The ecology of community environmental groups: Integrating restoration, partnerships and citizen science

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ABSTRACT

New Zealand is facing a biodiversity crisis as forest and wetland habitat loss continue, and the quality of freshwater declines. But in recent years, a grassroots, nationwide network of community environmental groups has been expanding its contribution to restoring, protecting and enhancing these terrestrial and aquatic habitats. At the same time, government agencies are becoming increasingly reliant on voluntary community input to enhance conservation outcomes and to manage freshwater values. Globally, volunteer participation in environmental monitoring (citizen science) is recognised as an important mechanism for producing robust data that contributes to research, management and policy development, and for enhancing scientific and environmental literacy. New Zealand, however, lags far behind international efforts in acknowledging the value of, and uses for, the type of data that community groups undertaking environmental restoration may generate. Furthermore, strategies and policies around supporting community data generation as well as use have not yet been developed at a government level.

This study sought to address this shortcoming by investigating characteristics of New Zealand community environmental groups and their projects, partnerships between groups and their project supporters, and the current and potential roles of environmental monitoring by these groups (i.e., citizen science). Data to inform this investigation was gathered using an online questionnaire sent to 540 community environmental groups across New Zealand, and 34 semi-structured interviews with project partners (e.g., resource managers and scientists), including nine interviews with members of four well–established (>10 y) community environmental groups. Qualitative data from the questionnaire and interviews were analysed using inductive and deductive thematic analysis, and

quantitative data from the questionnaire were analysed for frequency counts, chi-square significance and Random Forest modelling.

Most groups surveyed were in existence for ≥ 6 y, small (up to 20 participants), and comprised older participants, aged 51-65 y. Groups reported focussing their restoration efforts on a variety of ecosystem types including forests (64%), streams (42%) and freshwater wetlands (33%), which were mostly situated on agency-owned or administered land (68%, n=290). Over two-thirds of groups combined environmental actions (particularly weed and pest control, and native tree planting), with advocacy and educational activities. The vast majority (93%, n=295) of groups relied on their project partners for support (e.g., site visits, funding and technical support), and reported a need for ongoing support in the future. Groups managing larger areas (≥ 8.1 ha), with medium to high partner support, and working on Department of Conservation or private land were more likely to be conducting their own monitoring. Their data were primarily used to support funding applications (63%; n=151), inform project restoration management, and share results with resource management agencies (both 60%; n=151), and for educational purposes (48%; n=157). Conducting water quality monitoring emerged as a strong area of interest for future work, though groups reported a lack of funding and people (both 45%; n=98), as well as technical skills (31%) as the largest challenges they faced for establishing new monitoring programmes generally. Project partners expressed concern over data quality and highlighted a lack of institutional systems for using community-generated data.

This study provides insights into the methods used by groups to address environmental degradation in New Zealand and the contextual factors that shape their project activities. Enduring partnerships are critical, and more strategic approaches that are designed to support groups and their projects in the long-term are required. Both restoration and citizen science activities by

groups are generally carried out independently of other groups, highlighting the need for improved networks between groups and with key agency project partners in order to: (1) achieve stronger conservation outcomes; (2) quantify restoration gains, and (3) improve the efficiency and efficacy of the limited resourcing available. At the same time, expectations of enhancing groups' conservation and citizen science outputs must be balanced with the voluntary nature of community groups.

ACKNOWLEDGEMENTS

It is hard to know whom to thank first, as a three-year research project is shaped by many thought-provoking discussions and experiences. Little did I know, that when I began my work with community environmental groups over a decade ago, I would return to university in pursuit of higher learning. The community environmental groups that make real change happen on the ground and in their communities, are the inspiration for this study.

Wayne Todd (Moehau Environment Group) deserves special mention as a close friend and skilled restoration practitioner, who, through many hours of conversations gave me invaluable insights into the challenges and achievements of community-led restoration. I would also like to thank all groups that participated in the study and to interviewees who generously shared their thoughts and experiences. Many thanks to my former work colleagues at the New Zealand Landcare Trust who continued to share their expertise, and provided me with much encouragement over the last three years.

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INTRODUCTION

1.1 Overview

'Halt the decline in New Zealand's indigenous biodiversity…' so begins the description of the third goal of the New Zealand Biodiversity Strategy (Department of Conservation & Ministry for the Environment 2000). This document described the parlous state of the environment in this country, and emphasised the urgent need for coordinated action to maintain and restore the remaining indigenous biodiversity and ecosystem integrity. Lowland freshwater resources too have suffered widespread declines in quality that are likely to continue with further expansion of intensive dairy farming (Parliamentary Commissioner for the Environment 2013).

