agricultural stakeholders to exchange knowledge worldwide (https://saiplatform.org; accessed 27.02.2024), and OpenET, which tackles environmental challenges through information sharing (Environmental Defense Fund, https://www.edf.org; accessed 27.02.2024). When we asked how such an interactive platform could be set up, critical aspects mentioned were ease of data entry ("*It's got to be easy and quick to input the data. You don't want to be spending hours doing it, and you want to know that it's going to be useful.*" - Comm3), functionality ("*You decide what order [the data] go in.*" - Prod2), and consistency of information gathered ("*[We need] to make sure that everyone is measuring the same thing.*" - Comm3).

What motivates land managers to record and report?

Our cohort of land managers was willing to record and report land management actions. We probed whether there are certain drivers that would increase this willingness. Land management decisions can be influenced through various extrinsic mechanisms, including legal instruments, economic rewards, provision of advice, and collective actions (Yaffee & Wondolleck, 2000). Our interviews documented that there is more to successful recording and reporting of land management actions than clear guidance as to what and how to record; the role of socio-psychological variables such as attitudes and social pressures were key motivators for land managers to record and report. Attitude, subjective norms, and perceived behavioural control have been shown to positively influence farmers' intentions to adopt sustainable land management actions such as improved grassland management or riparian management (Borges et al., 2014; Coggan et al., 2021; Fielding et al., 2005). Our research builds and expands on this knowledge, focusing on the roles these social aspects and sense of identity have in motivating behaviours (Bandura, 2002; Longnecker, 2016) such as recording and reporting of land management actions.

Our thematic content analysis identified six overarching themes that motivated the recording and reporting of land management actions that improve water quality (Table 3). These themes resonated with five of the six cognitive and personality principles of our theoretical framework, which we discuss in the context of the Responsible Environmental Behaviour model (Hines et al., 1987).

Table 3: *Themes identified from interviews and their relation to the Model of Responsible Environmental Behaviour* (Hines et al., 1987).

Theme from participant interviews	Relation to model of environmental behaviour (reason for recording and reporting knowledge on land management actions)
Collective engagement	Member or part of a catchment group
Identity and social norms	Desire to be a socially approved farmer and to be seen as such by others
Efficient farm management	It is quick and easy to do, with multiple business benefits
Legislative	Required by national and regional legislation
Stewardship	Recognition of intergenerational responsibility
Economic	It makes sense financially and reduces costs

Some themes were 'top of mind' for certain stakeholders but not others (Figure 8). For example, collective engagement, social norms, efficient farm management, stewardship, and economic reasons acted as motivators for all types of stakeholder, whereas legislation was not specifically mentioned as a motivator for the public or community cohort (Figure 8). Similarly, our findings suggest that the legislation, stewardship, and economic themes may involve stronger motivators to record and report for Indigenous people of the land than for non-Indigenous primary industry stakeholders. However, just because a theme was not (or not often) mentioned by a certain cohort does not mean it is not relevant for them. We considered this idea during our analysis and discuss its implications in the following sections.

We especially acknowledge the low number of participants in the Indigenous people of the land tangata whenua category. Although we were interested to learn about the motivations and barriers to recording and reporting actions from the perspective of Indigenous people of the land tangata whenua, we recognise that Indigenous knowledge should be recorded and shared by tangata whenua themselves. Tangata whenua researchers are conducting research as part of the National Register of Land Management Actions project (Ruha et al., 2021).

We examined, in depth, the three most frequently mentioned themes (i.e., mentioned by > 16 interviewees during interviews; Figure 8). These themes are potentially useful principles for the successful implementation of new recording and reporting requirements and are key motivations shaping the missing piece of the freshwater restoration puzzle (Figure 9).

Motivation principle 1: collective engagement

In our study, 18 of 23 interviewees mentioned collaboration and the principle of collective engagement as a key motivator to record and report land management actions (Figure 9). We defined collective engagement as any form of action that is practised by communities within and between catchments whereby the community is actively learning and working together through multiple interactions and mutual exchange of ideas and knowledge. Often, the goal of collective engagement is to solve a common issue or problem, in our case, poor water quality.

In river catchments, collective engagement is often practiced in the form of catchment (care) groups that seek to connect and act around an issue of mutual interest and concern (NZ Ministry for the Environment & Stats NZ, 2020; Socientize Consortium, 2014). The people who live within a catchment are the protagonists of these collectives and play an important role in shaping catchment communities.

> *People are the key common factor in literally all the catchments that we're working within.* - Gov3

Horticulture and forestry representatives were the only two industry stakeholders who did not mention collective engagement as a motivator. Because both primary industries have very well specified and long-standing strategies to monitor land management, as well as well-established relationships within their own and across other primary industries in Aotearoa New Zealand, we expected this theme to be less frequently mentioned by them.

For tangata whenua, collective engagement recognises 'the act of caring', or Tikanga Tiaki and 'the act of handed down knowledge and practices', or Taonga Tuku. These two themes (or kete) were recognised as two of four major themes or kete in a literature review by Ruha et al. (2021), who looked at identifying land-based actions to improve water quality. These themes emphasise the importance of connectedness through collective engagement as part of the ‘te ao Māori’ worldview. Our findings suggest that these principles may be monitoring motivators across cultures, and we encourage further research on this topic.

Social learning through collective engagement has resulted in an increased uptake of land management actions that improve water quality at catchment scales (Barnett, 2014; Blackstock et al., 2010; Phillips et al., 2010; Reed et al., 2010), and our results support this idea.

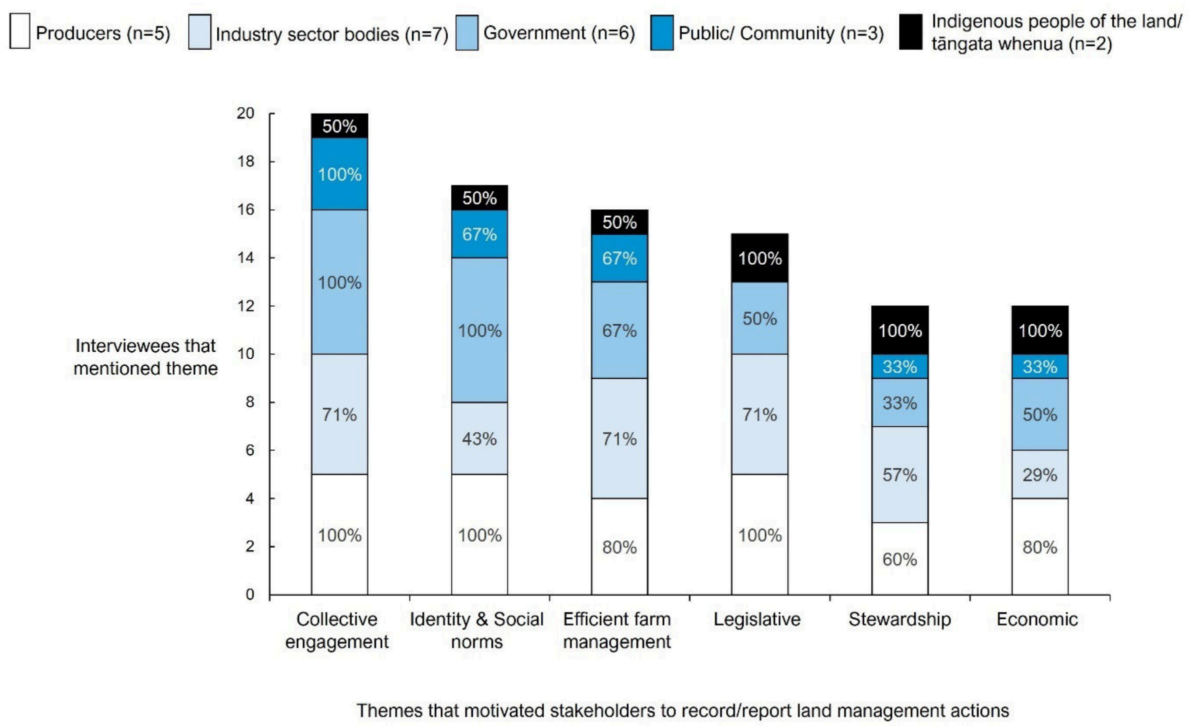


Figure 8: *Motivations to record and report land management actions, from the most frequently mentioned theme (left) to the least mentioned theme (right), shown by the number of stakeholders that mentioned the theme. Values within each part of a bar represent the percentage of each stakeholder group that mentioned the theme (e.g., 100% of producers mentioned ‘collective engagement’).*

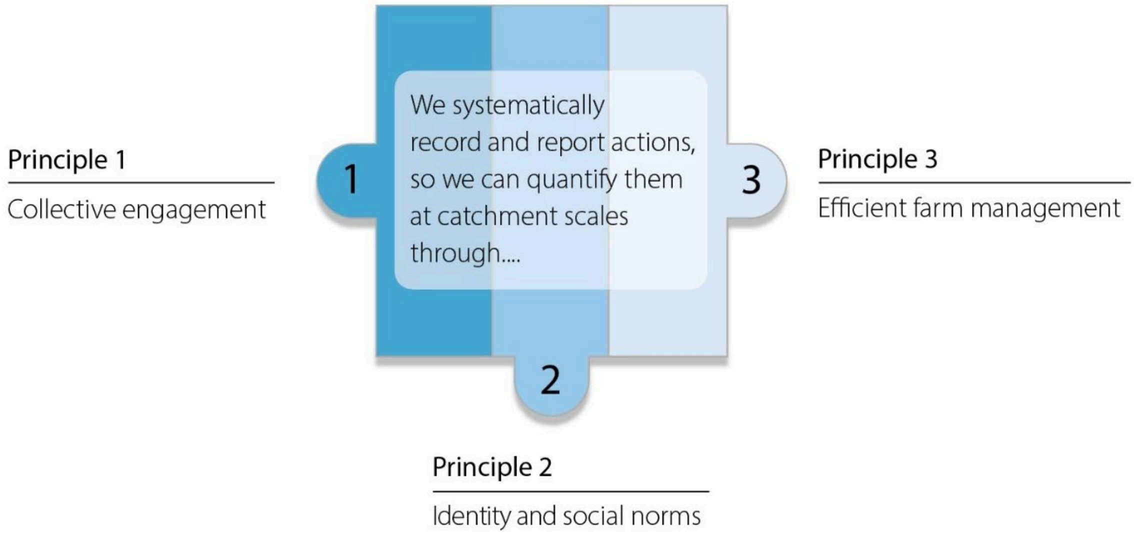


Figure 9: *Conceptual diagram of the three most mentioned principles that motivate land managers to record and report land management actions that improve water quality.*

> *From a catchment perspective, it is farmers working together on [...] issues and sharing information so that they find out that they're not working by themselves. But it's actually making progress collectively so they can share what works and what doesn't so they don't have to reinvent the wheel all the time. But they are continually improving what those practices look like.* - Gov5

The magnitude of influence that people in a community can have on the behaviour of others is well recognised. Collins (2018), for example, found that farmers' beliefs, emotions, behaviours, and attitudes toward land management actions that improve water quality were not only influenced by conversations between farmers themselves, but also by what farmers heard or observed other farmers saying or doing. Our findings confirmed the importance of collective engagement for environmental progress-making and social learning. Social networks included catchment care groups, organised farmer activities such as field days, and discussions between farmers and public or community groups (e.g., "*I was talking to one [a farmer] yesterday.*" - Comm2). Social learning through collective engagement can contribute to a change in the understanding of certain issues and can lead to change in community behaviour, in our case, an increase in systematic recording and reporting of actions that improve water quality.

> *You would hope that it would be motivating for people if they saw that there were a lot of other people [recording and reporting] and perhaps if they weren't, that they then wanted to do the same* - F2

By sharing knowledge, communities not only better understand specific water quality issues within their catchment (e.g., the river has too many nutrients), but also better understand what actions can be done to lessen the impact (e.g., we can keep stock out of the river to reduce nutrients). In the context of Responsible Environmental Behaviour theory, these principles align with variables 1, knowledge of issues, and 2, knowledge of action strategies (Hines et al., 1987), which are both linked to pro-environmental behaviour (Coggan et al., 2021; Lankester et al., 2009).

Collective engagement through catchment care groups can be a powerful way to induce changes in practice and can provide an important platform for capacity building, information exchange, and innovation in rural settings (Albizua et al., 2021; Blackstock et al., 2010; Bouwen & Taillieu, 2004; Pahl-Wostl et al., 2007; Tadaki et al., 2020; Yaffee & Wondolleck, 2000).

> *But if you start creating that collective responsibility, then you can go, 'Oh yeah, you've put a hundred [trees in] - we'll do a hundred, too.' - that kind of mentality.* - Comm1

Catchment community collaboration that addresses on-farm management issues to improve water quality has surged worldwide over the last 15 years, a testament to the importance of this issue (Barnett, 2014; Ministry of Agriculture and Forestry, 2010; New Zealand Landcare Trust, 2020; Sinner & Newton, 2018). Examples include Streamwatch (https://australian.museum/getinvolved/citizen-science/streamwatch/; accessed 26.02.2024), the Manawatu Catchment Group in Aotearoa New Zealand (Barnett, 2014), the Mersey Rivers Trust River Guardians (https://www.merseyrivers.org/index.php/projects/ river-guardians; accessed 27.02.2024), and the Chesapeake Monitoring Cooperative (https://www.chesapeakemonitoringcoop.org/; accessed 27.02.2024).

Our findings suggest that collaborative engagement can be a powerful motivator for land managers to record and report their land management actions that help improve water quality. However, making change through collective action is highly dependent on a land manager's identity and the social norms within a community (Emery & Franks, 2012; Mills et al., 2011), which is our second motivation principle.

Motivation principle 2: identity and social norms

The norms that govern communities influence behaviour (Cacciatore et al., 2016; Longnecker, 2016; Priest, 2016). Social norms are unwritten rules that reflect society's shared beliefs and ideas about how people should behave (Eggertsson, 2001) and what behaviour is or is not acceptable (Hechter & Opp, 2001). In our study, 17 of 23 participants alluded to the importance of social norms and how they motivated recording and reporting of land management actions. Looking at the 50 most-used words within the social norms theme, the word 'people' was the most frequently cited word (51 times), followed by 'look' (35 times; Figure 10).

We explored the connections that were made with those two most frequently used words through word trees and found that both words were commonly linked to the principle of satisfying the norms set by their communities. For example, the word most often used in conjunction with 'people' was 'other' (i.e., "*One of the big things is how we're perceived by other people [...]*" - Prod5; "*Yeah, but it's also important that other people driving past think that you care.*" - Prod2; Figure 11).

Similarly, the meanings behind the word 'look' were almost entirely related to the principle of being seen as a responsible community member by others (i.e., '*[We're] quite keen on making the place* ***look*** *nice*' - Prod2; '*[...]* ***look*** *at me, I am doing something*' - Prod4; Figure 12). This demonstration of a responsible farmer identity by following best practice land management actions was important for land managers themselves, as well as for others. This idea resonates with the theoretical framework's principle 'individual sense of responsibility', which predicts that land managers who feel some degree of personal responsibility toward the environment will be more likely to engage in pro environmental behaviour than land managers who do not hold such feelings (Hines et al., 1987).

Figure 10: *Word cloud showing the 50 most frequently used words within the theme 'identity and social norms'. The size of the text depicts their frequency, with larger words being mentioned more often. Function words (i.e., off, on, was, up) were excluded, and only words with a minimum length of three letters were included.*

Social norms can influence behaviour toward the adoption of environmental management practices (Anton et al., 2004; Collins, 2018; Farrow et al., 2017; Horbach, 2008). For example, Minato et al. (2010) showed that the visual evidence of trees being planted provided 'social proof' that tree planting was 'what everyone did' and increased the likelihood that others would change behaviour and plant trees. We also found that land management actions that were visible from the road were done first (e.g., hedge planting), before other, less-visible actions were conducted (e.g., septic tank upgrade). Although we did not specifically test whether social norms encourage recording and reporting of actions, we regard our findings as potential evidence of engaging stakeholders in recording and reporting as a course of habit to satisfy the environmentally responsible norms set by their communities. In our study, land managers' drive to record and report was influenced by what others did on their farms. This idea is commonly referred to as an 'over the fence mentality' (Streletskaya et al., 2020; Weersink & Fulton, 2020).

> *And they can see that farmers are [recording and reporting] themselves, and someone is having great success, then the guy across the fence will start doing it. Then you can start making inroads.* - Ind5

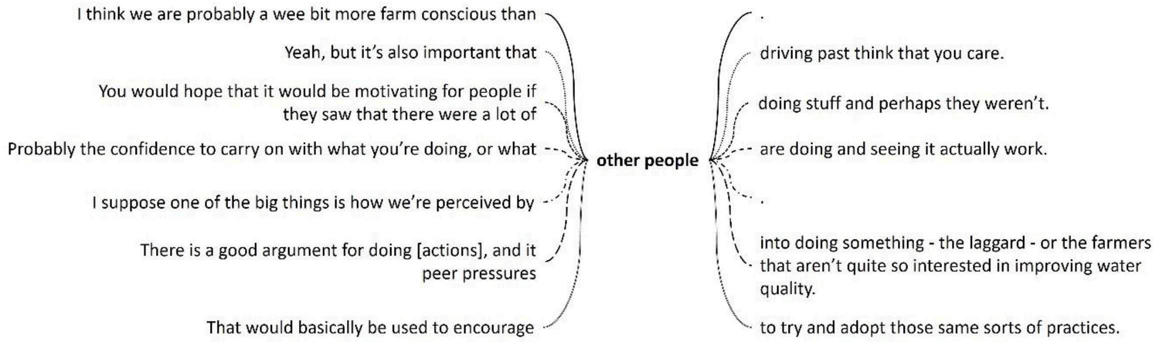


Figure 11: *Word tree showing the parallel sequences of words associated with the target word 'people' across all interviewees within the motivation principle 'identity and social norms'. The words preceding the target word match the words following the target word, indicated by the same shading of lines.*

A desire to comply with social norms is a factor in pro-environmental behaviour change (Farrow et al., 2017), and the concept of copying behaviour of others in the community is not new. Rust et al. (2021) showed that their research participants tried a new sustainable land use action if they had the willingness to try something new coupled with knowing someone in their community who had already successfully tried it. Similarly, Coggan et al. (2021) listed numerous examples of the effects that social processes can have on the adoption of improved land management actions, including social networks and social learning. Norms can change through observing respected 'trendsetters' or those who question existing norms and start behaving differently (Bicchieri & Mercier, 2014). In the context of land management practices, BenYishay and Mobarak (2019) found that if respected community members, also often referred to as champions, promoted pro-environmental behaviour, the uptake of actions within the community increased. This 'magnetic pull' of following actions done by champions is well documented (Milgram et al., 1969; Young, 2009) and has been linked to an 'information-processing advantage' and 'decisional shortcut' when one is choosing how to behave in each situation (Cialdini, 1988). Taken together, our results suggest that land managers would be more motivated to record and report under the following conditions.

1. The people they closely liaise with also record and report actions.

Farmers are a really social and gregarious people actually. They want to huddle together with their own and they're typically at sports clubs or bars or at field days, and they learn experientially. So they'll go, 'What would dad do? What would *granddad do? What are the neighbours doing? What can I pick out of that to put in my property?'* - Gov1

2. The entire community and beyond already records and reports.

But I think probably it is that peer pressure thing. If it's seen as good farming practice, if [recording and reporting] is seen as ***the*** *thing to do, then the farmers that don't [record and report] are the outliers.* - Prod3

3. Specific farmer 'champions' within the community or catchment record and report land management actions that improve water quality.

And there's now a freshwater champion's group which is set up and we've got two representatives on that group. And what they're doing is they're sharing knowledge in terms of 'Hey, we're in this catchment. This is what we're doing, this is what we're seeing', and they're sharing that. - Gov3

Sharing knowledge about land management actions will be essential for the subsequent uptake of those actions by others in the community, which is a critical step in achieving pro-environmental behaviour.

[B]y people like [us], and [us] submitting what [we] do, hopefully that encourages others to do what they need to do. - Prod2

Successful land management, however, goes beyond being 'socially approved' by others in a community, and also involves high levels of self-regulatory behaviour and self-efficacy. Our third motivation principle further explored this idea by looking at whether recording and reporting of actions that improve water quality can be encouraged by providing efficient farm management frameworks.

Motivation principle 3: efficient farm management

To link water quality actions accurately with water quality outcomes, information needs to be recorded in a meaningful way; as more meaningful information is being gathered, the results will be more reliable and applicable. However, collecting meaningful information that is also detailed and of high quality requires specific skills (e.g., capability to run certain programmes) and specific equipment (e.g., digital devices or SmartApps). Most of all, it requires time.

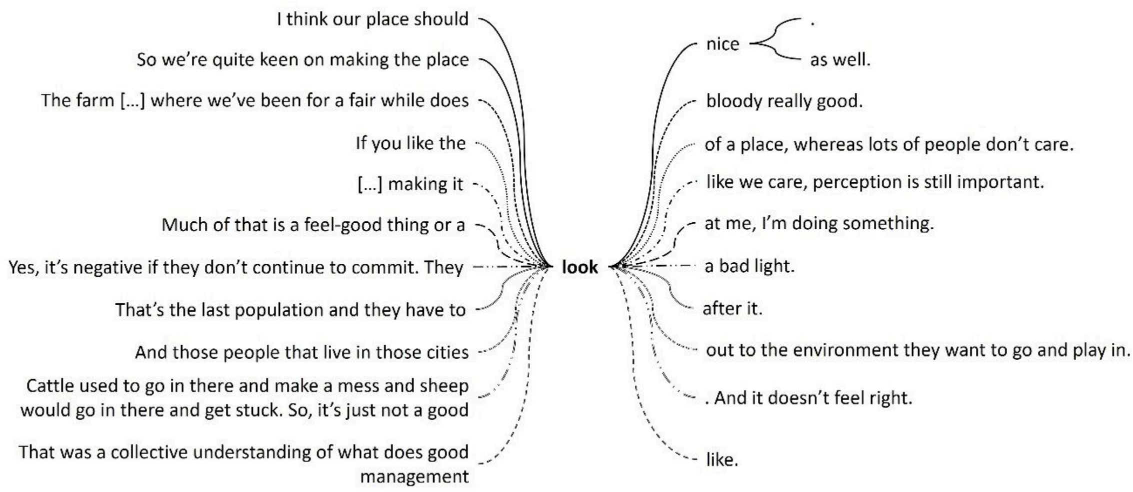


Figure 12: *Word tree showing the parallel sequences of words associated with the target word 'look' across all interviewees within the motivation principle 'identity and social norms'. The words preceding the target word match the words following the target word, indicated by the same shading of lines.*

> *After our group spends the morning collecting river quality data, one of the members spends the rest of the day entering the data into spreadsheets and the national database. So, it's quite time consuming.* - Comm3

We found that stakeholders subscribed to a vast range of quality assurance programmes that need to be followed, in addition to environmental standards (e.g., health and safety, food safety, people management).

> *We have to record for regional council. We have to be able to prepare a nutrient budget [...]. We have to record all our baleage made - nutrients in and out - all your land use stuff to prepare a nutrient plan. We have to record everything for the meat company - that's two. You have to record all your velveting - so that's three. If you've got a safe handler certification for using chemicals - so you do your own spraying - you have to have an inventory of all your drenches. You have to have all your material safety data sheets online, and you have to record all your spraying - so that's four.* - Prod2

So, asking stakeholders to increase the details and frequency of recording and reporting of land management actions will add another task to their already large recording portfolio in a time-short situation.

> *[F]or farmers on the ground [new recording and reporting requirements] potentially add more bureaucracy to the system - yet another document - another plan.* - Comm5

This situation can quickly become overwhelming, resulting in a barrier to record and report.

> *I'm not a great recorder of day-to-day stuff, no. I did start [recording] and it's bloody onerous actually. I'm just trying to think what's going to overcome my apathy of filling something else in. You should see the problems that [name] has to get me to fill this in every year. I usually wait till they're threatening to take me to court before I fill it in. It's usually about lambing time, too, isn't it?* - Prod3

A person's ability to make change empowers further action. Perceived control, or 'locus of control' is an integral factor in determining engagement with information and behaviour change (Hines et al., 1987; Longnecker, 2016). For example, Aytülkasapoğlu and Ecevit (2002) showed that locus of control was a key determinant among participants to engage in responsible environmental behaviour to protect a local lake. We considered efficient farm management as a key motivator to record and report, and any form of duplication with recording and reporting land management actions as a key barrier. We found that 'apathy toward filling something in' was a barrier to recording and reporting land management actions for participants, especially when the time commitments were large because the process of recording and reporting was not streamlined. When asked how this reluctance could be overcome, 16 of 23 interviewees agreed that any additional recording and reporting requirements will need to be incorporated with existing monitoring and assurance frameworks ("*Yeah, and I don't want to be going to six different apps to do stuff.*" - Prod2).

Global examples of integrated farm management systems include Linking Environment And Farming (https://www.leaf.eco; accessed 27.02.2024) and Red Tractor Assurance (https://www.redtractor.org.uk; accessed 27.02.2024). These systems allow primary industries to demonstrate the integrity of their farm management practices, including animal health and welfare, food safety and biosecurity, environmental accountability, and other factors.

> *The red meat sector and others are having conversations about how they adapt a quality assurance programme to allow for fresh water and other regulations going forward. So, it could be one system that encapsulates all that, rather than a whole heap of different ones for when you get new plans.* - Gov5

Land managers also indicated that they would be more inclined to record and report if a particular land management action fulfilled multiple purposes and resulted in multiple benefits to the farm. For example, while the primary aim of stock exclusion for water quality outcomes is often the reduction of sediments that get washed into the river by stock accessing the river, one land manager highlighted the co-benefit of not losing stock falling into a pond, saving him money in the long term.

> *You can see [...] there's a gully with a big pond. We drained that pond one year and I found 22 dead lambs in it. I think on average that creek used to take about six or seven lambs a year. If you said six lambs a year for ten years - sixty lambs at $100 - that's paid for all the work. That's how I look at it.* - Prod2

Moreover, any recording and reporting outcomes should also provide benefits beyond the farm system alone. Some of the benefits mentioned included amenity values ("*Well, it's a nice place to stop and walk. We've got pathways through it, and there's a little picnic area from some logs that were left there, and there's a little stone table. So there is an amenity there for people walking and people do stop.*" - Comm3), biodiversity benefits ("*To me, this is another biodiversity part of our farm and with trees and shelter for our stock, but it's good for birds and insects*" - Prod1), health and safety benefits ("*Sometimes there was a farm safety aspect to it - we didn't want people to drive through [the river]*" Prod1), nutrient management benefits ("*[W]e were trying to change stock behaviour with where you put trees. If you've got a low fertility area and you can get them to camp under trees, you're shifting your fertility back down to some of those areas.*" - Prod2), and general wellbeing ("*[Y]ou should be able to go out in the paddock and turn the bike off and sit there and enjoy what you're looking at. I reckon you do.*" - Prod2).

Our results suggest that efficient farm management goes beyond recording and reporting land management actions as a box-ticking exercise for funding bodies or agricultural levy-reporting frameworks. Interviewees mentioned they were more likely to record and report their actions if it was made easy for them to do so and if the actions resulted in more than just one positive outcome. Effective land management due to shorter time commitments and concurrent positive outcomes appeared to be an important factor in influencing the drive to record and report, referred to as the 'attitude-behaviour' relationship principle (Hines et al., 1987). For this principle, positive experiences are shown to positively influence the attitude of individuals, which leads to increased engagement in responsible environmental behaviours (Bøhlerengen & Wiium, 2022). Efficient land management will avoid additional strain on land managers and create the perception of capacity within the individual to carry out the act of recording and reporting at a certain point in time and to a specific level. However, if new recording and reporting requirements are added to already busy schedules in inefficient ways, we risk losing engaged and caring stakeholders in our communities.

4.5 Implications and conclusions

Our interviewees recognised recording and sharing knowledge of land management actions as critical steps toward improving freshwater quality, as well as the provision of consistent indicators and suitable tools to facilitate this knowledge exchange. Our results confirm that a lack of consistent land management indicators and suitable platforms, and the large range of existing farm management tools and guidelines (of which many are highly specific to region or type of land use) made it difficult for land managers to collate and summarise their knowledge for succinct environmental reporting. Although the processes of environmental recording and reporting are not new for Aotearoa New Zealand land managers, there is a perceived lack of guidance as to what, where, and how to record and report land management actions in the day-to-day running of their businesses. This situation results in inefficient environmental monitoring.

To successfully quantify land management actions that help improve water quality in the Aotearoa New Zealand context, national collaboration at multiple spatial scales between multiple players is required. Collaboration will ensure that consistent and suitable information is gathered and shared, enabling effective and meaningful freshwater restoration. Land managers are at the heart of this collaboration, and understanding what hinders and motivates them to record and report is essential for successful large-scale environmental management. Collective engagement, identity, and social norms, as well as efficient farm management were themes of key motivators for recording and reporting land management actions. Based on our findings, we propose that these socio-psychological aspects be considered during the establishment of any new on-farm environmental monitoring frameworks or policy implementations. Doing so will empower more holistic and effective farm management and bring us one step closer to linking land management actions to water quality outcomes (Figure 13).

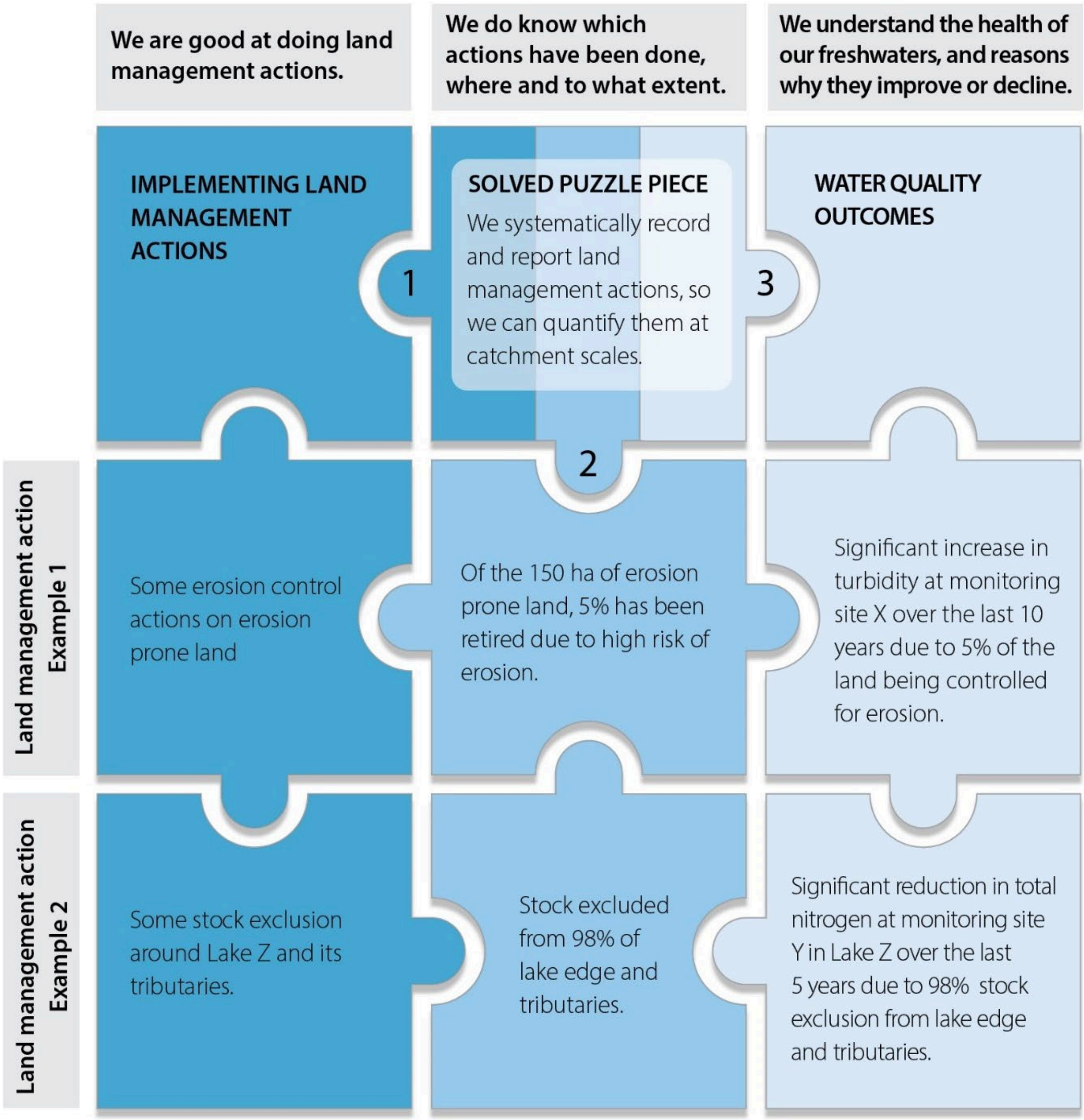


Figure 13: *If we consider the three socio-psychological principles (1 = collective engagement, 2 = identity and social norms, and 3 = efficient farm management), we are one piece closer to completing the complex puzzle of on-farm freshwater restoration. This figure represents an illustrative concept only, showcasing a subset of potential land management actions relevant to on-farm water quality restoration, their indicators, and hypothetical water quality outcomes.*

To conclude, we suggest that five key points need to be considered for systematic environmental recording and reporting to be successful at large scales. While these points are specifically relevant in the Aotearoa New Zealand context, they may be applied in other parts of the world facing similar recording and reporting challenges.

1. Development of standardised indicators of land management actions to allow robust assessment of change over time;

2. Development of easy-to-understand environmental recording and reporting platforms (e.g., National Register of Actions);

3. Integrating new recording and reporting requirements within existing frameworks;

4. Holistic farm management, including stakeholders' on-farm values (i.e., biodiversity, amenity), to encourage ongoing environmental recording and reporting, and;

5. The value of getting catchment champions involved for motivating others within the community to record and report land management actions.

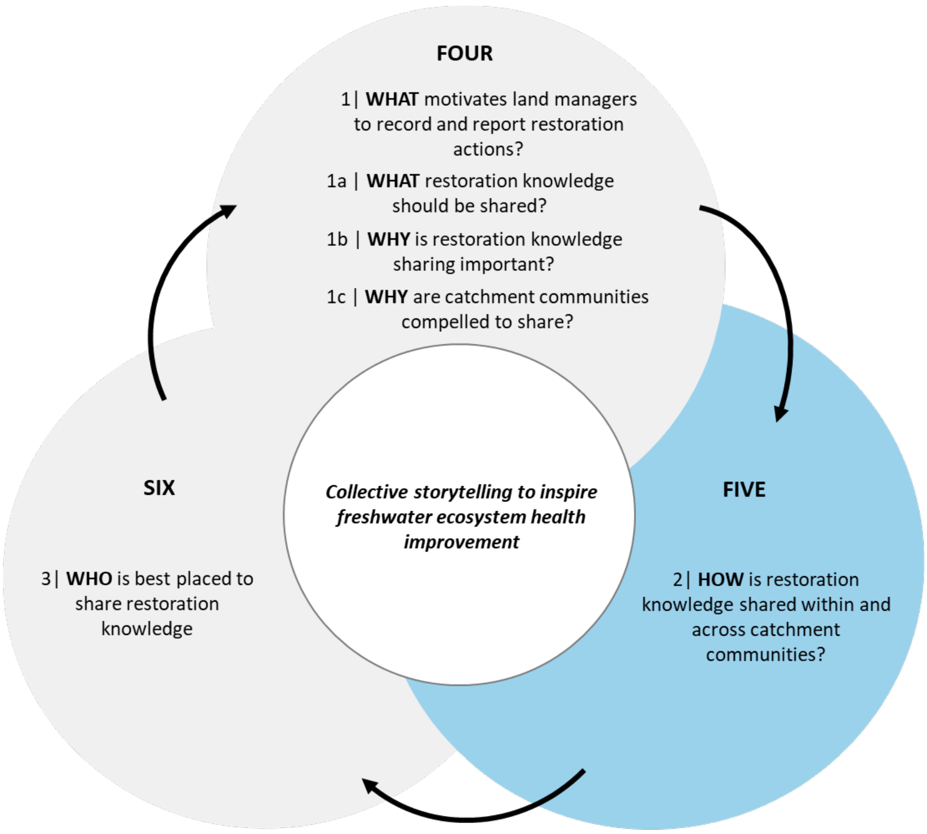
Successfully improving freshwater quality is a complex process that requires actions from different players, at different times, and in different places, while following specific guidelines. It is like solving a puzzle, just not on your own.

Naku te rourou nau te rourou ka ora ai te iwi

With your basket and my basket

the people will live/thrive

FIVE | Preface



Chapter FOUR synthesised motivators that encourage land managers to record and report restoration actions that improve water quality – collective engagement, identity and social norms, and efficient farm management. One overarching concept that emerged when speaking to land managers was the importance of '*getting our story out there*', such as through, for example, photographs and anecdotes. This format allowed the content to be personalised and relatable for others to understand. Dahlstrom (2014) explains that by placing knowledge into context through storytelling, the knowledge bundled within these stories is easier to process and generate more attention and engagement than traditional logical-scientific communication. In my research this could mean that knowledge sharing (in the form of stories) will have considerable power to provoke a change towards the recording and reporting of land management actions / restoration knowledge that can help improve water quality. If land managers understand the context and language of why recording and sharing of restoration knowledge is crucial for improved water quality within their catchment, intention to record and report may be increased.

Recognising that land managers, and by extension rural communities, are inclined to document and share their knowledge about land management and freshwater restoration sparked a deeper curiosity to explore this phenomenon further. I was interested to explore HOW restoration knowledge is shared within and across catchment communities. The next chapter provides insights into how storytelling may play a role in conveying restoration knowledge, fostering collective identity, and motivating action. I delve into the potential for storytelling to construct sustainable futures, benefiting ecosystems and the communities that depend on them.

FIVE | Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change

ONE
Research Strategy and Motivations

TWO
Introduction, Literature review and Theoretical Frameworks

THREE
Research Paradigm and Methodology

FOUR
A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?

FIVE
Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change

- 5.1 Abstract
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SIX
Trusted storytellers as freshwater restoration knowledge brokers: individual and collective voices can both be effective

SEVEN
Conclusions and Implications

5.1 Abstract[8]

In Aotearoa New Zealand, catchment communities have been actively working to restore the health of their rivers, in some cases for many decades. Their knowledge offers a valuable resource that could motivate and empower other groups to do the same, making river restoration more effective at large scales. We spoke to five catchment groups across Aotearoa New Zealand to conceptualise and define how knowledge sharing through storytelling could be used as a tool to inspire freshwater restoration action amongst their own community and elsewhere. Each group created a 'Catchment Journey,' a graphical artwork that told a story of their land and people, and their restoration activities. Whilst each of these 'Journeys' was unique, the following common elements were important for knowledge sharing: 1) the role of respected storytellers (e.g., community champions) in influencing restoration in their community; 2) recognition of responsibility to act (e.g., concern for future generations, land stewardship, prosperity and community cohesion); and 3) authenticity (e.g., true and honest stories, including weaknesses, threats and hardship). Participants recommended including each of these key elements in collective catchment storytelling to encourage large scale freshwater restoration.

Keywords: freshwater restoration, water quality, science communication, catchment, communities, stewardship, emotions, positive

[8] Doehring, K., Cole, C., Young, R. G., & Longnecker, N. (2023). Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change. *Frontiers in Communication*, *7*. https://doi.org/10.3389/fcomm.2022.1061634

Graphical abstract

5.2 Introduction

Globally, freshwater ecosystems (i.e., lakes, rivers, and wetlands) are detrimentally affected by agricultural practices (Allan, 2004; Carpenter et al., 2011). Scientific evidence for reducing, and even reversing these impacts, are widespread (Davies et al., 2009; Flávio et al., 2017; Monaghan et al., 2021). Despite the wealth of scientific research and local knowledge, the health of many freshwater systems continues to decline (United Nations Environment Programme, 2021). Scientific knowledge exchange often happens between researchers and project managers or advisors in the format of technical reports, policy briefs, and summaries (Schneider & Buser, 2017). While this form of knowledge sharing suits technical audiences, it is often unsuitable for practitioners and non-technical audiences, such as catchment[9] groups. Scientific knowledge also fails to make fertile space for lay knowledge to contribute meaningfully to discussions that focus on environmental problem solving (Richardson, 2022;

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[9] A catchment (also commonly referred to as watershed) is defined as the natural drainage area of rainwater where it gets collected and transported from the source to the sea.

Turnhout & Neves, 2019). There is compelling evidence, however, that involving key stakeholders from knowledge production, to communication, to solutions is essential in tackling a range of environmental and socially contentious issues (Jasanoff, 2004; Manyweathers et al., 2020; Schneider & Buser, 2017).

In the case of ecosystem restoration, accessibility to clear information is essential for progress to be assessed by different stakeholders across different spatial scales (Doehring et al., 2020). We suggest that catchment stories may be powerful tools to report on restoration progress, and lessons learnt along the way. Knowledge conveyed through stories aids understanding of complex issues (Rose, 2012), which is necessary for informed decision making (Moyer-Gusé, 2008). If these stories are then also told by the people that do the action on the ground, we hypothesise that story context and language become even further relatable to catchment communities, which is likely to further trigger restoration motivation. Storytelling may also be a powerful tool to convey indigenous knowledge for land management, which is being considered in a parallel component of this study (Ruha et al., 2021).

However, for change to happen, communities not only need to understand restoration actions, but need to be motivated to undertake them (Aronson et al., 2006; Society for Ecological Restoration International (SER), 2004). It is well understood that motivation is triggered, and sustained, if knowledge is shared between rural communities, as opposed to 'top-down' information provision (Doehring et al., 2022; Society for Ecological Restoration International (SER), 2004). Based on this, we explored the role catchment communities may play as 'storytellers' to motivate effective larger scale freshwater restoration.

In our study, catchment communities are a group of people with common interests in freshwater restoration, residing in the same locality (Mannarini & Fedi, 2009). Restoration, in our case, aims to address pressures on Aotearoa New Zealand's freshwater systems, such as pollution in urban, farming and forestry areas. These pressures are commonly caused due to increased levels of deposited sediment, and emerging contaminants (such as pesticides), changing water flows due to increased consented freshwater allocation, and climate change impacts such as more severe localised droughts and flooding (NZ Ministry for the Environment & Stats NZ, 2020). Because catchment communities consist of a multitude of players (including indigenous people, residents, farmers, land stewards, environmental groups, businesses, national and local government agencies, and visitors), their interplay and impact on the catchment can be varied, as can their aspirations, knowledge, perspectives, needs, and priorities. Because of this diversity, restoration actions can often be done in isolation (Morresey & Hellberg, 2015), missing opportunities for more effective collaboration. In addition, obligations for catchment communities to operate in accordance with their 'social license' have become more relevant, meaning that they should consider the expectations of society and avoid activities that societies deem environmentally unacceptable (Clark-Hall, 2018; Gunningham et al., 2004).

To overcome some of these challenges and to address the much-needed transformative environmental change (Díaz et al., 2019; United Nations, 2015), researchers are calling for more novel and accessible forms of scientific communication about the environment (Klöckner, 2015). At its foundation, environmental communication is "*interested in all settings and modes of messaging about the environment, but with an emphasis on improving human capacity to address [environmental] challenges in productive ways toward justice and sustainability*" (Sjölander-Lindqvist et al., 2022, p. 10). When applied correctly, the impact of successful environmental communication can be significant (Sjölander-Lindqvist et al., 2022; Stoknes, 2017). For example, McAfee et al. (2019) advocated for greater use of optimism in communicating conservation, which inspired people to behave in ways less destructive, and Fjællingsdal and Klöckner (2020) suggested that board games can be highly effective tools in simplifying complex systems of interconnected environmental issues, such as global warming or freshwater restoration.

We, thus, believe that the potential for pro-environmental change through tailored, and accessible, freshwater restoration communication may be large, particularly, if the communication is specifically tailored to catchment groups based on insights shared by suitable knowledge providers, or storytellers. For bottom-up collaboration to be successful, communities need to define a common vocabulary by discussing goals, motivations, and desired outcomes, which encourages open dialogue for knowledge sharing (Mamykina et al., 2002).

Exploring ways in which catchment communities can use storytelling to communicate their restoration actions could hence make a significant contribution to constructing sustainable futures (Gearey, 2018), including not only the sustainability of ecosystems, but also of catchment communities. Specifically, stories can help build collective identity and empathy of those communities that rely on functioning freshwater ecosystems. But what should this common vocabulary be, which instruments should be used to tell and share a story, and what should their content include? What inspires catchment groups to share their restoration story in the first place, and who would be a suitable narrator? Our research provides insights into these questions by exploring how storytelling may be used as a tool to convey restoration knowledge, and whether there are common elements to help guide their telling.

5.3 Methods

Data collection and analysis

Data were collected via five focus groups whereby each focus group represented a different catchment group (i.e., from here on 'catchment group'). This form of data collection enabled us to have in-depth discussions with participants, eliciting a wide range of views, perspectives, and understandings of land management issues with regards to large-scale restorations (Bratton & Liatto-Katukdu, 1994; Cyr, 2019; Wellings et al., 2000; Wilkinson, 1998). It also allowed us to gain insight on what storytelling generally meant to the groups, what knowledge should be shared, and how to present the content.

Discussions were held between June and November 2021 across Aotearoa New Zealand (Table 4). Participants were recruited based on recommendations by catchment group leads and individual interests. The spatial spread across the North and South islands of Aotearoa New Zealand provided diverse backgrounds of participants based on their geographical and regional circumstances (Table 4). This "*ensur[ed] homogeneity within the group and heterogeneity between them*" (Bedford & Burgess, 2001).

All participants were active members of their respective catchment groups, which included farmers, teachers at local primary schools, members of local lifestyle block[10] owners association or urban restoration communities (Table 4). Participants represented a sub-sample of their catchment groups, which generally were much larger. Our research was approved by the University of Otago's Human Ethics Committee (D20/03; Appendix M and N) and adhered to Cawthron Institute's research ethics (Appendix P).

[10] A 'lifestyle' block is a smallholding or small farm (<4 ha) run as a hobby, not as a commercial enterprise.

Table 4: *Summary of catchment groups used in this study.*

Catchment group	Number of focus group participants	Total number of catchment group members	Time since establishment	Predominant land use in catchment	Roles/affiliation of participants (*n*)
1	5	20	6 months	Rural	Sheep and beef farmers (2), small landowners/lifestyle block owners (2), mixed land use (goat, sheep and beef; 1)
2	7	209	1.5 years	Rural	Sheep and beef farmers (2), combination of land uses (e.g., dairy, beef; 1), primary school teacher (1), forestry (1), dry stock (2)
3	6	300	7 years	Urban	Retired professionals (6)
4	7	200	2 years	Rural	Dairy farmers (7)
5	5	190	8 years	Rural	Sheep and beef farmers (4), dairy farmer (1)

Facilitation of focus groups

All participants were briefed about this research by their catchment group leaders prior to us contacting them via email. Once participants agreed to take part in the research, information sheets and consent forms were sent out prior to the meetings and were returned signed (Appendix F). Focus groups were held in locations suggested by the catchment group leads—community halls (n = 2), a private home (n = 1), and workplaces (n = 2). The first author facilitated all focus groups. At the beginning of each, participants were reminded about the research project and briefed on the process of the discussion. A 'run-sheet' ensured consistency of content and timing for focus group facilitation (Appendix D). Each discussion had four main parts: a) introduction to the research project and participants, b) the creation of a catchment story using a story template provided by the facilitator, c) discussion about the creation of their catchment story and key insights gained about the template and story creation, and d) other important points to discuss before the closing of the meeting (Appendix D). Discussions were recorded using a handheld voice-recorder and transcribed verbatim.

Figure 14: *Examples of A) a template filled in by a focus group, and B) a digitised Catchment Journey. (The template has been made available online for catchment groups to record their Catchment Journeys – Appendix G)*

Story creation: Catchment Journeys

In our research, we initially used 'story' as an umbrella term whereby each story was made up of a predefined set of headings, or chapters, which provided some form of content guidance for participants. The emphasis of this process of story creation is on an *in-situ* construction, and the output's potential use in creating meaning, relevance, and empathy for others. The term 'story' is often understood as a narrative with a beginning, a middle, and an end. Catchment restoration is ongoing, following a timeline in which participants discuss catchment restoration actions across the past, present, and future, even though there is often a starting point to restoration (e.g., the forming of a catchment care group or a first planting event). Because of this continuation, we considered the name 'Catchment Journey' more appropriate in describing the ongoing process of restoration. We believe that sharing the events along this restoration Journey can be considered one form of storytelling.

We developed a Catchment Journey template to provide guidance for catchment groups on the overarching content that we wanted to capture as part of a group's restoration journey (Figure 14). This included information about the catchment group themselves ('Who are we'), including their group's strengths, weaknesses, obstacles, goals, their long-term vision ('Our vision [x] years from now'), description of already completed and anticipated restoration actions ('Our land today,' 'Our land—next 12 months'), and a specific message the group wanted to share with others either within their own or with other Aotearoa New Zealand catchments ('From us to you').

Participants were given a paper copy of the Journey template to fill in and printed symbols as examples of things that they could use to further emphasise their Journey content (e.g., a fence symbolising stock exclusion, a family symbolising needs for future generations, or an eel symbolising biodiversity; Figure 14A). Groups were encouraged to alter the template layout (e.g., change headings) and to create new symbols specific to their catchment group and restoration actions. Providing a Journey template ensured some consistency in content and enabled us to compare specific sections between focus groups. The template was designed based on insights gained from previous research done as part of a national Aotearoa New Zealand research programme called 'Register of Land Management Actions' (National Science Challenge Our Land and Water - Toitū te Whenua Toiora te Wai, 2023b).

After the focus group meetings, digital versions of the paper templates were created and sent back to participants for checking accuracy of the content and wording. Any symbols that were created by the focus group were photographed and copied into the digital template (Figure 14B). Each catchment group created their own Catchment Journey, which they were free to share with their wider restoration and land management communities.

Thematic analysis

Thematic analysis was conducted to identify and report patterns (themes) within the data, following Braun and Clarke (2006). In our study, a theme described something relevant about the data in relation to us wanting to understand the suitability of stories as a communication tool that may encourage freshwater restoration. Each theme (and sub-theme) represented some level of 'patterned' response or meaning within the data (Braun & Clarke, 2006). Themes were developed across and summarised between all focus groups, which holds the risk of missing important social and cultural differences within and between groups. While we acknowledge that every participant brought a different personal background to our focus groups, our research didn't focus on cultural differences, though it explored a geographical range of catchment care groups across Aotearoa New Zealand. We suggest that future research should explore cultural differences within catchment care groups in greater depth.

The development of a validated and robust coding manual involved an iterative process, where the first author created and refined codes, using feedback provided by the other authors and a research group of science communicators. The codes were then tested by an independent researcher (Lombard et al., 2002; Neuendorf, 2017). A total of 20% of the focus group discussions were tested for inter-rater agreement, calculated as Cohen's kappa and percentage agreement. The final agreement was Cohen's kappa of 0.443 with a percentage agreement of 99%, which was considered sufficient to validate the robustness of the coding manual (Lombard et al., 2002). All data handling was done in NVivo™ 12 (QSR International, 1999).

5.4 Results and discussion

Focus group dynamics and social settings

Establishment of each catchment group ranged from 6 months to 8 years prior (Table 4), so that each group was on a different time trajectory in terms of anticipated and already achieved restoration within their catchment. However, groups that only recently established a 'formal' group may have already been actively restoring their river. For example, Catchment Group 4 has existed for 'only' 2 years in the current format but catchment freshwater restoration (mainly stock exclusion and riparian planting) in their wider region had been occurring since the late 1990s.

Within each focus group, all participants knew each other from working together as part of their catchment group, with some also being related (e.g., siblings) or in a relationship (e.g., husband and wife). Because of the familiarity amongst participants, dynamics in the groups were generally relaxed, which was expressed by friendly banter and joking. There were no indications of participants feeling peer-pressured by other participants, nor of under-, or over-disclosure of either details of their lives or information about themselves. In all instances, group members appeared to be enjoying interacting with each other, offering their point of view, and learning from each other. The interactive aspect of the focus groups allowed participants to agree with each other (e.g., *I can totally relate to what you just said.* — CG1), but also question one another, or explore different points of views (e.g., *Yeah, I have a slightly different take.* — CG4). This open form of communication provided important insights into the practice of knowledge production and knowledge sharing in the form of stories, which we further discuss below.

Catchment Journey creation

Each catchment group created their own Catchment Journey during our meetings, which ranged in length from 1 h 40 min to 2 h. One person acted as scribe to fill in the blank template spaces on behalf of their group. Participants responded positively to filling out the template, which triggered a chain of responses (i.e., synergistic effect (Hay, 2016)). Discussions shifted from original questions asked by the convenor to other, related topics (e.g., discussions that started on the topic of sustainable land management shifted to debates about inspiring change to restore river ecosystems and how knowledge sharing in the form of storytelling could be a key driver in initiating this change).

Many participants mentioned that it was useful for them to have the time to reflect on their catchment group's current and future aspirations. Catchment Journeys allowed each group to tailor their messages to contextualise conditions specific to their group such as their social settings (e.g., time since group establishment, size and diversity of group, levels of engagement within group), their geographical location (e.g., high or low rainfall area), or their political situation (e.g., functioning relationship with regional authorities). Verbatim transcriptions of each group's self-identified strengths, weaknesses, opportunities, threats, visions, and 'take-home' messages are summarised in Table 5.

Thematic analysis: three overarching elements of knowledge sharing for river restoration

Each Catchment Journey was different, however content analysis identified three distinct elements across all Journeys, creating an 'Archetype Catchment Journey.'

Catchment Journeys should be produced and shared by authentic storytellers to encourage action-based change

The first commonality between all Catchment Journeys was the concept of 'community-based ownership of story' or 'bottom-up storytelling.' This principle was mentioned by every catchment group during focus group discussions. It describes the concept of sharing knowledge by communities of practice that actively restore their river catchments to improve freshwater ecosystem health. Common land management practices included planting vegetation along a river or fencing waterways to keep out livestock. Participants felt that if knowledge is produced and shared by those communities, they have the 'power' to tell their story and could motivate others to do the same.

> *[A]nd this is why [restoration] works, because it is farmers [...] educating farmers.* — CG5

As part of bottom-up storytelling, participants highlighted the importance of diverse (plurivocal) storytellers within the same community. A plurivocal story allows people to tell an inclusive story that considers distinct circumstances and knowledge while facilitating connection among diverse participants operating in different places (Goldstein et al., 2015). In our study participants recognised that their communities consist of a wide range of people with various backgrounds and that every one of them has different experiences and perspectives about on-land freshwater restoration.

> *[A]nd the people up near the mountain are different to the people down in the coast.* — CG4

They felt that Catchment Journeys needed to encompass this diversity by having a range of storytellers.

Table 5: *A summary of the strengths, weaknesses, opportunities, threats, and long-term visions for five catchment groups as captured in their Catchment Journeys, as expressed by focus group participants. Expressions are verbatim.*

	Catchment Group 1	Catchment Group 2	Catchment Group 3	Catchment Group 4	Catchment Group 5
Who we are	*Our catchment consists of farmers and life-stylers.* *Some of us have been in this catchment for 130 years.* *We have a long-term vision (~1000 years) because we are only 'passing through'.* *We deeply care for our river.*	*Entire catchment is part of the Catchment Collective. We see it as a place for everyone in the catchment.* *We started mostly as sheep and beef farmers in the upper catchment.* *We are inclusive and impartial.*	*The group has existed in some shape or form since 1977.* *We are a group of residents who advocate and work for an improved river with a rich and sustainable ecosystem.*	*'Mountain to Sea' Catchment Group.* *Intergenerational catchment.* *Mixed community within the catchment (dairy, towns, life-stylers).*	*Farmers* *Businesspeople* *Urban People* *Visitors* *Families* *Recreationists*
Strengths ('What do we do well?')	*We keep out stock.* *We plant along our river.*	*We organise stakeholder talks to share and learn information about our catchment.* *We monitor water quality.* *We inspire communities to improve our freshwaters.*	*We work well together and have a strong voice within the council and wider community.* *We plant and care for trees.* *We monitor river health.* *We engage communities through advocacy, education, and planting.*	*We are farming sustainably and update our practices.* *We formed a catchment group.* *We have good relations with our district and regional councils.*	*Communicate* *Telling our story* *Farmer ownership* *Getting it done* *Good leadership*
Weaknesses ('What could we do better'?)	*Communicate with each other.* *Record and report our actions better.*	*Build up trust, a track record and practical plan that sees results.* *Provide more support to bring in more people.* *Build on information provided in Farm Environmental Plans.*	*Encourage sustainability by attracting a wide range of ages.* *More educational efforts.*	*Work together as a community.* *Sharing of information and lessons learned. 'Farming 101, Inspire'* *Tell our story to engage and inform.*	*Iwi engagement* *Find a way to engage the non-engaged.*

	Catchment Group 1	Catchment Group 2	Catchment Group 3	Catchment Group 4	Catchment Group 5
Opportunities (‘What are our goals?’)	*To have as many people in the catchment on board as possible.* *Caring for the river together without being embarrassed.*	*Weaving community together around our river.*	*A clear, clean flowing river.*	*Knowing the ‘now’ to plan the future.* *Maintain the ability to farm.* *Cultural survey and engagement.*	*Sustainable project funding.* *Promote and grow a strong standalone water care group.* *Improve awareness by building knowledge so best practice becomes normal practice.*
Threats (‘What are our obstacles’?)	*[Ongoing costs and time commitment for] maintenance.* *[Lack of] time.* *Perceptions [by others].* *Costs [involved in restoration].*	*Time poor* *Persuading more to join.* *Little catchment coordination*	*Forestry industry* *Governmental bureaucracy* *Resistance to change* *Small group*	*Different information from trusted sources.* *Lack of guidance on data collection.*	*Government undermining the good work that has been done.* *We can only go so far; we have to concentrate on positive issues.* *We can't change land use.*
Vision (length/duration of vision set by catchment group)	*A river in good health that is fishable and swimmable. We will achieve this by improving its water quality.* *(1000 years)*	*We want to be resilient in the face of climate, social, regulatory changes.* *A river swimmable in the summer, sufficient water for everyone and for the river ecosystem.* *People are thriving, Te Taiao [the environment] is thriving, and we are all prosperous and peaceful.* *(4 Generations from now)*	*The majority of the catchment under continuous forest canopy with a healthy diverse ecosystem.* *(1000 years)*	*Healthy land, healthy water, healthy communities.* *Supporting the river catchment community by showcasing and promoting sustainability and the best land and water management practices.* *(Indefinite)*	*The river is recognised as having the absolute highest water quality so that future generations can enjoy the river as we have.* *(100 years)*

	Catchment Group 1	Catchment Group 2	Catchment Group 3	Catchment Group 4	Catchment Group 5
Take home message for the Journey reader ('From us to you')	*It is important to share what we know about Land Management and restoration: the things that worked and the things that didn't work.* *You need the will to restore then an idea will turn into action.* *Sometimes you don't have the time or the money for restoration. As long as you keep the thought in your mind it will happen one day.*	*We need to find funding and work with like-minded stakeholders to improve our rivers for the sake of our grandchildren.* *The involvement of the community is key.*	*We believe that good relations with other stakeholders (council, iwi, landowners, and forestry companies) helps to produce successful outcomes.* *Question everything.*	*The Community is doing great work such as planting.* *Iwi engagement needs to be meaningful and based on respect and trust.*	*Take Ownership of the issue – we are in charge of our own destiny.* *A lot of people doing little things make change.*

> *Well I don't think we should be telling iwi stories ourselves, that's up to the iwi to tell them.* — CG4

If these storytellers were then also authentic, restoration knowledge transfer was considered likely to be successful by our participants.

> *What we're trying to capture here is our narrative of what we ourselves are doing, and yet actually a very large part of our narrative is influencing others to cause them to be doing things. And if that's left out of the equation, then it basically drops a large portion out of the whole picture of what we are doing, and what we have done. But it needs to come from us, the people doing the work.* — CG3

Authentic storytellers hold an authority to tell their story, which then becomes "*true to the teller, the audience, the moment, and the mission*" (p.53; Guber, 2007). This allows social learning to happen, encouraging individuals and/or catchment communities to become communities of practice, developing their own agency as they learn from the actions and experiences of their champions. This brings listeners to a place of understanding that moves and captivates them, which has been shown to ultimately provoke action for change (Green, 2004). A CG1 participant explained what this learning could look like.

> *I'm a newcomer, so I was learning what's gone well and what works. I don't want to make someone else's mistake, I can't afford to already, so if I go 'Oh this works well—cool— they say ribbonwoods grow well,' I will do that, too.* — CG1

In our study, 'catchment champions' held all traits of authentic storytellers, which enabled them to energise others to then commit to freshwater catchment restoration. 'Catchment champions' in our research were individuals, or entire catchment groups, whose influence encouraged restoration in their own communities.

Previous research has highlighted the value of 'catchment champions' as storytellers to encourage freshwater restoration (Doehring et al., 2022; Gearey, 2018). Our findings, too, suggest that having an inspiring storyteller is important for Catchment Journeys to enthuse others within their own catchment. Catchment Journeys were told by locals, about their own actions, to share with others who may use their knowledge and experiences. This made Catchment Journeys true to the teller, and the listener, which our participants felt strongly about. It allowed our catchment communities to articulate a collective identity that transcended spatial and temporal limits, strengthening, and shaping a community into a coherent and plurivocal vision of their future. While this concept is more commonly known as 'collective action' or 'collective management' (Ostrom, 1990), we believe that 'collective storytelling' (referred to earlier as community-based ownership or bottom-up storytelling) is a key mechanism in enabling successful catchment restoration.

For collective storytelling to be successful, communication needs to be a two-way affair (De Groot & Zwaal, 2007) whereby both the storyteller and the listener share an understanding of restoration. Our participants, also, emphasised the critical role of audiences. For example, some participants stated that their stories would change depending on who the audience was, acknowledging that audiences, even within a single catchment, can differ.

> *[W]e'd write [our journey] very differently, yeah totally, depending on whether it's a public or a private audience.* — CG3

In the context of sustainable land management, social learning through collective engagement has been shown to increase uptake of restoration actions that improve water quality (Barnett, 2014; Blackstock et al., 2010; Phillips et al., 2010). If the information then also stems from an experienced and trusted source, in our case catchment champions, action-based change triggered by social learning is even more likely to happen in rural communities. For example, Lankford et al. (2004) showed that recommendations for farmers on good catchment management was partly ignored in their study if they were made by scientists, but Robinson (2006) showed that if recommendations for farmers on Environment Farm Projects were facilitated and encouraged by other farmers, uptake within the community was improved. Similarly, Brown and Roper (2017) showed that farmers are more likely to adopt new practices and technologies after seeing them demonstrated, but that demonstration needed to be undertaken within farmer networks.

Apart from exploring the roles storytellers and listeners have in collective storytelling, we also explored what drives catchment communities to restore their catchments in the first place, and how this drive may be sustained into the future.

Land stewardship through community cohesion motivates freshwater ecosystem restoration

All our participants expressed the overarching need to work toward a 'healthy river' by restoring freshwater ecosystems as portrayed in their 'Visions' (Table 5).

> *We're in this together, we're all wanting the same thing. I don't think you'd go through this valley and find anybody that doesn't want the river to get better. I don't think you would find that.* — CG1

Each catchment group in this study was already actively working toward their visions by restoring their waterways through sustainable land management actions (e.g., reducing fine sediment and nutrient concentrations entering the river through stream side planting and fencing; constructing new, or enhancing existing wetlands; having active farm environmental plans that outline sustainable land management practices and progress). Participants in our study recognised that freshwater restoration is part of a bigger picture that includes more than just the physical environment. Connections were specifically referred to (see 'Visions' in Table 5).

> *So, everything is connected, and to understand those connections changes completely the way that you see things, because then you're not [restoring] because you should, you're [restoring] because it's an important part of the wider picture.* — CG2

The concept of community coherence appeared to be a main determinant for the success of catchment restoration for our participants and was mentioned as a goal by three of the five groups (e.g., *Weaving community together around our river*, CG2; Table 5). For our participants, an interwoven catchment community also meant that working collectively was likely to achieve much bigger goals than restoring rivers individually.

> *A lot of people doing little things make change.* — CG5

> *I think that there's those opportunities around lifting the helicopter off just what your problem is on your farm and bring it to a catchment where it's neighbours helping neighbours.* — CC4

A CG2 participant also mentioned that strengthening their community through restoring their river would not only benefit them for the purpose of freshwater restoration, but also for different future challenges, such as flooding due to climate change.

Our results showed that the success of ecosystem restoration was highly dependent on the functioning of a catchment community. For example, a community that 'works together' was recognised as a 'Strength' (CG3; Table 5), but a lack of community engagement, for example in the form of a small catchment group or lack of collaboration, were either seen as an obstacle (CG3) or a weakness (see 'Obstacles' for CGs 2, 4, and 5; Table 5).

> *I think the main goal would be to have as many people on board as possible pulling the same way. Many people—residents, farmers, lifestylers just going in the same direction.* — CG1

Sandercock (2003) found that through the crafting of community stories, diverse players found common threads that bound them to a shared vision and allowed opposing parties to work out catharsis and healing. In our study, catchment groups that ‘pulled the same way’ were also able to focus on restoring their freshwater ecosystems in the long term, which was a key driver for inspiring change.

> *The longest journey starts with the first step, and I think that’s what we’re on—the longest journey probably.* — CG1

Participants in our study agreed that ecosystem restoration is an ongoing process, and not a short-lived aspiration. Our findings revealed that there were a range of factors that played key roles in keeping catchment communities motivated to reach their visions. For example, the concept of ongoing care for waterways was regularly linked to *intergenerational catchment management* (CG4), but particularly to the need to restore freshwaters for future generations (Table 5).

> *[We need] to improve our rivers for the sake of our grandchildren.* — CG2

> *You talk to most farmers that have been around for a long time and they don’t want to stuff up their land. They usually want to leave it to their kids, so you try and pass on something that’s worth passing on.* — CG1

> *Future generations can enjoy the river as we have.* — CG5

The importance of long-term restoration and sustainable land management was emphasised by the length of each group’s vision, which were set to 100 years/4 generations (CGs2 and 5, respectively), 1,000 years (CG1 and 3) or indefinite (CG4) (Table 5). CG1 acknowledged that *it’s going to take a wee while* (CG1) to restore river water quality in their catchment. The duration of their visions in other focus groups was *over generations* (CG5) to see improvements in freshwater health. This is because a key component adding to complexity of catchment restoration is the lag in time between restoring before a response to actions can be seen. For example, lag times can range from between <1 year (for faecal bacteria waste management) to over 500 years (for sediment erosion control at a catchment scale) (Meals et al., 2010). Our participants recognised these lag-effects and adjusted their restoration visions accordingly.

Restoring freshwater ecosystems for future generations, regardless of the envisaged timespan, requires determination and ongoing motivation of current and future catchment groups. Participants expressed an intrinsic drive to restore their catchments, which was based on *the will to restore* (CG1; Table 5) and *their feelings for the land* (CG5) because they *deeply care for [their] river* (CG1). This fundamental desire to restore, and the connection to the land, are powerful drivers for action. We wanted to further investigate how catchment groups would *sustain* this drive to last for the duration of their visions and what role effective communication may play in this context.

The good, the bad, and the ugly: comprehensive storytelling, including successes and failures, is needed to sustain restoration momentum

The Catchment Journeys documented in this project were emotionally charged and included uplifting information (e.g., restoration successes such as return of a specific fish or bird species) as well as details about hardship, and failure. They were 'unconditional' stories. Unconditional stories such as these can connect people through memory, emotion, and the granularity of a life lived (Gearey, 2018). One CG4 participant described the importance of unconditional stories and the need of sharing.

> *Exciting to be farming and feeling the pain, living and breathing what farming challenges there are at the moment, but also full of optimism for the [catchment] groups and what they're looking to achieve. But no-one has captured their story. No-one in New Zealand has captured the story of the progress that they have done.* — CG4

Many participants were affected by the stories told by their community members with emotional responses ranging from elated and happy to empathetic and sad, depending on whether group members focused on strengths and opportunities or weaknesses and threats. Catchment Journeys that are emotional are likely to affect the listener, triggering emotional responses. Emotional responses evoke interest and engagement in readers and listeners (Green, 2004; Huang & Grant, 2020; Lambert, 2013).

While the role of emotions is too often disregarded in the physical sciences, it is well-understood and accepted in social science disciplines that content, which evokes high emotional arousal triggers action (Berger, 2011; Berger & Milkman, 2012; Hemmings, 2005; Nelson-Field et al., 2013; White, 2009). Emotions have been shown to be one of the most potent means researchers can use in terms of igniting an audience's engagement and potentially understanding (Carrus et al., 2008; Speckemeier & Tsivrikos, 2021; Wang et al., 2021).

By understanding the emotions that shape experiences, we can come to appreciate the meaning we make out of them (Davies et al., 2019). Then action-based change may be triggered, communities may be strengthened, and some of the discussed obstacles overcome. Below, we elaborate our participants' responses and emotions and the implications for comprehensive restoration storytelling.

The good: positive storytelling inspires ongoing restoration

In our research, participants noted that if Catchment Journeys were to elicit positive emotions, ongoing momentum to restore may be triggered. Examples of positive emotions included gratitude for financial support to restore, hope for future generations to be able to enjoy the rivers, and pride of the restoration already achieved. For example, one participant in CG5 had started to fence off his waterways 17 years ago to reduce impacts on the river caused by his livestock. Now, he said, that he was proud that he and his wife had fenced off all four km of riverbanks on their land and planted on average *a couple of thousand trees a year* along the fences.

Other participants talked about their restoration achievements with similar passion, listing the different kinds of restoration actions done by themselves or their group. This passion turned to elation when participants were able to show progress made over time as proof of the change they had initiated (through, for example, photographs), but also the potential change that could be made.

> *You don't necessarily always feel like you're achieving much and then you look at pictures. We've been there seven years now and it's like: 'Actually this doesn't even look anything like what it did when we moved here.' So then you feel like you are achieving something.* — CG1

> *Seeing the photos of 50 years ago now is quite inspiring for someone like me who has just got a blank canvas.* — CG1

Stories of exemplary actions serve as inspirations (Sandercock, 2003) and our participants agreed that sharing knowledge on restoration actions was considered a 'positive thing.'

> *I can only see [sharing restoration progress] as being a positive thing. That it's showing that there's work going on, and we want to share it with everyone because it is a positive thing.* — CG4

> *I was thinking of it more as a community to show what we are achieving as opposed to showing off, so that people are like, 'Actually we are doing some amazing stuff.'* — CG1

Being able to positively influence wider communities to change their behaviour toward improved land management (e.g., increasing the extent of their restoration actions, helping restoration communities to take action that is most effective) should be the goal of successful restoration science communication. This is '*because almost every river—it's about human change.' — CG3*

By providing an opportunity to act in a positive way, for example through involvement in a community-based restoration project, people are able to gain a sense of accomplishment and efficacy, based on their feeling of making a meaningful contribution to positive change (Leigh, 2005; Martinez & McMullin, 2004; Rogan et al., 2005; Ryan et al., 2001). Our research confirmed sharing restoration success, such as the 'good work' and 'what has worked,' was perceived to create an ongoing momentum to enable long-term freshwater restoration, as suitably phrased by a CG5 participant.

> *If you want to effect ongoing change you need to show what is working and have some positive stories out there.* — CG5

The bad: including threats and challenges as part of restoration storytelling creates empathy and trust

Some participants also raised the point that to encourage ongoing restoration momentum, Catchment Journeys should not only include positive stories, but also restoration actions that 'did not work' and why they didn't work.

> *It is important to share what we know about Land Management and restoration: the things that worked and the things that didn't work.* — CG1

> *To be quite honest, I know lots of people in the valley that have been here for a wee while and they would [be happy] to [tell] their story. But ours is not all positive like this— it's certainly not—it's certainly a very unhappy little river especially through the middle there.* — CG1

Some of the restoration stories our participants shared included hardship and failure, such as the story told by one CG1 participant who explained that his neighbour's cattle managed to enter his land and significantly damaged some of his waterway plantings that he had worked on for the last 20 years.

> *So that work can be undone in ... three days they were in [amongst the planting].* — CG1

Stories such as this caused other catchment group members to feel empathetic toward this farmer (*It's heart-breaking, isn't it?* — CG1) and many participants recognised that for Catchment Journeys to have a lasting impact, they will have to include stories that share failure and hardship, because such is the 'real world.' Catchment Journeys created by participants in our study reflected parts of the 'real world' and included sections that focused on what catchment restoration groups could do better to restore their catchments (weaknesses) and what obstacles each group experienced that hindered their restoration (threats).

In addition to the environmental challenges related to freshwater restoration, social obligations for farmers to act responsibly in accordance with their 'social license to operate' added further challenges to our participant's restoration journeys, as explained by one CG4 participant.

> *[W]e're under pressure here. We've got 13–14-odd neighbours now who complain about cowshed noise—they complain about dust. We're zoned rural but it's rather urban now, and it depends on who your neighbour is. We put new baffles, and everything, in the cowshed a few years ago to make it quieter, and I don't milk as early as I used to in the mornings so hopefully that makes people a little bit happier, but who knows. We've got a lot of issues like that.* — CG4

By providing a safe space for participants to discuss threats and challenges, true and honest knowledge could be shared. Honesty has been shown to create trust, which is a key factor for social licence to be granted (Woodward, 2017). That social licence is something our participants strived to achieve or maintain.

> *The goal must be for us to maintain our ability to [farm]. It's our social license to be able to continue farming.* — CG4

However, we were interested to note that despite the considerable political and cultural challenges associated with agriculture (many exacerbated by climate change) in Aotearoa New Zealand (NZ Ministry for the Environment & Stats NZ, 2020), our participants did not dwell on these topics during our discussions. Instead, they focused on finding pragmatic solutions to improve river health in their catchments through comprehensive, and emotional, knowledge sharing.

The ugly: better communication of freshwater restoration is needed to inspire change

Freshwater restoration is ongoing, and our participants recognised the need to communicate any learnings that happened along this journey. This would allow catchment communities to raise awareness about what restoration has already been achieved and what else is needed to achieve their long-term visions.

> *Knowing the 'now' to plan the future* — CG4

In our study, a hunger for improved communication within and across catchment communities was apparent. All five catchment groups mentioned communication and education of community members as a weakness or a threat in their Journeys (Table 5), emphasising the need for improved communication within (and beyond) their communities to encourage freshwater restoration. Of the 28 weaknesses or threats statements, ten specifically mentioned communication or education as an issue (e.g., *Communicate with each other* — CG1, *Persuading more to join* — CG2, *More educational efforts* — CG3, *Sharing of information* — CG4, *Find a way to engage the non-engaged* — CG5; Table 5).

For CG1 it was *important to share the things that worked and the things that didn't work*, but they recognised, along with CG3 that they could do better at educating and engaging others about what has, and what hasn't worked (Table 5). In contrast, Catchment Groups 2 and 5 explained that they already did well in *telling their story*, thereby inspiring communities to improve their freshwaters (Table 5).

Because Catchment Journeys are told by the people of the catchment about their restoration work and any associated successes and failures, our participants showed an increased interest in the example story we shared with them as part of the story creation process. We believe that their engagement was enhanced by their emotional response (Bandura, 1989) and positive affect (Longnecker, 2016) resulting from participation in the collective act of storytelling in the focus group. They were able to relate to the experiences of the 'champion' catchment group.

This sharing of catchment journeys means that catchment champions may not only act as role models for their own, but also for other catchment communities, thereby expanding the potential reach and impact of their shared knowledge significantly, as explained by this CG2 participant:

> *So, where you've got a tight community, and you're introducing better information and more informed and encouraging action, [members of that catchment group] are taking on more issues outside of [their own] catchment. And so, there's other strong groups that are now saying, okay, let's absorb this [knowledge] on catchment restoration.* — CG2

Bandura (1989) explains this principle as 'socially guided learning,' which influences cognitive development as humans turn to others who are well-informed for advice on matters of concern. By observing 'modelled expertise' (Bandura, 1989), not only from within their own, but also from other catchment groups, our participants appeared to express increased interest about restoring their catchments.

While we acknowledge the importance of sharing restoration knowledge as widely as possible and to as many restoration practitioners as possible, our project did not investigate this aspect. However, we anticipate that future research as part of the National Register of Land Management Actions project will address this knowledge gap.

Using Catchment Journeys to inspire wider action-based change: theoretical considerations

For the interpretation of our results, we referred to the Koru Model of Science Communication (Longnecker, 2016) to help us map our findings into pathways for closing the gap between knowledge and action through storytelling.

The Koru model focusses on the response of individuals to information, presented in our case as Catchment Journeys. Factors impacting an individual's engagement with information depends on internal and external factors. Internal factors determine a person's self-perceived identity and include values, beliefs, attitudes, skills and behaviour (Figure 15). External factors that impact engagement with and use of information include the social norms of the community, the support available to the individual, and whether an individual can control their own response and behaviour. Together these internal and external factors influence how an individual may (or may not) engage with information. In our study, focus group discussions exemplified important internal and external factors, helping us to understand how Catchment Journeys may consolidate existing understanding and influence participants to create and use new knowledge (Figure 15).

However, understanding how to restore a catchment does not automatically result in people doing so, with a gap between possession of environmental knowledge and adoption of pro-environmental behaviour (Kollmuss & Agyeman, 2002; Naustdalslid, 2011). We did not assess the impact of Catchment Journeys on retention and reproduction processes and will be conducting future research to explore this further.

5.5 Conclusions

Encouraging freshwater restoration, while delivering value to society, requires supplementary approaches and tools to science communication. These approaches and tools need to apply to a wide network of researchers and practitioners. In this paper, we developed storytelling as a potential tool to communicate freshwater restoration actions at catchment scales to inspire others within their catchment to follow suit. We did this by exploring how a catchment community can engage in collaborative construction of 'collective narrative.' We conclude our research with two take-home messages:

	Koru Model of Science Communication 	Koru Model applied to Catchment Journeys 
New information is presented	Individuals are interested in new information based on how it is communicated	Catchment Group A acts as 'champion' by restoring their catchment and sharing their knowledge in form of Catchment Journeys
Engagement with new information	Individuals respond differently to new information How we respond to and act on new information to make meaningful use is based on **internal** and **external** factors	Catchment Journeys consolidate existing understanding and influence participants to create and use new knowledge
INTERNAL FACTORS	**Values**	*I want to leave it in a better condition than when I came here.*
	Beliefs	*It's having the will to do it and the fact that you've got your idea of what restoration you want.*
	Attitudes	*I mean farmers at the moment feel they're under attack. So anything that actually threatens them in that respect would be a negative, if you get what I mean.*
	Affect	*Cause even like looking at our place, when they updated their photo recently it was quite inspiring, just for my little bit. Oh, you can actually see some dark green with actual trees. If you can see something has changed, it's nice isn't it?*
	Awareness	*But it's one of these things, you tend to look forward all the time what you need to do, but occasionally you have to look backwards and say oh I have done a lot already.*
	Understanding	*And just learning too, like I'm a newcomer so I was learning what's gone well and what works. I don't want to make someone else's mistake; I can't afford to.*
	Skills	*So we've fenced off that section. It's not totally sheep-proof but it's cattle-proof and we tend not to put the sheep in the hill paddocks so it's pretty much stock-free.*
	Behaviour	*So we thought "Well if we popped it into mānuka and fenced it along the top of the hill, at least then we've got our stock still staying over there, and maybe keep some of the goats out."*
EXTERNAL FACTORS	**Social norms**	*I was thinking of it more as a community to show what we are achieving as opposed to showing off, so that people are like actually we are doing some amazing stuff.*
	Control	*I feel we as a group have integrity and people do sort of listen to us. But it's an ongoing battle. That's what democracy is about, I suppose.*
	Support	*So one thing I will say is just "Start small because then you learn, and you learn from your mistakes, and from your friends' mistakes." That is the key thing for me.*

Figure 15: *Examples in focus group discussions that illustrate internal and external factors in the Koru Model of Science Communication that impact engagement with communicated information.*

Firstly, creation of Catchment Journeys encouraged collective narrative. This allowed common identity to be built through bridging different ways of knowing among people who are already working together to restore their rivers. Our participants showed an interest in the example story we shared with them as part of the story creation process, and this appeared to facilitate the creation of their collective Catchment Journey. While we have not empirically tested the 'from knowledge to action' process, we hypothesise that 'collective agency' is likely to trigger ongoing future restoration momentum within individual catchment groups, as it has in the past. Participants in our study left the focus group discussions with apparent positivity and motivation 'to get out there and restore.'

Because Catchment Journeys are created by the people of the catchment about their restoration work and any associated successes and failures, they have potential to stimulate action-based change in other restoration communities. In fact, three of the five catchment groups in this study have subsequently shared their Catchment Journey with a range of audiences, such as their wider catchment groups, their local councils, agricultural extension practitioners, and other river restoration communities across Aotearoa New Zealand. Further research related to this project will attempt to quantify the potential of Catchment Journeys to stimulate action-based change.

Secondly, stories in the form of Catchment Journeys appeared promising as a freshwater restoration communication tool. This unique form of storytelling allowed each catchment group in our study to carefully tailor their messages to contexts specific to their group and catchment, such as their social settings (e.g., time since group establishment, size and diversity of group, levels of engagement within group), geographical location (e.g., high, or low rainfall area) or their political situation (e.g., functioning relationship with regional authorities).

Despite the uniqueness of each Catchment Journey, our research showed that there are overarching elements, which should be part of freshwater restoration communication to inspire pro-environmental behaviour within catchment groups. We suggest that this 'Archetype Catchment Journey,' if included in restoration communication, would be valuable for large scale freshwater restoration. Moreover, the insights gained from our findings on communicating complex environmental processes can be applied to other environmental restoration such as biodiversity or matters such as climate change.

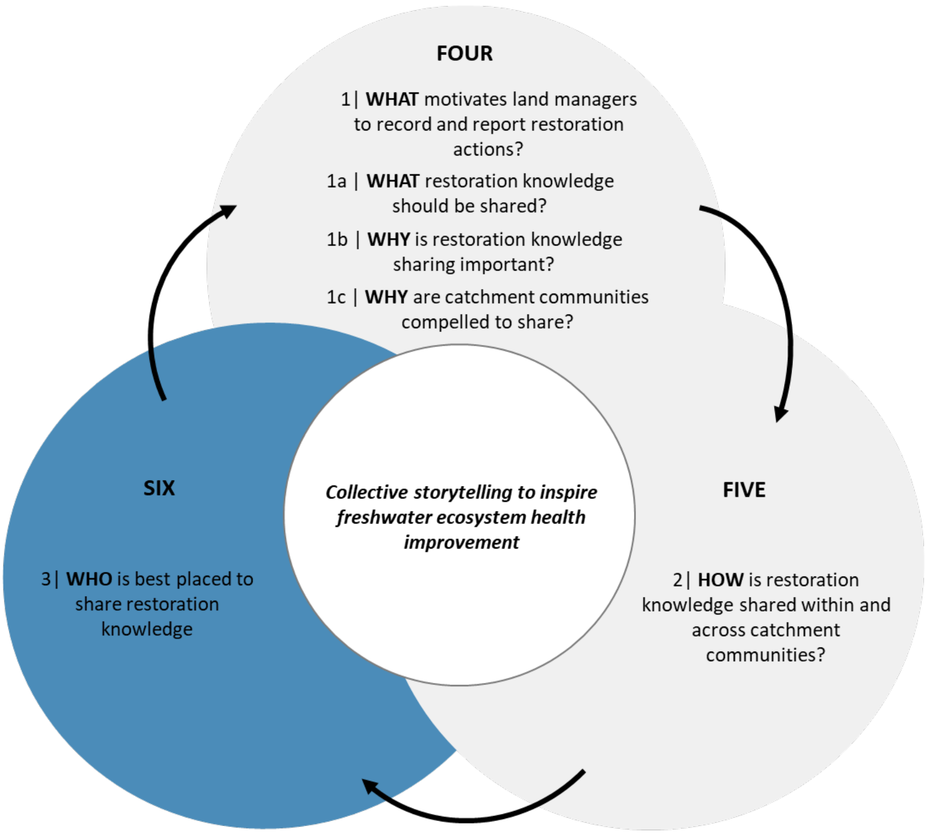
He aha te kai a te rangatira?

He kōrero, he kōrero, he kōrero.

What is the food of the leader?

It is knowledge. It is communication.

SIX | Preface



Previous chapters established what motivates land managers to record and report restoration actions, why knowledge sharing is important (Chapter FOUR) and how restoration knowledge can be shared through storytelling (Chapter FIVE). I used the term story to describe an account of specific events, places, and people. Key constructs of freshwater restoration storytelling highlighted the importance of collectivism, long-lasting restoration momentum, and emotions. Knowledge sharing through collective storytelling also inspired meaningful engagement with (new) information. I was interested in investigating whether these constructs are influenced by WHO delivers the story. Could the way audiences engage with and remember information vary depending on whether a story is told by an individual or a group of diverse voices? The dynamics of peer-to-peer knowledge exchange, social norms around being a 'good farmer,' and the 'over the fence' mentality prompted me to delve deeper into the role of the messenger in storytelling.

Throughout this final data chapter, I seek to elucidate a storyteller that most likely may be driving pro-environmental behavioural change, enhancing the collaborative efforts of communities and sharing the wisdom of those who have been at the forefront of restoration. I quantitatively assess the impact of storytellers on information uptake, recall, and motivation to restore. My research delves into the complexity of freshwater restoration decision-making, the significance of cross-boundary knowledge exchange, and the transformative potential of storytelling. I use ArcGIS StoryMaps© as an innovative way to convey knowledge from two different storytellers online, providing a visual and scrollable overview of shared restoration knowledge.

SIX | Trusted storytellers as freshwater restoration knowledge brokers: individual and collective voices can both be effective

ONE
Research Strategy and Motivations

TWO
Introduction, Literature review and Theoretical Frameworks

THREE
Research Paradigm and Methodology

FOUR
A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?

FIVE
Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change

SIX
Trusted storytellers as freshwater restoration knowledge brokers: individual and collective voices can both be effective

SEVEN
Conclusions and Implications

6.1 Abstract[11]

Aotearoa New Zealand's aquatic ecosystems are declining despite widespread awareness of mitigation needs. This study employs storytelling to address this issue, testing the role of the messenger in encouraging freshwater restoration in rural catchment communities. We quantified peer-to-peer knowledge exchange on three cognitive processes (retention and extraction of information, motivation to reproduce modelled restoration behaviour, and recall of acquired information), using ArcGIS® 'StoryMaps'. We created two restoration stories; one told through the voice of a respected catchment group member known for leadership, and one through a collective catchment group voice. We surveyed freshwater community members (*N* = 82) before and after reading the stories, and one month later, and found that participants reading either catchment restoration story 1) accepted both the catchment collective and the respected individual member as a trusted source, and could therefore relate to either, and 2) thought the story was informative and contained new details, independent of the time span land managers have been actively restoring. While our study found no significant differences between individual or collective storytellers, it confirms the value of trusted messengers as restoration knowledge brokers in rural catchment communities, a critical step in value-led freshwater restoration at large scales.