In response to these challenges, the last 15 years has seen a growing number of community environmental groups contributing a sizeable, though currently unknown, quantum of effort to an existing suite of resource management agency, government and science provider-led initiatives that seek to protect, enhance and restore New Zealand's largely endemic flora and fauna, and natural habitats (Campbell-Hunt & Campbell-Hunt 2013; Ross 2009. In order to gauge the effectiveness of their restoration interventions, these groups may carry out community-based environmental monitoring (CBEM), a form of citizen science where community members are involved in scientific research. The roles of community groups, their environmental restoration projects and CBEM (as it relates to citizen science) create a dynamic field of research, and comprise the three interconnected strands of inquiry in this study. The meta-theme threaded throughout each strand centres on the importance of public participation, community engagement and partnerships. These three interrelated themes were chosen as the guiding principles for the study as: (1) Public participation in environmental restoration and biodiversity conservation is required to help halt the ongoing decline of New Zealand's biodiversity (Brown et al. 2015; Department of Conservation 2014); (2) Meaningful engagement between professionals and volunteers may enable concepts of reciprocity to be embedded in conservation practice (Phipps 2011; Buchan 2007); and (3) Effective partnerships can enhance environmental and social outcomes resulting from groups' project activities (Department of Conservation 2014; Handford 2011).

1.2 Researcher background

I have worked for 17 years in the fields of community conservation and environmental restoration for diverse government agencies and non-government organisations (NGOs). For the seven years prior to beginning this study, I facilitated New Zealand-based community groups in the course of their environmental restoration projects, and carried out experiments related to plant species translocation to restore wetlands in the Waikato region (Peters 2007). This provided numerous insights into the complexity of environmental restoration, and highlighted the interdependent nature of social and ecological factors influencing community members and their project activities. An interest in the interface between science and the public also grew, resulting in two studies, the first, investigating how monitoring resources designed for community environmental groups could facilitate the collection of scientifically robust data (Peters 2003), and the second, how Māori pastoral farmers determined soil health on their properties (Peters 2010). The opportunity to work directly with individuals, community groups and their project partners (e.g., government agencies and science providers), while also working for groups in the capacity of a NGO project partner, was integral to the current study. These diverse roles lent credibility, both to myself and to the study, as well as facilitated access to interviewees, contacts and databases of community groups, and community events such as landcare networking days and restoration workshops.

1.3 New Zealand: a history of loss

So peculiar is New Zealand's ecology, that it has been described as 'a completely different experiment in evolution from the rest of the world' (Flannery 2002). The high degree of endemism resulting from around 80 million years of isolation from other landmasses, positions New Zealand as a biodiversity hotspot (Gibbs 2006). Unusually, prior to the arrival of humans (in the early thirteenth century), terrestrial mammals were only represented by three species of bat (*Chalinolobus tuberculata, Mystacina tuberculata*, and *M. robusta,* now extinct) (Hogg et al. 2003; Craig et al. 2000). Instead, a highly diverse avifauna dominated forests and other ecosystems, which, together with large-bodied, flightless invertebrates such as wētā (Orthoptera: Anostostomatidae and Rhaphidophoridae), filled many niches typically occupied by mammals in other countries (Duthie et al. 2006; Craig et al. 2000).

Over a period of seven centuries, human colonists intentionally introduced a wide range of new flora and fauna species to New Zealand: to establish alternative sources of food and fibre; to control erosion created by clearing native vegetation; to provide economic and recreational opportunities; for decoration, and to serve as tangible reminders of the colonists' origins (Dawson 2010; Hogg et al. 2003; Craig et al. 2000). A large number of these introduced species are now targeted for eradication, control or management on account of their ability to threaten ecosystem integrity and food security (e.g., Waikato Regional Council 2014). The Australian brushtail possum (*Trichosurus vulpecula)*, for example, was introduced in 1858 to establish a fur trade, yet by 1947 it was declared a pest due to functioning as a vector for diseases, damaging crops, predating native birds and insects, as well as causing forest canopy collapse through browsing pressure (Clout 2006; Cowan 2005). Unintentional arrivals of flora and fauna species, such as rats (*Rattus rattus*), also continue to threaten the long-term survival of native species (Innes 2005).