Keywords: observational learning; catchment freshwater restoration; sustainable land management; water quality

6.2 Introduction

Globally, the restoration of freshwater ecosystems has become a large and growing challenge, mitigating against damaging human activities. Intensive agricultural practices especially have resulted in water quality degradation (Mateo-Sagasta et al., 2017; NZ Ministry for the Environment & Stats NZ, 2023; UN Water - WWAP, 2022). Restoration, including similar concepts like river rehabilitation or mitigation can include physical measures (e.g. the re-establishment of natural flow regimes through expanding floodplains, sustainable management of the land surrounding a waterway (Gann et al., 2019; Sayer et al., 2018) as well as social-

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[11] Doehring, K., Cole, C., Casanovas, P., Young. R., & Longnecker, N. (2024). Trusted storytellers as freshwater restoration knowledge brokers: individual and collective voices can both be effective. *Kōtuitui:New Zealand Journal of Social Sciences Online*. https://doi.org/10.1080/1177083X.2023.2298914

ecological interventions (e.g. stakeholder participation in decision-making (Newig et al., 2023; Reed, 2008; Scott, 2015).

With regards to the latter, community-led freshwater collectives are a collaboration of people who take ownership of a problem, jointly addressing the most pressing issues at local scales. These collaborations build from existing connections between people who share an attachment to the land and people in their catchment [12], often because they live close to the waterway of concern. Together they bring about on-the-ground change by working collectively and sitting at the core of decision-making, a principle commonly termed 'grassroot' community engagement (Ministry of Agriculture and Forestry, 2010; O'Meara et al., 2007). They foster governance and responsibilities grounded in local culture and social and community values (Wakefield et al., 2006), generating positive social and environmental outcomes (Bodin, 2017; Gunningham & Holley, 2016; Innes & Booher, 2018). These groups are commonly supported by substantial investments by government, industry and philanthropic organisations (Shanahan et al., 2021).

Community-based catchment (or watershed) management is currently prevalent around the globe (e.g., Da Costa Silva, 2011; Mekuriaw & Amsalu, 2023; Pumicestone Region Catchment Coordination Association Inc, 2017; Scott, 2015; Tadaki et al., 2020). In Aotearoa New Zealand, for example, the Southland region has established 35 community catchment groups since 2013, forming a network covering over 90% of the Southland region. Their vision is to 'create a prosperous Southland, healthy people, healthy environment from the mountain to the sea.' (Thriving Southland, 2023). These catchment groups achieve their goals by supporting farmers to navigate regulation changes and future challenges such as climate change and help them to get ahead of issues by participating in events and projects to develop localised responses that reflect their expertise and experience. In 2021/22 the Southland Region groups held 156 catchment meetings and events with 2,657 attendees, receiving NZ$ 623,015 worth of funding that covered 41 projects (Thriving Southland, 2022). Similarly, a group of farmers and growers from the Taranaki Region came together in 2020 as 'Taranaki Catchment Communities' to establish 15 catchment groups under the region-wide umbrella organisation. Their collective aim is to 'lead, engage and mobilise Taranaki's rural sector to ensure a more environmental, economic and socially sustainable future' (Taranaki Catchment Communities, 2023). Within

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[12] A catchment (also commonly referred to as watershed) is defined as the natural drainage area of rainwater where it gets collected and transported from the source to the sea.

three years, the Taranaki region has had 6000 volunteer hours committed to setting up the 15 groups and facilitated 60 events which have been attended by more than 500 farmers. This surge in community-led freshwater restoration groups means that a large (and growing) proportion of rural citizens now participate in freshwater ecosystem restoration activities in Aotearoa New Zealand (McFarlane et al., 2021; Peters et al., 2015; Tadaki et al., 2020).

The value of stories for information exchange

Collaboration in freshwater restoration takes place at all scales, from small district to large regional scales. As the scale increases, so does the complexity of restoration decision-making due to the differences and heterogeneity in environmental, cultural and social values, economies and politics (Kark et al., 2015). This complexity should also be considered for cross-boundary knowledge exchange. In Aotearoa New Zealand, many freshwater restoration groups have been restoring their catchments for decades and have a wealth of knowledge about actions that have and haven't worked.

Exchanging restoration knowledge between catchment communities across boundaries allows freshwater restoration communities to learn from each other about their restoration experiences (Doehring et al., 2023), help prevent mistakes being repeated and enable more impactful pro-environmental behaviour (Armitage et al., 2008; Blackmore, 2007).

To encourage behaviour change, it is important to know which intervention strategies are most effective and under which circumstances for particular groups of people. More recently, the role of storytelling in freshwater management has been explored as a way to contextualise various types of knowledge to support management processes through collaborative action (Stevens, 2022), and for the sharing of restoration knowledge as a strategy to maintain restoration momentum (Doehring et al., 2023).

Stories have been integral to human culture and are instrumental in our cognitive processes of retention and extraction of information (e.g., Goyes, 2022; Morris et al., 2019; Robin et al., 2022). Stories allow us to effectively share knowledge and learning, engage us by evoking emotion and compel us to think and behave differently (Dahlstrom, 2014). Van Bavel et al. (2021) suggest that stories about personal experiences that are shared in a genuine and caring manner are more digestible than argumentative or generic commentary. And Negrete and Lartigue (2010) suggest that information conveyed in the form of stories is retained for longer periods than information presented in a factual way, making stories an "*important means for* *science communication to transmit information in an accurate, memorable and enjoyable way*" (p. 104).

However, while information provision (in the form of stories) is a critical component of behaviour change, information is made meaningful only after it is placed within a certain social network. If we then also believe this network (in our study restoration catchment groups) to be trustworthy, an audience is likely to feel the same about knowledge that comes from that social network (i.e. that knowledge is considered to be true) (Collins, 1992; Jasanoff, 1998). Essential here is the element of trust, a heuristic used to evaluate information which is based, amongst other factors, on whether new information comes from credible sources that are also trusted by peers (Lewandowsky et al., 2012). For example, Brown and Roper (2017) showed that farmers are more likely to adopt new practices and technologies when that demonstration was undertaken within farmer networks, because these networks already provided that interpersonal trust. Similarly, farmers did not tend to trust information that came from people with limited farming experience (Mauro et al., 2009; Rust et al., 2020; Skaalsveen et al., 2020). So, social similarity to an audience allows them to identify with the storyteller and is key in building trust (Neef & Neubert, 2011). Once an audience can identify with a storyteller and content is understood, modelled behaviour (in our case the uptake of sustainable restoration actions and the act of sharing restoration knowledge) is more likely to be adopted (Dahlstrom, 2014; Oatley, 1999; Sundin et al., 2018; Toolan, 1988).

The potential of storytelling to trigger behaviour change has not been fully recognised as an effective technique for engaging behaviour-changing pathways in the conservation and restoration sectors. While researchers have started to address this knowledge gap (e.g., Goyes, 2022; Morris et al., 2019; Robin et al., 2022), evidence is lacking about the part messengers (in our case storytellers) play as trusted role models. Our research aims to bridge this knowledge gap. Specifically, we explore the role that an individual or a collective storyteller voice may play in encouraging freshwater communities to increase on-land restoration actions. In this study, we used digital storytelling as a medium for sharing freshwater restoration knowledge.

Digital stories as a medium for peer-to-peer restoration knowledge exchange

Online interactive communication tools to share information in the form of stories are popular due to their ability to engage a wide range of audiences, their relative simplicity for users, and their potential for wide reach over a short timespan (Cortes-Arevalo et al., 2020). Restoration knowledge and advice networks are important components of rural communities' innovation systems (Fielke et al., 2020). Worldwide, land managers and catchment groups build 'digital relationships' online with their peers, communicating with each other and potentially forming communities of practice (Rust et al., 2022). Peer-to-peer information exchange enables rural communities to engage and learn from each other. Farmers, for example, often believe that information conveyed from another farmer is more useful than from others, especially where this information has demonstrated value and benefits to other farmers in their network (Blackstock et al., 2010). Rust et al. (2022), for example, documented farmers' preference for learning about restoration actions from other farmers through in-person events such as farm visits. Further research confirms the critical role of peers as advisors and support, suggesting successful sharing occurs when the farmer sharing the knowledge does not have a conflicting agenda but has applied, practical experience relevant to the farmer seeking information (McKitterick et al., 2019; Rust et al., 2022; Wood et al., 2014). This means that farmers see themselves and other farmers as experts (Palmer et al., 2009), acknowledging the many different sources from which knowledge is generated, notably by the farming community themselves (Chambers et al., 1989).

Many catchment groups have active Facebook pages where they publish information about freshwater restoration, publicise upcoming community engagements and link to other restoration-related knowledge and/or activities (e.g., Brisbane Catchments Network, 2023, Australia, 2200 followers; Friends of the River Roding, 2023, UK, 2700 members; Pomahaka Catchment Project, 2023, Aotearoa New Zealand, 1200 followers). However, while digital storytelling is a popular tool amongst catchment groups to share information, it is unclear whether this supports pro-environmental behaviour. To fill this gap, we quantitatively tested the effect of recognised freshwater restoration storytellers on information uptake, recall and motivation to restore. To do this we used ArcGIS® 'StoryMaps' (esri; https://storymaps.arcgis.com/; accessed 18.05.2023) as a digital storytelling medium to exchange restoration knowledge across restoration communities in Aotearoa New Zealand. We created one story that was told by a catchment group through a 'collective voice' and one story that was told by an individual member or 'influencer'. We tested these two storytelling methods in the context of Social Cognitive Theory.

Social Cognitive Theory and pro-environmental behaviour change

Learning through modelling the behaviour of peers is a concept recognised as 'observational learning' in Bandura's Social Cognitive Theory (Bandura, 1989), the theoretical framework used in our research. Observational learning postulates that learning can occur by observation and/or interaction with others in communities through the process of behaviour modelling, rather than individual cognitive learning. In the field of environmental management, it has been recognised that observational learning can help avoid repetition of past management failures in complex social-ecological systems (Armitage et al., 2008; Blackmore, 2007). In rural catchment community terms, this would be 'looking over the fence to see what my neighbour has done', rather than solely 'learning by doing'. The land manager over the fence then acts as a 'model' or an 'influencer', a critical source of learning within farming communities (Burton, 2004; Zeng et al., 2022).

Social Cognitive Theory provides a framework for understanding psycho-social mechanisms that influence human thought, and for predicting and changing human behaviour (Bandura, 1989). Story parts or narrative elements influence cognitive involvement by sparking the interest of the audience in a way that they can identify, recall, remember, and contextualise the content (Dahlstrom, 2014). Providing information that resonates with the audience is an important aspect of whether new information is used (Longnecker, 2016, 2023).

We hypothesised that audiences who received freshwater restoration knowledge shared by an individual 'model', in our case a farmer called Mark on behalf of 'his' catchment group, would pay greater attention to the information, remember more of the information provided, and be more likely to restore in the future. In contrast, we predicted that audiences who received restoration knowledge from a catchment community (i.e. a collective voice) would take up less information, recall fewer details and be less motivated to restore their freshwaters. The following four cognitive processes were used to test our hypotheses (Figure 16).

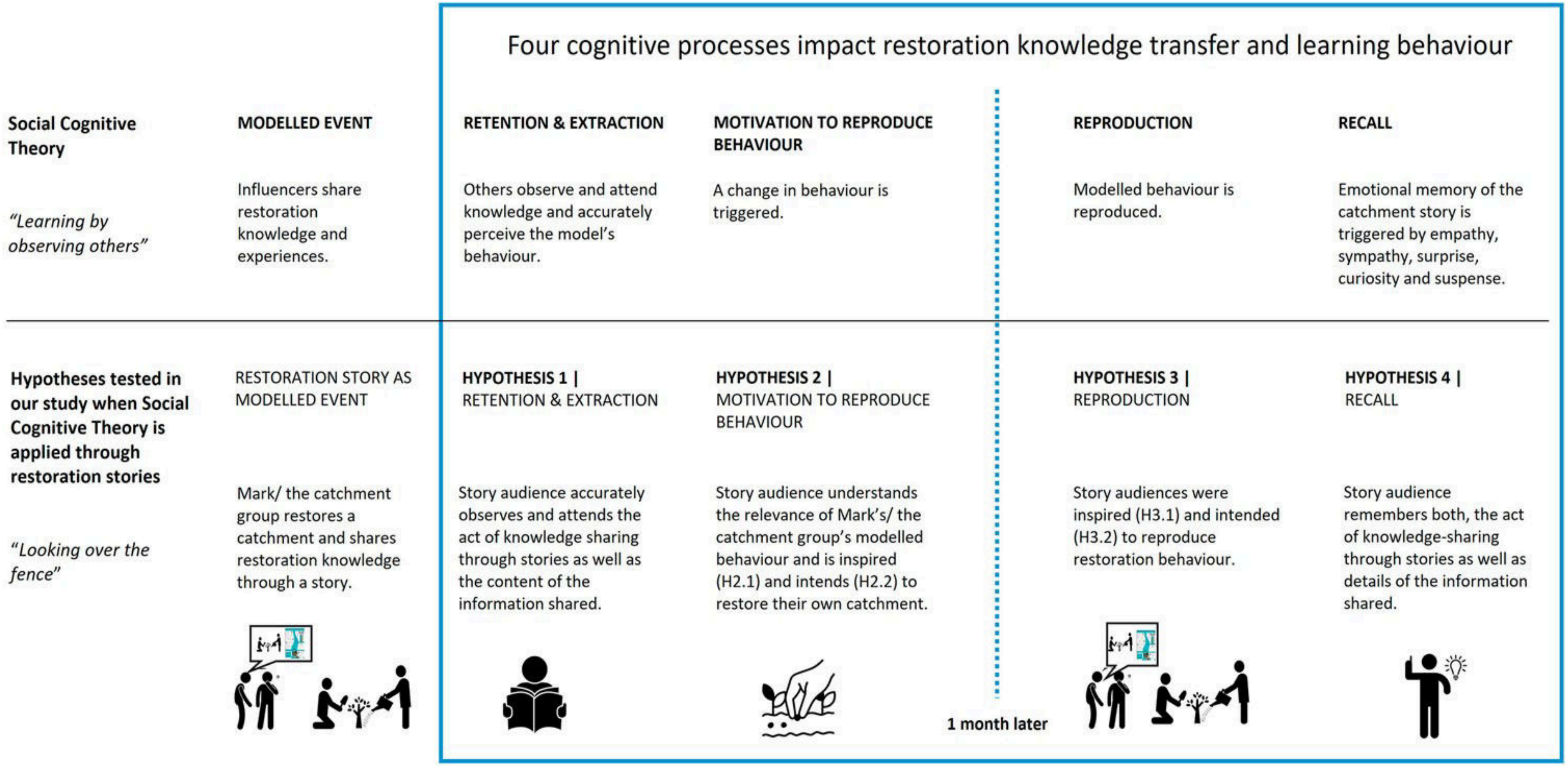


Figure 16: *Four cognitive processes that impact restoration knowledge transfer and pro-environmental behaviour change tested by applying Social Cognitive Theory.*

Retention and extraction of information | hypothesis 1

Attentional processes determine what people observe from modelling influences and what information they retain and extract from what they notice (Bandura, 1989). In our case, the individual storyteller, Mark, is an influential model who shares his freshwater restoration knowledge in the form of a catchment story. We predicted that audiences who observed Mark's behaviour would be more likely to pay attention to his behaviour and extract information from what they notice, in comparison to audiences that read the story with a collective storytelling voice.

Motivation to reproduce modelled behaviour | hypothesis 2

For a modelled behaviour to be copied, the reader needs to be motivated. We tested this with our second hypothesis whereby we asked about the audience's inspiration in response to the story (H2.1) and intention (H2.2) to restore and share knowledge. We predicted that our audience's inspiration and intention to restore would be influenced by the credibility of the storyteller and his/their modelled restoration behaviour.

Reproduction | hypothesis 3

Reproduction of a modelled behaviour is a desired outcome that may occur after the viewer's interaction with the text, visuals, and interface of a story. Our third hypothesis tested whether participants acted on their inspirations (H3.1) and intentions (H3.2) to restore and share knowledge one month later.

Recall | hypothesis 4

Recall refers to the mental process of retrieval of information that was previously seen or experienced. For learning to take place, it requires that the information that is processed is committed to memory and can be recalled when needed. In our study, we hypothesised that landholders who observed an individual's catchment story could better recall details presented in the story, compared to the same details presented in the collective voice story.

The need for this research

As freshwater ecosystems deteriorate globally, guidance for on-land freshwater restoration is widely available to counter these trends. However, the abundance of information can lead to overload, complicating the distinction between valuable and subpar content. According to Baumgart-Getz et al. (2012), quality information – not quantity – drove successful adoption of agricultural best practices in the United States. In Aotearoa New Zealand, rural land managers need to be able to filter and prioritise any information that comes their way, too, making knowledge exchange from trusted sources more important than ever. To enhance trust and usability, information should be communicated in an understandable, relatable manner (McKitterick et al., 2019) and we argue that catchment restoration stories may be a suitable tool, minimising the risk of information overload and resulting in meaningful information uptake.

In addition, Aotearoa New Zealand's land managers have consistently faced demands to comply with recently established freshwater management legislation as part of the National Policy Statement for Freshwater Management 2020 (NZ Ministry for the Environment, 2020d). This policy mandates completion of regional plan changes by 2025, listing 22 standards for which the primary mechanism to achieve improvement is individual farm plans.[13] Not only do these plan alterations require land managers to understand what changes they will have to implement to comply with the law, they also must adapt land management practices within a relatively short timeframe. Restoration communication through storytelling is likely to help with the effective implementation of these required changes.

6.3 Materials and methods

StoryMap© as a testing mechanism

To test the effects of storytelling on information extraction, recall and motivation to restore and share knowledge, we created two stories. One story was told in a 'collective voice' by a catchment group with no identified individual storyteller (referred to as 'Collective's story'; https://arcg.is/GOC4D; accessed 26.02.2024; Appendix J). This story described restoration efforts of the Rangitīkei Rivers Catchment Community, a community-based freshwater restoration group in the North Island of Aotearoa New Zealand (Rangitīkei Rivers Catchment

[13] As indicated previously, there is a high probability of substantial revisions to these objectives in 2024 following the election of a new national government in Aotearoa New Zealand in October 2023. At present, the specific nature of these revisions remains unclear. Therefore, the objectives outlined here are aligned with the National Policy Statement for Freshwater Management 2020. (amended January 2024; https://environment.govt.nz/publications/national-policy-statement-for-freshwater-management-2020-amended-january-2024/)

Community, 2023). The farmer-led group was established in 2017 to encourage and facilitate farmers to work collectively within their catchment to 'set environmental standards that improve our waterways, soils, and enhance biodiversity'. We used this group as a pilot to quantify the effects of 'collective learning' using restoration storytelling. The second story was told by an individual 'influencer' who is a known and respected Rangitīkei Rivers Catchment Community member, Mark (referred to as 'Mark's story'; https://arcg.is/0L8Lmj; accessed 06.02.2024; Appendix K). Both stories were co-designed with the Rangitīkei Rivers Catchment Community to ensure authenticity of the content and 'voices' used.

To tell the story in an interactive and engaging way, we used ArcGIS® StoryMap© (ESRI, 2023) which are a visual storytelling tool that offers a mixed media approach combining different functionalities such as maps, videos, graphs, and text into a simple online interface. On the tool, stories are set-up like a website, whereby users scroll through the content, allowing them to engage and interact with the story (Kallaher & Gamble, 2017) through navigating, zooming and hyperlinking, thereby being a "*complete and promising means of communication*" (Oubennaceur et al., 2021, p. 2). By using this tool, we were able to test two independent stories hosted on the same platform using the same system, ensuring information shared on the platform was kept secure and was accessible by our survey participants only. This allowed us to analyse user-specific behaviour through Google Analytics. StoryMaps© have become a well-recognised tool for conveying environmental information in Aotearoa New Zealand with a broad user-base including national government (e.g., NZ Ministry for the Environment & Stats NZ, 2023), regional government (e.g., Northland Regional Council, 2022), community organisations (e.g., NZ Landcare Trust, 2022) and catchment care groups (Te Hoiere Project, 2021) alike.

To enable qualitative and quantitative comparisons, the layout and content were the same apart from a short additional introduction of Mark as the storyteller in Mark's story which increased the word count from 1057 (Collective's story) to 1184 words (Mark's story) (see Appendix J and K).

Data collection

Survey design and set up

We used a web-based survey to collect our data designed and hosted through Qualtrics© software (https://www.qualtrics.com; accessed 27.02.2024). The survey questionnaire was workshopped, and pilot tested with representatives of Aotearoa New Zealand catchment groups with whom we had existing relationships. It was refined based on their feedback to ensure questions and terminology were clear. Pilot testing can help decrease question context effects (Cobanoglu et al., 2001) and our pilot testing did so. This allowed us to measure retention and recall of information, and motivation for restoration reliably and validly, before using the questions in a real situation, as recommended by Etchegaray and Fischer (2011).

The overall survey structure consisted of two separate surveys – the Intervention Survey and the Follow-up Survey (Figure 17; Appendix H). The Intervention Survey consisted of four parts: Part 1 which covered welcome pages and general introductory questions, Part 2 which randomly assigned participants to one of the two storytelling methods (Collective's or Mark's story) and Part 3 which quantified the effect of the storytelling methods as part of the Intervention Survey. Participants who expressed interest in being part of a Follow-up Survey (Part 4) provided their contact details at the end of Part 3 and were contacted one month later. Without further reference to the story, the Follow-up Survey repeated the same questions as Part 3, to test for reproduction of the modelled behaviour and recall of facts and differed only in their reference to the storyteller (Figure 17).

The survey consisted of a range of question formats, including open-ended (freeform) questions (e.g. 'What makes the story relatable to you?'), closed-ended nominal questions (e.g. 'What is your age?'), partially closed-ended questions (e.g. 'other: please specify'), ranking questions (e.g. 'What actions have you most commonly done, in terms of resources spent'), multiple choice questions (e.g. 'What holds you back from restoring your catchment?'), and Likert-scale slider questions allowing participants to choose where to position the slider between 0 and 100 (e.g. 'How much do you agree with the following statements?') (Appendix I).

Our research was approved by the University of Otago's Human Ethics Committee (D20/037; Appendix M and N); it also adhered to Cawthron Institute's research ethics protocol (CAWETH-200804; Appendix P). Prior to the start of the survey, all participants were reminded that their participation was voluntary with the option to pull out any time. Responses were anonymous but, if participants chose to contribute to the Follow-up Survey (Part 4), they had the option to provide their names and email address. Final responses were anonymised prior to analysis.

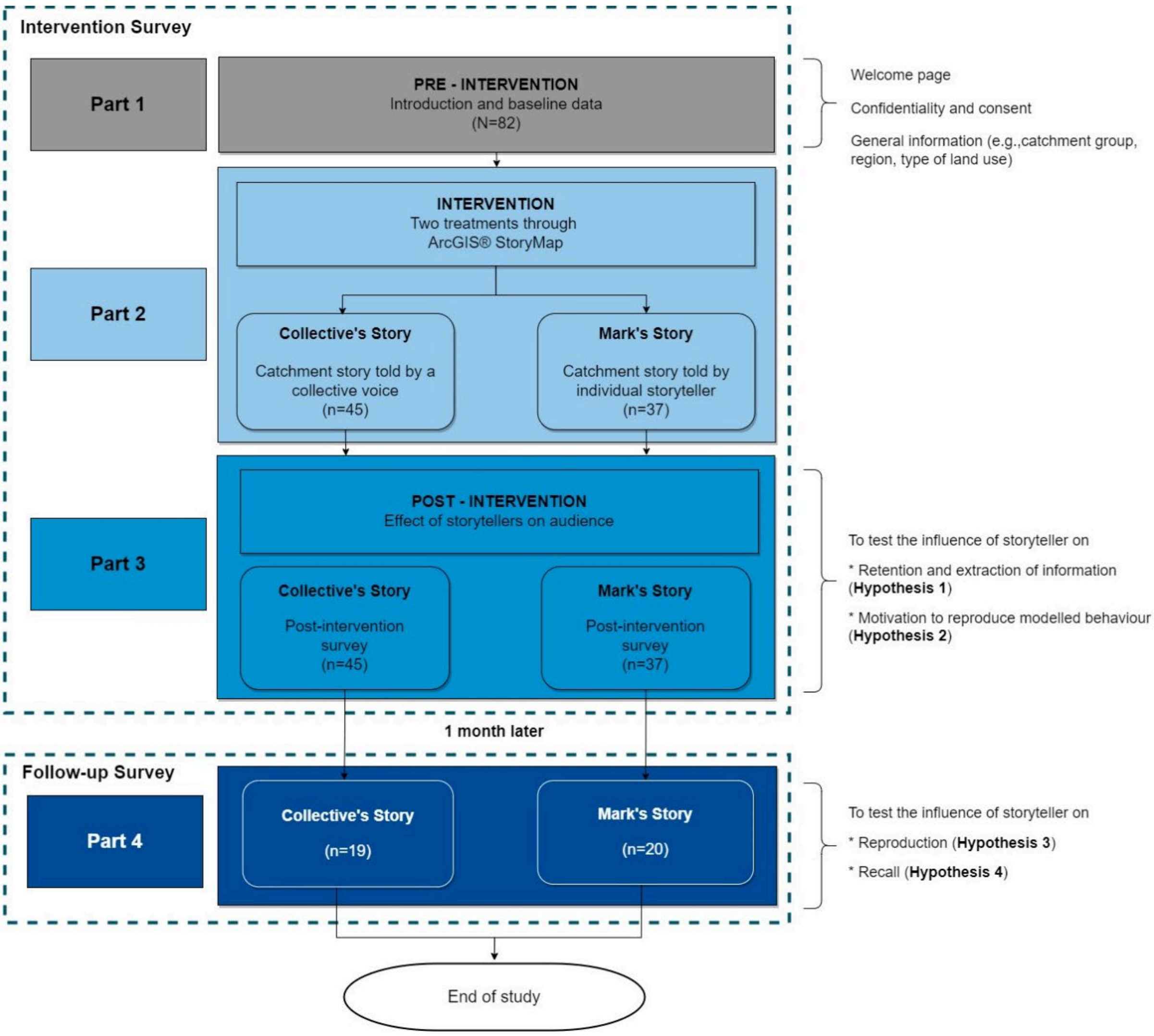


Figure 17: *Two surveys were conducted for data collection – the Intervention Survey (Parts 1–3) and the Follow-up Survey (Part 4) which was sent to willing participants one month later.*

Survey recruitment and implementation

Target audiences for our study were rural land managers of all types of land uses (e.g. dairy, sheep, beef, forestry) across Aotearoa New Zealand. Because waterway degradation is most widespread in rural areas in Aotearoa New Zealand (NZ Ministry for the Environment & Stats NZ, 2023), we purposefully recruited communities that can bring about the biggest change in pro-environmental behaviour in these areas. Survey participants were recruited via mailing lists of catchment and/or community environment groups in Aotearoa New Zealand. Access had been established through existing connections and related research programmes. In addition, the New Zealand Ministry for Primary Industries, the New Zealand National Science Challenge Our Land and Water, as well as certain industry umbrella groups (i.e. NZ Farming, Silver Fern Farms) promoted the survey on their social media platforms. A single email address per group was used, where possible addressed to the lead coordinator or lead communication contact. A reminder to non-respondents was sent out two weeks after the initial recruitment email. To incentivise participation, we explained NZ$5 would be donated to the Rural Support Trust (www.rural-support.org.nz; accessed 27.02.2024) for each completed survey.

Analysis of survey results

For quantitative survey analysis, we used a generalised linear model approach to explore if the responses to the survey were different between the Collective's and Mark's story and among categories of the demographic variables (Dobson, 1990). We fitted these models using a binomial family for the error distribution. The responses to the survey questions of interest were not categorised; the participants could choose any value between 0 and 100 on a sliding-scale. This allowed us to investigate the responses in more granularity and understand the variability across responses. Even though the response variable for the survey was not based on a percentage or proportion, the data distribution had the same properties (bounded between 0 and 100). We then computed the estimated marginal means for specified groups in the linear models and the contrasts among them. Probability values were adjusted using the Tukey method for comparing a family of estimates (Lenth, 2023). All quantitative analyses were carried out using the statistical computing software R v4.2.3 (R Core Team, 2023). We used the tidyverse v2.0.0 (Wickham et al., 2019) metapackage for data manipulation and the emmeans package for estimating marginal means (Lenth, 2023).

Demographics data were summarised using descriptive statistics. For analysis of qualitative, open-ended survey responses, we thematically grouped responses and tested 20% of them for inter-rater agreements with other researchers. The final agreement was Cohen's kappa of 0.904 with a percentage agreement of 99% which was considered sufficient to validate the robustness of the coding manual (Lombard et al., 2002).

6.4 Results

Survey responses and participant demographics

The Intervention Survey (Parts 1, 2 and 3; Figure 17) ran from 16 March 2023 to 7 June 2023 and received a total of 126 responses, 82 of which were fully completed and included in the data analysis. For Mark's story (n = 37), respondents took on average 17 min to complete the survey, of which they spent on average 2 min and 45 s engaging with Mark's Story. For the

Collective's story *(n* = 45), participants took on average 19 min to complete the survey of which they spent on average 3 min and 50 s engaging with the Collective's Story.

Survey responses were evenly distributed across Aotearoa New Zealand with 13 of the country's 16 regions represented. Most participants were in the Auckland (18%), Tasman (16%) and Otago (16%) regions, with the least in the Wellington, Southland, Nelson and Manawatū-Whanganui Regions (Table 6). The 55–64 years age group was most represented (26.8%), with the 34 year and underage group the least represented (9.8%; Table 6). More than half of participants were sheep and beef farmers (61%), with the second highest land use type being lifestyle[2] farming (41.5%; Table 6).

All, but one participant, were actively restoring their land, with 37% of participants (*n* = 30) having actively restored their land for more than 9 years. Sixty-five of the 82 participants (79%) were a member of a catchment group, with almost a third of participants (30.5%) having been part of a catchment group for less than three years. When asked to rank land management actions based on the most resources (time and money) spent for restoration on their land, 82% of participants indicated that they have spent most resources on vegetation actions (e.g. planting of riparian zones, steep hill country planting), followed by stock exclusion and grazing actions (e.g. fencing of waterways; 26%) and erosion control actions (e.g. cover crop after harvesting; sediment traps; afforestation; 20%) (Table 6).

Table 6: *Summary of survey participants' demographics, land use type and amount of restoration resources spent (*N *= 82).*

Metric	Category	Percent (%)	n
Age	Under 34	9.8	8
	35 - 44	15.9	13
	45 - 54	23.2	19
	55 - 64	26.9	22
	> 65	24.4	20
Geographical Region	Auckland	18.3	15
	Otago	15.9	13
	Tasman	15.9	13
	Canterbury	14.6	12
	Waikato	7.3	6
	Taranaki	6.1	5
	Hawkes Bay	4.9	4
	Northland	4.9	4
	Bay of Plenty	2.4	2
	Manawatu-Wanganui	2.4	2
	Nelson	2.4	2
	Southland	2.4	2
	Wellington	2.4	2
Type of land use	Sheep & Beef	60.98	50
	Lifestyle	41.46	34
	Dairy	26.83	22
	Arable	20.73	17
	Forestry	15.85	13
	Horticulture	10.98	9
	Deer	9.76	8
	Other	26.83	22
Catchment group member	Yes	79.27	65
	No	19.51	16
	NA	1.22	1
Time in catchment group	<3 years	30.49	25
	4-6 years	20.73	17
	7-9 years	7.32	6
	10-19 years	7.32	6
	>20 years	6.10	5
	NA	28.05	23
Actively restoring land to improve water quality	No	1.22	1
	Yes	98.78	81
Duration of actively restoring	1 - 3 years	17.07	14
	4 - 6 years	21.95	18
	7 - 9 years	14.63	12
	Other/ doesn't apply	4.88	4
	< 1 year	3.66	3
	> 9 years	36.59	30
	NA	1.22	1
Most resources spent (time and money), ranked from most resources to least	Vegetation	81.71	67
	Grazing/ Stock exclusion	2.44	2
	Nutrient management	4.88	4
	Erosion control	4.88	4
	Water management	3.66	3

Retention and extraction of information | hypothesis 1

Scores were consistently high for retention and extraction of information across both storytellers (median score ≥ 80, Figure 18), indicating that participants substantially enjoyed reading the stories. For both storytelling methods, most participants reported that they could relate to the restoration story (median score >80, n = 81, Figure 18(a)), thought that both stories were trustworthy (median score >80, n = 72, Figure 18(c)), thought the story contained interesting facts (median score >80, n = 82, Figure 18(d)), learned something new (median score = 80, n = 81, Figure 18(e)), and liked reading the story (median score ≥80, n = 81, Figure 18(f)). One participant scored consistently low (<20) across all questions as shown by the outlier in Figure 18(a), (c), (d), (e) and (f). We were unable to detect any statistical differences between storytelling methods for the cognitive process of retention and extraction of information.

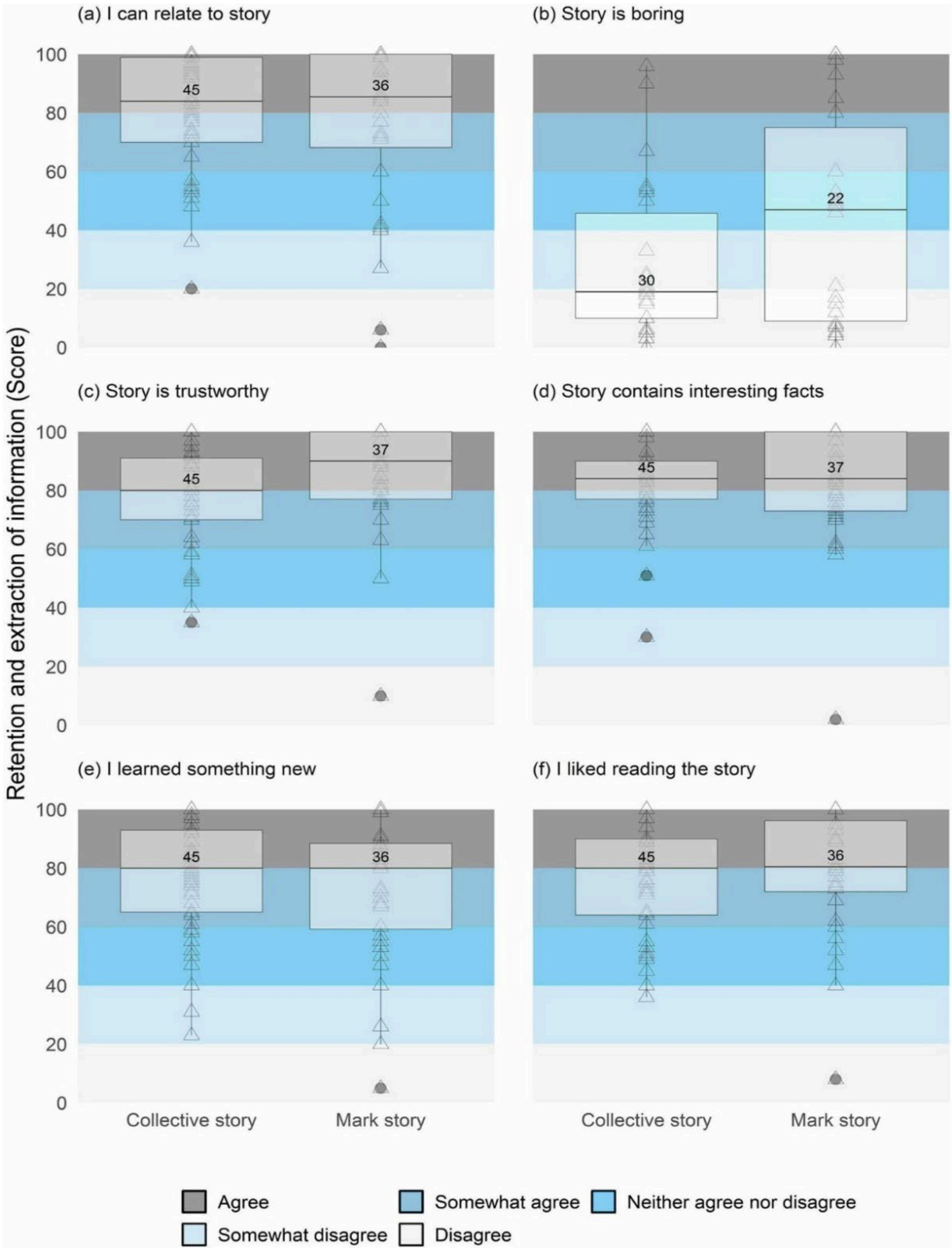


Figure 18: *Cognitive process of 'Retention and Extraction of restoration knowledge' (response distributions) for the stories told by either the Collective or Mark. The line inside the boxes represents the median. The lower and upper hinges correspond to the 25th and 75th percentiles. The upper whisker extends from the hinge to the largest value no further than 1.5 * distance between the first and third quartiles (interquartile range (IQR)). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Dots beyond the end of the whiskers are considered outliers, and triangles show all responses collected from the survey (sliding-scale 0–100).*

When asked to describe the stories using three words, participants used similar vocabulary for each story, using the same four most frequently mentioned words for both stories (i.e. inspirational was mentioned 31 times out of 243 words for both storytelling methods, informative was mentioned 16 times, community was mentioned 15 times and interesting was mentioned 12 times). To understand overall perceptions participants had of the stories, we categorised any words that contained emotional descriptions into positive and negative categories. Of the 243 words used to describe both stories, we could attribute 86 words to an emotion (Figure 19). Of those 86 words, 62 were attributed to positive emotions (e.g. visionary, motivating, insightful, fantastic) and 23 words to negative emotions (e.g. exaggerated, frustrating, idealistic, regressive, sad). This finding concurs with participant's responses that they learned something new (Figure 18 (e)), that the story contained interesting facts (Figure 18 (d)), and that they liked reading the story (Figure 18 (f)).

Motivation to reproduce modelled behaviour | hypothesis 2

All participants agreed that restoration knowledge sharing is important (i.e. median score > 75, n = 82, Figure 20 (c)), were inspired by the stories to restore in the future (i.e. median score ≥ 75, n = 78; Figure 20 (e)), and intended to engage in restoration actions in the future (i.e. median score > 90, n = 80; Figure 20 (f)). Still scoring medium to high, participants somewhat intended to share the story (i.e. median score > 40, n = 77, Figure 20 (d)). They felt that the story had a small impact on their intentions to restore (i.e. median score > 30, n = 44, Figure 20 (a)). We were unable to detect any statistical differences between the two storytelling methods when asked to what degree participants were motivated to reproduce modelled behaviour by the storytellers.

Figure 19: *Word cloud showing all words used (*N *= 121) to describe the Collective's and Mark's stories. The size of the text depicts their frequency, with larger words being mentioned more often. The colour of the text indicates whether it describes a positive emotion (blue,* n *= 62), a negative emotion (black,* n *= 23), or neutral/not applicable emotion (grey,* n *= 46).*

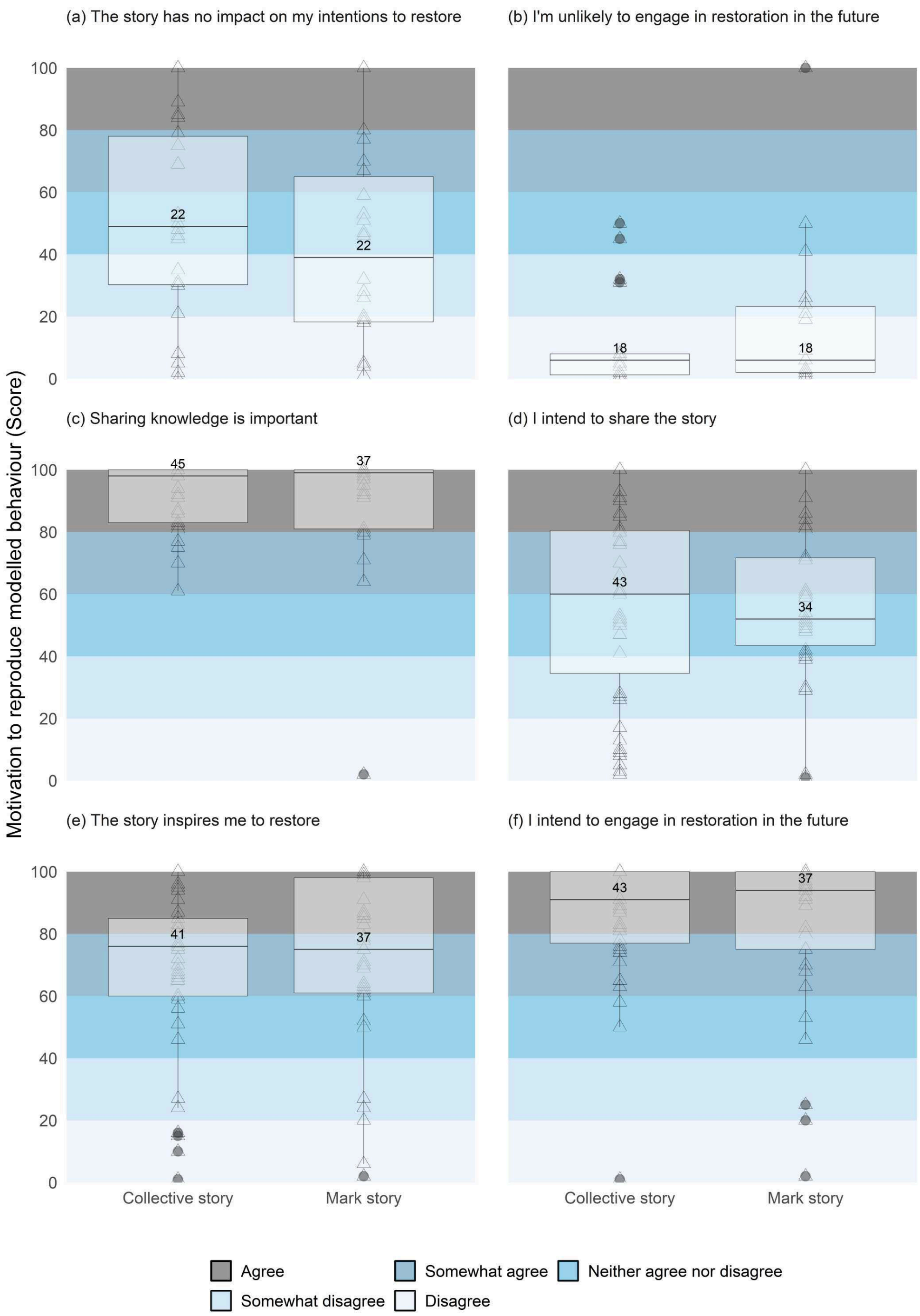


Figure 20: *Cognitive process of 'Motivation to reproduce modelled behaviour' (response distributions) for the stories told by either the Collective or Mark. The line inside the boxes represents the median. The lower and upper hinges correspond to the 25th and 75th percentiles. The upper whisker extends from the hinge to the largest value no further than 1.5 * distance between the first and third quartiles (interquartile range (IQR)). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Dots beyond the end of the whiskers are considered outliers, and triangles show all responses collected from the survey (sliding-scale 0–100).*

Reproduction | hypothesis 3

We tested whether participant's intentions and inspirations to restore their land and share restoration knowledge held true to what they had indicated a month prior. Of the 82 participants who had completed the first survey, almost half (48%, *n* = 39, 19 from the Collective's story and 20 from Mark's story) agreed to be contacted for a follow-up survey one month later.

Intention and inspiration to restore their land

There were no significant differences between the two storytelling methods, meaning that our participant's intention and inspiration to restore over a one-month period were similar between storytellers.