The ecological impact of weeds and pests have been compounded by major land use changes, by fragmenting, removing or otherwise severely modifying (e.g. through the drainage of wetlands) existing terrestrial and aquatic habitats (Craig et al. 2000). Increases in intensive agriculture (such as dairy farming), combined with a lack of national policies to guide resource management, have also contributed to declines in the quality of freshwater resources (Parliamentary Commissioner for the Environment 2013).

Compared with other nations, New Zealand has a brief but severe record of biodiversity loss (Craig et al. 2000). To date, 56 species of endemic bird and eight species of endemic plant are now extinct (de Lange et al. 2013; Robertson et al. 2013). Many others are classified as threatened (i.e. nationally critical to nationally vulnerable): 12 species of native fish and a total of 289 species of vascular plant (Goodman et al. 2014; de Lange et al. 2013; Robertson et al. 2013). Amongst these is the one of New Zealand's icons, the Okarito brown kiwi (*Apterxyx rowi*). Although more than 30% of the land area (c. 8.5 million ha) is administered by the Department of Conservation, the protection of indigenous species from predation and competition by exotic species, along with restoring ecosystem integrity, is critical (Brown et al. 2015, Department of Conservation 2014).

1.4 Environmental restoration

At its most basic, environmental restoration is an intentional activity designed to facilitate the process of recovery of a degraded or destroyed ecosystem (Society for Ecological Restoration 2004). Restoring the environment is therefore integral to the protection, conservation and preservation of ecosystem integrity. Globally, the scale and pace of human-induced environmental change has reached unprecedented levels (Sutherland et al. 2015). The pressing need to address environmental concerns for current and future well-being has resulted in diverse approaches to restoration that are inevitably influenced by an equally diverse set of perspectives and rationales (Table 1.1).

Table 1.1 Range of perspectives, rationales and motivations informing restoration activities. Range of perspectives, rationales and motivations informing restoration activities. Adapted from Ecological restoration: Principles, values, and structure of an emerging profession (p.16), by A. Clewel and J. Aronson, 2013, Washington, USA: Island Press. Reprinted with permission. Additional material summarised from Clewel and Aronson 2006.

Perspective	Rationale	Motivation
Ecological	Technocratic	Intentionally rehabilitate ecological processes, possibly to satisfy agency or institutional directives or aims.
Conservation	Biotic/ heuristic	Recover biodiversity from extinction; investigate or demonstrate ecological principles underpinning restoration.
Socio-economic	Pragmatic	Recover ecosystem services; offset effects of climate change.
Cultural	Idealistic	Build relationships between individuals, within and between communities, and institutions; concern and compensation for environmental degradation.
Personal/Spiritual	Idealistic	Restore self through reconnecting with nature; concern and compensation for environmental degradation.

A more acute understanding, both of ecological complexity and the socio-economic contexts in which restoration takes place, has resulted in cross-disciplinary and cross-sectoral approaches increasingly being used to inform environmental restoration initiatives (Clewel & Aronson 2013). In the context of urban sites, broad concepts such as 'civic ecology' have been applied to activities within built environments that include the human dimension (Krasny & Tidball 2012). Civic ecology thus refers to environmental stewardship activities that support ecosystem services, enhance green infrastructure (i.e. vegetation and soils) while contributing to human well-being.

Recent acknowledgement that biodiversity conservation goals remain unachievable without major assistance from the community (Department of Conservation 2014), has set the scene in New Zealand for a future where partnerships between the public and private sector are an essential component of environmental restoration. The collaborative, partnership model is not limited to terrestrial ecosystems, and is also being employed to engage community stakeholders for managing and restoring freshwater resources (Waikato River Authority, undated; Canterbury Regional Council 2013).

However, this has not always been the case as discourse on the role of the wider community in environmental restoration, has largely excluded non-specialists (Phipps 2011). Galbraith (2013), for example, reported that public participation in a high-profile island restoration project, in the early years (1980s) of project development, was regarded as controversial by governing agencies and traditional ecologists, given the 'scientific' nature of the restoration. In the case of freshwater resources, the growing emphasis on collaboration is a direct response to the failure of approaches that did not adequately consider the necessity of broader community input for preventing or slowing decline in water quality (Land and Water Forum 2012). The more recent shift towards including community perspectives and participation has occurred alongside the growth of capacity to do so through the emergence of community environmental groups.

1.5 Community environmental groups

The term 'community' is used throughout this thesis, and when used in a social context describes a spectrum of relationships from a group of people residing in the same locality, to a body of unified individuals (Merriam-Webster 2005). A sense of community may arise when members of the group share particular attitudes or have common interests (Mannarini & Fedi 2009). Community environmental groups can thus be described as 'communities of interest' who have a collective focus on restoring, enhancing and protecting flora, fauna and landscape values (Phipps 2011).