When looking across both storytelling methods and across both intention and inspiration, of the 39 people that filled in the Follow-up Survey, more participants reported that they had engaged in restoration actions (*n* = 27, Figure 21 (a) and (c)), than not engaged in restoration actions (*n* = 12, Figure 21 (b) and (d)) over the one-month period between the two surveys. Even the three participants who read the Collective's story but were not inspired by the story (score <20) engaged in restoration actions one month later Figure 21 (c)).

Of the twelve people who did not restore, the most stated reasons across both storytelling methods were that one month between the questionnaires was too short a timeframe to conduct any actions (six people), that autumn was the wrong season to do any restoration actions (five people), and that they were too busy to restore (two people). Two participants made the clear distinction that while they had been restoring over the last month, they had not implemented any 'new' restoration actions. We were unable to determine whether the participant's restoration behaviour was a result of our stories, or because they were already an actively restoring community, a limitation we will further discuss below.

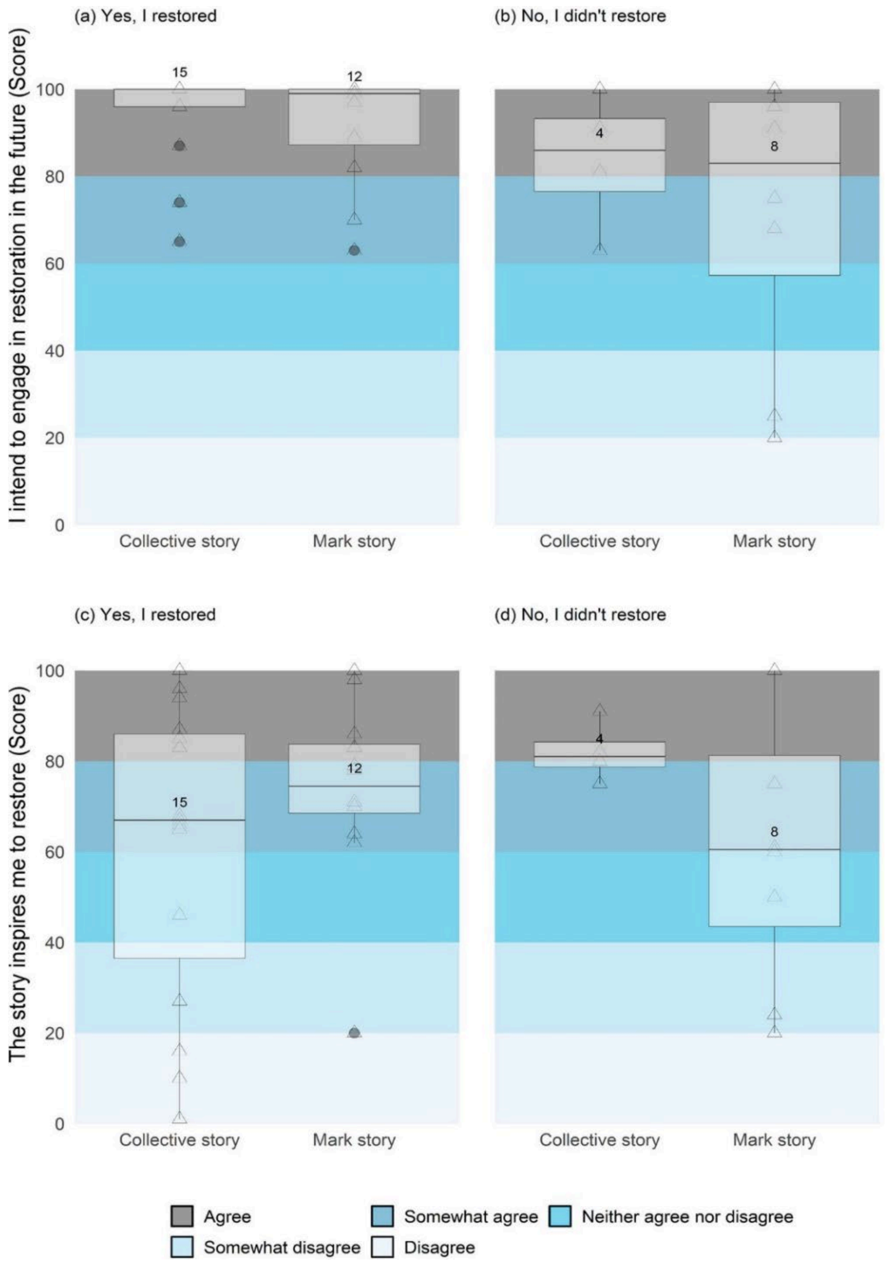


Figure 21: *Participants who intended to engage in restoration or were inspired by the story to restore one month ago (y-axis) either restored over the last month (Yes, I restored) or didn't restore over the last month (No, I didn't restore) compared across the two storytelling methods (x-axis; Collective story and Mark story).The line inside the boxes represents the median. The lower and upper hinges correspond to the 25th and 75th percentiles. The upper whisker extends from the hinge to the largest value no further than 1.5 * distance between the first and third quartiles (interquartile range (IQR)). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Dots beyond the end of the whiskers are considered outliers, and triangles show all responses collected from the survey (sliding-scale 0–100).*

Intention and inspiration to share restoration knowledge and reach out to the influencer

We hypothesised that participants who read Mark's story would be more likely to share restoration knowledge one month later than participants that read the Collective's story. Of the 41 participants who took part in the Follow-up Survey, 33 (80%) reported that they had shared restoration knowledge over the last month, with no significant difference in responses between the two storytelling methods. This finding aligns with the responses we collected for the Intervention Survey where participants had agreed that sharing knowledge is important (score >60, Figure 22 (a)). Only six participants (15%) reported that they had not shared any restoration knowledge over the last month, and even these had reported that sharing is important one month prior (Figure 22 (b)).

Of the 33 participants who had shared restoration knowledge, 17 (52%) reported that they had shared information with their wider (restoration) community, nine (27%) with their catchment group, three (9%) with farmers and four (12%) with 'others' (e.g. business, clients, students). The six people that had not shared any restoration knowledge (Figure 22 (b)) said they did not do so because they were too busy (n = 2), didn't have the opportunity over the last month (n = 2), didn't feel qualified enough to share their knowledge (n = 1), or hadn't associated with relevant people (n = 1).

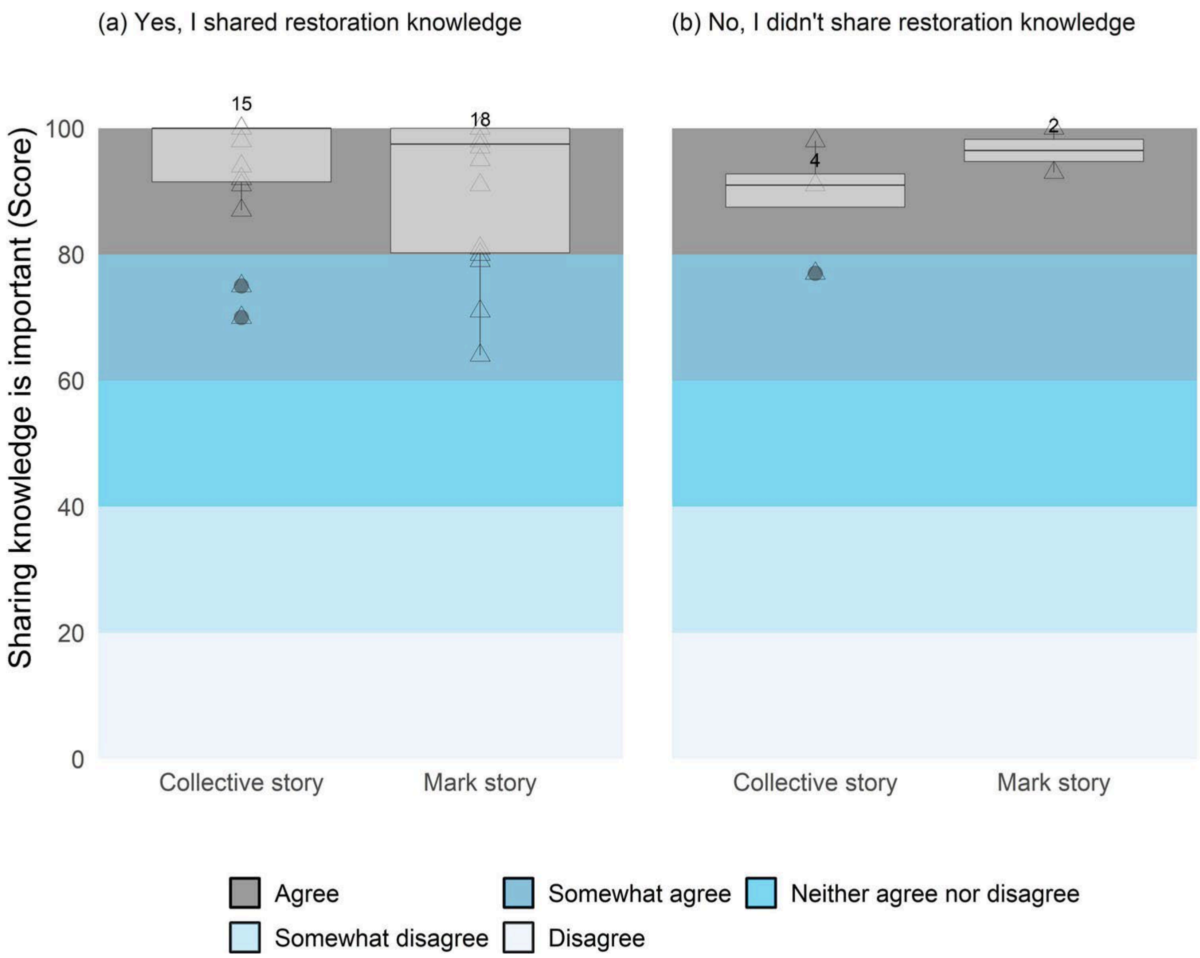


Figure 22: *Participants who intended to share restoration knowledge one month ago (y-axis) shared knowledge over the last month (Yes, I shared knowledge), or didn't share knowledge over the last month (No, I didn't share) for the two storytelling methods (Collective story and Mark story). The line inside the boxes represents the median. The lower and upper hinges correspond to the 25th and 75th percentiles. The upper whisker extends from the hinge to the largest value no further than 1.5 * distance between the first and third quartiles (interquartile range (IQR)). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Dots beyond the end of the whiskers are considered outliers, and triangles show all responses collected from the first survey one month prior (sliding-scale 0–100).*

We hypothesised that participants who read Mark's story would be more likely to share his story compared to participants who read the Collective's story. Analysis showed that storytellers had no significant influence on whether participants shared a story, or not. Of the 41 participants that completed the Follow-up Survey, 30 (73%) reported that they had not shared their specific story over the last month, even though the majority had (somewhat) agreed to do so one month previously (median score > 50, Figure 23 (b)).

Of the eight participants who ended up sharing the story, four (10%) reported that they 'neither agreed nor disagreed' to share the story and four (10%) 'somewhat agreed' to share the story one month prior (Figure 23 (a)). Six (75%) shared their specific story with the wider (restoration) community and two (25%) with their catchment group. Two participants that read Mark's story didn't reply to the intention question in the first survey, however one of those two did share the story. We did not perform a generalised linear model to test for the differences described above, because of the imbalance in the distribution of participants between the storytelling methods (Figure 23).

The four most stated reasons for not sharing the story were that the participant's community was already actively restoring (*n* = 9, 23%), they forgot to share the story (*n* = 6, 15%), they ran out of time between the Intervention Survey and the Follow-up Survey (*n* = 6, %15%), the story didn't contain anything new to share (*n* = 6, 15%), and there was a lack of relatable content (*n* = 5, 13%).

We also hypothesised that participants who had read Mark's story would be more inspired to reach out to Mark, compared to those who read the Collective's story. Our results showed that none of the 41 participants in the Follow-up Survey had contacted Mark or the catchment group over the last month, reasons why they did not reach out are shown in Figure 24.

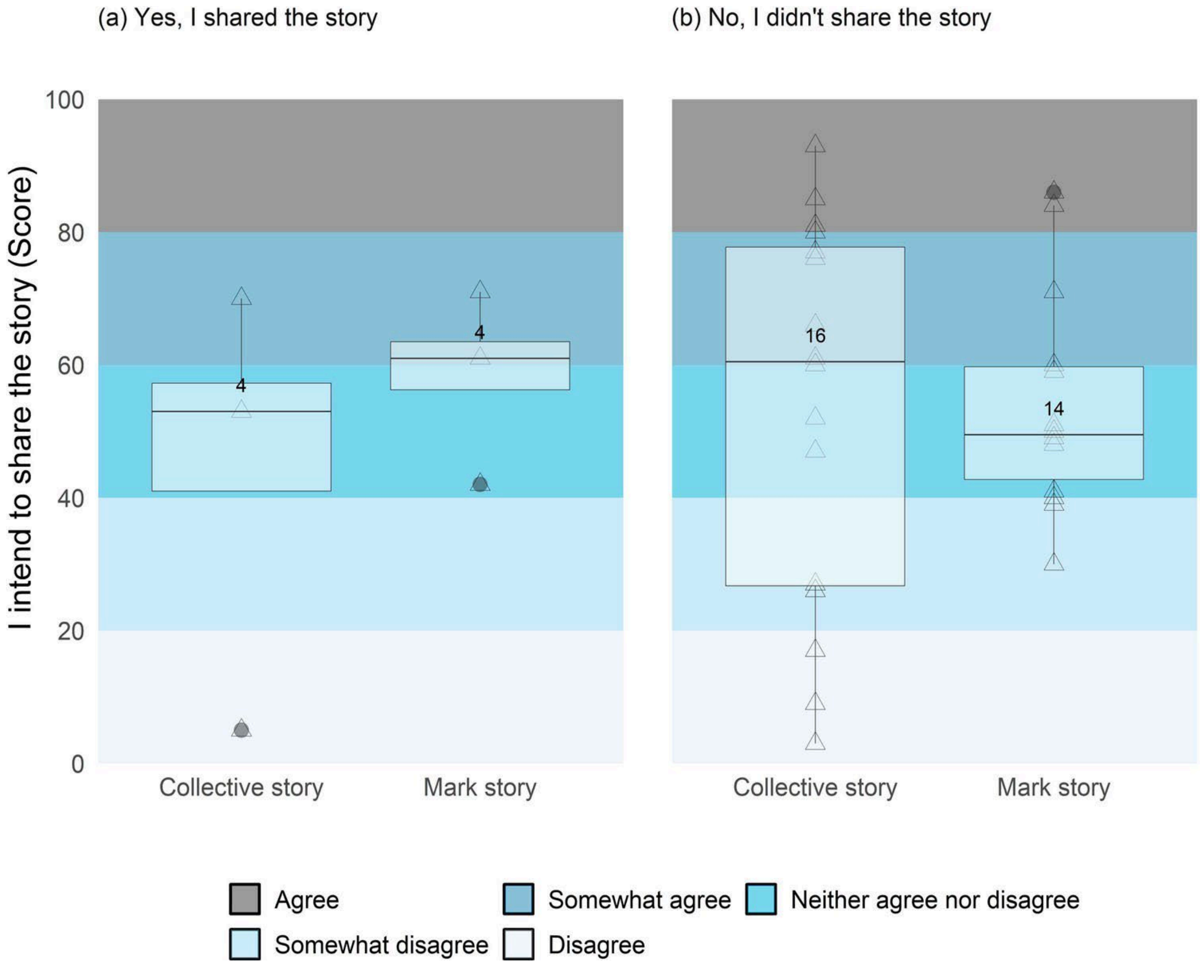


Figure 23: *Participants' intention to share the story one month ago (y-axis) and their behaviour one month later (Yes, I shared the story/ No, I didn't share the story) for the two storytelling methods (Collective story and Mark story). The line inside the boxes represents the median. The lower and upper hinges correspond to the 25th and 75th percentiles. The upper whisker extends from the hinge to the largest value no further than 1.5 * distance between the first and third quartiles (interquartile range (IQR)). The lower whisker extends from the hinge to the smallest value at most 1.5 * IQR of the hinge. Dots beyond the end of the whiskers are considered outliers, and triangles show all responses collected from the first survey one month prior (sliding-scale 0–100).*

No specific questions | already have sufficient catchment group & restoration knowledge	29
Doesn't relate to me because of different land use | different catchment group | catchment size | different location/region/area	11
Too busy | I am at full capacity	10
Am planning to reach out | would like to know more	3
I am not involved in restoration	3
Mark/the catchment group are too busy, I don't want to bother them	1

Figure 24: *Six key reasons why participants did not contact their storytellers over a month-long period.*

Recall | hypothesis 4

Our stories described three 'Challenges' and three 'Lessons Learnt' that the Rangitīkei Rivers Catchment Collective had experienced as part of their restoration journey. To test for recall ability of these six details we hypothesised that participants who read Mark's story would have better recall than participants who read the Collective's story. In our survey, participants were given five possible answers, of which they were asked to select the three that were mentioned in each part of the story. The 'correct' way to answer the five questions was by selecting the three correct details, and not selecting the two incorrect answers (i.e. 'five right answers').

Recall was not influenced by the storytellers, and there were no differences between the storytelling methods on the number of right answers that the participants provided one month after they read the stories. There were only two participants who scored five by answering all questions correctly; both participants read the Collective's story. Most participants across both storytelling methods and both questions scored three out of five correct answers, remembering at least one correct detail. More participants selected four correct details for the 'Challenges' (44% for the Collective's story and 35% for Mark's story) than for the 'Lessons Learnt' (10% for Mark's story, and none for the Collective's story).

Effect of demographics on retention and extraction of information and reproduction of modelled behaviour

While we did not find any significant differences between storytellers for any of the cognitive processes, we wanted to explore whether certain demographics (i.e. region, land use type, age, time in catchment group and duration of active restoring) may influence how readers extract information and may become motivated to reproduce modelled behaviour. We only tested the regions that had the highest response rate (>10%; Auckland, Canterbury, Otago, Tasman (Table 6), to avoid bias towards under-represented regions. We hypothesised that sheep and beef farmers may relate better to Mark's story, because Mark himself is a sheep and beef farmer, however, we found no meaningful and statistically significant differences for any of the demographic categories, or for the cognitive processes tested.

6.5 Discussion

Our research aimed to explore how freshwater restoration storytellers influence the sharing of restoration knowledge and motivate pro-environmental behaviour in rural communities in Aotearoa New Zealand. We hypothesised that there would be significant differences in cognitive processes in our participants depending on whether they read a story told by a collective voice or an individual member from a catchment group, but we found no quantitatively significant differences between the storytelling methods. Nonetheless, interpretation of the combined dataset gave us two valuable insights into cognitive and behavioural principles relevant to freshwater restoration storytelling.

Both individual and collective storytellers can be relatable and trustworthy knowledge brokers

Firstly, we found that the role of a single freshwater restoration champion or influencer was not as important for information processing in our audience as we hypothesised. Our participants could relate the same way to both stories, independently of whether their story was told by a collective or an individual. Comments provided by participants showed that Mark, as the individual storyteller, was indeed influential and relatable (e.g. 'give him a medal'; 'inspirational'), so this suggests that the content of the story outweighed the effect of storyteller on our participants cognitive processes. Each story profiled collective restoration action, highlighting the community aspect of freshwater restoration in catchment contexts. Making collective action the focal point of our stories by lifting the collective efforts into the role of protagonist (rather than the actual storyteller), allowed our readers to make contextual connections between themselves and the story content. Because the content of each story was the same, we found no differences in any of the cognitive processing tested.

Our participants also considered the storytellers and the content of the stories as trustworthy, independently of whether the story was told by an individual or a collective. Trust affects the reader's belief in the information and their likelihood of pro-environmental behaviour change (e.g., Blackstock et al., 2010; Rust et al., 2022; Small et al., 2016), an outcome desired in our study. Both of our storyteller voices were active freshwater restorers, suggesting that our audience was building on trust that already existed between them and the storytellers, serving as a foundation for the acceptance of (new) information (Zeng et al., 2022).

Once an audience can identify with a storyteller and content is understood, modelled behaviour (in our case the uptake of sustainable restoration actions and the act of sharing restoration knowledge) is more likely to be adopted (Dahlstrom, 2014; Oatley, 1999; Sundin et al., 2018; Toolan, 1988). Our stories were true and depicted real-life experiences that were achieved and told by a community that lives and works around their river. In our study, participants (many of whom were already active restorers) could relate to different storytellers and found them inspirational independent of whether they are an individual or a collective, as long as they're a trusted voice.

Our findings underscore the importance of trust and relatability as a critical element in freshwater restoration storytellers, especially in the agricultural context. Authenticity and reliability of information sources play a crucial role to the effectiveness of communication efforts, and we suggest communicators and policy makers should be mindful of the credibility of the messenger and the narratives they employ. Including this understanding in freshwater communication initiatives may have significant implications for how, and by whom, restoration stories should be told and shared to maintain freshwater restoration momentum over long periods of time. For future research, we suggest repeating a similar sample design, but testing stories that compare trusted with 'less-trusted' storytellers (e.g. local government) (Small et al., 2016). This will provide valuable insights into how trust of information sources (or the lack thereof) may be a potential hurdle for the diffusion of information. Additionally, we recommend focusing on non-restorers or land managers who are not currently part of a catchment group. This will provide useful insights into the role storytellers may have in motivating pro-environmental behaviour change in a sample more representative of Aotearoa New Zealand's non-restoration population.

Catchment restoration stories provided new knowledge to short and long-term restorers but did not increase recall

Secondly, most participants reported learning something new from the stories and thought they contained interesting details. 'Informative' was the third and second most frequently used word to describe the Collective's and Mark's story, respectively. Even though most participants were already actively restoring for longer than four years, the information shared in our restoration stories still provided new knowledge to an experienced audience. This shows that restoration knowledge sharing is not only relevant for communities that are just starting out on their restoration journey, but also for those, who have been restoring for several years.

Research by Doehring et al. (2022) found that rural stakeholders in Aotearoa New Zealand were willing to share restoration knowledge, and our current study was able to demonstrate this in action. Eighty percent of our participants reported sharing some form of restoration knowledge with others over the one-month period since reading the story (e.g. sustainable land management practices, farm environment planning, nutrient and sediment interventions). Many factors influence whether an audience engages with new information and whether they act on it (Longnecker, 2016), a desired outcome of freshwater restoration. Unfortunately, we did not probe survey participants to clarify why they had shared restoration knowledge, what knowledge they considered 'new', and whether the act of sharing knowledge was specifically influenced by our stories. So, we were unable to link any specific information provided in the story to their statement, a limitation of our study which we suggest future studies could focus on.

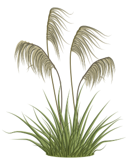
We also quantified our participants' ability to recall information by testing whether they would correctly answer key details mentioned in the 'Lessons Learnt' and 'Challenges' sections of the story. Of the 41 participants, only two were able to recall all correct 'Challenge' details one month later (none remembered the 'Lessons Learnt'), substantially less than we had hypothesised. Recall is commonly triggered through emotions, such as empathy, sympathy, surprise, curiosity and suspense (Keen, 2006), so by including content that may arouse a positive emotional response (i.e. Lessons Learnt) or a negative emotional response (i.e. Challenges), we anticipated more participants would answer correctly. In hindsight, we suggest that the lack of recall may be because both sections were written as factual, bullet-points, rather than as narratives, failing to trigger emotional responses in our audience. Research suggests that negative information more effectively triggers recall than neutral information (Adolphs, 2000; Hamann, 2001). Although low in number, the information correctly recalled in our study were details that were mentioned as part of the ‘Challenges’, potentially indicating that details arousing negative emotions may have been better recalled. While we did not test for any emotional arousal to our stories, more positive words were used to describe the stories than negative words, suggesting that our audiences felt positively inspired after reading our stories. While inspiration may not increase recall of facts, including positive and negative emotions in restoration knowledge exchange plays a critical role in motivating long-term restoration (Doehring et al., 2023).

6.6 Conclusions

The poor health of Aotearoa New Zealand’s rivers, lakes and wetlands severely impacts the wellbeing of Aotearoa New Zealanders. Given the complexity of this problem, exploring innovative tools to transfer evidence more effectively to multiple audiences (e.g. decisionmakers, land managers, catchment communities) is critical. We acknowledge that observational learning in the form of storytelling is not a silver-bullet for addressing freshwater health decline, however, it serves as a valuable addition to the toolbox of methods for transferring knowledge of freshwater restoration. Globally, the principle of collectivism is increasingly recognised in policy, with Aotearoa New Zealand being no different as demonstrated by the ongoing rise of rural communities of action across the country. But for collective action to be meaningful, a shared understanding is required to tackle the ongoing freshwater health crisis. We argue that freshwater restoration storytelling can be a suitable tool to create this shared understanding, enabling knowledge exchange between groups who implement freshwater restoration in situ through trusted voices, regardless of whether it is done through a collective voice or an individual respected storyteller.

Titiro whakamuri,

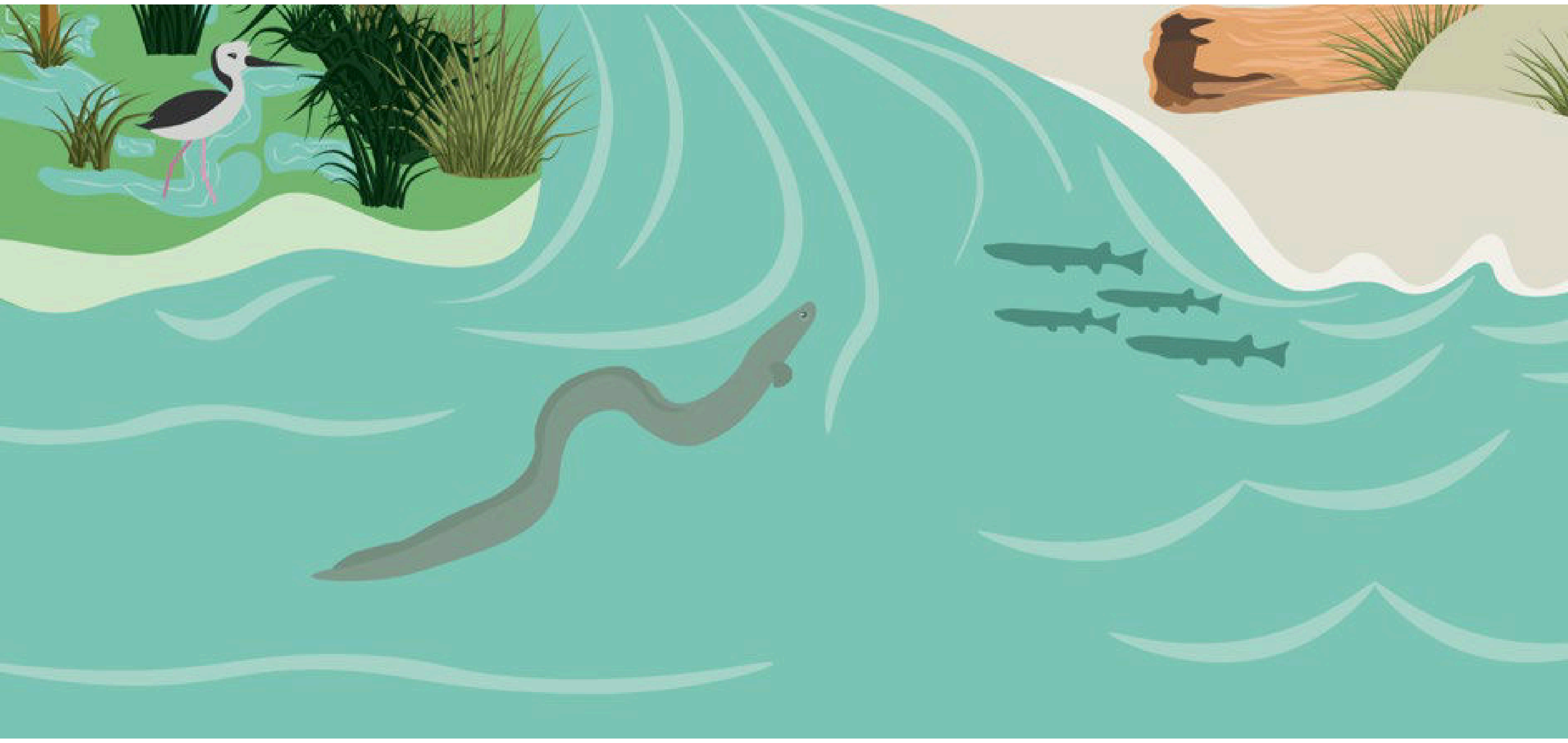
haere whakamua



We look to the past,

As we move forward into the future

SEVEN | Conclusions and implications



ONE
Research Strategy and Motivations

TWO
Introduction, Literature review and Theoretical Frameworks

THREE
Research Paradigm and Methodology

FOUR
A missing piece of the puzzle of on-farm freshwater restoration: what motivates land managers to record and report land management actions?

FIVE
Collective storytelling as a river restoration tool: the role of catchment communities in inspiring environmental change

SIX
Trusted storytellers as freshwater restoration knowledge brokers: individual and collective voices can both be effective

SEVEN
Conclusions and Implications

7.1 Solving the freshwater restoration puzzle through collective kowledge sharing
7.2 Investing in the future: lasting catchment restoration through intergenerational stewardship
7.3 "*And this is why restoration works, because it is farmers educating farmers*" – Trusted knowledge brokers are critical for restoration knowledge exchange
7.4 Challenges and Limitations
7.5 Implications

Globally, the restoration of freshwater ecosystems has become a large and growing challenge, mitigating against damaging human activities. Encouraging freshwater restoration, while delivering value to society, requires strategies and tools tailored to engage a diverse network of people dedicated to enhancing freshwater ecosystem health, including researchers, policy makers, and practitioners, such as rural catchment communities. Together, these networks hold a wealth of knowledge about how to restore freshwater ecosystems which, if shared meaningfully, will avoid mistakes being repeated allowing for effective and sustained freshwater ecosystem health improvements.

For meaningful communication of freshwater restoration knowledge within and beyond catchment communities, transformative approaches to science communication are needed, with accessibility at the heart. My study investigated collective storytelling as a knowledge sharing tool, responding to the pressing need for open and clear communication channels across restoration networks to act on and reverse the ongoing global health decline of rivers, lakes, wetlands and aquifers.

My work addressed four key knowledge gaps identified through review of the literature on freshwater restoration science communication in Aotearoa New Zealand (Figure 25), which I address in detail below. I highlight my research findings and place them within the context of Aotearoa New Zealand, envisaging that the insights gained may be applicable for freshwater management and serve as a foundation for policy development.

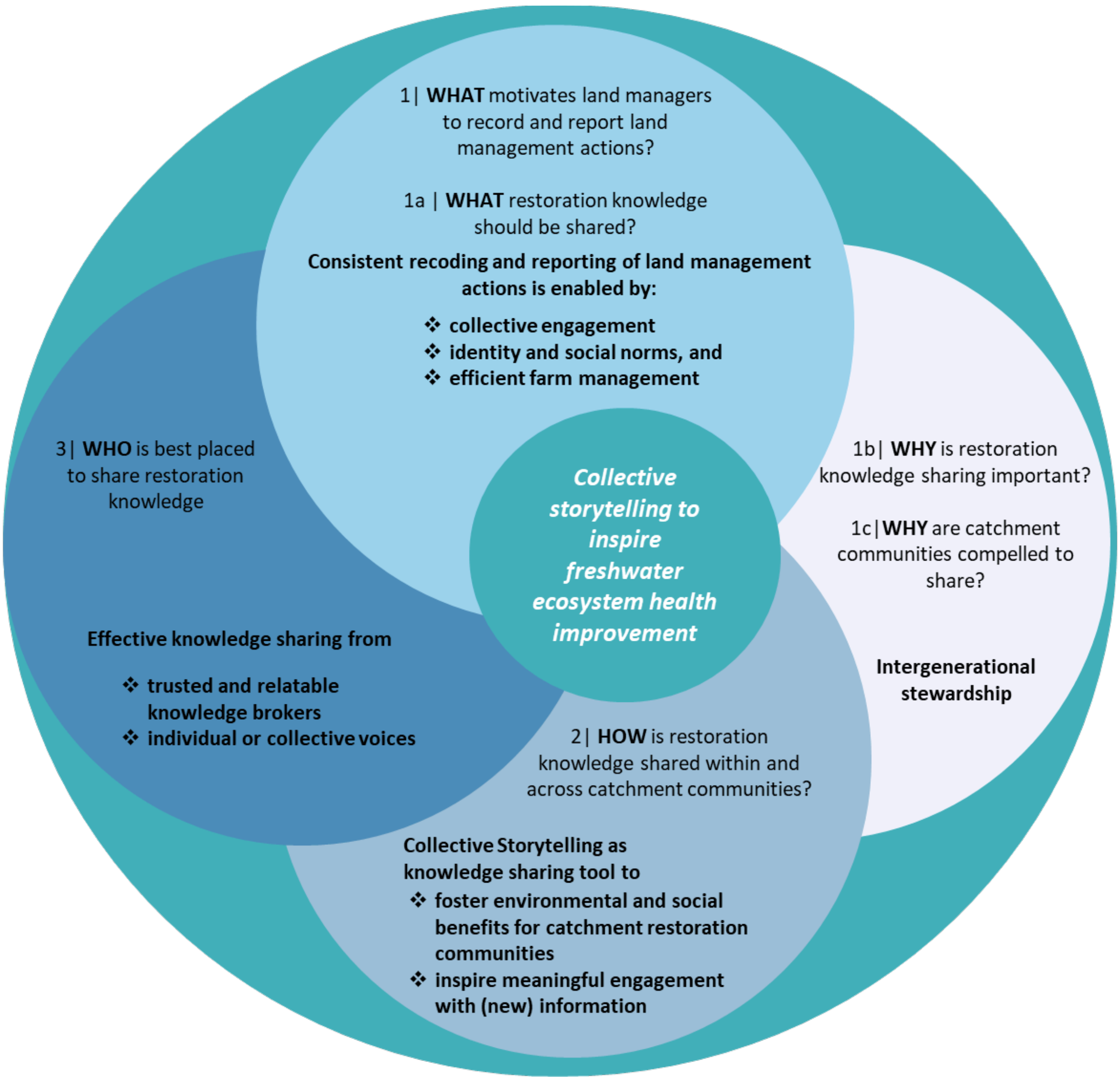


Figure 25: *Summary of research findings answering the questions of WHAT restoration knowledge should be shared and WHY sharing is considered important for rural catchment communities, HOW restoration knowledge may be shared through collective storytelling, and WHO is best placed in a community to share restoration knowledge.*

7.1 Solving the freshwater restoration puzzle through collective knowledge sharing

The state and trends in water quality of Aotearoa New Zealand's freshwaters are well understood with data being collected at over 1500 river and lake monitoring sites across the country, at some sites for up to 20 years (Land Air Water Aotearoa, 2022). However, just measuring water quality outcomes (e.g., reduction in nitrogen concentrations) without simultaneously quantifying actions (e.g., 98% of stock excluded from riverbanks) leads to an inability to evaluate accurately which actions are most effective and why (Doehring et al., 2020). The systematic recording and reporting of what type of land management actions (or restoration actions) have been done, where, and to what extent is a missing piece of a large freshwater restoration puzzle. To find this puzzle piece, my research provided insights into the social-ecological aspects of freshwater restoration knowledge sharing. I explored whether rural restoration communities were willing to record and report their sustainable land management actions. And if so, I explored what social constructs are relevant for the meaningful sharing of restoration knowledge, what restoration knowledge could be shared, how, and who may be a suitable messenger to best share the knowledge.

Emerging from my research are two key outcomes that stem from collective storytelling; 1) it fosters environmental and social benefits for catchment restoration communities, and 2) it enables meaningful engagement with (new) restoration information. I discuss these two aspects in detail below.

Collective storytelling fosters environmental and social benefits for catchment restoration communities

Collective engagement, or collectivism, was a recurring theme for motivating and sustaining freshwater restoration expressed by participants in my work. This recurring theme emphasised how important it is for rural communities to actively learn and work together through interaction and mutual exchange of ideas and knowledge. My findings specifically emphasise the importance of collectivism in restoration knowledge sharing, a concept I termed 'collective storytelling' throughout my work. For example, Chapter FOUR revealed that collective engagement (here communities working together with, or as part of catchment care groups) was a powerful motivator for land managers to record and report their land management actions that help improve water quality. Recording restoration knowledge amongst catchment communities enabled them to gather consistent and trustworthy information by those who implement restoration actions. This, in-turn, allowed the information to then be meaningfully shared with other catchment restoration communities across Aotearoa New Zealand, in the form of Catchment Journeys.

Collective knowledge sharing (as a form of collective engagement) through Catchment Journeys was a key building block for inspiring pro-environmental behaviour, as described in Chapter FIVE. Catchment Journeys were told by local people about their land management actions and were intended to be shared with others who may use their knowledge and experiences. This made Catchment Journeys true to the teller and the listener, which my participants reported feeling strongly about. My results align with Sandercock (2003) who showed that collective crafting of community stories allowed diverse players to find common threads that bind them to a shared vision which encourages different opinions to be voiced. This ‘plurivocal’ vision allowed catchment communities in my study to articulate a ‘collective identity’. This collective identity helped them experience a feeling of ‘community cohesion’ (i.e., the success of ecosystem restoration was highly dependent on the functioning of their catchment community) that transcended spatial and temporal limits, strengthening, and shaping their community.

Community cohesion creates a unified, inclusive, and resilient framework that supports diverse voices and narratives (Goldstein et al., 2015), resisting external manipulations and internal conflicts. While not found as part of my research, politics and power relations may play a significant role in the development of collective storytelling. For example, political interests can shape which stories are told and how they are framed. Politicians, governments, and political groups may use collective storytelling to promote their agendas, garner support, or legitimise their actions. This can result in narratives that highlight certain issues while downplaying or ignoring others, influencing public perception and action in line with political goals. Power dynamics within communities or organisations may also influence whose voices are heard and whose stories are prioritised. Those with more power or resources often have greater control over the narrative. This can lead to the marginalisation of less powerful voices and perspectives, affecting the inclusivity and representativeness of the collective story. For example, Blake et al. (2008) found that ‘new arrivals’ in the community faced particular barriers to their voices being heard within existing social structures and decision-making processes in three case study areas across the UK. They concluded that the creation of joint working groups and collectives would give the newcomers a voice in those well-established communities. Here, collective storytelling could be used as a potential mechanism to capture diverse voices in the community, regardless of whether community members are new arrivals, or long-term members. Also, social obligations to act responsibly, set by social norms, was important for many of my participants. Social norms, the unwritten rules that reflect society’s shared beliefs and ideas about how people should behave (Eggertsson, 2001), can influence how an individual engages with information (i.e., whether we receive it, how we process it, and what use we make of it; Longnecker, 2016) and the behaviour toward the adoption of environmental management practices (Anton et al., 2004; Farrow et al., 2017), in my case sustainable land management to improve water quality.

Social norms and identity influenced how participants engaged with the restoration information presented in my study in the form of Catchment Journeys (Chapter FIVE) and StoryMap© stories (Chapter SIX). Participants reported feeling strongly about how they were perceived by their peers, this being an important component of their sense of belonging to their rural farming and restoration community. For example, land managers in my study were conscious of what others in their community thought of their sustainable land management. Depending on where their community was in terms of restoration progress, their advanced sustainable land management was either seen as a 'good' thing or as a negative, getting labelled as 'greenie'. While some land managers felt inspired by the positive feedback of their peers about the restoration actions done on their land, others felt deflated that their work wasn't as recognised by their community as they had hoped, and felt embarrassed by their actions (i.e., "*Caring for the river together without being embarrassed*"; Catchment Group 1, Chapter FIVE).

Social norms may inhibit certain restoration behaviours or the involvement of key players in catchment groups, a phenomenon that could influence what kind of stories are told, how they are told and by whom. In addition to the marginalisation of voices due to power dynamics as discussed above, certain voices from non-engaged community members may be excluded from collective restoration stories because a community member may not play an active role in the catchment group or is not engaged due to negative experiences in the past (e.g., getting labelled as 'greenie'). When certain community members do not actively engage with catchment groups, their perspectives may be left out of collective restoration narratives. This exclusion can result in a narrow representation of the community's experience and contributions to restoration efforts. As a result, the stories told about restoration initiatives may lack diversity and fail to capture the full range of experiences and insights from all members of the community. The dominant narratives may reflect the views of those who are more vocal or who hold more power within the group, while the experiences and opinions of those who are less engaged or marginalized are overlooked. This can create a skewed understanding of the restoration efforts and the community's involvement, potentially reinforcing existing power imbalances and social divides.

In summary, social norms and past negative experiences can inhibit certain restoration behaviours and exclude key voices from collective storytelling. This dynamic not only affects who participates in catchment groups but also shapes the content and scope of the stories told, potentially limiting the richness and inclusivity of the narratives surrounding community-based restoration efforts.

Participants in my research alluded to the risk of marginalisation, but emphasised the importance of creating spaces and opportunities that allowed all voices to be heard. By collectively sharing restoration knowledge, a collective identity is established which helps define social norms within restoration communities that embrace new knowledge and new land management practices, mitigating negative feedback and marginalisation.

In addition, collective storytelling can also help better identify and understand specific issues within their own catchment (e.g., water quality is poor because of too many nutrients), and what actions can be done, where and to what extent to lessen the impact (e.g., we can keep stock out of the river to reduce nutrients, but it needs to be across the entire catchment, not just on a few individual farms).

The strength of collective storytelling lies not only in the sharing of knowledge, but also in the co-creation of it. Collective knowledge creation empowers communities and stakeholders by recognising and valuing their knowledge, skills, and contributions to restoration efforts. Here, knowledge is created within the context of its use (Greenhalgh et al., 2016; Rycroft-Malone et al., 2016), based on a collaboration of those who are likely to use it. For freshwater ecosystem restoration to be successful over generations to come, I argue that catchment communities need to be empowered to co-create and disseminate the collective knowledge held by their people. A science communication mechanism such as storytelling is a fitting tool, as it makes use of the diverse expertise and experiences that exist across Aotearoa New Zealand's catchment communities.

Catchment stories inspire freshwater restoration through meaningful engagement with (new) knowledge

My findings add to the wider literature on collective catchment management and the recognised role that catchment collectives play in achieving large scale freshwater restoration (Biological Heritage NSC, 2019; Ministry for Primary Industries, 2021; Peters, 2019; Sinner et al., 2022). I was eager to further explore the potential for triggering pro-environmental behaviour through tailored, and accessible, freshwater restoration communication. To do this, I focussed on the elements that would need to be included in a catchment story to encourage others to follow suit. I discuss the most prevalent of these elements below.

The role of emotions in engaging with information

In my research, collective storytelling provided a meaningful framework for enabling community cohesion through collective action. It also encouraged restoration communities to create and engage with new knowledge, a desired outcome of science communication. Here, the role of emotions, both positive and negative, was a recurring theme that influenced how participants engaged with (new) restoration knowledge. Recent developments in environmental science communication research have focused on the significance of emotions in influencing pro-environmental behaviour (Kaufmann et al., 2023). Studies have found that content which evokes high emotional arousal can ignite engagement and potentially increase understanding (Berger, 2011; Carrus et al., 2008; Speckemeier & Tsivrikos, 2021; Wang et al., 2021).

Throughout my research, positive and negative emotional engagement with restoration knowledge was prevalent in my participants (i.e., affect as an internal factor; Longnecker, 2016). For example, rural community members noted that if Catchment Journeys were to elicit positive emotions (e.g., gratitude for financial support to restore, hope for future generations to be able to enjoy rivers, and pride of restoration already achieved), ongoing momentum to restore may be triggered (Chapter FIVE). My results also showed that the process of sharing knowledge itself was considered a ‘positive thing’ by participants. By providing an opportunity to act in a positive way (e.g., proof of restoration progress through return of a rare fish species or successfully sharing sustainable land management knowledge with neighbours) my participants were able to gain a sense of accomplishment and efficacy (Hines et al., 1987), making a meaningful contribution to positive change. If this change in behaviour can be sustained over long periods of time, complex and long-term issues such as freshwater restoration can be addressed.

In addition to provoking positive emotions, my participants also raised the point that for knowledge sharing to create empathy and to be trustworthy, restoration stories need to include threats and challenges (e.g., flood damage caused to new fencing, large-scale die-off of newly planted riparian vegetation due to drought). By providing a safe space for participants to discuss threats and challenges, true and honest knowledge can be shared. Honesty creates trust between the storyteller and the audience, another key construct of effective restoration knowledge sharing which I will discuss further below.

Being able to influence wider communities to change their behaviour toward improved land management should be the goal of successful restoration science communication. This is ‘*because almost every river - it's about human change’* (Catchment Group 3; Chapter FIVE). My research showed that sharing restoration knowledge that includes successes and failures was perceived to create trust and stimulate ongoing momentum to enable long-term freshwater restoration.

However, to what extent ‘human change’ should be encouraged and ‘how much restoration is enough?’ needs careful consideration. While it is important to highlight the positive impacts individual and collective restoration can achieve, pro-environmental behaviour can be highly subjective and occur across a spectrum from ‘substantial land-use changes to reduce my farms environmental footprints’ to ‘harming the environment as little as possible’. The latter may particularly foster a mindset of minimising harm, rather than actively pursuing improvements leading to behaviours where people aim only to do the least amount of damage rather than striving for innovative, proactive solutions that could lead to significant environmental improvements. For example, a farmer might adopt practices like reducing pesticide use and managing soil erosion to ‘minimise harm’ to the environment. While these actions are beneficial, if the approach is limited to merely reducing harm, the farmer might not explore or invest in more innovative practices such as regenerative agriculture or agroecology. These advanced practices go beyond just minimising damage but can actively enhance soil health, increase biodiversity, and improve ecosystem resilience (Khangura et al., 2023; Lambert et al., 2023). By focusing only on reducing negative impacts, there’s a risk of missing out on opportunities for more transformative changes, such as implementing cover cropping, rotating crops, and integrating livestock into farming systems in ways that can significantly improve environmental outcomes and sustainability in agriculture.

Another potential drawback of ‘harming the environment as little as possible’ may be the mindset of ‘perceived minimal impact’, whereby farmers might feel that their efforts are insignificant or not worth pursuing if they believe they can only achieve minimal improvements. For example, if the benefits of reducing pesticide use are seen as small compared to the costs or effort involved, farmers might be reluctant to change their established methods. This reluctance can hinder the widespread adoption of practices that, while seemingly minor in individual cases, could collectively lead to significant positive environmental outcomes.

Catchment stories could be a useful tool debunking these constraining mindsets by allowing holistic perspectives to be shared at large scales within and beyond a farming community, addressing systematic issues and driving large-scale restoration actions. Restoration stories can also help raise awareness about diversity in approaches and inclusivity which promotes diverse strategies and actions which recognise that different approaches are needed to contribute to environmental goals (such as wholesale land use change).

However, for ongoing restoration to be triggered, it is not only important to consider what mindsets and social constructs support successful restoration knowledge sharing (i.e., social norm and collective identity), but also what knowledge sharing mechanisms are suitable for catchment communities. Here I found that written restoration stories created by either a catchment group or an individual enabled audiences to share their '*complete*' restoration experiences, including successes and failures, encouraging others to also share their knowledge and actively restoring their waterways.

Observational learning as a process to allow environmental progress-making

Collective knowledge sharing through restoration stories encourages and fosters 'observational learning' which can help avoid repetition of past management failures and enable more impactful pro-environmental behaviour (Armitage et al., 2008; Blackmore, 2007). It also contributes to a better understanding of the complexities involved in large-scale freshwater restoration as well as encouraging social learning which is critical for on-the-ground environmental progress-making (McDonnell & Buswell, 2018; O'Meara et al., 2007).

Collective restoration knowledge sharing in my research allowed observational learning to happen through farmers' 'over the fence mentality' (Streletskaya et al., 2020; Weersink & Fulton, 2020). My participants mentioned the 'magnetic pull' of following actions done by 'trendsetters', or 'champions' – others in their community who question existing norms and lead by example. So, while some land managers may have felt deflated about being labelled a 'greenie' at the beginning of their restoration journey, they inadvertently may have acted as a trendsetter, encouraging others in their community to start, or increase, sustainable land management practices to improve water quality. For example, one catchment group in my study had been restoring their waterways through sustainable land management for eight years at the time of my research (i.e., Catchment Group 5; Chapter FIVE). During focus group discussions, participants regularly mentioned how attitudes of their farming peers towards their restoration actions had changed over that timespan, from not being recognised for their work, to winning awards and championing national catchment forums. This particular catchment care group has also been nationally recognised for their storytelling skills and knowledge sharing, encouraging many other rural freshwater restoration communities. In fact, over the previous eight years, the catchment care leads of this group travelled across Aotearoa New Zealand to share their restoration journey with other groups, helping them with anything related to farmer-led, bottom-up freshwater restoration (e.g., funding acquisition, how to successfully engage members, how to form a catchment group, or what challenges are to be expected and how to address them).

Sharing collective knowledge allows catchment groups to learn from each other about their restoration experiences, independently of the time span that a group has been actively restoring (Chapter SIX). I was able to show that restoration knowledge sharing is beneficial to both types of restoration communities, those that are at the beginning of their catchment restoration journey, as well as to those communities that have been restoring their catchments for a decade or more.

As the number of well-established freshwater restoration groups across Aotearoa New Zealand grows, and knowledge and experience within those groups is accrued, the sharing of this accrued knowledge is critically important to enable successful long-term freshwater restoration at large scales. This is especially important as the content of information accrued and shared changes with time. As catchment groups are starting their restoration journey, for example, the information sought from restoration stories may be about aspects related to starting a catchment group or getting the community involved. Whereas groups that are well along on their restoration journey may seek information on how to ensure ongoing funding or getting late-adopters on board. Collective storytelling, as I facilitated in this research project, allowed for this required flexibility, making it a fitting communication tool for rural restoration communities.

In summary, collective storytelling together with the meaningful engagement with information are promising constructs towards finding and filling the missing puzzle piece of effective freshwater restoration.

7.2 Investing in the future: lasting catchment restoration through intergenerational stewardship

Freshwater ecosystem restoration is an ongoing process, and not a short-lived aspiration. Across the globe, the health of freshwater ecosystems has been degraded over many decades. Restoring these systems is complex and will take both substantial time and collective ambition including industry, government and landowners. One reason for this complexity is the lag in time after restoration actions before a response to those actions can be seen. For example, lag times can range from between < 1 year (for faecal bacteria waste management) to over 500 years (for sediment erosion control at a catchment scale) (Meals et al., 2010).

Members of the catchment communities in my studies were aware of the complexities associated with on-land freshwater restoration and realised what is required of them to successfully achieve freshwater health improvements. For example, they understood the lag-effects between actions and water quality outcomes and adjusted their visions for restoring their waterways in the Catchment Journeys accordingly, such as setting their visions to long time spans (i.e., from 100 years to indefinite; (Chapter FIVE)). While this showed that rural communities were strongly motivated to restore, this motivation needs to be sustained for generations to come in order to reach their intergenerational visions. Understanding what may motivate rural communities to keep up their restoration actions is, therefore, critical for the successful restoration of freshwater catchments. This is especially true, as many of the freshwater ecosystem health outcomes may not be visible to the people who do the actions on the ground today and will only be experienced by their future generations.

My research identified a range of motivators for triggering restoration actions and keeping catchment communities committed to reach their visions (Chapters FOUR and FIVE). The most prevalent mentioned motivation for ongoing care for waterways was regularly linked to intergenerational catchment management and the need to restore freshwaters for future generations. Land managers (Chapter FOUR) as well as catchment groups (Chapter FIVE) emphasised the need for land stewardship through actively restoring Aotearoa New Zealand's rivers, lakes and wetlands today, so that their grandchildren could enjoy them in the future, as they have done. Statements such as "*[We need] to improve our rivers for the sake of our grandchildren*" (Catchment Group 2; Chapter FIVE), or "*The river is recognised as having the absolute highest water quality so that future generations can enjoy the river as we have.*" (Catchment Group 5, Chapter FIVE), emphasised a responsibility by land managers to act for future generations.

In addition, understanding *why* catchment communities feel inspired to restore their catchments is another critical component of successful freshwater restoration. In my research, I also examined how this collective passion could be extended more widely through storytelling, and *why* communities might be compelled to share their restoration stories. Stories have always had a particular power to transect time, and to connect people with past and future generations. Multi-generational visions are likely to encourage ongoing freshwater restoration to fulfil those goals. This encouragement was shown in my study by participants leaving the focus group discussions with apparent positivity and motivation 'to get out there and restore'. They said they felt even more inspired and motivated to keep going if they restored their catchments, and shared their achievements, as a collective, the second key principle and motivator for ongoing freshwater restoration in my study.

Collective storytelling appeared to be a suitable tool to portray the importance of intergenerational restoration. Catchment Journeys (Chapter FIVE) or restoration stories (Chapter SIX) allowed this future-focussed knowledge sharing to be applied beyond individual catchment groups, but across all of Aotearoa New Zealand, triggering ongoing restoration momentum through sharing intergenerational visions for healthy freshwater systems. The Catchment Journeys created by the focus groups in my research emphasised the importance of stewardship for future generations and focus group participants were keen to share their visions with other groups, hoping that they might inspire others to adjust their visions to a more intergenerational outlook, if needed.

The concept of sharing and understanding knowledge systems across places and generations in the form of storytelling is well recognised in te ao Māori as mātauranga (Mead, 2003). Storytelling is an important part of Māori culture, where history, art, mythology and local knowledge come together and tikanga (traditional practices), te reo (the language) and history are shared and passed down through generations through kōrero (conversations, discussion). The narratives recounting the beginnings of the universe and Māori people serve as reservoirs of knowledge and wisdom, shaping Māori perspectives on the environment and influencing their conceptualisations and connections (Henare, 2001; Marsden, 1988). By recognising the shared aim of communicating knowledge through storytelling in te āo Māori and the worldviews held by rural communities of Aotearoa New Zealand, the importance of intergenerational freshwater stewardship becomes apparent. Acknowledging this mutual objective and weaving together those two worldviews may allow for the successful restoration of rivers, lakes and wetlands of Aotearoa New Zealand.

7.3 "*And this is why restoration works, because it is farmers educating farmers*" – trusted knowledge brokers are critical for restoration knowledge exchange

For bottom-up freshwater ecosystem health restoration to succeed, collective storytelling is required at multiple scales, between multiple players over long periods of time. For this, rural communities need to define a common vocabulary by discussing goals, motivation, and desired outcomes, encouraging open dialogue for knowledge sharing (Mamykina et al., 2002). I was able to show that collective peer-to-peer knowledge exchange could give rural communities a 'voice' to share their extensive knowledge on sustainable land management by employing an existing common vocabulary and authentic narratives used by respected storytellers.

Just like Catchment Group 5 (Chapter FIVE), many other freshwater restoration groups in Aotearoa New Zealand have been restoring their catchments for a long time and have a wealth of knowledge about actions that have and haven't worked. My research demonstrated that sharing this knowledge may be amplified and become meaningful when an audience can relate to and trust the storyteller (CHAPTER SIX). In my study, 'catchment champions' held all traits of relatable and trustworthy storytellers if social similarity existed between the storyteller and their audience. Catchment Journeys (Chapter FIVE) and restoration stories (Chapter SIX) highlighted this social similarity – they were told by locals, about personal experiences, shared in a genuine and caring manner. Participants stated that if knowledge is produced and shared by those communities, they have the 'power' to tell their story. This made the information true to the teller, and the listener, which my participants expressed strong views about. One of my focus group participants summed it up, "*And this is why restoration works, because it is farmers educating farmers*".

My findings align with existing literature which has found that the success of peer-to-peer knowledge exchange is dependent on trust that already existed between the knowledge broker and their audience, serving as a foundation for the acceptance of (new) information (Neef & Neubert, 2011; Rust et al., 2022; Zeng et al., 2022). My results add to this body of knowledge by providing evidence in the context of Aotearoa New Zealand freshwater restoration communities, showing that 'catchment champions' could be both individuals or an entire catchment group, as long as the content of the information shared was authentic (Chapter FIVE), trustworthy and relatable (Chapter SIX).

Encouraging rural communities to speak-up and share their restoration knowledge with their peers is a necessary step in successful catchment planning and restoration. Many environmental scientists are underprepared to effectively communicate with and engage stakeholders and policy makers (von Schneidemesser et al., 2020). Sharing that responsibility with people who live and breathe freshwater catchment restoration is vital, calling for a transformational change in how knowledge is shared. My research supports the role of 'bottom-up knowledge sharing', suggesting a paradigm where information flows organically from the grassroots level. This leverages the expertise of those directly engaged in freshwater catchment restoration, as they possess valuable insights derived from hands-on experiences. By encouraging these individuals to speak up and share their knowledge with peers, a web of communication networks is envisioned to emerge. These networks are anticipated to transcend temporal and spatial boundaries, fostering meaningful connections and collaborations among diverse stakeholders involved in restoration efforts.

Essentially, collective storytelling recognises the agency and expertise of the communities residing in freshwater catchments. These communities, who are intimately connected with the ecosystems they seek to restore, can contribute substantially to the success of catchment planning. The change in knowledge sharing not only promotes inclusivity but also aligns with the broader goal of establishing more sustainable and community-driven environmental management practices. If these practices then also include diverse knowledge systems, such as te ao Māori, freshwater restoration can be transformative. Ultimately, the aim is to create a collaborative and dynamic framework where local knowledge becomes a driving force in the restoration of freshwater catchments, making use of innovative science communication approaches.

7.4 Challenges and limitations

Participant recruitment

A profound challenge working with farmers and the wider rural communities of Aotearoa New Zealand was to recruit participants for my research. Producers, farmers and land managers are busy working throughout the year, and although some seasons may be quieter than others in terms of on-farm work, time is taken up with 'catch-up' tasks such as maintenance and administration. This meant that my research participants were time-limited which was reflected during my recruitment periods when I struggled at times to find participants, especially for Chapter SIX (online survey). While the number of participants were adequate for the quantitative analysis I conducted, higher participant numbers would have meant increased statistical power (i.e., the ability to detect a true effect if it exists) and reduced sampling bias (i.e., a better chance of capturing the diversity within the sampled population accurately, minimising the impact of biased selections). However, because I was interested to study a specific target population (i.e., rural restoration communities), I anticipated larger similarity among individuals. In this case, a smaller sample size can be sufficient to capture the essential characteristics and provide a representative snapshot of the targeted population (Martínez-Mesa et al., 2014).

Despite recruitment challenges, participants were open to collaborate with me, showed genuine interest in my research and volunteered to make time during their busy days to participate in interviews, focus groups and the survey. I am grateful for their generosity.

Bias towards communities that are already engaged in restoration activities

Participants for each research chapter were recruited through either existing relationships and connections, networks of local and national organisations that work with rural communities (i.e., NZ Landcare Trust, New Zealand Ministry for Primary Industries), related research programmes (i.e., the New Zealand National Science Challenge Our Land and Water – Toitū te whenua, Toiora te wai), and certain industry umbrella groups (i.e., NZ Farming, Silver Fern Farms). Because of this recruitment method, my sampling pool was biased towards participants that were self-selected based on who was prepared to take part in the focus groups or complete the survey. Moreover, participants may have been more inclined to be part of my research if they were already an active restorer since the information provided in the ethics information sheet contained background information about my project which covered freshwater ecosystem health restoration.

Nonetheless, the sampling pool of participants in my research stemmed from a specific population that was targeted for the purpose of my study, namely freshwater restoration communities. Because I wanted to explore aspects of restoration knowledge sharing across this target population, my participants needed to be active restorers to be able to share their stories. Based on my results, I believe I was able to present a diverse range of views, representing a continuum of restoration experiences from those starting out to those having restored for over a decade. Future research may specifically target non-restorers which could provide useful insights into the role knowledge creators and knowledge brokers may have in motivating pro-environmental behaviour change in a sample more representative of Aotearoa New Zealand's non-restoring population.

Lack of cultural diversity and alternative knowledge systems

In addition to the recruitment process and the channels used to find participants for my research, my sampling pool was limited in terms of cultural diversity. While Chapter FOUR targeted land managers of diverse cultural backgrounds (including tangata whenua), participant's demographics for Chapter FIVE were limited to Pākeha (non-Māori Aotearoa New Zealanders, usually of European decent). Although I did not ask participants to identify their cultural background in my focus groups (Chapter FIVE), none of the participants specifically identified themselves as tangata whenua or strongly spoke from te ao Māori (a Māori worldview) perspective. I also did not probe for cultural background demographics in my survey for Chapter SIX, so am unaware of the cultural diversity of my survey participants. I recognise that my theoretical framework and methodologies used for Chapters FIVE and SIX reflect characteristics of what I understand to be western culture views of collective storytelling. By adopting these frameworks, my findings are unlikely to represent methods that may suit a diversity of world views and backgrounds (e.g., te ao Māori) which is a limitation to my study.

However, I did not specifically recruit Māori participants for my research as this aspect was focus of a parallel study led by Māori researchers (see Ruha et al., 2021). To allow for Māori participation in my studies, I sought and obtained Ngāi Tahu research approval prior to conducting my studies. The Committee supported my research and saw the value in my studies to iwi/hapū/whānau (Appendix L). Nonetheless, future research into pro-environmental behaviour in Aotearoa New Zealand should include diverse demographics and cultural backgrounds of research participants to represent the diversity of cultures that live in a catchment.

Indigenous knowledge systems and approaches provide a significant resource for improving and maintaining the wellbeing of the planet (Harmsworth, 2013). Harcourt et al. (2022) state: "*If we are to achieve our vision for Aotearoa New Zealand to improve the health of te taiao (the environment) and of people, we need to change the way that people interact with their environment from a position of extractive resource use, to one of reciprocal exchange*" (p. 392). Māori rights and interests in natural resource management are being increasingly acknowledged by non-Māori people and the Aotearoa New Zealand government (Taylor et al., 2020) and the validity of mātauranga Māori in decision-making processes is recognised (Fisher & Parsons, 2020; Hikuroa, 2017). Along with this, the concept of 'reciprocal exchange' is gaining momentum across Aotearoa New Zealand as shown by national-scale research projects such as the 'Revitalise Te Taiao' programme (National Science Challenge Our Land and Water; https://ourlandandwater.nz/project/revitalise-te-taiao/). This programme is a national collaboration of 25 team members from 25 different organisations, acknowledging the value of multiple knowledge systems including mātauranga Māori. The aim is to produce evidence of how specific markets respond to te Taiao (the environment) narratives based on connection to people, place, and indigenous knowledge. It aims to understand the values, beliefs, and practices that underpin collective understanding, motivation, and action to revitalise te Taiao.

Recognising and honouring diverse cultural perspectives and beliefs is crucial in advancing sustainable practices, preserving the environment, and ensuring the wellbeing of both present and future generations.

My research did not encompass alternative knowledge systems such as mātauranga Māori and world views such as te ao Māori. Fostering acceptance of alternative knowledge systems entails working towards the establishment of a collective identity, a key mechanism for sustained freshwater restoration as shown by my research. The premise here is that a shared sense of identity promotes alignment of values and visions for the freshwater ecosystems of Aotearoa New Zealand. This sentiment is succinctly captured by the Māori whakataukī: 'He waka eke noa – We are all in this together – we rise together, fall together, work together, keep going together.' Awatere et al. (2023) emphasise the necessity of partnership-approaches with the potential of Māori thinking to rejuvenate environmental management "*by virtue of adopting a holistic approach to environmental stewardship and having intimate knowledge at place*" (p. 4).

While I did not explore the role of collective restoration storytelling in a te ao Māori context, the principles and outcomes of knowledge sharing through storytelling to preserve and foster ecosystem health share many commonalities between the Pākeha (non-Māori) and Māori knowledge systems. Based on this, my findings may be useful for future studies that employ a collaborative freshwater restoration approach across multiple knowledge systems.

Focus on written storytelling as a medium for communication

My thesis used written story and text interventions to test storytelling as a freshwater restoration tool. There are many other media that can be used to tell a story (e.g. movies or social media such as Instagram, LinkedIn, Facebook and SnapChat). On farm, podcasts can be listened to in the tractor during, for example, harvesting times. It is likely that different audiences will be attracted to different types of story media, depending on their age, tech-savviness, or even cell phone reception on farm. The effectiveness of a written story will also likely vary based on personal preferences – some people prefer to see images compared to written text. While I tried to accommodate this diversity in learning preferences by using StoryMaps©, future research could investigate the effectiveness of using different types of media to reach and persuade different audiences, potentially better reflecting the diversity of audiences present in rural communities.

7.5 Implications

I conclude my thesis by emphasising the practical applications of my research in the context of freshwater restoration in Aotearoa New Zealand. As outlined in Chapter ONE (1.2 Rationale of Research), the overarching goal of my PhD has been to enhance and expedite the dissemination of extensive freshwater science knowledge among diverse knowledge holders. While I believe that my research findings will contribute to achieving this goal by highlighting the importance of knowledge dissemination through collective storytelling, it is equally important to emphasise that my research only contributes understanding towards one of several aspects of pro-environmental behaviour change, such as policy and regulation, innovation and technology, and monitoring and evaluation. It is also important to acknowledge that while collective storytelling can amplify positive messaging and allow for plurivocal visions to be formed and communicated, the risks exist of over-simplifying the complex phenomenon that is freshwater restoration, as well as inadvertently hindering or obstructing discussions that challenge existing conditions or practices. As discussed earlier, science communication can help address these challenges through ensuring critical engagement (e.g., by encouraging diverse perspectives and facilitating open dialogue), focussing on evidence-based messaging (e.g., using accurate data and highlighting success stories), promoting inclusivity and engagement (e.g., through involving stakeholders and tailoring key messages to a range of audiences), promoting systematic thinking (e.g., through encouraging long-term, intergenerational thinking), and leveraging collaborative approaches (e.g., through fostering partnerships between experts and community leaders).

Based on these considerations, two key implications of my research are: 1) restoration communications should be bottom-up, with catchment communities at the heart of knowledge exchange, and 2) collective freshwater restoration stories inspire change and may be valuable in driving widespread and long-lasting improvements.

Restoration communications should be bottom-up, with catchment communities at the heart of knowledge exchange.

Initiatives like national-scale, multi-stakeholder engagement programmes demand substantial resources (i.e., NZ$8 million over two and a half years for the 'Revitalise Te Taiao' programme; National Science Challenge Our Land and Water; https://ourlandandwater.nz/project/revitalise-te-taiao/). It is imperative to ensure that the results of such programmes are not only meaningful but also impactful, benefiting both Aotearoa New Zealand's environment and its society.

Drawing from my research findings, I propose collective knowledge sharing as one tool that fosters reciprocal exchange. By embracing this strategy, we can harness the strengths of multiple knowledge systems to contribute effectively to the shared cause.

Achieving a collective understanding and creating shared visions among those involved in restoring the freshwater ecosystems of Aotearoa New Zealand is more likely possible only if the language and methods employed are comprehensible. In the diverse landscape of Aotearoa New Zealand, where various forms and systems of knowledge coexist, it is essential to recognise that a pragmatic approach involves having knowledge producers also serve as messengers, whether the knowledge pertains to mātauranga Māori, farmer-generated insights, or collective restoration knowledge.

Moreover, restoration knowledge is not created in isolation but through active engagement and exchange among various stakeholders, including researchers. Even when scientists are not physically situated within the catchment, they can complement local knowledge and experiences by providing scientific rigour, methodologies, and analytical tools, playing a crucial supporting role. Through co-creation and collaboration with the scientific community, rural communities can harness their respective strengths and resources to address complex challenges, such as freshwater restoration, and the associated social benefits. Scientific advancements can assist rural communities in their endeavour to restore freshwater health as demonstrated by the National Science Challenge Our Land and Water over the past decade (National Science Challenge Our Land and Water - Toitū te Whenua Toiora te Wai, 2023a). Many of the scientific tools developed by this programme were co-created with farming communities, with their adoption championed across Aotearoa New Zealand. One such tool is the National Register of Land Management Actions (National Science Challenge Our Land and Water - Toitū te Whenua Toiora te Wai, 2023b), where collective storytelling has been integrated based on my research as a mechanism to record and disseminate restoration knowledge from the bottom-up, using a scientifically developed platform. Allowing diverse knowledge holders, including the scientific community, to share their experiences in an understandable and relatable way fosters mutual learning and trust, leading to more inclusive and effective freshwater restoration efforts, ultimately resulting in more resilient and equitable outcomes.

The degradation of Aotearoa New Zealand's freshwater ecosystems and their management has been at the top of the mind for many Kiwis for a long time. Yet despite policy changes and ongoing restoration efforts of the communities surrounding the country's freshwaters, improvements in ecosystem health are slow. Local and national governments are acknowledging the value of bottom-up knowledge sharing and are seeking new ways to communicate with rural communities. For example, the New Zealand Ministry for the Environment has asked for communication experts and rural extension providers to produce a portfolio of 'learning resources' for farmers to communicate about necessary changes to land management actions required as part of the National Policy Statement for Freshwater Management (NPS-FM). In their 'Registrations of Interest' document, they specifically emphasised the importance of '*reflecting local and tangata whenua perspectives'* and asked for their involvement in the development of these learning resources. This co-production of knowledge and resources is a recent way to implement freshwater policy in Aotearoa New Zealand and, if done meaningfully, could be a significant step towards accelerating freshwater ecosystem health improvements.

Collective freshwater restoration stories inspire change and may be valuable in driving widespread and long-lasting improvements.

The human brain is conditioned for stories, acknowledging the potential of stories as powerful tools for communicating about complex phenomena, such as freshwater restoration. My participants found the stories produced as part of my research interesting and could relate to the content and the storyteller. They also affirmed being encouraged by them to follow-suit and restore their land after reading the stories. These findings support the importance of bottom-up, collective storytelling as a valuable approach for engaging audiences with (new) information. They also serve as robust foundations for the effective communication of freshwater restoration knowledge. For example, after hearing about this work, the Tasman District Council contacted me to provide advice on how to improve their dialogues with the farming community in their district concerning the management of riparian margins. This work was funded through a service called 'A2E – Access to Experts' a programme set up by the government to help implement its Essential Freshwater reform package by 2025. The programme pays for 'experts' to provide advice to land managers related to the improvement of freshwater ecosystem health (see https://www.access2experts.net.nz/; accessed 27.02.24). In my case, I was asked to provide advice on how to effectively communicate with rural communities to encourage them in sustainable land management practices, such as the creation of riparian margins.

Traditionally, farmed land included the areas around waterways, allowing livestock to enter rivers, lakes and wetlands, causing damage to riverbanks and degrading water quality. More recently, fences have been built to keep out livestock, however, fence lines were positioned close to the waterway to maximise the land area farmed. But studies have shown that creating strips of 'riparian margins' that are not used for farming purposes result in a range of environmental and financial benefits to the farmer. With regards to the latter, for example, riparian planting provides increased bank stability, resulting in reduced land loss during flooding events. This reduces costs for bank re-stabilisation and re-construction. Environmental benefits encompass cooler water temperatures resulting from enhanced shading provided by riparian plantings, as well as the reduction of nutrients and bacterial pollution facilitated by fences preventing livestock access to waterways.

Despite the evidence of these benefits, some farmers are reluctant to 'donate productive farmland' to the river. Tasman District Council was eager to apply collective storytelling as a science communication tool, especially relying on farmer champions in their district to act as role model and messenger for the sharing of their experiences and knowledge with regards to riparian margin land management. While their community engagement has been a combination of in-person meetings and online resources (e.g., Healthy water, healthy communities - Te Mana o te Wai | Tasman District Council; accessed 16.01.2024), they wanted to increase awareness and engagement through effective online communication. Using farmer champions as storytellers was one of the methods they wanted to investigate further, something we are exploring at the time of writing. Examples such at these show the appetite for collective knowledge sharing in rural communities in Aotearoa New Zealand.

In summary, I argue that collective storytelling should be used as a mechanism to inspire change, motivate action, and facilitate knowledge exchange between freshwater catchment communities across Aotearoa New Zealand. If the knowledge exchanged is then also communicated between peers (e.g., from farmer to farmer), I envisage pro-environmental change to happen.

As this thesis concludes, it is my hope that my findings serve as a call to action, inspiring researchers, policymakers, and local communities to join in safeguarding our freshwater ecosystems by ensuring diverse knowledge is communicated and shared. Let us build upon the knowledge gained and embark on collaborative efforts that bridge the gap between science and society, from the bottom up. The future of rivers, lakes and wetland in Aotearoa New Zealand lies not only in understanding the past and present but in actively shaping a common approach that ensures the health and vitality of our freshwater ecosystems for generations to come. The story of restoration is ongoing, and each one of us has a role to play in ensuring a sustainable and resilient future for our water resources.

Kua tipu ngā rākau

Kua pūāwai ngā hua

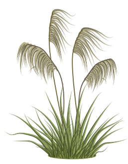
Kua waiata ngā manu

Kua tau te wao

Kua tau, kua tau, kua tau e

Haere mai te āiotanga

Haume e, hui e, tāiki e



The trees have grown

The flowers have bloomed

The birds have sung

The forest has settled

It is settled, it is settled, it is settled

Let the peace be amongst us

Let us all be as one

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Appendices

Appendix A | Interview schedule

Protocol:

- Introduce self as researcher.
- Introduce project
- Confirm participant understands terms to which they earlier consented, particularly:
  - o Purpose and length of interview, o Nature of confidentiality,
    - That interview will be audio recorded and
    - That they can decline to answer any question and may withdraw at any time without negative consequence to themselves.
- Ask if participant has any additional questions before we start.
- Ask questions in semi-structured format, where participant does not need to answer in suggested order. If a participant brings up topic earlier or raises new questions, maintain flow of conversation so that the participant is as relaxed as possible.
- At conclusion, thank participant and check if they have any further questions. Remind them that they'll get a summary/ key quotes of their interview within four months and have the opportunity to clarify or correct anything. Invite participant to get in touch if they have anything that they would like to add.

Questions:

Expert panel

A | Personal background

1. What is your role where you work? What is your main responsibility in your role? Do you manage any land as part of your role? Can you tell me about the land/ organisations you manage?

B | Sustainable land use actions

2. Does your workplace have any processes in place to help improve the environmental impacts on water quality?

3. What do you think are the opportunities associated with SLUA? What are the challenges associated with SLUA? Why?

C | Recording and quantification of SLUA

4. Do you record SLUA? If yes, how? If not, why not?

5. Can you describe the types of monitoring systems that your workplace has in place that tell you about what SLUA you manage? If yes, are you able to measure/quantify the actions? If yes, would you describe how you measure your actions?

D | Information gathering and reporting of SLUA

6. Thinking about how you keep yourself up to date about SLUA, where do you and your company go to seek information? (internet groups, field days, neighbours, forums etc)

7. To what extent do you think that SLUA data should be shared?

8. What are the advantages/issues that you foresee? Why? Do you have any plans in place to mitigate the challenges?

9. Would you be willing to share your workplace's SLUA data and make it publicly available?

10. Which challenges/risks do you associate with sharing your data? Prompt: confidentiality, privacy. At what level would you be willing to share your data? Prompt: Neighbours, catchment, catchment group?

11. Where would you like to see SLUA data stored and shared?

E | National register of sustainable land use actions

12. If there was a national register of SLUA, what would you use a register like this for? To what extent would this be useful? Which questions would you try to answer with it?

13. What would make it easy for you to use?

14. Is there something that you would like to see included on such a register?

15. Are there things you would not want to see on such a register?

16. What do you think would encourage other land managers to share their SLUA data on such a register?

F | Other

17. Is there anything else you would like to add that could help make this register useful? Do you have any other comments that you would like to make?

Individual landowners

A | Personal background

1. Can you tell me about the land that you manage/own/work on?

Prompts *- how long have you managed/owned/worked with this land? History of the land – bought, inherited, Treaty settlement? What was the condition of the land? Describe what changes have been made? What parts of the land have been difficult to manage? Why? What is the underlying strategic driver for this land? Why? How does this influence the decisions that you make? (N.B. Māori land usually has a long-term investment plan for future generations as opposed to making money and then selling)*

B | Sustainable land use actions

2. About the pictures you brought with you today, why did you choose these pictures?
3. What can you tell me about sustainable land use actions on your land?

Prompts *– Is this practice something that your farm has adopted? If yes, why? If no, why not?*

(financial, legislative-driven, neighbouring properties has influenced action? Other?)

4. What opportunities do you see associated with SLUA?
5. What are challenges associated with SLUA? Why? Describe what plans are in place to mitigate the challenges?
6. What information would help you to do something about these challenges?
7. Which actions do you believe are the most important ones on your farm to improve WQ?

C | Recording and quantification of SLUA

8. What types of monitoring systems do you have in place that tell you about the SLUA you have done? How do you record your actions?
9. Are you able to measure/quantify your actions? If yes, can you tell me about how you measure your actions?

D | Information gathering and reporting of SLUA

10. To what extent do you think that SLUA data should be shared? What are the advantages/issues that you foresee? Why?
11. Would you be willing to share your SLUA data and make it publicly available? Which challenges/risks do you associate with sharing your data? *Prompt: confidentiality, privacy.* At what level would you be willing to share your data? *Prompt: Neighbours, catchment, catchment group?*
12. Where would you like to see SLUA data be stored and shared?

E | National register of sustainable land use actions

13. If there was a national register of SLUA, what would you use a register like this for? To what extent would this be useful? Which questions would you try to answer with it?
14. What would make it easy to use for you? Is there something that you would like to see/not see included on such a register?
15. What do you think would encourage other land managers to share their SLUA data on such a register?

F | Other

16. Is there anything else you would like to mention today that could help make this register useful? Do you have any other comments that you would like to make?

Survey instrument/ interview schedules for producers, community and tangata whenua

A |Personal background

1. Can you tell me about the land that you manage/own/work on?

B| Land management actions

2. Did you bring any pictures of your land where you applied management actions to improve WQ? Do you want to tell me about the pictures you brought with you today? Why did you choose these pictures?
   a. What do you understand under sustainable land management?
   b. Do you think your actions are sustainable?
3. Tell me about land management actions on your land which help improve water quality?
4. What do you think are the challenges associated with management actions that help improve water quality? Why are they challenges?
   a. Do you have any plans in place to mitigate the challenges?
   b. What information/ tools would help you to do something about these challenges?
   c. Are there also opportunities/benefits?
5. Which actions do you believe are the most important ones to improve WQ?

C| Recording and quantification of SLUA

6. Do you record land management actions? If no – go to Q9 - If Yes
   a. What kind of management actions to improve WQ do you record?
   b. How do you record your actions? To what detail?
   c. Do you use an app to manage your land?
   d. Can you describe the monitoring systems you have in place that tell you about what management actions you currently do?

7. Do you keep track of your management actions to improve water quality?

   a. Do you do regular 'stocktakes'? If so, how often?

8. With the data you record, are you able to measure/quantify the actions that help improve WQ?

   a. If yes, can you tell me about how you measure your actions?

   b. What indicators/measures do you collect?

D| Information gathering and reporting of management actions

9. Thinking about how you keep yourself up to date about management actions, where do you go to seek information? (Internet groups, field days, neighbours, forums etc)

10. So overall, how much of the data collected about management actions by landowners should be shared by everyone?

    a. What are the challenges/risks that you foresee with sharing management action data? Are there particular ones that you associate with sharing your data?

    b. Do you have any plans in place to mitigate these challenges?

    c. What are the advantages that you foresee with sharing management data? Why?

11. Would you be willing to share your management data and make it publicly available?

    a. How would you like to see your data shared?

    b. Where would you like to see/be comfortable with your data to be stored and shared?

    c. At what level would you be willing to share your data?

    d. How would you like to see your data protected?

E| National register of land management actions to improve WQ

12. If there was a national register of management actions, what would you use a register like this for/ to what extent would this be useful to you?

13. Which questions would such a register help you to answer?

a. Is there something that you would like to see/not see included on such a register?

b. What actions/ indicators should we be recording on the register?

c. How should it be set up to make it easy for you to use?

14. What do you think would encourage other land managers to share their action data on such a register?

a. What would you get out of others sharing their data? Could this information help you with overcoming some of the challenges we talked about earlier?

b. Would you yourself add management action data onto a platform?

F| Other

15. Is there anything else you would like to mention today that could help me make this register useful? Do you have any other comments that you would like to make?

Appendix B | Coding manual for interviews

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
1 Acquiring information	1.1 Accessibility of information	Includes comments on information that is still needed on LMA such as which LMA should be implemented; Providing information to others through teaching/ education/workshops/fora/cultural land management advisors done by government/ comm groups; Communication between scientist to communities; Mention of preferred ways of how/which format information is acquired (ie hard copies, websites, phone calls)	*"[W]e've also created our dedicated roles which are our cultural land management advisor roles called our 'Pou matai ko', and Ngai Tahu individuals employed by the council who work with land users, farmers, on the ground, right down to what can I do on my farm to protect Ngai Tahu mahinga kai values."*	
	1.2 Already learnt	Stakeholders have already learnt (in the past) about LMA from others or through their own actions by doing them over many years or in the past; Reference to change in mindset or change in practices over time.	*"We took a look at the place with a fresh set of eyes and said no we've got to chuck some fences in here - this isn't really good enough - after we'd done a wee bit of testing."*	
	1.3 Willingness to learn	Stakeholders express a current interest/willingness in learning about how to improve land management practices, how to implement actions - in the present	*"I'm learning Te reo and part of that is about being able to set this catchment group up in the right way. So I'm on a bit of a journey there as well in understanding, and right at the beginning really, so I've got a lot of work around that to do."*	
2 Actions		Any reference to any land management actions, i.e., what kind of action has been done, should be done	*"I think over 3000 farms in the region already have a farm environment plan." "We've done sediment traps on our laneway"*	

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
3 Motivations to record/report/ implement Land Management Actions (LMA)	3.1 Co-benefits	Any reference to co-benefits of doing actions; e.g., increased ecosystem health, new/higher biodiversity, better water quality, better animal welfare, no loss of life stock due to fencing	*"I'd quite like to see a bit more biodiversity - in some of the birds in particular."*	
	3.2 Credibility/ Trust	Mention of credibility or trust in relations to data source or data provider; trust to person promoting/proposing LMA	*"[...] it takes such a long time to build the trust with the partners involved. And so that's basically been the whole focus of this job for the last 18 months or two years before we've even said what we're interested in achieving in that catchment."*	
	3.3 Economic	Any comment on funding/income/monetary value including governmental/council funding specific to LMA; funding might incentivise the implication of actions	*"And the other thing they're obviously really focused on is I don't want to do this and lose money cause I can't afford to.* *"You shouldn't be paid for bloody doing the right thing."*	Funding for farm purchase; mortgages; implied reference to money saving (loss of livestock)
	3.4 Emotive	Any reference to positive/negative emotions associated with actions. What feels good. Being proactive towards actions.	*"I always think you need to celebrate people's successes more and really push that, because from a public perspective we just seem to continually get nailed a bit."*	Negative emotions that are related to peer-/societal pressure
	3.5 Engagement	-Community: Any comment on collective work/engagement/ Farmer-led initiatives/ extention services within a catchment/town -Specific reference to positive engagement between farmers or council and how this can change behaviour/ perceptions of rural communities	*"We're taking an approach that basically puts one person on the farm with the landowner talking to them about their issues on their property, and working out solutions that we're putting in."*	self-motivation; engagement within own family/business
	3.6 Legislative	Implementation through legislative pressure/compliance; Includes reference to farm insurance programme	*"We have to record for Otago Regional Council."*	Incentivisation on own accord; funding

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
	3.7 Looking forward	Specific to future generations and how they might benefit from LMA. References to land tenure. Longevity of LMA, rather than just fixing things for today. Reference to actions that need to be implemented	*"We are looking at land's tenure and understanding whether that has a role to play on their view of how they work the land."*	
	3.8 Societal pressure	Peer pressure; Any comment on what others might think about a farmer and his/her actions on land and how this might influence their social license to operate and behaviour; perception of others	*"It's also important that other people driving past think that you care, too."*	legislative/compliance
4 Recording actions & Recording knowledge	4.1 Benefits and Challenges with recording	**Benefits**: Any positive comments related to recording of actions; includes protection of recorded data. **Challenges**: Any concerns related to recording, such as lack of recording; what are the barriers to recording (e.g., time-constraints)	***Benefit:*** *"So the moment you can get that level of agreement when recording the consistency of expectation then is shared more widely, and ultimately it then lands across all of the industry or a whole catchment."* ***Challenge:*** *"Some of us aren't big on recording stuff. And we've done quite a few of the blocks with poplars and everything else but I didn't even record that."*	
	4.2 Recording - Yes/No, how, what, where	Any reference to recording data/knowledge: **Do** you record (Yes/No); **How** is data recorded (e.g., photos, through specific apps, platforms, through third parties (e.g., fertiliser company); **What** actions/knowledge are recorded (i.e., number of trees planted); **Where** (spatial scales of recording, i.e., catchment vs. farm scale)	*"We have got a farm management app called Resolution. You can record everything from health and safety to how many metres of fence you've put in and you can just tag it."* *"The data we collect comes from two sources – economic service and surveying 500-odd farms."*	**Why** data is recorded - if positive it should be coded in 'benefits of recording' if negative it should be coded to 'challenges with recording'
5 Reporting actions & Sharing knowledge	5.1 Benefits and Challenges with sharing	**Benefits:** Any reference to benefits of sharing; stakeholders support sharing (i.e., are happy for their action data to be shared). **Challenges**: Expression of caution to share too detailed information such as profit; includes protection of reported data	**Benefits:** *"You probably will because if we share data other people share it back, and that's a learning. It would be interesting to know when people started fencing off their waterways to see what impact that had."* **Challenges:** *"Any of my personal stuff probably shouldn't be on a government page. I'm more than happy for it to be on a Beef and Lamb page. But a government page, I would be okay with the data there, but probably not have my name associated with it."*	

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
	5.2 Sharing - Yes/No, how, what, where	Any reference to sharing of knowledge/data: **Do** you share/report (Yes/No); **How** is data shared (i.e., through specific apps, platforms); **What** actions/knowledge is shared (i.e., stories, specific actions); **Where** (i.e., spatial scales of sharing such as catchment vs. farm scale)	*"I think [we should share] at a catchment level."* *"Sheep and beef farmers are probably more open to sharing than dairy farmers – just my personal observations. Most of them keep things fairly close to their chests."*	**Why** data is shared - if positive it should be mentioned under 'benefits of sharing' if negative it should be coded to 'challenges with recording'
6 Other		Does not fall into any of the above categories	*"I think the ones that aren't doing anything should get a bloody rocket up them."*	

Appendix C | Information sheet and consent form for participants for interviews

Reference Number: *D20/037- DEC 2019*

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

A NEW ZEALAND REGISTER OF SUSTAINABLE LAND ACTIONS TO IMPROVE WATER QUALITY

INFORMATION SHEET FOR PARTICIPANTS

Thank you for considering participation in this project. Please read this information sheet. If you decide to participate, we thank you. If you decide not to take part, we thank you for considering this request.

What is the Aim of the Project?

The aim of this project is to find out what kind of sustainable land use actions land managers would like to record and report on a national online database or register; the aim is to improve water quality by answering questions about sustainable land use actions. This research will inform the design and content of this register by determining the most effective and meaningful ways of setting up this online tool. The register will be a new 'module' of the Land, Air Water Aotearoa (www.lawa.org.nz) online tool which is New Zealand's largest environmental reporting platform. Your interview will contribute to Kati Doehring's PhD in Science Communication.

What Types of Participants are being sought?

We are looking for land managers/owners over the age of 18 who manage or own land in primary production (e.g., dairy, beef, lamb), horticultural land (e.g., viticulture, market gardens, etc.) and forestry. Participants might already be part of a catchment care group or are individual landowners.

We will not collect any contact details as part of the interview, however, participants willing to participate in follow up interviews can elect to provide an email address. These lists will be stored in a secure server or locked office at the Cawthron Institute in Nelson and destroyed after five years.

What will Participants be asked to do?

Should you agree to take part in this project, this face-to-face interview could take up to one hour. We will ask you a series of questions about the land you manage, sustainable land use actions you use or have considered, whether you record and report any sustainable land use actions and what you would like to see on a national register of sustainable land use action.

Remember that you may withdraw from this interview at any time without any disadvantage to yourself.

What Data or Information will be collected and what use will be made of it?

You are not required to provide any personal details. If you would like to be kept informed on the progress of our project, the outcomes and potential follow-up participation, we would record your name and email address for these purposes only. Interviews will be audio recorded and transcribed. The only people who will have access to this project's recordings and transcripts will be the researchers.

The recordings and transcripts will be securely stored on a password-protected drive at the University of Otago. Data obtained as a result of the research will be retained for **at least 5 years** in secure storage. Any personal information held on the participants such as contact details and email addresses will be destroyed immediately after the publication of the research even though the anonymised data will, in most cases, be kept for much longer and possibly indefinitely. No material that could personally identify you will be used in any reports on this study without your express consent. Results of this research may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity.

On the Consent Form you will be given options regarding your anonymity. It is entirely up to you which of these options you prefer. We will make every attempt to preserve your anonymity. However, with your consent, there are some cases where it would be preferable to attribute contributions made to an individual participant. Within four months of your interview, we will provide a summary and any quotes that might be used in reports or publications, for you to check and approve.

If the line of questioning develops in such a way that you feel hesitant or uncomfortable you may decline to answer any particular question(s).

Follow-up focus groups

If you agree to be involved, a follow-up focus group will be conducted in the form of a semi-structured workshop held in a location convenient to participants. The general line of questioning will focus on the future use of the register and how associated learnings can be shared effectively.

Can Participants change their mind and withdraw from the project?

Yes, you may withdraw from participation in the project at any time and without any disadvantage to yourself. If you have any questions about our project, either now or in the future, please feel free to contact either:

Kati Doehring	or	*Prof Nancy Longnecker*
Centre for Science Communication		Centre for Science Communication
Email: Kati.doehring@cawthron.org.nz		Email: Nancy.longnecker@otago.ac.nz
		Phone: +64 (3) 479 7885

This study has been approved by the Department stated above. However, if you have any concerns about the ethical conduct of the research you may contact the University of Otago Human Ethics Committee through the Human Ethics Committee Administrator (ph +643 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

A NEW ZEALAND REGISTER OF SUSTAINABLE LAND ACTIONS TO IMPROVE WATER QUALITY

CONSENT FORM FOR INTERVIEW PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary;
2. I am free to withdraw from the project at any time without any disadvantage;
3. Personal identifying information such as email addresses will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for at least five years;
4. I understand that this project involves an open-questioning (semi-structured) technique. The general line of questioning will ask me about my relationship to my land, the sustainable land use practices done on my land, how I keep myself informed and my ideas about a national register of sustainable land use actions. If I feel hesitant or uncomfortable, I know that I can decline to answer any particular question(s) or withdraw from the project;
5. I understand that I will get a summary and any quotes that might be used in reports or publications within four months of my interview. This allows me to check and approve/decline the use of my quotes.
6. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I, as the participant: a) agree to being named in the research, OR; ☐

b) would rather remain anonymous. ☐

I agree to take part in this project.

....

(Signature of participant) (Date)

....

(Printed Name)

Appendix D | Focus group schedule

PART 1 – INTRODUCTION TO THE RESEARCH PROJECT AND PARTICIPANTS – 10 mins

- *Meet and greet – everyone introduces themselves*

- *Outline of next 1.5 hours*

    a) Signing of confidentiality agreement
    b) Recording of Focus Group for thematic content analysis

- *Introduction of Register of Actions and previous research*:

- *Purpose of research*: 1) How can we incentivise change towards sustainable land management? 1a) Which role do stories play in incentivising change? 2b) What content do catchment stories have to cover to incentivise change?

- All information is confidential and my research will inform where the boundaries are

PART 2 – THE CREATION OF A CATCHMENT STORY USING A PROVIDED STORY TEMPLATE – 45 mins

A| Listening to a story: I will tell a catchment story based on the 1-page story template. The story includes personal information, past, current and future land management and Strengths, Weaknesses, Opportunities and Threats.

1. When listening to this story, how did you feel? *(prompt: Surprised, confused, curious, anxious, excited, frustrated, bored?)*
2. Why do you think you felt that way?
3. What parts of the story foster your interest to hear more about this catchment? Why?
   What parts don't foster your interest to hear more? Why?
4. Was there anything in particular that surprised you about this catchment group? If yes, what?
5. Is there any detail missing in this story that you would like to hear about that would make it relevant to you and your catchment?
6. What should be part of a good catchment story? Why? What should be left out? Why?
7. What aspects of the story would encourage you to create your own? Why? Why not?

B| Create a story using the template: Give the group symbols and a story template and get them to compose their catchment story. *(Note: Don't tell them that they will share their story).*

8. How did you feel when you came up with your story? Why did you think you felt that way?
9. Did you have any concerns/ were you worried about certain aspects when composing your story? *PROBE: Why did that concern you?*
10. How did your group decide on your story?
11. Was this template useful? Did it make it easier/harder for you to compose your story? What did you like about this template? What didn't you like?
12. What else is needed on this template to make it relevant to your catchment? Why do you think that is relevant?
13. Did your group create any new symbols?
14. Would you be willing to share your story in this format? *PROBE: Why is that?*
15. Would you be OK to share your story? If Yes, why? If No, why not? If YES – please share.

PART 3 – DISCUSSION ABOUT CREATION OF CATCHMENT STORY – 30 mins
Sharing knowledge: Get the group to share their story (5 minutes for each story – 2 stories) 16. How did you feel sharing your story with others? PROBE: Why do you think you felt that way? 17. Who would you be willing to share this story with– at what level? Just within your catchment? Family? Within FG? PROBE: Why? 18. Are there parts of your story that you would be more willing to share than others? Which parts would you rather not share and why? 19. How would a story need to be told to encourage **you** to change towards SLMA and start recording and reporting? 20. How would a story need to be told to encourage **others** to change towards SLMA and start recording and reporting? 21. What aspects of your story do you think are most important to share with other catchments to encourage behaviour change towards SLMA? *Prompt: Personal, action data, etc* 22. How can we use stories as a tool to get 'laggards' on board? 23. How could we improve this template to make you want to share your story with others?
PART 4 – OTHER IMPORTANT POINTS TO DISCUSS AND CLOSE OFF – 5 mins
24. Is there anything else you would like to mention about how stories could be used to get land managers to come back to the register? 25. Would you be happy for me to share your stories outside of your community group?

Appendix E | Coding manual for focus groups

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
1 HOW to tell a catchment story	1.1 Range of audiences	Reference to **how** stories need to be told in a different way for different audiences; Recognising that different audiences need different forms of communication.	"*Yeah, we'd write it very differently, if it's a public or a private audience.*"	
	1.2 Tools and skills used to tell a story	1) Any reference on tools that can be used to tell catchment stories; e.g., photos, drones, books, etc. 2) References to skills of storyteller. Their Pragmatism/ Can-do-attitude; Any actions/ thoughts that relate to the practicability of landowners. Doing sustainable land management actions based on their 'Number-8 wire mentality'; any recording of land management actions that can be done easily (i.e., photographs, drone imagery).	"*A community map where we can all put on our sections of planting and then you can see the gaps.*" "*I'm a really visual person so I like seeing before and after photos.*"	

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
2 Inspire change (the WHY and WHY NOT)	2.1 Because it's an ongoing journey and we could do better	Participants recognise that there is room to improve and that they still learn; catchment restoration is a journey; Any reference to learning and avoiding making same mistakes; acknowledging that 'things take time'	"*Communicate with each other a bit more and to the new people who are wanting to take on the project because everyone makes probably the same mistakes so it would be nice to …*" "*The longest journey starts with the first step, and I think that's what we're on – the longest journey probably.*"	includes template section "we can we do better"
	2.2 Disadvantages to telling stories / obstacles (WHY NOT)	1) Reference to any issues/difficulties with sharing, problem of keeping information up to date; 2) Disadvantages of sharing, confidentiality/ privacy-related comments, second thoughts/ caution to share, contentious topics. 3) Mentioned in specific 'Our Obstacles' Section in template 4) Reference to challenges/ pressures farmer face with day-to-day; e.g., government, legislations, social license, community pressures, time constrains)	*"But [sharing] automatically would mean you'd see who hasn't fenced, and is that a contentious thing?" "Cause some people are concerned that it will be used as a battering ram in terms of oh well you've actually only done that…"* *"Yeah, and maybe for a lot of people it's just too hard – too much. See I haven't been to any of these meetings cause I'm just like 'phew'."*	includes template section "What are our obstacles?" excludes reference to how things take time
	2.3 For community cohesion / catchment-wide communities	1) Any reference to farmers/ catchment groups/ communities creating momentum from the bottom-up. Developing farm plans suitable for their catchment, rather than templates from other catchments. 2) Taking ownership of an issue (e.g., water quality, non-sustainable farming) and dealing with it themselves. 3) Reference to catchment groups already telling their story, to groups owning their story; reference to being part of a wider network; seeking support from catchment community; community cohesion	*"We want to be in charge of our own destiny. That can't come from the top down otherwise it won't work, as we all know."* *"[The group] built a movement as opposed to a compliance."* *"I think this is where this Groundswell comes up, with citizen scientists, that they step up and say people use this SHMAK kit which makes it really easy for you to sample water quality."*	

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
2 (Cont'd) Inspire change (the WHY and WHY NOT)	2.4 For stewardship/connection to land/pride of place	1) Reference to stewardship of the land; 'Passing-through'; Land-tenure; recognising the importance of the past/ancestors and future/vision for sustainable land management; 2) Connection to the land & river; Pride of place, holistic view of land management.	*"Yeah, so we're lucky. My great grandfather was the first one here, so we don't really see the farm as ours. We're just passing through. I mean it's pretty ridiculous to think you actually own land, isn't it, when the land's been here forever and you're only here for [a short while]."* *"I want to leave it in a better condition than when I came here. So you've always got that in the back of your mind [...]."*	excludes reference to how things take time
	2.5 Through listening to others and learning from others	Importance of listening to others and learning from others; importance of sharing stories with others	*"It's farmer to farmer learning as well, cos we haven't got everything right, that's for sure. We're always trying to improve."* *"That's the only reason I'm here is I think it [the story] needs to be told."* *"I was thinking of it more as a community to show what we are achieving as opposed to showing off, so that people are like actually we are doing some amazing stuff."*	
	2.6 To restore river ecosystems and communities	1) Inspiration to change towards sustainable land management through learning 2) Benefits of listening to others to learn, importance of sharing knowledge to others, eagerness to learn and to listen, there is a need to share information/ communicate to allow others to learn 3) Reference to specific visions and goals relating to restoration; short-term (= next 12 months) and long-term (=infinite, 1000 years, 100 years); 4) Any reference to healthy ecosystems/ healthy people 5) Includes examples of what has been achieved/done already.	*"Say I set up a catchment group, I want to see what other catchment groups are doing that have been really successful in changing water quality, and also the resources that they're getting that we're not [laughs], if I'm honest, cos I feel like we're missing out on something here."* *"I just think the goal is that we all care for the river openly, without having to be embarrassed about it."* *"We have got goals in the catchment collective of weaving the communities in the catchment together around the health and enhancement of freshwater system."*	includes template section "What are our goals" specific to inspiring change; ,excludes reference to making mistakes or how things take time

Theme	Sub-themes	Description	Examples	Exclusions/ Notes
3 Sentiment/Emotion of stories (==> WHAT kind of stories)	3.1 Non-positive stories	Examples of how non-positive stories can stop momentum	*"It's heart-breaking to see some work undone, isn't it?"* *"Yeah you see and it was hard to justify how do you put in all those fences if those willows are then going to smash the fences and crush all your plants and then you have to get into an area that's fenced and planted and try and clear …"*	
	3.2 Positive and honest stories about catchment restoration	Reference to the momentum/ inspiration that can be found if stories focus on a positive aspect (opposed to just looking at the negatives/ what hasn't been achieved/ who is to blame); Often includes proof of restoration progress; Example of stories shared that could be of interest to other catchment groups (e.g., progress on restorations made, local seed-sourcing for vegetation, river as baby-sitter, how to approach iwi, etc); reference to what catchment groups 'do well';	*"When we won the river story award all of a sudden we sort of looked at each other in Wellington and go 'shit, well now we've blurted all that out, I suppose we'd better go and do something about it now'".* *"Cause even like looking at our place, when they updated their photo recently it was quite inspiring, just for my little bit, oh you can actually see some dark green with actual trees. If you can see something's changed it's nice, isn't it?"* *"But it's one of these things, you tend to look forward all the time what you need to do, but occasionally you have to look backwards and say oh I have done a lot already"*	Includes template section "We Do Well'
4 Storytellers are... (WHO should share knowledge/ tell a catchment story)	Community; Champions; People of the land; iwi	Reference to how it takes a village to share knowledge, tell a story; working together to share knowledge; communal effort to tell stories; reference to iwi and their stories; a story can be told by multiple owners/ people	*"Doing it together – getting buy-in from everybody. It's got to be a communal effort. There's no point in people battling away on their own. If you're not going to get buy-in from everybody then you get frustrated and bitter and … worn out."* *"Well I don't think we should be telling iwi stories ourselves, that's up to the iwi to tell them."*	excludes challenges with iwi collaboration; lack of trust/ relationship between farmers and iwi
5 Other		Does not fall into any of the above category		

Appendix F | Information sheet and consent form for focus group participants

Reference Number: *D20/037- JUNE 2021*

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

A NEW ZEALAND REGISTER OF LAND MANAGEMENT ACTIONS TO IMPROVE WATER QUALITY

INFORMATION SHEET FOR FOCUS GROUP PARTICIPANTS

Thank you for considering participation in this project. Please read this information sheet. If you decide to participate, we thank you. If you decide not to take part, we thank you for considering this request.

What is the Aim of the Project?

The aim of this project is to find out what kind of sustainable land use actions land managers would like to record and report on a national online database which will help answer questions about sustainable land use actions and improve water quality. This research will inform the design and content of this register by determining the most effective and meaningful ways of setting up this online tool. The use of stories as a tool to share knowledge will be a key component of this research. The register will be a new 'module' of the Land, Air Water Aotearoa (www.lawa.org.nz) online tool which is Aotearoa New Zealand's largest environmental reporting platform. Your interview will contribute to Kati Doehring's PhD in Science Communication.

What Types of Participants are being sought?

We are looking for participants that are likely to use the Register of Land Management Actions and are 18 years or over. These might include food & fibre producers, members of urban/ rural catchment care groups, life-style block landowners, citizen scientists, iwi/tangata whenua, primary/secondary teachers, or primary sector representatives (e.g., dairy, beef, lamb, forestry).

We will not collect any contact details as part of the focus group, however, participants willing to participate in follow up research can elect to provide an email address. These lists will be stored in a secure server or locked office at the Cawthron Institute in Nelson and destroyed after five years.

What will Participants be asked to do?

Should you agree to take part in this project, you will be part of a focus group meeting (4-6 participants) which will take between 2 – 2.5 hours. We will ask you questions about the land you manage, whether you use any sustainable land use actions, if you record and report any sustainable land use actions, whether you would be willing to share your achievements in the form of a story and which information your story could include/ not include.

Remember that you may withdraw from this discussion at any time without any disadvantage to yourself.

What Data or Information will be collected and what use will be made of it?

You are not required to provide any personal details. If you would like to be kept informed on the progress of our project, the outcomes and potential follow-up participation, we would record your name and email address for these purposes only. The focus group meetings will be audio recorded and transcribed. The only people who will have access to this project's data will be the researchers.

The data collected will be securely stored on a password-protected drive at the Cawthron Institute in Nelson, New Zealand. Data obtained as a result of the research will be retained for at least 5 years in secure storage. Any personal information held on the participants such as contact details and email addresses will be destroyed immediately after the publication of the research even though the data derived from the research will, in most cases, be kept for much longer or possibly indefinitely. No material that could personally identify you will be used in any reports on this study without your express consent. Results of this research may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve your anonymity.

On the Consent Form you will be given options regarding your anonymity. It is entirely up to you which of these options you prefer. We will make every attempt to preserve your anonymity. However, with your consent, there are some cases where it would be preferable to attribute contributions made to an individual participant. Within four months of your participation, we will provide a summary and any quotes that might be used in reports or publications, for you to check and approve.

If the line of questioning develops in such a way that you feel hesitant or uncomfortable you may decline to answer any question(s).

Follow-up contact

If you agree to be involved in any follow-up research, the interview will be conducted in the form of a semi-structured interview which will provide content for a podcast series about freshwater catchment stories. The general line of questioning will focus on how the future use of the register can be ensured and how associated learnings can be shared effectively.

Can Participants change their mind and withdraw from the project?

Yes, you may withdraw from participation in the project at any time and without any disadvantage to yourself.

If you have any questions about our project, either now or in the future, please feel free to contact either:

Kati Doehring or *Dr Cathy Cole*

Kati Doehring
Centre for Science Communication
Email: Kati.doehring@cawthron.org.nz

Dr Cathy Cole
Centre for Science Communication
Email: cathy.cole@otago.ac.nz
Phone: +64 (3) 479 7885

This study has been approved by the Department stated above. However, if you have any concerns about the ethical conduct of the research you may contact the University of Otago Human Ethics Committee through the Human Ethics Committee Administrator (ph +643 479 8256 or email gary.witte@otago.ac.nz). Any issues you raise will be treated in confidence and investigated and you will be informed of the outcome.

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

A NEW ZEALAND REGISTER OF SUSTAINABLE LAND ACTIONS TO IMPROVE WATER QUALITY

CONSENT FORM FOR PARTICIPANTS

I have read the Information Sheet concerning this project and understand what it is about. All my questions have been answered to my satisfaction. I understand that I am free to request further information at any stage.

I know that:

1. My participation in the project is entirely voluntary;

2. I am free to withdraw from the project at any time without any disadvantage;

3. Personal identifying information such as email addresses will be destroyed at the conclusion of the project but any raw data on which the results of the project depend will be retained in secure storage for at least five years;

4. I understand that this project involves an open-questioning (semi-structured) technique. The general line of questioning will ask me about my relationship to my land, the sustainable land use practices done on my land and how stories could be used as a tool to share land management information within my community and beyond. If I feel hesitant or uncomfortable, I know that I can decline to answer any particular question(s) or withdraw from the project;

5. I understand that I will get a summary and any quotes that might be used in reports or publications within six months of my interview. This allows me to check and approve/decline the use of my quotes.

6. The results of the project may be published and will be available in the University of Otago Library (Dunedin, New Zealand) but every attempt will be made to preserve my anonymity.

I, as the participant: a) agree to being named in the research, OR;
b) would rather remain anonymous.

I agree to take part in this project.

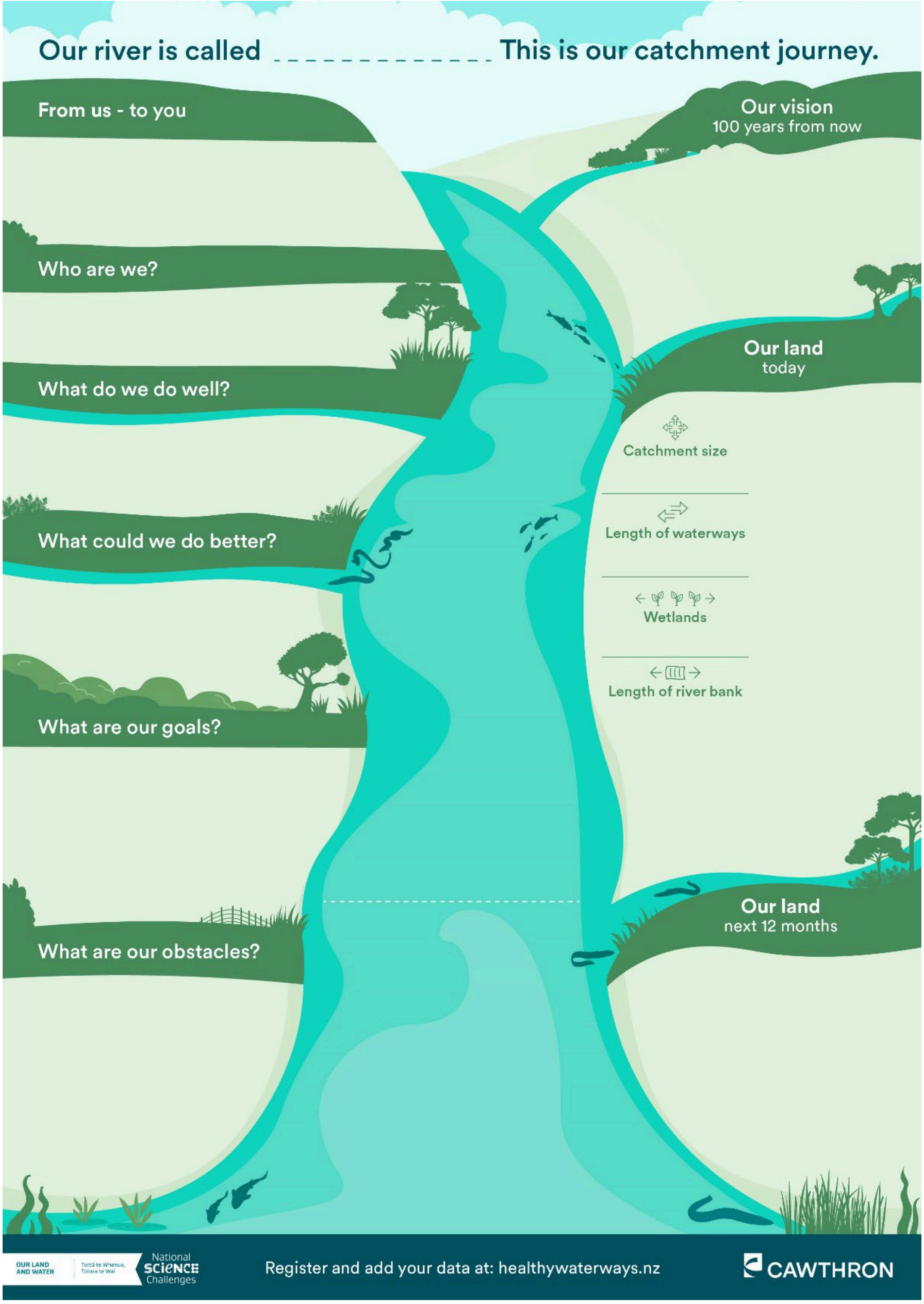
....

(Signature of participant) (Date)

....

(Printed Name)

Appendix G | Catchment Journey template as online resource



Can be downloaded from the Our Land and Water Website
(https://ourlandandwater.nz/outputs/catchment-journey-template/)

Appendix H | Survey flow

PART 1/2/3

Standard: Part 1/2/3_Introduction and Confidentiality (2 Questions)

Standard: PART1_General information about you and your freshwater catchment care group (4 Questions)

Standard: Background Freshwater Improvement (5 Questions)

BlockRandomizer: 2 - Evenly Present Elements

Group: CONTROL GROUP - Collective Story

Standard: PART2_CONTROL GROUP_START SM (2 Questions)

Standard: PART 3_CONTROL_Welcome back! (1 Question)

Standard: PART 3_CONTROL - A - Testing extraction of info (4 Questions)

Standard: PART 3_ CONTROL - B - Testing of Recall (2 Questions)

Standard: PART 3_CONTROL - C - Testing Motivation (5 Questions)

Standard: PART 3_CONTROL_Thank you! (2 Questions)

EndSurvey:

Group: INTERVENTION GROUP – Mark's Story

Standard: PART 2_INTERVENTION_START SM (2 Questions)

Standard: PART 3_INTERVENTION_Welcome back (1 Question)

Block: PART 3_INT - A - TESTING Extraction of information/ Attention to champion (4 Questions)

Standard: PART 3_INTERVENTION - B - TESTING Retention/ recall & memory (2 Questions)

Standard: PART 3_INTERVENTION - C - TESTING Motivation (5 Questions)

Standard: PART 3_INTERVENTION- Thank you! (2 Questions)

EndSurvey:

PART 4 – Control – Collective story

Standard: PART 4_CONTROL_Introduction and Confidentiality (2 Questions)

Branch: New Branch

If

Invalid Logic Click Here to Edit Logic

EndSurvey: Advanced

Standard: A| TESTING Attention to the behaviour and its consequences of the storyteller (2 Questions)

Standard: B| TESTING Retention/ recall & memory (3 Questions)

Standard: C| TESTING Motivation & Reproduction (9 Questions)

EndSurvey:

PART 4 – Intervention – Mark's Story

Standard: PART 4_INTERVENTION_Introduction and Confidentiality (2 Questions)

Standard: A| TESTING Attention to the behaviour and its consequences of the storyteller (3 Questions)

Standard: B| TESTING Retention/ recall & memory (3 Questions)

Standard: C| TESTING Motivation & Reproduction (9 Questions)

EndSurvey:

Appendix I | Survey

Part 1/2/3_Introduction and Confidentiality

Kia ora and Welcome!

Thank you for agreeing to take part in this survey on freshwater catchment restoration.

By doing this survey, we can make sure that our research has greater meaning and a positive impact on Aotearoa New Zealand's freshwaters.

Here is how:

Sharing freshwater restoration knowledge within your catchment community improves awareness. If we don’t share our successes and failures with our peers, we don’t know which land management actions are the most effective ones. This is partly the reason why water quality is not improving in some waterways across Aotearoa New Zealand.

Many of our catchment communities are already doing great work to address this, but many of us could do with some help.

And you can provide this help. By completing this survey, you are part of a research project that tries to find out what role catchment restoration stories play in motivating others to share knowledge. The findings of this research will inform the set-up of a National Register of Land Management Actions which, by June 2023, will be a part of the Land, Air, Water Aotearoa webtool (LAWA.org.nz).

There are twelve questions in this survey and a catchment story to read - I know, quite a lot, but this is our chance to work together to better Aotearoa New Zealand's freshwaters. So please hang in there! Grab a cuppa and see if you find out anything new about your catchment group.

Thank you!

Ngā mihi nui

Kati Doehring

Freshwater Ecologist and Science Communicator | Cawthron Institute

Participation in this survey is voluntary and your answers will be anonymous.

Survey responses will be retained by the University of Otago in a secure database for up to 12 months. Our research is approved by the University of Otago's Human Ethics Committee (D20/037) and Cawthron Institute research ethics application protocol (CAW-ETH-200804).

If you have any queries about confidentiality or anything else concerning this survey, please contact Kati Doehring (kati.doehring@cawthron.org.nz).

We truly appreciate your time.

Thank you!

- ○ I understand the above information about confidentiality and **AGREE** to do the survey

PART1_General information about you and your freshwater catchment care group

What is the name of your sub-catchment group (if applicable)?

How long have you been part of your catchment group?

What type(s) of land use do you do? Tick as many as apply.

- [ ] Dairy
- [ ] Sheep
- [ ] Beef
- [ ] Forestry
- [ ] Horticulture or viticulture
- [ ] Arable
- [ ] Deer
- [ ] Lifestyle
- [ ] Other (please tell us)

What is your age?

- Under 18
- 18–24
- 25–34
- 35–44
- 45–54
- 55–64
- 65–74
- 75–84
- Over 84

Background freshwater improvement

Do you carry/ have you carried out actions that help improve water quality?

- Yes
- No

How long have you been restoring your catchment?

- Less than 1 year
- 1–3 years
- 4–6 years
- 7–9 years
- More than 9 years
- Don’t know
- Other / doesn’t apply

Over the last five years, what actions have you most commonly done, in terms of resources spent (resources can include money and/or time). Please drag and drop the land management actions into the boxes based on the amount of resources you spent. You can then rank them within each box.

Items

Riparian for streams/rivers/wetlands (e.g., Vegetated buffer strips / planting; Stock exclusion)

Grazing & Crop

Management (e.g., Restricted grazing; Change of animal type)

Nutrients & Contaminants (e.g., Bridging stock access; precision application)

Soil Conservation & Erosion Control (e.g., Cover crop after harvesting; sediment traps; afforestation)

Water Use (e.g., Precision irrigation; water recycling)

Most resources spent

Less resources spent

These actions are relevant for my farm, but I haven't spent any resources on them, yet.

N/A (these actions don't apply to me)

What holds you back from restoring your catchment through actions that help improve freshwater quality? Tick all that apply.

- ☐ Too costly
- ☐ Not enough time
- ☐ Not interested
- ☐ I don't own the land
- ☐ I have completed all I could do at this stage
- ☐ Other

PART2_CONTROL GROUP_START SM

Enough questions for the time being! Please explore the Rangitīkei Catchment Story and then there will be some final questions.

(For this research to provide meaningful results, it is vital that the survey is completed once you've explored the Catchment Story.

To get back to this survey, close the Catchment Story tab in your browser and come back to this tab.)

Click THIS LINK or the image below to get to the story.

Click **NEXT** when you are done exploring the story.

PART 3_CONTROL_Welcome back!

Ka pai! I hope you enjoyed reading the Rangitīkei restoration story.

Please close the browser window with the story if you haven't already done so and click NEXT to get to the final section of this survey.

Remember, for every survey completed, we will donate to the Rural Support Trust.

PART 3_CONTROL - A - Testing extraction of info This section is about **the catchment story**.

Which three words would you use to describe the **story**?

1 [ ]

2 [ ]

3 [ ]

How much do you agree with the following statements about the catchment **story**:

I strongly disagree - I disagree - I don't know - I agree - I strongly agree

0 10 20 30 40 50 60 70 80 90 100

The story is trustworthy

The story contains interesting facts

I learned something new when reading the story

I liked reading the story

I can relate to the story

The story is boring

I can't relate to the story

What makes the story relatable, or inapplicable, to you?

More than halfway there! Thanks for making it this far.

PART 3_ CONTROL - B - Testing of Recall

In this section, we are interested in the **content** of the story.

What **lessons** has the catchment group learnt over time? Tick any that you remember were mentioned in the story.

- ☐ Water quality testing is an important first step in forming a sub-catchment group.
- ☐ Any planting needs to be looked after for at least three years.
- ☐ A goal and vision workshop helps to give a new group direction and purpose.
- ☐ Getting children involved in restoration ensures our river will be looked after in the future.
- ☐ Allowing for extra social time for catch-ups is key for group members to connect.

What **challenges** did the catchment group talk about? Tick any that you remember were mentioned in the story.

- ☐ The community suffers from workshop fatigue.
- ☐ Water quality testing is too expensive to cover the entire catchment.
- ☐ Because the catchment collective is quite large, catering to everyone's needs and issues is not always possible.
- ☐ Lack of funding to attend 'practical-based' workshops.
- ☐ Most of the catchment community is not interested in improving water quality.

PART 3_CONTROL - C - Testing Motivation

How much do you agree with the following statements:

I strongly disagree - I disagree - I don't know - I agree - I strongly agree

0 10 20 30 40 50 60 70 80 90 100

Sharing restoration knowledge is important

I intend to share the story with others (a link to the story is provided at the end of this survey)

The story inspires me to restore my catchment

I intend to engage in freshwater restoration actions in my catchment in the near future

The story has no impact on my intentions to restore my catchment.

I am unlikely to engage in freshwater restoration actions in my catchment in the near future.

After reading the story, do you **intend to contact** the catchment group?

- Yes
- No

Why do you intend to contact the catchment group? Click as many as apply.

- To find out more information about getting funding
- To find out more information about land management actions
- To initiate a new sub-catchment
- To find out more about the catchment group membership
- I want to contact the group because...

What are the reasons you do **not intend** to contact the catchment group? Click as many as apply.

- I am already an active member of the catchment group.
- I don’t have any questions at the moment.
- I don’t feel inspired enough.
- Other

Is there any other comment you would like to make about the catchment story? Go for it – this is your chance.

PART 3_CONTROL_Thank you!

Rawe! You have contributed to making Aotearoa New Zealand's freshwaters healthier.

Thank you for participating in this survey. Your time and commitment are truly appreciated.

If you want to share the catchment story with others, use this link.

There is one more thing...

To get a better understanding about knowledge sharing, I would love to contact you again in four weeks' time for a follow-up short survey (8 questions).

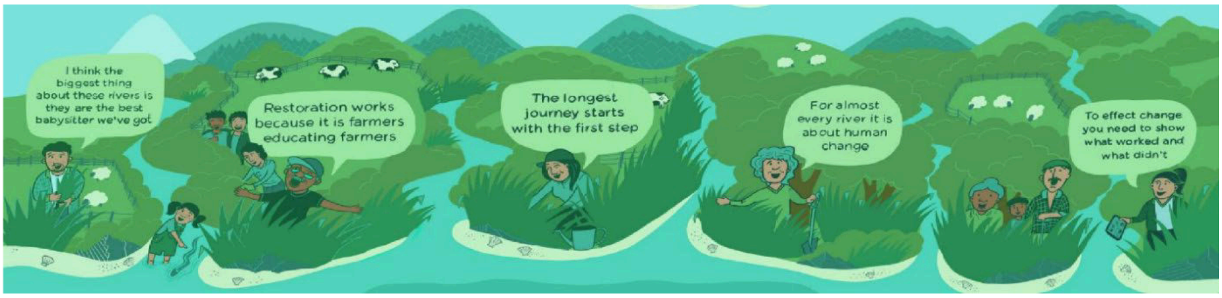
I know that you have already given me a lot of your time (which is immensely appreciated) and I can understand if you'd prefer to leave it at that. But I really want to make sure that the new Register of Actions on LAWA will be of use to you and your fellow catchment restoration practitioners.

So, if you still have some energy left to help me better our freshwater environment, please let me know by entering your details below. I will then be in touch soon. And as always, you can pull out at any stage!

Once again - Many thanks!

Kati Doehring

Your name	
Your email	



PART 2_INTERVENTION_START SM

Enough questions for the time being! Please explore the Rangitīkei catchment, and then there will be some final questions.

(For this research to provide meaningful results, it is vital that the survey is completed once you've explored the Catchment Story.

To get back to this survey, close the Catchment Story tab in your browser and come back to this tab.)

Click THIS LINK or the image below to get to the story.

Click **NEXT** when you are done exploring the story.

PART 3_INTERVENTION_Welcome back

Ka pai! I hope you enjoyed reading the Rangitīkei Catchment Story.

Please close the browser window with the story (if you haven't already done so) and click NEXT to get to the final section of this survey.

Remember, for every survey completed, we will donate to the Rural Support Trust.

PART 3_INT - A - TESTING Extraction of information/ Attention to champion This section is about the **catchment story**.

Which three words would you use to describe the **story**?

1 [ ]

2 [ ]

3 [ ]

How much do you agree with the following statements:

I strongly disagree - I disagree - I don't know - I agree - I strongly agree

0 10 20 30 40 50 60 70 80 90 100

The story is trustworthy

The story contains interesting facts

I learned something new when reading the story

I liked reading the story

I can relate to the story The story is boring

I can't relate to the story

What makes the story relatable, or inapplicable to you?

More than halfway there! Thanks for making it this far.

PART 3_INTERVENTION - B - TESTING Retention/ recall & memory

In this section, we are interested in the **content** of the story.

What **lessons** has the catchment group learnt over time? Tick any that you remember were mentioned in the story.

- ☐ Water quality testing is an important first step in forming a sub-catchment group.
- ☐ Any planting needs to be looked after for at least three years.
- ☐ A goal and vision workshop helps to give a new group direction and purpose.
- ☐ Getting children involved in restoration ensures our river will be looked after in the future.
- ☐ Allowing for extra social time for catch-ups is key for group members to connect.

What **challenges** did the catchment group talk about? Tick any that you remember were mentioned in the story.

- ☐ The community suffers from workshop fatigue.
- ☐ Water quality testing is too expensive to cover the entire catchment.
- ☐ Because the catchment collective is quite large, catering to everyone's needs and issues is not always possible.
- ☐ Lack of funding to attend 'practical-based' workshops.
- ☐ Most of the catchment community is not interested in improving water quality.

PART 3_INTERVENTION - C - TESTING Motivation

How much do you agree with the following statements:

I strongly disagree - I disagree - I don't know - I agree - I strongly agree

0 10 20 30 40 50 60 70 80 90 100

Sharing restoration knowledge is important

I intend to share the story with others (a link to the story is provided at the end of this survey)

The story inspires me to restore my catchment

Mark inspires me to restore my catchment

I intend to engage in freshwater

restoration actions in my catchment in the near future

The story has no impact on my intentions to restore my catchment

I am unlikely to engage in freshwater restoration actions in my catchment in the near future.

After reading the story, do you **intend to contact** the catchment group and/or Mark?

- ○ Yes
- ○ No

Why do you intend to contact the catchment group and/or Mark? Click as many as apply.

- ☐ To find out more information about land management actions
- ☐ To initiate a new sub-catchment
- ☐ To find out more about the catchment group membership
- ☐ I want to contact Mark because...

What are the reasons why you do not intend to contact the catchment group and/or Mark? Click as many as apply.

- ☐ I am already an active member of the catchment group.
- ☐ I don't have any questions at the moment.
- ☐ I don't feel inspired enough.
- ☐ Other ______________________

Is there any other comment you would like to make about Mark and/or the story? Go for it – this is your chance.

____

PART 3_INTERVENTION - Thank you!

Rawe! You have contributed to making Aotearoa New Zealand's freshwaters healthier.

Thank you for participating in this survey. Your time and commitment are truly appreciated.

If you want to share the catchment story with others, use this link.

There is one more thing...

To get a better understanding about knowledge sharing, I would love to contact you again in four weeks' time for a follow-up short survey (8 questions).

I know that you have already given me a lot of your time (which is immensely appreciated) and I can understand if you'd prefer to leave it at that. But I really want to make sure that the new Register of Actions on LAWA will be of use to you and your fellow catchment restoration practitioners.

So, if you still have some energy left to help me better our freshwater environment, please let me know by entering your details below. I will then be in touch soon. And as always, you can pull out at any stage!

Once again - Many thanks!

Kati Doehring

Your name	
Your email	

Powered by Qualtrics

OUR LAND AND WATER | Toitū te Whenua, Toiora te Wai | National Science Challenges | University of Otago

PART 4_INTERVENTION_Introduction and Confidentiality Welcome back!

Thank you for your ongoing support to help us find out how to restore our freshwater catchments most effectively.

By completing this follow-up survey, we will better understand the role collective storytelling plays in sharing freshwater restoration knowledge as well as in encouraging others to follow suit.

This survey will be a lot shorter than the first one, so let's get going!

We will keep your answers secure.

Just like in the first survey, participation in this survey is completely voluntary and your answers will be anonymous. Survey responses will be retained by the University of Otago in a secure database for up to 12 months. Our research was approved by the University of Otago's Human Ethics Committee (D20/037) and Cawthron Institute research ethics application protocol (CAW-ETH-200804).

If you have any queries about confidentiality or anything else concerning this survey, please contact Kati Doehring (kati.doehring@cawthron.org.nz).

I truly appreciate your time.

Thank you!

Ngā mihi nui

Kati Doehring

Freshwater Ecologist and Science Communicator | Cawthron Institute

○ I understand the information about confidentiality and **AGREE** to do the survey

A| TESTING Attention to the behaviour and its consequences of the storyteller

One month ago, we asked you questions about your catchment's restoration story. We are interested to find out whether your perspectives have changed since then.

When thinking about the **catchment story**, which three words would you use to describe it?

1 [ ]

2 [ ]

3 [ ]

How much do you agree with the following statements:

I strongly disagree - I disagree - I don't know - I agree - I strongly agree

0 10 20 30 40 50 60 70 80 90 100

The story was trustworthy

The story contained interesting facts

I can't relate to the story

I learned something new when reading the story

I liked reading the story

I can relate to the story The story was boring

How much do you agree with the following statements about **Mark**:

I strongly disagree - I disagree - I don't know - I agree - I strongly agree

0 10 20 30 40 50 60 70 80 90 100

I could relate to Mark

Mark was trustworthy

I recognised Mark

I could not relate to Mark

Mark was not trustworthy

B| TESTING Retention/ recall & memory

What **lessons** has the catchment group learnt over time? Tick any that you **remember** were mentioned in the story.

- ☐ Water quality testing is an important first step in forming a sub-catchment group.
- ☐ Any planting needs to be looked after for at least three years.
- ☐ A goal and vision workshop helps to give a new group direction and purpose.
- ☐ Getting children involved in restoration ensures our river will be looked after in the future.
- ☐ Allowing for extra social time for catch-ups is key for group members to connect.

What **challenges** did the catchment group talk about? Tick any that you **remember** were mentioned in the story.

- ☐ The community suffers from workshop fatigue.
- ☐ Water quality testing is too expensive to cover the entire catchment.
- ☐ Because the catchment collective is quite large, catering to everyone's needs and issues is not always possible.
- ☐ Lack of funding to attend 'practical-based' workshops.
- ☐ Most of the catchment community is not interested in improving water quality.

Already halfway there – that was quick, eh?

Did you know that other catchment groups are more likely to restore their freshwaters if they hear from their peers what can be done, and how?

That is why sharing what you know is so important!

C| TESTING Motivation & Reproduction

Over the last month, have you **contacted** Mark and/or the catchment group to find out more about land management actions?

- ☐ YES, I contacted **Mark**, because...
- ☐ NO, I didn't contact **Mark**, because...
- ☐ YES, I contacted the **catchment group**, because ...
- ☐ NO, I didn't contact the **catchment group** because...

Over the last month, did you **share the story** with others? A link was provided as part of the first survey.

- ○ Yes
- ○ No

Who did you share the **story** with? Tick as many as apply.

- ☐ Other catchment group members
- ☐ Other members of the community, but not within my catchment
- ☐ Family and/or friend
- ☐ Other ________

You did **not** share the story with others. What were your reasons? Tick as many as apply.

- ☐ The story wasn't that interesting
- ☐ I was unsure who I should share it with
- ☐ My neighbours in the catchment are already active and don't need persuading
- ☐ I forgot
- ☐ The story didn't have anything new to share
- ☐ I ran out of time
- ☐ Other ________

Over the last month, did you **share any restoration knowledge** with others? This may include knowledge about sustainable land management or farm planning.

- ◯ Yes, I shared restoration knowledge with ...
- ◯ No, I didn't share any restoration knowledge, because ...

Nearly there....Over the last month, did you **engage in any new freshwater restoration actions** after reading the story? These can be physical actions (e.g., weeding, fencing) or generic actions (e.g., sharing knowledge about land management, visiting farm open days, plan and apply for funding, joining a catchment group).

- ◯ YES
- ◯ NO

Which restoration actions did you engage in over the last month? Tick as many as apply or list a new one under 'other'.

- ☐ Generic land management actions (sharing knowledge, farm planning, joining a catchment group)
- ☐ Riparian for streams/rivers/wetlands (e.g., Vegetated buffer strips / planting; Stock exclusion)
- ☐ Grazing & Crop Management (e.g., Restricted grazing; Change of animal type)
- ☐ Nutrients & Contaminants (e.g., Bridging stock access; precision application)
- ☐ Soil Conservation & Erosion Control (Cover crop after harvesting; sediment traps; afforestation)
- ☐ Water Use (e.g., Precision irrigation; water recycling)
- ☐ Other (in case we haven't listed what you did above)

You did **not engage** in restoration actions over the last month. Can you tell us why? Tick as many as apply.

- ☐ My land is completely restored
- ☐ Wrong season for the actions I want to do
- ☐ Not enough time
- ☐ Not enough funding
- ☐ One month is too short a time frame to restore
- ☐ On holiday
- ☐ Other ______

PART 4_CONTROL_Introduction and Confidentiality

Welcome back!

Thank you for your ongoing support to help us find out how to restore our freshwater catchments most effectively.

By completing this follow-up survey, we will better understand the role collective storytelling plays in sharing freshwater restoration knowledge as well as in encouraging others to follow suit.

This survey will be a lot shorter than the first one, so let’s get going!

We will keep your answers secure

Just like in the first survey, participation in this survey is completely voluntary and your answers will be anonymous. Survey responses will be retained by the University of Otago in a secure database for up to 12 months. Our research was approved by the University of Otago’s Human Ethics Committee (D20/037) and Cawthron Institute research ethics application protocol (CAW-ETH-200804).

If you have any queries about confidentiality or anything else concerning this survey, please contact Kati Doehring (kati.doehring@cawthron.org.nz).

I truly appreciate your time.

Thank you!

Ngā mihi nui

Kati Doehring

Freshwater Ecologist and Science Communicator | Cawthron Institute

○ I understand the information about confidentiality and **AGREE** to do the survey

A| TESTING Attention to the behaviour and its consequences of the storyteller

One month ago, we asked you questions about your catchment's restoration story. We are interested to find out whether your perspectives have changed since then.

When thinking about the **catchment story**, which three words would you use to describe it?

1

2

3

How much do you agree with the following statements about the catchment **story**:

I strongly disagree - I disagree - I don't know - I agree - I strongly agree

0 10 20 30 40 50 60 70 80 90 100

The story was trustworthy

The story contained interesting facts

I can't relate to the story

I learned something new when reading the story

I liked reading the story

I can relate to the story

The story was boring

B| TESTING Retention/ recall & memory

What **lessons** has the catchment group learnt over time? Tick any that you **remember** were mentioned in the story.

- ☐ Water quality testing is an important first step in forming a sub-catchment group.
- ☐ Any planting needs to be looked after for at least three years.
- ☐ A goal and vision workshop helps to give a new group direction and purpose.
- ☐ Getting children involved in restoration ensures our river will be looked after in the future.
- ☐ Allowing for extra social time for catch-ups is key for group members to connect.

What **challenges** did the catchment group talk about? Tick any that you **remember** were mentioned in the story.

- ☐ The community suffers from workshop fatigue.
- ☐ Water quality testing is too expensive to cover the entire catchment.
- ☐ Because the catchment collective is quite large, catering to everyone's needs and issues is not always possible.
- ☐ Lack of funding to attend 'practical-based' workshops.
- ☐ Most of the catchment community is not interested in improving water quality.

Already halfway there - that was quick, eh?

Did you know that other catchment groups are more likely to restore their freshwaters if they hear from their peers what can be done, and how? That is why sharing what you know is so important!

C| TESTING Motivation & Reproduction

Over the last month, have you **contacted** the catchment group to find out more about land management actions?

- ☐ YES, I contacted the **catchment group**, because ... [ ]
- ☐ NO, I **didn't contact** the catchment group because... [ ]

Over the last month, did you **share the story** with others? A link was provided as part of the first survey.

- ○ YES
- ○ NO

Who did you share the **story** with? Tick as many as apply.

- ☐ Other catchment group members
- ☐ Other members of the community, but not within my catchment
- ☐ Family and/or friend
- ☐ Other [ ]

You did **not share** the story with others. What were your reasons? Tick as many as apply.

- ☐ The story wasn't that interesting
- ☐ I was unsure who I should share it with
- ☐ My neighbours in the catchment are already active and don't need persuading
- ☐ I forgot
- ☐ The story didn't have anything new to share
- ☐ I ran out of time
- ☐ Other [ ]

Over the last month, did you **share any restoration knowledge** with others? This may include knowledge about sustainable land management or farm planning.

- ○ Yes, I shared restoration knowledge with ... [ ]
- ○ No, I didn't share any restoration knowledge, because ... [ ]

Nearly there....

Over the last month, did you **engage in any new freshwater restoration actions** after reading the story? These can be physical actions (e.g., weeding, fencing) or generic actions (e.g., sharing knowledge about land management, visiting farm open days, plan and apply for funding, joining a catchment group).

- ○ YES
- ○ NO

Which restoration actions did you engage in over the last month? Tick as many as apply or list a new one under 'other'.

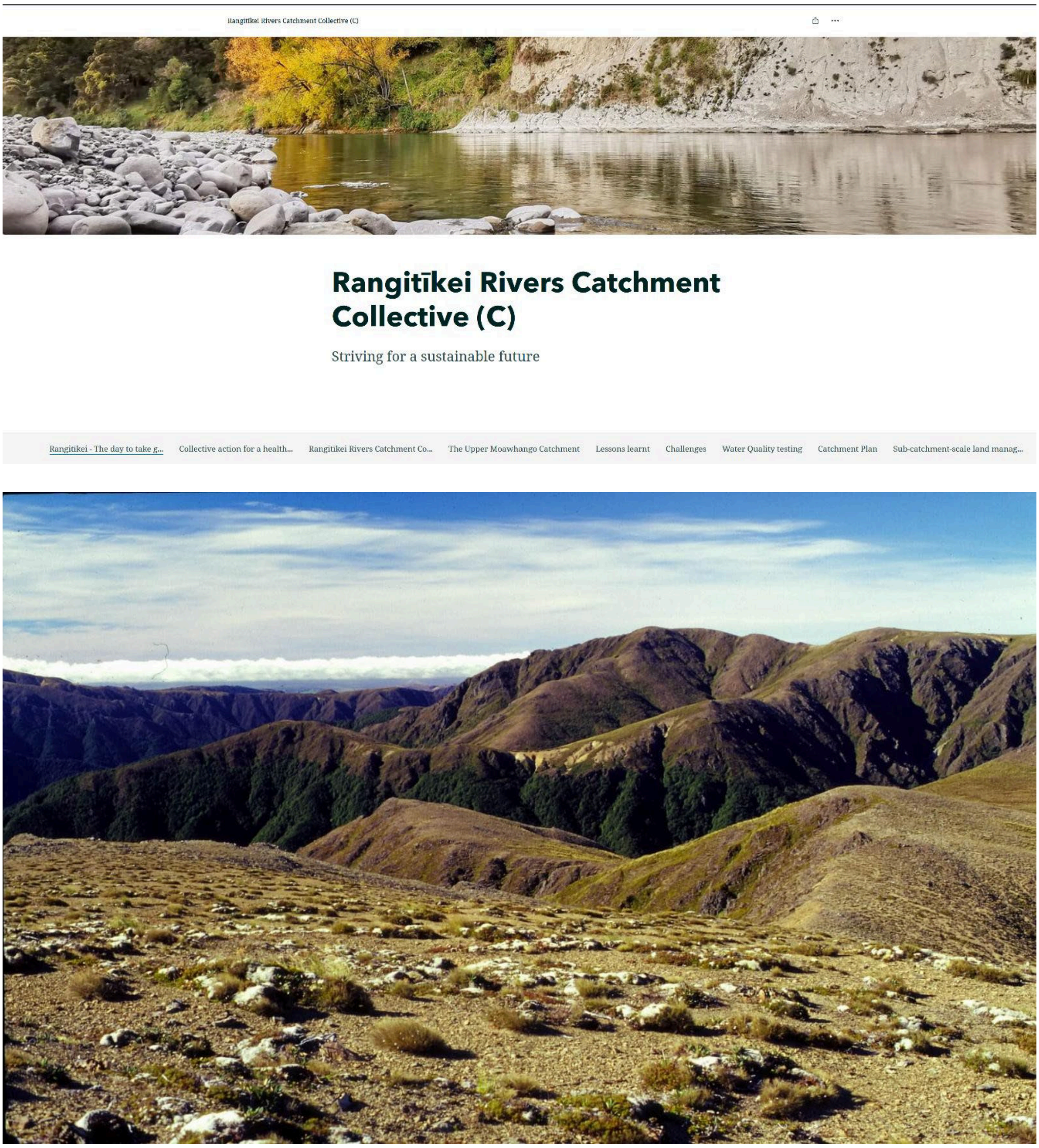
- ☐ Generic land management actions (sharing knowledge, farm planning, joining a catchment group)
- ☐ Riparian for streams/rivers/wetlands (e.g., Vegetated buffer strips / planting; Stock exclusion)
- ☐ Grazing & Crop Management (e.g., Restricted grazing; Change of animal type)
- ☐ Nutrients & Contaminants (e.g., Bridging stock access; precision application)
- ☐ Soil Conservation & Erosion Control (Cover crop after harvesting; sediment traps; afforestation)
- ☐ Water Use (e.g., Precision irrigation; water recycling)
- ☐ Other (in case we haven't listed what you did above) [ ]

You did **not engage** in restoration actions over the last month. Can you tell us why? Tick as many as apply.

- ☐ My land is completely restored
- ☐ Wrong season for the actions I want to do
- ☐ Not enough time
- ☐ Not enough funding
- ☐ One month is too short a time frame to restore
- ☐ On holiday
- ☐ Other ____________

Appendix J | StoryMap© – Collective Voice

Digital version of the Collective Voice StoryMap© - https://arcg.is/GOC4D



Rangitīkei – The day to take great strides

The mighty Rangitīkei River carves its way south, from its tussocky headwaters in the Kaimanawa Range to the Tasman Sea, forming majestic canyons and towering cliffs. Taihape, the centre of the Rangitīkei District is world famous for its formal footwear – the gumboot.

The Rangitīkei River is Aotearoa New Zealand’s fifth-longest river (253 km).

Its name translates to '**The day to take great strides**' which is based on the story of Hau, an ancient Māori warrior.

Hau had been traveling from Taranaki for many days, crossing rivers, trudging through swamps, climbing hills and fighting through bush in pursuit of his errant wife and her lover. Perhaps feeling that those he chased were not far ahead of him, Hau hurried his pace, pushing his body as much as he dared.

Later that day he came upon a particularly beautiful river where he chose to sit and rest for short time.

Looking at the river he gave it a name: **Rangi (the day), tikei (to take great strides)**.

Decisions are made collectively in the Rangitīkei Catchment.

Collective action for a healthy river

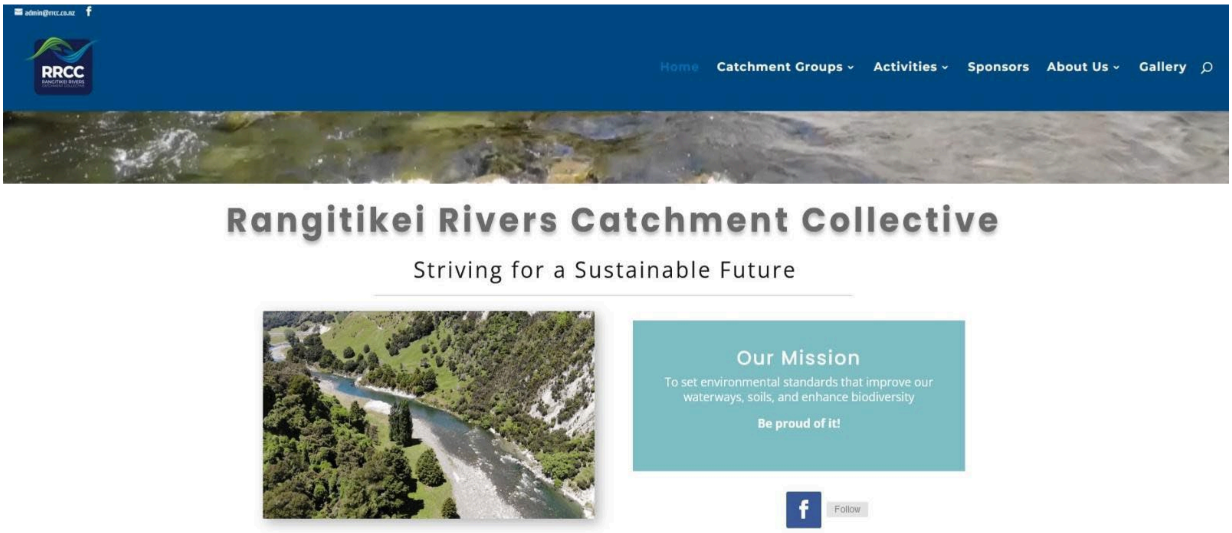
The people that live in this catchment today are like you and I, true New Zealanders who value their river for many reasons.

They love swimming in it and fishing and share the love for their natural environment that sustains them and their children.

Decisions are made collectively in the Rangitīkei Catchment.

The communities that live in the Rangitīkei Catchment stand at the heart of the decision-making when it comes to managing their land and its environment.

It is they who define the boundaries of sub-catchments, which helps them manage their waterways more effectively.



Rangitīkei Rivers Catchment Collective

The catchment is looked after by a 400-strong catchment group called the '**Rangitīkei Rivers Catchment Collective (RRCC)**', a farmer-led initiative that strives for resilient communities who get together to do the right thing for their environment and future generations.

The Catchment Collective enables members to work together freely on improving the water quality of their river. They now have 85 water quality monitoring sites across 23 sub-catchment groups in the area.

Their work is richly varied from encouraging and supporting water and soil monitoring, establishing smaller sub-catchment community groups, or managing and protecting biodiversity. The fact that the group works together on a common goal that achieves positive environmental outcomes, really boosts their enthusiasm.

Click the box if you want to find out more about the RRCC.

RRCC

The Upper Moawhango Catchment

The Upper Moawhango Catchment group was the first to establish of the 23 sub-catchment groups within the RRCC.

It started in August 2018, with the first water quality sample taken in December 2018.

Farmers willingly paid for the first water sample themselves, not knowing that they would be reimbursed later.

Paying for their water sample test was only a small sacrifice for the farmers in this sub-catchment, since it would help them tell their restoration story (and in the end, they got the costs for the sampling refunded anyway).

The Upper Moawhango is one example of a sub-catchment group where the collective efforts and enthusiasm have paid off.

In 2022, they have won the 'Horizons 2022 NZ Landcare Trust Catchment Group of the Year Award' which recognises the valuable work that farmers are doing in the environmental space, showing how far they have come in a short period of time.

In the picture you can see Harriet Gibson (RRCC Catchment Coordinator), Mark Chrystall (RRCC Vice Chairman; catchment lead for the Upper Moawhango catchment group), and Roger Dalrymple (RRCC Chairman) with the Environment Award.

Lessons learnt

By getting together and sharing knowledge of the things that worked and didn't work, the RRCC has learnt **three lessons**.

1. Employ a catchment coordinator: 95% of the catchment is actively managed by 23 sub-catchment groups. Managing these groups as volunteers is not sustainable which is why the community has decided to **employ a catchment coordinator** to support their work.

2. Have an environmental budget: To be able to continue improving the environment on their land, each farm needs to have an **environmental budget**.

3. Social time off-farm for mental health: Getting together off-farm at social events allows the Rangitīkei community to form a strong bond and talk about issues that aren't necessarily related to freshwater. For example, topics such as mental stress of farming and climate change.

Challenges

But like for every good story, there are some things that work better than others when it comes to restoring complex ecosystems such as the Rangitīkei river.

There are **three challenges** that the catchment group faces while restoring their river.

1. Bums on seats: Because the catchment has been actively restoring for about five years now, overall 'workshop fatigue' has caused things to slow down a bit. So **trying to get 'bums on seats'** is a challenge.

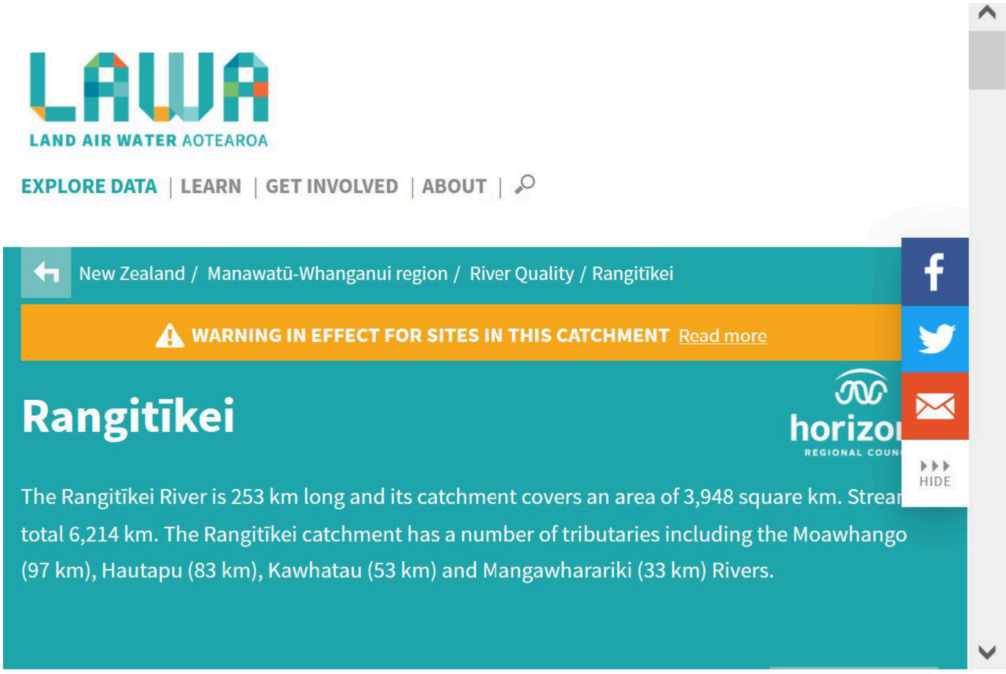
2. Ongoing funding: The group has restricted funding for the next three years, but it is unclear where **new funding** will come from after that.

3. Lack of 'model for overall catchment size': With over 700,000 ha, the Rangitīkei catchment is quite large. Because there is **no model for overall catchment size**, hitting the 'sweet spot' in terms of admin efforts is a challenge. For example, in large catchments, people have the ability to get away with not restoring their land (something the RRCC wants to avoid). In contrast, small catchments have comparatively high levels of administration, which is labour intensive.

Water quality testing

Despite these challenges, the RRCC is optimistic and focuses on the greater benefits. For example, they have their 'own' water quality testing programme where they test 85 sites across 23 RRCC sub-catchments.

This sampling is in addition to the 40 State of the Environment water quality monitoring sites that the council samples every month (see the interactive map below).



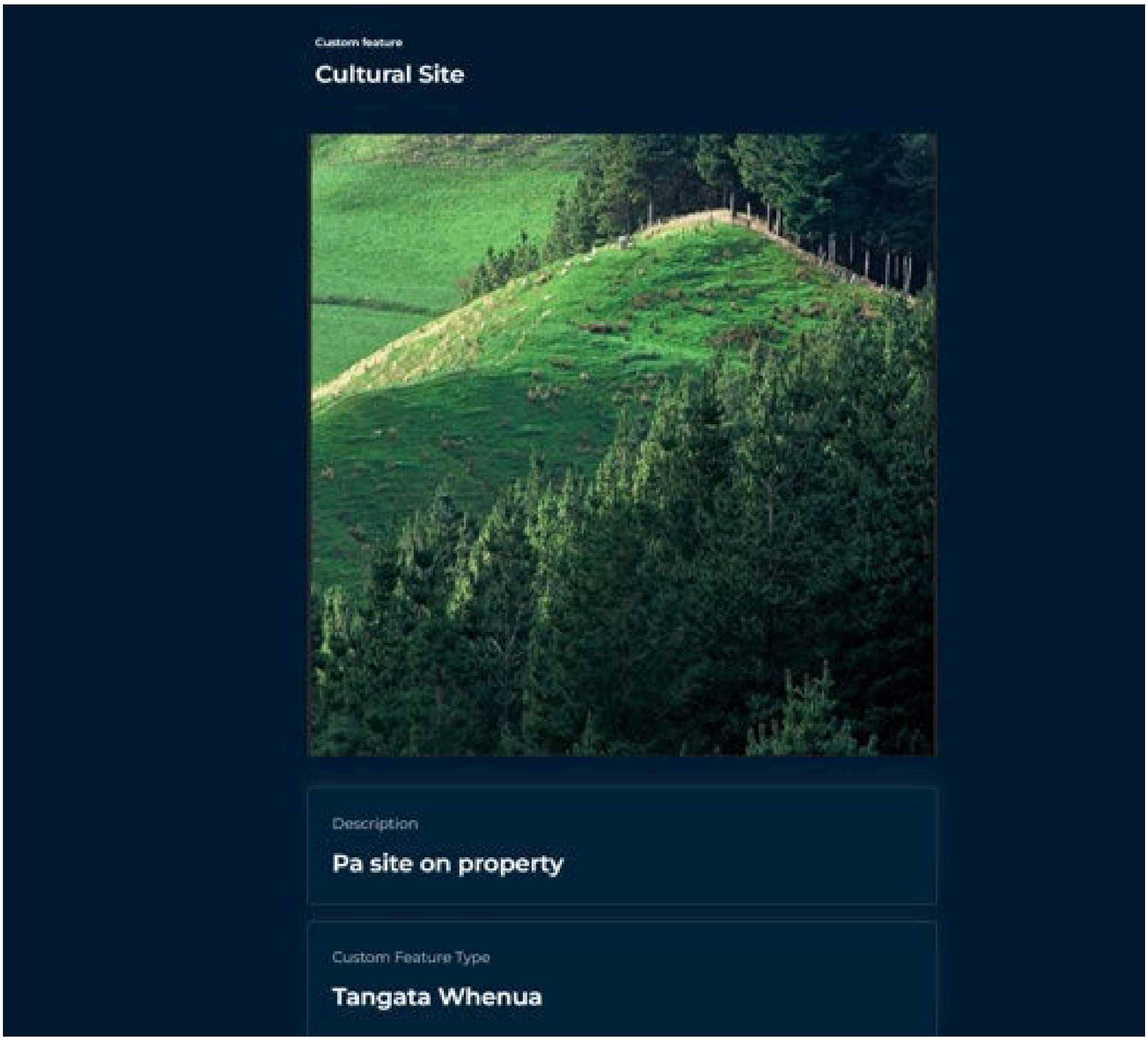
The additional sampling provides a more detailed picture of water quality for the catchment which enables landholders to target place-specific water quality pressures that might otherwise not get picked up from council water quality monitoring sites. Samples are tested for Nitrate, Soluble Inorganic Nitrogen, Dissolved Reactive Phosphorus, Turbidity, and *E. coli*.

Water samples are collected at 85 sites by the catchment group and sent to a government approved agency.

Catchment plan

Monitoring water quality is an important part of restoring river catchments, but so is monitoring land management actions.

This is why the Upper Moawhango group are developing a plan for their catchment that also covers land management actions such as length of waterways fenced, stock numbers in the catchment and critical source areas.

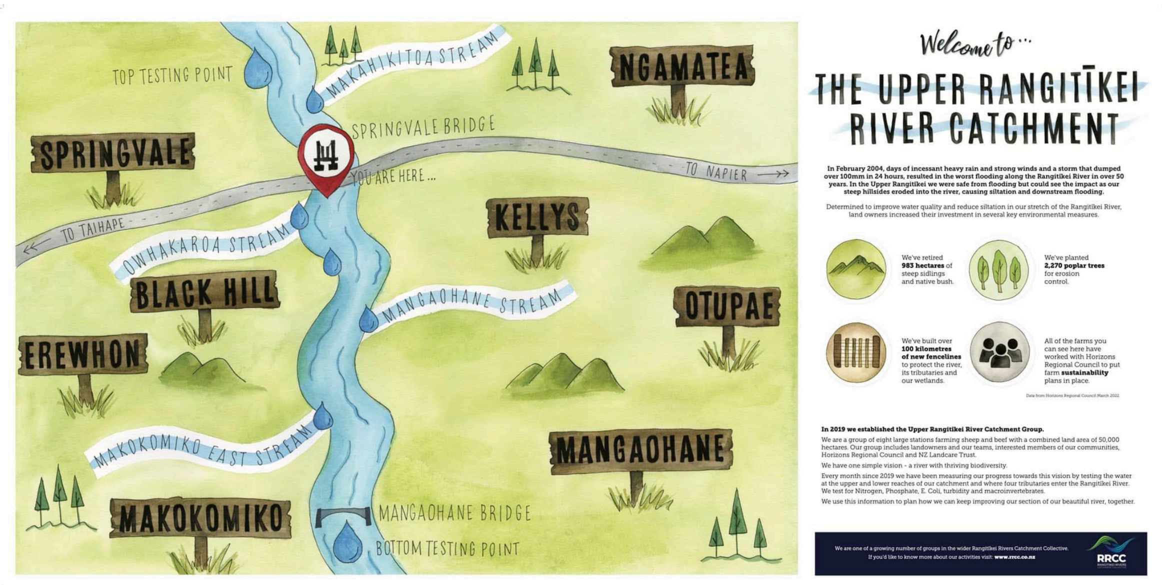


Because the group recognises that there is more to a healthy catchment than land management, the plan also includes values in a broader catchment context. For example values such as historic pā sites and the principles of Te Mana o te Wai.

By establishing this catchment plan of their own accord, rather than through top-down incentives, the Upper Moawhango catchment group is an inspiring example of effective community-led catchment management.

Sub-catchment-scale land management

The Upper Rangitīkei, like the Moawhango, is a sub-catchment group within the RRCC. The community in this catchment has been determined to reduce siltation in their stretch of the river since 2019.



The storyboard above summarises where water quality is being sampled in the sub-catchment and what land management actions have been achieved to date.

Since then, the sub-catchment has:

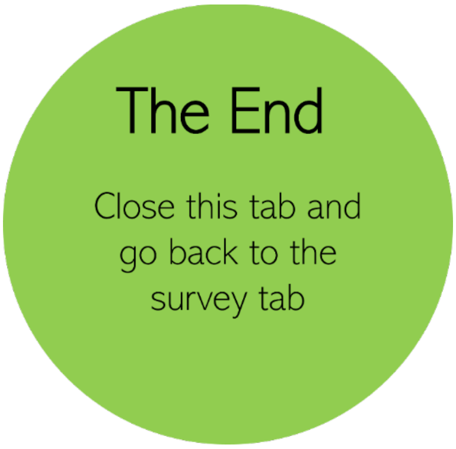
- retired 983ha of steep sidlings and native bush,
- planted 2,270 poplar trees for erosion control,
- built over 100km of new fence lines to exclude stock from entering the river, and
- put farm sustainability plans in place for all of the eight farms part of the sub-catchment.

Did you know?

A **National Register of Land Management Actions** is in development which is a free online tool that allows catchment groups to record and report their actions across Aotearoa New Zealand. It will be ready for you to enter your action data by June 2023.

Click on the box if you want to find out more.

Land Management Actions Register



End of Catchment story

Please close this browser window and continue with the survey.

Appendix K | StoryMap© – Individual Voice

Digital version of Mark's StoryMap © (Individual Story) - https://arcg.is/0L8Lmj

Rangitīkei – The day to take great strides

The mighty Rangitīkei River carves its way south, from its tussocky headwaters in the Kaimanawa Range to the Tasman Sea, forming majestic canyons and towering cliffs. Taihape, the centre of the Rangitīkei District is world famous for its formal footwear – the gumboot.

The Rangitīkei River is Aotearoa New Zealand’s fifth longest river (253 km).
Its name translates to ‘**The day to take great strides**' which is based on the story of Hau, an ancient Māori warrior.

Hau had been traveling from Taranaki for many days, crossing rivers, trudging through swamps, climbing hills and fighting through bush in pursuit of his errant wife and her lover. Perhaps feeling that those he chased were not far ahead of him, Hau hurried his pace, pushing his body as much as he dared.

Later that day he came upon a particularly beautiful river where he chose to sit and rest for short time.

Looking at the river he gave it a name: **Rangi (the day), tikei (to take great strides).**

Collective action for a healthy river

The people that live in this catchment today are like you and I, true New Zealanders who value their rivers for many reasons.

They love swimming in it and fishing and share the love for their natural environment that sustains them and their children.

The communities that live in the Rangitīkei Catchment stand at the heart of the decision-making when it comes to managing their land and its environment.

It is they who define the boundaries of sub-catchments, which helps them manage their waterways more effectively.

Decisions are made collectively in the Rangitīkei Catchment

Mark

For example, meet Mark.

"I am a third-generation sheep & beef farmer and grew up next to the Moawhango River. As a child I loved catching eels in the river."

One of his favourite places in the catchment are Tikirere Falls.

"It's the sheer beauty of the river there that I love."

Tikirere Falls in the Moawhango Catchment

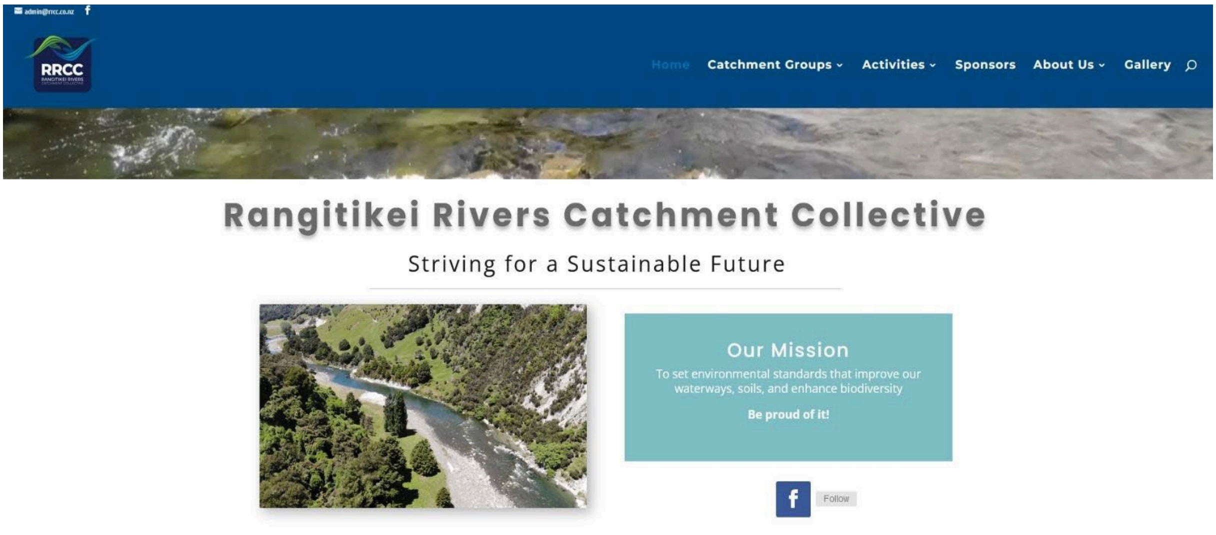
Rangitīkei Rivers Catchment Collective

Mark is also the deputy chair of the Rangitikei Rivers Catchment Collective (RRCC).

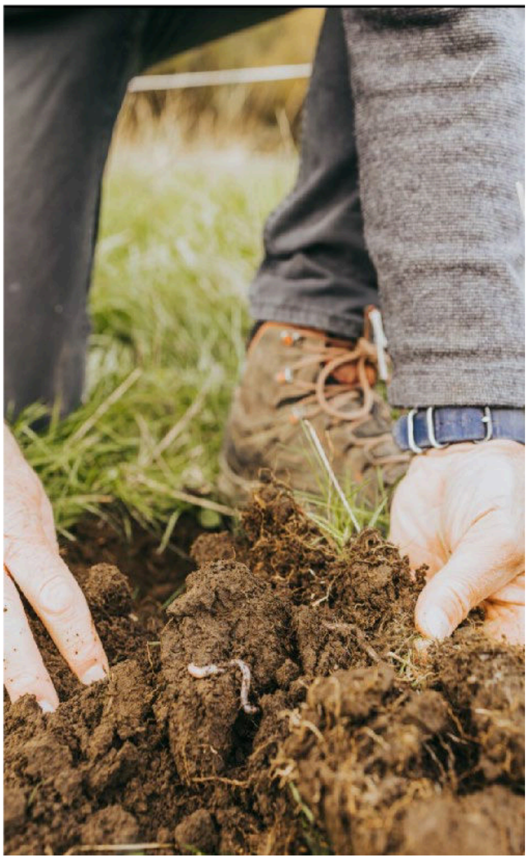
The 400-strong **Rangitīkei Rivers Catchment Collective (RRCC)** is a farmer-led initiative that strives for resilient communities who get together to do the right thing for their environment and future generations.

Mark particularly loves how the Catchment Collective enables him to work together freely with his peers on improving the water quality of their river.

"We now have 85 water quality monitoring sites across our area, which is amazing."



His own catchment, the Upper Moawhango, was the first sub-catchment group within the RRCC. There are now 23 sub-catchment groups altogether.



Their work is richly varied from encouraging and supporting water and soil monitoring, establishing smaller sub-catchment community groups, or managing and protecting biodiversity. The fact that they work together on a common goal that achieves positive environmental outcomes, really boosts their enthusiasm.

Click the box if you want to find out more about the RRCC.

RRCC

The Upper Moawhango Catchment

The Upper Moawhango Catchment group, which is led by Mark, was the first to establish of the 23 sub-catchment groups within the RRCC.

"We established the Upper Moawhango group in August 2018. By December 2018 we took our first water sample."

Mark willingly paid for the first water quality sample, not knowing he would be later reimbursed. He says that the environmental post keeps shifting and with it, our businesses.

"Our farming businesses need to evolve. You can't farm with dads diary."

Paying for this water sample test was only a small sacrifice for him, since it would help him tell his restoration story (and in the end, he got the costs for the sampling refunded anyway).

And their collective efforts and enthusiasm have paid off.

In 2022, they have won the 'Horizons 2022 NZ Landcare Trust Catchment Group of the Year Award'. Mark explains:

"The Award recognises the valuable work that we are doing in the environmental space, showing how far we have come in a short period of time."

In the picture you can see Harriet Gibson (RRCC Catchment Coordinator), Mark Chrystall (RRCC Vice Chairman; catchment lead for the Upper Moawhango catchment group), and Roger Dalrymple (RRCC Chairman) with the Environment Award.

Our lessons learnt

Mark explains that by getting together and sharing knowledge of the things that worked and didn’t work, the RRCC has learnt **three lessons**.

-1-
Employ catchment coordinator

-2-
Have an environmental budget

-3-
Social time off-farm

1. Employ a catchment coordinator: "*95% of the catchment is actively managed by 23 sub-catchment groups. Managing these groups as volunteers is not sustainable. This is why we have decided to* ***employ a catchment coordinator*** *to support our work.*"

2. Have an environmental budget: "*To be able to continue improving the environment on our land, each farm needs to have an* ***environmental budget****."*

3. Social time off-farm for mental health: ***"Getting together off-farm*** *at social events allows us to form a strong bond and talk about issues that aren't necessarily related to freshwater. Especially topics such as mental stress of farming and climate change are often top of mind."*

Our challenges

But like for every good story, Mark highlights that there are some things that work better than others when it comes to restoring complex ecosystems such as the Rangitīkei river.

He mentions **three challenges.**

-1-
Trying to get 'bums on seats'

-2-
Ongoing funding

-3-
Lack of model for catchment size

1. Bums on seats: "*Because our catchment has been actively restoring for about five years now, overall 'workshop fatigue' has caused things to slow down a bit. So **trying to get 'bums on seats'** is one of our challenges.*"

2. Ongoing funding: *"We have restricted funding for the next three years, but it is unclear where **new funding** will come from after that."*

3. Lack of 'model for overall catchment size': *"Our catchment is quite large with over 700,000 ha. Because there is **no model for overall catchment size**, hitting the 'sweet spot' in terms of admin efforts is a challenge. For example, in large catchments, people have the ability to get away with not restoring their land (something the RRCC wants to avoid). In contrast, small catchments have comparatively high levels of administration, which is labour intensive."*

Water quality testing

But Mark is optimistic and focuses on the greater benefits, such as their 'own' water quality testing programme.

"Every month, we sample 85 water quality sites across 23 sub-catchments. This is in addition to the 40 sites that the regional council samples."

The additional sampling provides a more detailed picture of water quality for the catchment which enables landholders to target place-specific water quality pressures that might otherwise not get picked up from council water quality monitoring sites.

Water samples are collected at 85 sites by the catchment group and sent to a government approved agency.

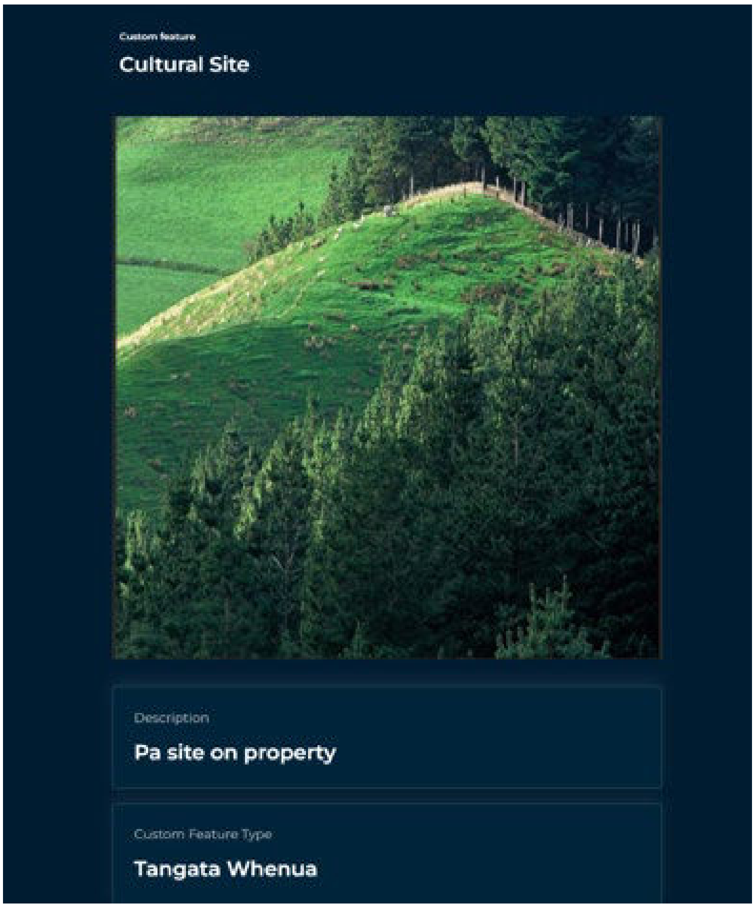
Samples are tested for Nitrate, Soluble Inorganic Nitrogen, Dissolved Reactive Phosphorus, Turbidity, and *E. coli*.

You can find detailed information about the councils State of the Environment water quality monitoring sites in the interactive map below.

Catchment plan

Monitoring water quality is an important part of restoring river catchments, but so is monitoring land management actions. Mark explains that:

"This is why the Upper Moawhango is developing a catchment plan that also covers land management actions."



The actions recorded include length of waterways fenced, stock numbers in the catchment and critical source areas.

But Mark recognises that there is more to a healthy catchment than land management.

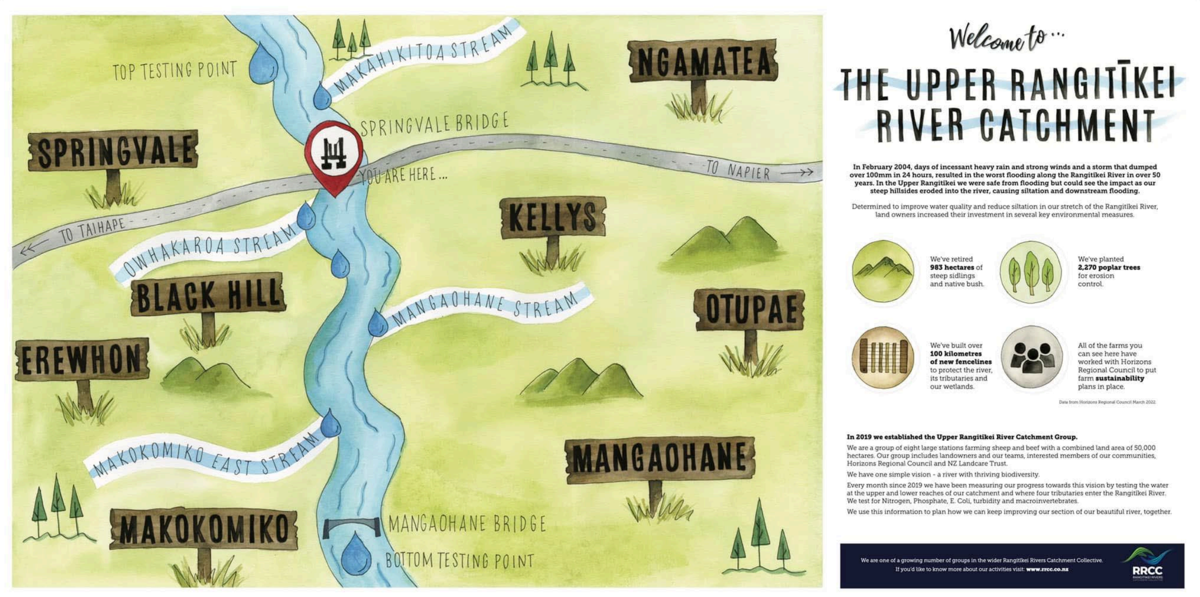
"That's why the catchment plan also includes values in a broader catchment context, for example values such as historic pa sites and the principles of Te Mana o te Wai."

Mark proudly points out that:

"The way we establish this catchment plan is groundbreaking, because we did it of our own accord, rather than through top-down incentives."

Sub-catchment-scale land management

The Upper Rangitīkei, like the Upper Moawhango, is another sub-catchment group within the RRCC. The community in this catchment has been determined to reduce siltation in their stretch of the river since 2019.



The storyboard summarises where water quality is being sampled in the sub-catchment and what land management actions have been achieved to date.

Since then, the sub-catchment has:

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Click on the box if you want to find out more.

Land Management Actions Register

The End

Close this tab and
go back to the
survey tab

End of Catchment story

Please close this browser window and continue with the survey

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KĀI TAHU

Wednesday, 12 February 2020
Professor Nancy Longnecker
Centre for Science Communication
University of Otago
PO Box 56
Dunedin 9054

Tēnā Koe Professor Nancy Longnecker,

A New Zealand register of sustainable land use actions to improve water quality

The Ngāi Tahu Research Consultation Committee (the Committee) met on Tuesday, 11 February 2020 to discuss your research proposition.

By way of introduction, this response from the Committee is provided as part of the Memorandum of Understanding between Te Rūnanga o Ngāi Tahu and the University. In the statement of principles of the memorandum it states ″Ngāi Tahu acknowledges that the consultation process outline in this policy provides no power of veto by Ngāi Tahu to research undertaken at the University of Otago″. As such, this response is not ″approval″ or ″mandate″ for the research, rather it is a mandated response from a Ngāi Tahu appointed committee. This process is part of a number of requirements for researchers to undertake and does not cover other issues relating to ethics, including methodology they are separate requirements with other committees, for example the Human Ethics Committee, etc.

Within the context of the Policy for Research Consultation with Māori, the Committee base consultation on that defined by Justice McGechan:

"Consultation does not mean negotiation or agreement. It means setting out a proposal not fully decided upon; adequately informing a party about relevant

information upon which the proposal is based; listening to what the others have to say with an open mind (in that there is room to be persuaded against the *proposal); undertaking that task in a genuine and not cosmetic manner. Reaching a*

NGĀI TAHU RESEARCH CONSULTATION COMMITTEE
TE KOMITI RAKAHAU KI KĀI TAHU

decision that may or may not alter the original proposal."

The Committee commends the submission which addresses the concerns for Māori and offers practicable solutions for sustainable land use information of value to all users.

The Committee also commends the researchers on the thought that has gone into future policy regarding land use in Aotearoa.

The Committee supports the contact with mana whenua when conducting surveys and assessment of actions.

The Committee suggests dissemination of the research findings to Te Rūnanga o Ngāi Tahu as well as to individual iwi/hapū.

This letter of suggestion, recommendation and advice is current for an 18-month period from Tuesday, 11 February 2020 to 11 August 2021. The Committee would appreciate receiving a copy of the research findings.

The recommendations and suggestions above are provided on your proposal submitted through the consultation website process. These recommendations and suggestions do not necessarily relate to ethical issues with the research, including methodology. Other committees may also provide feedback in these areas. Nāhaku noa, nā

Claire Porima

Claire Porima
Manager, Māori Research Consultation; Senior Project Manager
Office of Māori Development
Te Whare Wānanga o Otākou
Ph: +64 3 4798081
Email: claire.porima@otago.ac.nz
Web: www.otago.ac.nz

The Ngāi Tahu Research Consultation Committee has membership from:

Te Rūnanga o Ōtākou Incorporated
Kāti Huirapa Rūnaka ki Puketeraki
Te Rūnanga o Moeraki

Appendix M | University of Otago Human Ethics Approval Letter

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

D20/037

Academic Services
Manager, Academic Committees, Mr Gary Witte

20 February 2020

Professor N Longnecker
Centre for Science Communication
133 Union St East

Dear Professor Longnecker,

I am writing to confirm for you the status of your proposal entitled "**A New Zealand register of sustainable land use actions to improve water quality**", which was originally received on February 4, 2020. The Human Ethics Committee's reference number for this proposal is **D20/037**.

The above application was Category B and had therefore been considered within the Department or School. The outcome was subsequently reviewed by the University of Otago Human Ethics Committee. The outcome of that consideration was that the proposal was approved.

Approval is for up to three years from the date of HOD approval. If this project has not been completed within three years of this date, re-approval must be requested. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing.

Yours sincerely,

Gary Witte

Mr Gary Witte
Manager, Academic Committees
Tel: 479 8256
Email: gary.witte@otago.ac.nz

UNIVERSITY OF OTAGO HUMAN ETHICS COMMITTEE APPLICATION FORM: CATEGORY B

(Departmental Approval)

1. University of Otago staff member responsible for project:

Prof Nancy Longnecker

2. Department/School:

Centre for Science Communication

3. Contact details of staff member responsible:

Phone: +(64) 3 4797885

Email: Nancy.longnecker@otago.ac.nz

Address: 133 Union Street East

PO Box 56

Dunedin 9054

4. Title of project:

A New Zealand register of sustainable land use actions to improve water quality

5. Indicate type of project and names of other investigators and students:

Staff Co-investigator ☑ **Names** Hugh Campbell

Student Research ☑ **Names** Katharina Doehring

Level of Study (e.g. PhD, Masters, Hons) PhD

External Research ✓ **Names**

Marie McCarthy

SCION

Institute/Company

6. When will recruitment and data collection commence?

As soon as approved

When will data collection be completed?

31 December 2022

7. Brief description in lay terms of the aim of the project, and outline of the research questions that will be answered (approx. 200 words)**:**

This research is part of the Our Land and Water National Science Challenge (OLW NSC) and aims to set up a national online register on sustainable land use actions (SLUA) to improve water quality throughout Aotearoa New Zealand. The research will inform the design and content of this register by determining the most effective and meaningful ways of setting up this online tool. The register will be a new 'module' on the online tool 'Land, Air Water Aotearoa (www.lawa.org.nz)' which is Aotearoa New Zealand's largest environmental reporting platform.

Most commonly applied SLUA in Aotearoa New Zealand include riparian management (e.g., fencing and planting of riparian areas) and soil conservation practices (e.g., wintering practices of stock to reduce sediment flushing into rivers, construction of sediment retention ponds). Recording and reporting SLUA in one place at a national scale is an Aotearoa New Zealand-first, and this study's findings will synthesise what sustainable land use actions have been applied by land managers in the past, encourage them to adopt sustainable land use practices in the future and eventually inform stakeholders about which restoration actions are most cost-effective to improve water quality at a catchment scale. Stakeholders include Aotearoa New Zealand land managers covering primary industry (e.g., dairy, beef & lamb farmers, forestry), community groups (e.g., NZ Landrace Trust) and iwi (e.g., Te Tau Ihu).

The research covered by this ethics application aims to answer the following research questions:

- *What questions do stakeholders have about sustainable land use management practices and their effects on water quality?*
- *How can we best answer them to encourage informed decision making?*
- *How can information be collected for the national register?*
- *How can the register be set up to be most useful for its users?*

8. Brief description of the method.

This research will adopt qualitative research methods. Data will be collected from three different groups of data providers as understanding and interest in setting up a SLUA register will differ amongst and between each group. The data recording of SLUA will be restricted to four pilot river catchments: One of the Te Arawa Lakes catchment; a Taranaki ring plain catchment; Motueka Catchment and Pomahaka Catchment.

1) Expert panel: As part of the OLW NSC project, a steering group has been set up since the start of the project in January 2019, consisting of 'strategic decision-makers' including Department of Conservation managers, Ministry for the Environment staff, representatives of the dairy and beef/lamb sectors, regional council managers and Māori researchers. Experts who are part of this group (up to 5) will be asked to participate in **semi-structured face-to-face interviews** (Appendix 1). This first set of interviews enables us to build relationships and project awareness amongst key stakeholders and to query experts at an industry-body level.

2) Individual land managers: A similar set of questions as for 1) will be asked to individual land managers who represent the 'people on the ground'. **Semi-structured face-to-face interviews** will be conducted with individual land managers from different industries via Skype or in person at a time and place convenient for the interviewee. The questions will be more specific to individuals and their type of land use.

   Landowners will also be asked to provide two photographs of their land that can show successful SLUA done to improve water quality on their land, unsuccessful actions done, parts of their land where land management practices need to change or have been changed, etc. This interview method is known as 'Photovoice' which is an action-oriented methodology with the premise that the individuals being studied have expertise to share, using photos to record their reality (Wang *et al.* 1997). Photos have the benefit of providing data collection of the specific culture or experience being studied.

3) Freshwater catchment care groups: **Focus-group** discussions will be conducted within existing freshwater catchment care groups. There will be four focus group meetings (one per pilot catchment) with up to 10 participants.

Interviews will last between 30 - 60 minutes (for 1 &2), and between 2-3 hours (for 3). All data collected from the interviews/groups will be qualitatively analysed from interview transcripts. All voice recordings and transcripts will be securely stored using Syncplicity which can only be accessed by the researchers. The person who will be contracted to transcribe some of the interviews has signed a confidentiality agreement. Anonymised data will be stored on a password protected Cawthron Institute server which can only be accessed by the researchers and selected Our Land and Water NSC project members. Data files will be retained for five years or longer if required for publication in a peer-reviewed journal. Each interview transcription will be summarised; a summary and key quotes will be provided to each participant within two months of their interview for member checking. A summary report or presentation will be provided to all participants at the conclusion of the project.

Māori stakeholders will be asked to participate as part of these interviews. All research involving Māori will be guided and supervised within the wider partnership agreements established by both Cawthron more generally, and through the Our Land and Water National Science Challenge (NSC OL&W) project which has all relevant Māori collaboration frameworks established and gives effect to the Māori world view 'te ao Māori' and 'Vision Mātauranga'. More specifically, the Challenge governance and management structures require respectful practices and Māori partnerships and operate under the Government's Vision Mātauranga strategy (MBIE, 2015). The Our Land and Water NSC requires a dedicated te ao Māori lead for each project which has been established as part of our research.

Guidance will be sought from each organisation involved in the steering group about who within their organisation should be interviewed. This will include iwi partners in guiding who should participate and how Māori research will be undertaken. This project aims to interview between two to three iwi-led enterprises and partnerships along with individual Māori land-users in the relevant catchments. Consequently, an important first phase of the research is to enable a secure process for involving Māori participants in the project. For the interview process in the project, the project's te ao Māori lead Marie McCarthy is an experienced Māori researcher who will co-lead the interviews with Māori respondents along with the student researcher, Katharina Doehring.

All participation is limited to adults (>18 years). Prior to the interview, participants will be reminded about the protocol and asked to sign a consent form (attached). This form describes the voluntary nature of the interview and addresses the confidentiality of the data. Participants have the opportunity to confirm or decline, as well as end the interview at any time. There will be no pressure, explicit or implicit, on people to participate and no consequences for non-participation. Respondents will be allowed to withdraw from the study at any time up to 4 weeks after receiving their interview summary. Names and identifying details will be collected as part of the interviewing process but will be stripped from the data files when published. Interviewees will be identified only by broad industry categories (e.g., dairy industry, horticultural farmer) and any verbatim quotes only used with consent.

The researchers will be contactable by phone or email for any further discussions, queries or relevant updates. It is anticipated that the PhD thesis and subsequent findings will be publicly available at the University of Otago library and online.

Reference: Wang C, Burris MA 1997. Photovoice: Concept, Methodology, and Use for Participatory Needs Assessment. *Health Education & Behavior.* 24: 369-387.

9. Disclose and discuss any potential problems and how they will be managed:

Physical or psychological dangers to respondents from their involvement in the research is not anticipated, and no medical or other insurance has been arranged. There is some risk that a respondent or their employer could be embarrassed if they say something damaging to themselves, their company or to a third party and their identity becomes known. This risk will be mitigated by not identifying individuals or the companies they work for, and by offering respondents a chance to review material from the interview, and to withhold sensitive information or comments.

***Applicant's Signature:**

Name (please print): …………Nancy Longnecker

Date: 9 December 2019

**The signatory should be the staff member detailed at Question 1.*

ACTION TAKEN

X Approved by HOD   Approved   by Departmental Ethics Committee   Referred to UO Human Ethics Committee

Signature of **Head of Department:

under delegated authority of the HOD

Name of HOD (please print): Fabien Medvecky

F.

Date: 9/12/2019

**Where the Head of Department is also the Applicant, then an appropriate senior staff member must sign on behalf of the Department or School.

Departmental approval: *I have read this application and believe it to be valid research and ethically sound. I approve the research design. The research proposed in this application is compatible with the University of Otago policies and I give my approval and consent for the application to be forwarded to the University of Otago Human Ethics Committee (to be reported to the next meeting).*

Appendix O | Amendment to Ethics Approval – 2023

D20/037

UNIVERSITY of OTAGO
Te Whare Wānanga o Otāgo
NEW ZEALAND

Academic Services
Manager, Academic Committees and Services, Mr Gary Witte

23 February 2023

Professor N Longnecker
Centre for Science Communication
133 Union St East

Dear Professor Longnecker,

I am again writing to you concerning your proposal entitled "**A New Zealand register of sustainable land use actions to improve water quality**", Ethics Committee reference number **D20/037**.

Thank you for your email dated 23 February 2023. The Committee accepts and approves the outlined amendments. Our records have been updated accordingly.

Your proposal continues to be fully approved by the Human Ethics Committee. If the nature, consent, location, procedures or personnel of your approved application change, please advise me in writing. I hope all goes well for you with your upcoming research.

Yours sincerely,

Mr Gary Witte
Manager, Academic Committees and Services
Tel: 479 8256
Email: gary.witte@otago.ac.nz

c.c. Assoc. Prof. J M Bering Director Centre for Science Communication

Appendix P | Cawthron Institute Ethics Application and Approval

Research Ethics application– Cawthron Institute
1. Project name:
What's been done? A national record of land management actions to improve water quality and restore catchments
2. Lead researcher and names of other researchers:
Roger Young (Cawthron Institute) is the programme leader, Kati Doehring (Cawthron Institute) is the science lead, Marie McCarthy/Sylvia Tapuke from July 2020 (SCION)[14] is the te ao Māori lead, Christina Robb (Happen Consulting) is the project manager and implementation lead, Aneika Young (Cawthron Institute) is involved with mana whenua and Māori landowner/manager engagement in the Motueka catchment, and Jonathan Alsop (Effect) provides IT expertise to the project. The lead researcher for the interviews and research component of the project is Kati Doehring. We are also likely to use students as part of the research both through Cawthron or OLW Scholarships and through Master students at Massey University. OpenLab (Massey University) is part of the research team responsible for 'visual design' aspects of the final online tool. All students will be subject to ethics requirements set out in this application, and their signature will be added to the research team signature page at the end of this application and be provided to the Cawthron's ethics committee. Assigned students will also be required to follow Ethics processes as related to their designated universities. .
3. Date by which a decision on this application is required in order that the project can proceed as planned, if approval is required:
As soon as possible
4. Expected date of completion:
Contracted to 30 June 2022.
5. Sources of funding: [The organisation, individual or group funding the study.]
MBIE – Our Land and Water National Science Challenge (OLW NSC)

[14] Marie McCarthy left the project in mid-June 2020 and will be replaced once a candidate is approved by Our Land and Water. Nevertheless, she has been instrumental in the design of the interview approach and questions.

6.	What conflicts of interest – real, potential or perceived – do the researchers or their employers or funders have in this research? How will this be acknowledged and managed?

All members of the research team are involved in consultancy and research projects on related topics, with organisations who are interested in this work and in locations included in this research. Roger Young is a member of the Environmental Monitoring and Reporting group who oversee the quality control and integrity of the LAWA website. We do not consider these connections pose any real or potential conflicts of interest.

However, to manage any concerns or perceptions of conflict, we have and will continue to make all clients and research-funders aware of our participation in this research. To date, our ability to make connections between this research and other aligned initiatives has been viewed as a positive.

No members of the project team have financial interests in the outcome of the project.

7.	**Does the project require ethical/cultural approval by other bodies? If yes, please name the other bodies, and confirm that you have appropriate permissions:** [Research undertaken with, within, or for iwi organisations, universities, and other groups may require special permission or ethics approval.]

This project already holds two approved ethics applications and one Māori consultation approval.

1) University of Otago Category B Ethics (D20/037) as part of Katharina Doehring's study for her PhD in Science Communication
2) SCION as submitted by Marie McCarthy under SCION project contract J04900
3) University of Otago Ngai Tahu research Consultation Committee approval

All three documents are attached to this application and are relevant for separate sections and (sub-) tasks of this research project. However, the research team felt that there is no over-arching ethics application which covers the entire width and depth of this national project. We therefore decided to file a separate ethics approval under the Cawthron ethics procedures which will cover the entirety of this research project, including in-depth and detailed ethics relevant to Māori.

Individual students involved in this research project may also require ethics approval from their own organisation.

We also anticipate that there may be specific requirements in the Motueka and Te Arawa catchments where we are working in co-design with Māori research partners. This involves both mana whenua and Māori landowners/managers. It is important to us to social the ethics with mana whenua and allow adjustments/additions at part of our co—design approach. Any additional requirements will be documented and agreed as part of the design. We anticipate these will be additional requirements and consistent with the ethics approach in this application. However, once we have confirmed arrangements with partners, the programme leader (Roger Young) and Cawthron's Māori Business manager (Anaru Luke) will confirm alignment or suggested changes to the project ethics.

8.	**Relevant skills and experience of researchers in research with human participants:** [Provides an indication of whether the team has the appropriate social research knowledge and experience to undertake the project, or if not, how they will be supported by people with appropriate skills, e.g., an independent professional facilitator.]

Three team members have been involved in designing the interview framework and will be involved in the interviews.

1. Marie McCarthy is a social researcher with extensive interview research and experience. She has experience in sociological intersections and complexities between competing groups and interests; social and cultural resilience; social impact and research evaluation and qualitative research with a specific focus on Māori. She has been a member of the ethics committee at Victoria University of Wellington and AUT (Auckland).
2. Sylvia Tapuke has now replaced Marie McCarthy. Sylvia is a researcher - Kairangahau Māori - at SCION with a background in land resources science and the education sector.
3. Kati Doehring is a senior freshwater ecologist with wide-ranging experiences in freshwater restoration and science communication. Kati has been working closely with Marie in the design phase of the interview process. As part of her PhD research in Science Communication, Kati is supervised by Dr Nancy Longnecker, Professor of Science Communication and Dr Hugh Campbell, Professor of Sociology at Otago University. Both have overseen numerous social research projects that examine attitudes and behaviour change towards science related issues and closely collaborate with Kati on her research design and methods.
4. Aneika Young is an experienced Māori researcher who will lead the interviews with Māori respondents in the Motueka catchment – she is our te ao Māori lead for the Motueka work. She specialises in Māori Resource Management and Environmental Science and sits in the Māori Business Development team within Cawthron assisting the connection between Mātauranga Māori and Western Science discourse. She is connected locally to the Motueka whānau and hapū and has a strong understanding of te ao Māori and tikanga as well as the local issues for Māori in the freshwater space. She also works within wider Māori networks across Aotearoa.

All project partners have extensive national networks and experience across government, research, and private sectors in Aotearoa New Zealand. These networks will help ensure awareness of the project and invite participation and information sharing with regards to any ethics related topics throughout the project. Christina Robb convenes the project steering group.

9.	**Purpose of study and scientific rationale:** [Describe the aims and objectives of the study. If this investigation has been done previously, why repeat it?]

This research is part of the Our Land and Water National Science Challenge (OLW NSC) and aims to set up a national online register on land management actions to improve water quality throughout Aotearoa New Zealand. The research will inform the design and content of this register by determining the most effective and meaningful ways of setting up this online tool. The register will be a new 'module' on the online tool 'Land, Air Water

Aotearoa (www.lawa.org.nz)' which is Aotearoa New Zealand's largest environmental reporting platform.

Most commonly applied land management actions in Aotearoa New Zealand include riparian management (e.g., fencing and planting of riparian areas) and soil conservation practices (e.g., wintering practices of stock to reduce sediment flushing into rivers, construction of sediment retention ponds). Recording and reporting land management actions in one place at a national scale is an Aotearoa New Zealand-first, and this study's findings will synthesise what sustainable land use actions have been applied by land managers in the past, encourage them to adopt sustainable land use practices in the future and eventually inform stakeholders on which restoration actions are most cost-effective to improve water quality at a catchment scale. Stakeholders include Aotearoa New Zealand land managers covering primary industry (e.g., dairy, beef & lamb farmers, forestry), community groups (e.g., NZ Landcare Trust) and iwi/hapū/whānau (e.g., Te Tau Ihu o te Waka a Māui iwi, hapū, whānau).

The research aims to answer the following research questions:

1. *What questions will the online register help iwi/Māori and stakeholders answer and how can we design the register to best answer them and encourage its future use?*
2. *What is a consistent set of indicators that can be used to quantify mitigation actions over time?*
3. *How can the register help with data limitations?*
4. *How can we best share the information from the register and associated learnings?*

10. Design of study – methods and participants

a. Describe briefly **what will be done** and how research subjects are expected to participate.

A co-design ethic underlies our approach, and we are using an extensive set of networks and a national steering group, alongside interviews and focus groups. Co-design builds our confidence that the register meets expectations and needs, and allows us to identify and address obstacles.

Our study includes four main components with human interaction:

1. Participation of local land managers, mana whenua, council staff, and the public (from four pilot catchments) in interviews and potentially local focus groups, twice over 2020-2022). In the Motueka and Te Arawa pilot catchments, there will be a wānanga involving mana whenua and Māori landowners/managers. These wānanga will report back on collective findings, address any issue of confidentiality concerns particularly with Mātauranga Māori, and seek views on options for presentation of data from the national register.
2. Working with existing Māori networks with iwi/hapū/whānau to ensure we have a Māori perspective from other rohe than the pilot catchments. This would include the cultural roles of kaitiaki and application for cultural processes and practices.
3. A national steering group of primary and environmental sector, council and government representatives 2019-2022
4. Discussions with potential data providers such as levy organisations (e.g. Beef and Lamb), companies (e.g. Fonterra) and providers of electronic farm environment plan platforms (e.g. regional councils and FarmIQ).

For interviews and focus groups, we will adopt qualitative research methods as per Wang C, Burris MA 1997. Photovoice: Concept, Methodology, and Use for Participatory Needs Assessment. *Health Education & Behavior.* 24: 369-387. See also Pihema http://www.rangahau.co.nz/rangahau/180/;

Key informant interviews

Key informant interviews with mana whenua, land managers (including Māori landowners/managers), the public, and council staff will occur in four pilot catchments: 1) Motueka River (Tasman), 2) Pomahaka River (Otago), 3) Te Rerewhakaaitu (Bay of Plenty), 4) Waingongoro (Taranaki). These will be semi-structured face-to-face interviews conducted via an online video-platform (e.g. ZOOM, Skype or MS Teams) or in person at a time and place convenient for the interviewee.

Landowners will also be asked to provide photographs of their land that can either show examples of successful land management actions done to improve water quality on their land, unsuccessful actions done, parts of their land where land management practices need to change or have been changed, etc. This interview method is known as 'Photovoice' which is an action-oriented methodology with the premise that the individuals being studied have expertise to share, using photos to record their reality (Wang *et al.* 1997). Photos have the benefit of providing immediate and in-the-moment data collection of the culture or experience being studied.

Participants can agree to be involved in follow-up interviews, which will be conducted as either face-to-face interviews or in the form of a semi-structured workshop held in a location convenient to participants and their peers. The general line of questioning will focus on answering research questions 3 and 4 (i.e., on data confidentiality and how the future use of the register can be ensured and how associated learnings can be shared effectively).

Local Focus groups/wānanga in pilot catchments:

Focus groups to workshop and test findings and early options for the register will be conducted with existing freshwater catchment care groups in the pilot catchments Focus-group discussions will be conducted utilising a semi-structured interview style approach. There will be four focus groups with up to 8 participants.

We will also conduct wānanga with mana whenua and Māori landowners/managers in the Motueka and Te Arawa pilots. The size of these will be determined in discussion with mana whenua. These wānanga will report back on collective findings, address any issue of confidentiality concerns particularly with Mātauranga Māori, and seek views on options for presentation of data from the national register.

National Māori networks – perspective of iwi/hapū/whānau across Aotearoa New Zealand

At the national scale, our proposal anticipated a National Māori Advisory group to ensure we had a Māori perspective from other rohe than the pilot catchments. In discussions with OLW that approach has since been replaced by connection into existing Māori networks s addressing data confidentiality, register 'rules', data presentation and recording.

Project steering group:

As part of the OLW NSC project, a steering group consisting of 'strategic decision-makers' including Department of Conservation, Ministry for the Environment, Ministry of Primary Industries, Dairy NZ, Beef and Lamb NZ, Fertilizer NZ, Ngāi Tahu, regional council (science, land monitoring and IT managers), NZ Landcare Trust and Māori researchers has been set up since we started scoping the project in January 2019.

National sector representatives who are part of this group were asked to participate in individual semi-structured face-to-face interviews (refer to key informants description above). This first set of interviews enabled us to build relationships and project awareness amongst key stakeholders and to query national sector representatives at an industry-body level. These interviews were conducted in January – April 2020 and were covered by the Otago University Ethics approval.

Data providers

We will hold discussions with potential data providers – predominantly primary sectors and regional councils. Data provider discussions will contribute to data confidentiality constraints, data availability and transfer protocols. Discussions will not use a structured interview, but any data provided will be subject to appropriate confidentiality constraints as covered by this ethics application.

b. Describe **who will take part**, **how many**, and **how they will be chosen** and/or recruited, e.g. the approach used to identify and select stakeholders. **If Māori are involved**, describe any engagement you have undertaken or plan to undertake with iwi/hapū or other Māori entities about this research.

Participants are recruited through pre-established networks, targeted sampling and snowball technique (Patton 2002). Participants are provided with a written overview of the project prior to participation. Further, the project objectives are explained prior to interviews commencing, allowing time for any queries and questions.

Negotiating entry into the Māori community spaces will be achieved through established networks. In all three catchment areas, key mana whenua individuals will be contacted. We have adjusted the questions to align with local kaupapa based on our strong connections with Motueka hapū, and will co-design an approach with Te Arawa. Through these networks, advice was and will be gained as to appropriate approaches and who should be contacted.

Selection of pilot catchments and land managers

The selection of pilot catchments was undertaken in consultation with the project steering group. Māori research partners Wakatū Incorporation, Cawthron Māori Business Development and Research team and Te Arawa provided advice on catchments within their rohe. Other catchments were selected to cover a range of land use mixes, and catchments with active restoration programmes. Contacts for land managers were provided by regional councils, mana whenua and organisations such as the New Zealand Landcare Trust.

Project steering group

The project steering group was selected at the scoping stage of the project in consultation with the OLW NSC. Participants have suggested further membership where there were obvious gaps, and we continue to be open to suggestion. Organisations such as Horticulture NZ who have chosen not to participate in the Steering group are still kept informed of the project. The project steering group has developed and approved a terms of reference.

National sector interviews

Guidance will be sought from each organisation involved in the steering group on who within their organisation should be interviewed.

Structured interview with Māori participants and Māori focus groups

All research involving Māori will be guided and supervised within the wider partnership agreements established by both Cawthron more generally, and through the Our Land and Water National Science Challenge (NSC OL&W) project which has all relevant Māori collaboration frameworks established and gives effect to 'te ao Māori' and 'Vision Mātauranga'. More specifically, the Challenge governance and management structures require respectful practices and Māori partnerships and operate under the Government's Vision Mātauranga strategy (MBIE, 2015). The Our Land and Water NSC requires a dedicated te ao Māori lead for each project which has been established as part of our research.

Research partners are guiding who should participate and how Māori research will be undertaken. This project aims to interview between two to three iwi-led enterprises and partnerships along with individual Māori land-users in the relevant catchments. Consequently, an important first phase of the research is to enable a secure process for involving Māori participants in the project. This engagement is being led by the project's te ao Māori lead Marie McCarthy[15] and Māori researcher Aneika Young.

c. Is there any sense in which a participant might be required (or feel obliged) to participate? It must be made clear to participants that participation is **voluntary**, and entitlement to withdraw consent must be indicated along with the date when that entitlement lapses.

All participation is voluntary, and participation may be ended at any time without question. Prior to the interview, participants will be reminded about the protocol and asked to sign a consent form (attached). This form describes the voluntary nature of the interview and addresses the confidentiality of the data. Participants have the opportunity to confirm or decline, as well as end the interview at any time. There will be no pressure, explicit or implicit, on people to participate and no consequences for non-participation. Respondents will be allowed to withdraw from the study at any time up to 4 weeks after the interview. Names and identifying details will be collected as part of the interviewing process but will be stripped from the data files once transcribed. Interviewees will be

[15] See earlier note about that Marie has left SCION and will be replaced as soon as possible

identified only by broad industry categories (e.g., dairy industry, horticultural farmer) and any verbatim quotes only used with consent. All participation is limited to adults (>18 years).

Focus group participants will be addressed the same way as individual interviewees and will sign a consent form. For iwi/hapū/whanau focus groups, additional kaupapa may be added to ensure cultural safety of participants and the project team.

Consent forms are attached.

d. Briefly describe the intended **data analysis methods** for the data collected.

Structured interviews and focus groups

Voice recordings will be transcribed and qualitatively analysed following a thematic content analysis framework.

Each interview transcription will be summarised; a summary and key quotes that are relevant to the write up will be extrapolated. Identified quotes and the context associated with the quote (conversation) will be sent to each participant for review within three months of their interview for member checking. A summary report or presentation will be provided to all participants at the conclusion of the project.

Māori interviews will be recorded. Each recording will be sent back to the participants for review. These wānanga will report back on collective findings, address any issue of confidentiality concerns particularly with Mātauranga Māori, and seek views on options for presentation of data from the national register.

Project steering group

Notes of the project steering group are taken during the meeting and circulated to the steering group within two weeks. All comments/feedback are anonymised. The notes are available for circulation beyond the group.

11. How much time are participants expected to give to the project?
[Need to ensure that this is realistic and considerate of stakeholders' input.]

Face-to-face interviews will last between 50-80 minutes. Focus groups are intended to be 1.5 – 2 hours.

The project team appreciatively recognises the time interviewees have already spent on this research project during the first round of interviews. The researchers will therefore further highlight the voluntary nature of these follow-up interviews with the ongoing option to withdraw from any interview.

The project steering group will meet 5 times during the project for one-day workshops. They are also available to the project team for phone discussions on an as needed basis.

12. Is any deception involved in the study?
[This will not be applicable to many studies. It covers things such as the use of placebos in medical research. In social research, deception could be involved if participants are not told

	the real purpose of the research or if they are given information that is presented as true when the researcher knows that it is not.]
No deception is involved.	
13.	**What are the anticipated benefits to participants from their involvement in the research?**

The benefits to participants arise from the development of the register and LAWA platform.

The land management register will be another layer to the LAWA platform and as such will be of benefit to land-users, farmers, community groups, iwi/hapū/whānau, Māori land trusts, industry, local council and all other groups that have an interest in water quality and sustainable land action. The project envisages that farmers, mana whenua, and community groups will be enabled to learn from sustainable land action undertaken with a view that others may also adopt forms of uptake. The farms that participate within catchments areas will contribute to an overarching catchment 'picture' of the extent to which sustainable land-use action has been implemented and the impacts of actions.

We have funding within the project to develop outputs identified by mana whenua in the Motueka and Te Arawa pilots. Part of the process of engagement will allow identification and co-design of an output, data provision or a capability opportunity specific to mana whenua, reflecting a philosophy of giving back in return for participation of the research. We recognise that Mātauranga Māori is a taonga to mana whenua and will respect that taonga in all aspects of this project.

The researchers will be contactable by phone or email for any further discussions, queries or relevant updates. It is anticipated that the PhD thesis and subsequent findings will be publicly available at the University of Otago library and online.

We are open to co-authorship opportunities if they arise.

14. **Risks and mitigations:**
[What risks to participants might the research entail, and how will these be mitigated? Are there any potential physical, psychological, cultural, social or disclosure dangers that can be anticipated? Has the individual or target group been subjects of previous research and, if so, is it reasonable to ask them to participate in another study?

Physical or psychological dangers to respondents from their involvement in the research is not anticipated, and no medical or other insurance has been arranged.

Risks relate to three areas;

- Interviews and focus group information
- Mātauranga Māori
- Provision of information on land management actions

Interviews and focus group information

This research is not collecting personal information beyond name and job position. Detailed questions will be asked surrounding views and perceptions as related to the development of a national water register. Specifically, seeking to establish criterion on data exclusion and inclusion and rationale for such. There is no identified harm (no risk of criminal or civil liability, harmful retaliation, emotional or financial, employability, or reputation) to participants from this study. Some information may be considered commercially sensitive. Participants will not be obliged to share information that places themselves and/or business in jeopardy.

The primary risk for this type of research arises from being recorded, analysed and reported in a way that might reveal participants' identity and/or strain participants' relationships with others. To mitigate this, we will ensure confidentiality of participants through our data interpretation and reporting practices, and we will clearly inform participants that they can revoke their participation at any time without personal consequence. If there is difficulty in anonymising identity, we will either i) seek express permission from the quoted participant to use the material in a named way, and/or ii) abstract the quote by paraphrasing or generalising to a wider issue.

There is some risk that a respondent or their employer may be held in an untenable position given the information that has been shared either purposefully and/or unintentionally. This is mitigated through the adopted process of sending key quotes and the context of the quotes (as existing in transcripts) back to the respondents for review prior to forms of inclusion.

Mātauranga Māori

Interviews with mana whenua or Māori landowners/managers may discuss Mātauranga Māori that is sensitive. Interviewees will be able to identify sensitive information at any point. To protect those individuals interviewed, findings from the interviews will be reported back to the interviewee and findings will be presented to a collective of mana whenua via wānanga to ensure that any confidential information is identified and that the project team understands sensitivities. As part of those discussions, we anticipate confirming a process for approving any information that goes into the public arena.

Information on land management action

The final version of the register will report information publicly but will be able to keep some data anonymous and confidential particularly at a local scale – those details will be refined during the design. There is therefore a risk that as we develop and demonstrate options for the register that we might present options which do not meet the confidentiality expectations of those who have provided data.

We will mitigate this risk by ensuring that anyone who provides data for the purposes of testing and demonstrating the register will have control over the use of that data. Further, the checking back process as planned for the key informant and focus group interviews will help mitigate against the inclusion of data that is sensitive.

There is also a risk arising from the close connection of land management data with compliance data – regional rules and the new National regulations for freshwater. We are being very clear that the register is not a compliance tool and will not report at a scale that enables its use for individual compliance assessment.

Covid-19

Covid-19 has altered our ability to do face-to-face interviews in some catchments. We have carried out interviews over Zoom and still applied all the ethics protocols. Cawthron and SCION have Covid-19 protocols relating to travel, group numbers, visitors to sites, and protocols when on site that apply at each level of Covid-19 restrictions. All project team members will abide by these, and those of any partner organisation.

15. Confidentiality and anonymity:
[Describe the degree of confidentiality and anonymity to be provided to participants. If the project is promising confidentiality and anonymity, detail the steps taken to safeguard the confidentiality of records and any potential identifying information about participants. If confidentiality and anonymity are not being promised, explain what is being offered and how participants' consent will be obtained.]

Structured interview and focus groups

We will offer confidentiality and anonymity to interviewees, as is standard practice for most social-ecological research, especially where respondents are encouraged to express personal views that may or may not have been approved by the organization for which they work, as in this case. Respondents' organisations will be identified only by broad industry categories (e.g. dairy, sheep & beef, horticulture) so that respondents are not identified by virtue of their company. Respondents will also have an opportunity to review and correct a summary of the transcript of their interview, and to ask that some responses not be used.

Interviews will be treated as confidential, and any quotes used for research will be anonymised unless attribution is expressly permitted in writing by the quote. Notes from correspondence (email, phone calls) will be treated as data but will be anonymised in any research publication unless express permission for attribution is obtained. This will be described in the information sheet issued to all participants, and our intended use of (anonymous/anonymised) quotes will be explained, and consent sought verbally before the interview. Within this permission, the research team must use their judgement to ensure interviewees are protected within this. If quotes provided and used might pose risks for participants, we will either seek explicit permission to use the quote with our categories (e.g. tangata whenua) or we will expand the scale of our category to lower the risks of attribution.

At all stages, Māori interviewees and wānanga participants will be able to identify any confidential or sensitive information.

Interviews will be recorded digitally and stored on Cawthron's secure password-protected server. They will be transcribed by a third-party contractor who will sign a confidentiality agreement that specifies that interview material cannot be shared with anyone outside the research team.

Any personal information held on the participants such as contact details and email addresses will be destroyed immediately after the publication of the research.

16.	**What outputs will be generated by the research, and who owns the intellectual property included in these outputs? e.g. interview material, traditional knowledge, co-produced knowledge that may be reported in a publication.** [Be careful to distinguish between 'background knowledge and IP' – i.e. that which existed prior to the research and is being used or reported in the research, and new knowledge or IP that has been generated by the research.]

There are five main outputs from the research

1. Scientific manuscripts
2. The national register/LAWA module
3. Interview data

Respondents will be invited to identify any responses given or other information shared that is commercially sensitive and not to be quoted or shared. Similarly, Māori respondents will be invited to identify any local knowledge or mātauranga that is shared during interviews and to specify limitations on its use so that their rights will be protected. In addition to signing off that their transcript summary is a correct record, any information identified as sensitive, from Māori participants or others, will only be used with their permission.

4. Output for Māori participants

As well as informing the wider research, there is potential for the data collected from Māori landowners/managers and mana whenua to be reported in an additional report or tool solely for their use, and not publicly available. This approach allows for the possibility of demonstrating how mana whenua could assess confidential Mātauranga Māori alongside the information from the national register. These types of options could arise from co-design in the Motueka and Te Arawa pilots and reflects a philosophy of giving back in return for participation of the research.

5. Data on land management actions

In developing and testing the register we will seek data from regional/national datasets and pilot catchments. Councils, primary sectors and landowners including Māori landowners/managers are likely to provide data to test and demonstrate the register. During the development phase, ownership of that data will remain the property of those who supplied it. All demonstration data will be anonymised, and any use of it beyond reporting back to those who supplied it will require the approval of the data owners and will be shown only to parties approved by the data owners. Those who provided the demonstration data will be able to withdraw data at any time. Data provided for demonstrating and testing processes will not be transferred into the final version of the register without prior approval of the data owners and can only occur when the data access and confidentiality protections have been agreed in writing and are acceptable to the data provider.

Understanding and responding to concerns about confidentiality and data stewardship is a fundamental part of the research. The register is an opportunity for people to tell their stories in their way and must therefore strongly respect confidentiality requirements of those who provide information. Developing access protocols and clarity over data ownership will be part of the register design. Anyone who provides data for the purposes of testing and demonstrating the register will have control over the use of that data.

IP from the project

The Challenge philosophy is to provide open access to data and information to Aotearoa New Zealand communities from Challenge funded investments, whilst having due regard for the rights of third parties and the appropriate protection and management of Intellectual Property.

The New IP created by this project will be scientific manuscripts using interview and focus group information; demonstration versions of the register; and the final register. As noted above, there may also be some reports or tools created specifically for mana whenua which may include information that will be kept outside the public arena.

For clarity, the IP of land management practice information provided to the final register will be determined as part of the register design. The IP of any information provided for demonstration purposes is existing IP and remains with the information provider.

New IP created by this programme will be managed in accordance with the IP Plan in Schedule 3 of the OLW Parties Collaboration Agreement unless otherwise specified in a written contract between the Challenge Contractor and one or more Challenge Parties, or in associated sub-contracts. As per the contract, the programme will aim to maximise national benefit, provide open access to data and information, protect privacy and Mātauranga Māori, provide ownership to the Challenge Parties that generate Intellectual Property, and ensure appropriate protection and management of Intellectual Property.

17. Informed consent:
[Consent may be provided in different ways depending on the research context. These can include written, oral, and proxy (i.e. by a caregiver on behalf of someone else). Describe what form of consent is proposed and why. Where written consent is involved, consent form templates must be included in this application. Where oral consent is proposed, the basic explanatory script that will be communicated to the participant should be provided.]

Written consent forms (attached) will be used for interviews. These will be discussed with the respondent at the beginning of each interview and, respondents will be required to sign the form before the interview. The consent form will also seek permission for the interview to be recorded and transcribed. A written explanation of the project will also be distributed to the participants and time will be allocated at the beginning of the interview to outline the project's aims and objectives. Further, time will also be allocated prior to interview commencing for any questions and queries from participants to be responded to by the interviewer.

18. Data protection and storage:
[How the project will comply with the requirements of privacy and data protection legislation should be disclosed to research participants and reported here. This should include how and where the consent forms and data will be stored pre- and post-project completion; proposed data storage arrangements, degree of security, and any terms and dates of destruction of data.]

All data will be securely stored. The interview data collected will be securely stored on a password-protected drive at the Cawthron Institute in Nelson, New Zealand. Data obtained as a result of the research will be retained for at least 5 years in secure storage. Any personal information held on the participants such as contact details and email addresses will be destroyed immediately after the publication of the research even though the data derived from the research will, in most cases, be kept for much longer or possibly indefinitely. No material that could personally identify participants will be used in any reports on this study without the participant's express consent.

The person who will be contracted to transcribe some of the interviews has signed a confidentiality agreement

19. Are there any plans for future use of the data beyond those already described?
[This should detail whether the data can be stored and used again in the future. Care needs to be taken so that any data used in the future can appropriately be understood "in context". Consideration also needs to be given to the benefits/risks of future use for participants, and how to articulate this in the consent process.]

As outlined above, one output of this research is a national register of actions to improve water quality. The register will be ongoing beyond this project and will require a stand-alone set of protocols around data confidentiality, ongoing maintenance, data entry, data ownership and presentation of information. This ethics application does not cover that ongoing supply and reporting of land-action data in the register.

There are no current plans for future use of the interview data beyond this project. Only members of the research team for this project will have access to the raw data (recordings and transcripts) for this purpose. Data files will be retained for five years or longer if required for publication in a peer-reviewed journal. In 2025, the programme leader (or their successor) will consider whether the data will be destroyed or retained longer, but in any case, the data must be destroyed by 2030 unless further permission is sought and received from the person(s) from whom the data has been collected.

20. Dissemination of findings:
[Outline the process and forms in which research outputs will be shared with participants and publicly.]

Results of this research may be published and will be available on the Our Land and Water website, in the form of scientific manuscripts or in the University of Otago Library (Dunedin, New Zealand) as part of Katharina Doehring's PhD study. Every attempt will be made to preserve anonymity of participants. We will produce technical reports, academic papers, articles for popular media and presentations to conferences or other public events. Participants in interviews and focus groups will be offered copies of any publications.

In consultation with the mana whenua and iwi/hapū/whānau, a hui will be held to present the findings, providing an overview of the proposed platform. Where possible the team will purposefully target conferences/forums/hui that specifically reaches Māori audiences as integral to dissemination processes. At all times the confidentiality of any sensitive Mātauranga Māori will be respected. Only information that has been agreed with mana whenua as appropriate for a public forum will be presented.

21. What steps will you take to ensure that members of the research team understand and comply with the procedures described in this application? Will ethics considerations be reviewed as the project proceeds, and if so, how?
[This is particularly relevant for projects that go on over a longer time period, e.g. have Ethics as a standing agenda item for team meetings.]

Team members are encouraged to contact the programme leader with questions or concerns about ethics procedures as soon as such issues arise. In addition, the research team will include 'ethics considerations' as an agenda item at each project team meeting.

The ethics approach will be reviewed annually as part of the project team annual review of the project and milestones. Moreover, the University of Otago Ethics has been approved for 18 months and will need to be revised in June 2021. This will ensure any changes to the project relevant to the ethics approval process will be reviewed.

Any students conducting work contributing to this project will be provided with this ethics application and taken through it by a member of the project team.

22. Is any other information relevant for considering the ethical issues related to this project?

Nothing further comes to mind.

DECLARATION
The information supplied above is, to the best of my knowledge, accurate.

Signature of researcher: ....

Date: 18/12/20

PEER ASSESSMENT (If applicable – Social research peer reviewer/s to complete)

I, Will Allen, have reviewed the above project in discussion with *Roger Young, Kati Doehring, Christina Robb, Aneika Young and Sylvia Tapuke* on 10 September 2020 and have agreed with the research team that:

✓ The proposal demonstrates robust ethical reflection by the researcher(s) and provides a robust ethical design for the research

☐ ~~The proposal requires further consideration of ethics issues~~

Signature: ....

Title: **Principal, Will Allen & Associates**

Date: **12 December 2020**

This review has been jointly conducted by those named above, with the reviewer asking questions and prompting the researchers to reflect upon, clarify and expand upon, the responses in an earlier draft of this application. The researchers remain responsible for ensuring that appropriate procedures are followed.

23.	**Please provide brief information about the reviewer(s) and their credentials, and a link to their website or pages if applicable.** Reviewers may be contacted about their review by the Cawthron Ethics Committee.

Dr Will Allen - willallennz@gmail.com - is an independent systems scientist and action researcher. He has more than 25 years of experience in sustainable development and natural resource management. He also manages the Learning for Sustainability (LfS) website – https://learningforsustainability.net – as an international clearinghouse pointing to on-line resources around collaboration and adaptation. He has been involved in a number of social research ethics peer review processes over the past decade, and led the team that developed the initial social research ethics protocol for Landcare Research in 2007/8 – which has since been adapted and used in other New Zealand research institutes.

CAWTHRON APPROVAL

This application is approved as meeting the ethics requirements of the Cawthron Institute, as described in the Policy on Ethics in Research involving Human Participants.

Signature of Cawthron Ethics Convenor: James A. Sinner

Name: James A. Sinner

Date: 18 Dec 2020

Approval number: CAW-ETH-200804

The End