The widespread, largely self-mobilising nature of community environmental groups undertaking restoration projects and environmental monitoring throughout New Zealand appears to be a distinctive phenomenon. Despite the autonomous nature of these groups, many strongly identify as being part of the wider community restoration community. This is evidenced by publicly accessible databases comprising growing numbers of groups. These databases have been compiled by the Department of Conservation (Department of Conservation, undated), non-government organisations such as Forest & Bird (Forest & Bird, undated), funders (Waikato Regional Council, undated), and the supported Naturespace website (Naturespace, undated). The latter database includes over 370 individual groups as of July 2016.

Although similar grassroots initiatives have occurred, e.g., in Australia (prior to the development of the nationwide Landcare programme; www.landcareaustralia.org.au), the US (Krasny & Tidball 2012) and in Sweden (Schultz et al. 2007; Barthel 2005), either a higher, more cohesive level of support and coordination is provided to groups (e.g., via Landcare Australia) than has been provided in New Zealand, or groups lack informal ‘membership’ to regional organisations such as biodiversity fora (e.g., http://www.waikatobiodiversity.org.nz/) or national restoration fora such as Naturespace. Overall, community-led environmental groups undertaking similar urban, peri-urban and rural environmental restoration projects in other countries have been relatively poorly studied when compared with scientist/institutionally-led community restoration partnerships where a publication may occur as a research output. However, a compounding factor may related to terminology. Descriptions of groups of volunteers engaged in environmental activities lack consistency, challenging the ability to make comparisons between countries. For example in the US, terms for similar groups include community or local stewardship groups (Silva & Krasny 2014), while in Australia ‘Landcare’ now forms the overarching term for environmental restoration and sustainable land management initiatives within the agricultural sector (Ferraro 2013).

In New Zealand, the term ‘care’ groups, such as ‘landcare’ or ‘streamcare’, is widely employed to describe community-led environmental restoration. The need for ‘care’ through coordinated environmental action led by groups of ordinary citizens, evolved from growing public awareness of threats to native fauna. The impending extinction of the endemic bird, the huia (*Heteralocha acutirostris*), for example, precipitated the establishment of the nation’s longest-serving conservation organisation, the Royal Forest and Bird Society of NZ (est. 1923) (Skinner, undated), formerly known as the New Zealand Native Bird Protection Society. Today, community environmental groups undertake a diverse range of restoration-related projects, and are scattered throughout New Zealand (Ross 2009). These groups are mostly grass-roots initiatives, with many having evolved in response to a local issue, e.g., declining water quality in a stream, lake or river; a forest remnant with increasing pest numbers; weed invasion, and declining numbers of native birds (e.g., Nature Space, undated). A number of these groups' projects are now achieving major biodiversity gains through sustained pest and weed control, the construction of pest-proof fenced sanctuaries, and translocations of native flora and fauna species to establish new populations (Cromarty & Alderson 2012; Phipps 2011; Campbell-Hunt et al. 2010; Hardie-Boys 2010).

Despite the largely autonomous nature of community environmental groups, the enormity of the restoration task and the need for specialist advice, equipment and funding often necessitates partnerships with resource management agencies, NGOs and others (Ritchie 2011; Hardie-Boys 2010). For example, agencies and science providers may assist groups with setting up and operating monitoring programmes, given that not all group participants possess the technical expertise to do so (Byrd 2008).

1.6 Community-based environmental monitoring and citizen science

Determining the ecological outcomes resulting from restoration interventions is dependent on systematic, repeated formal observations that form the foundation of science-based monitoring (Spellerberg 2005). Where this activity is carried out by non-specialists or volunteers, several terms have been used, including volunteer biological monitoring, community-based environmental monitoring (CBEM) or variations thereof (e.g., Conrad & Hilchey 2011; Pfeffer & Wagenet 2008; Danielsen et al. 2005). Monitoring may be carried out by community groups, for example, to quantify the outcomes of pest trapping or poisoning (Masuda et al. 2014), measure changes in water quality (Hoyer et al. 2014), or determine the condition of a forest remnant (Handford 2004). CBEM best summarises community groups' activities in New Zealand as community members play a leading role in data collection, and they may also undertake analyses and report results.

CBEM forms a key component of citizen science, where volunteers participate in scientific research, outreach and educational activities, environmental management and policy-making processes (Conrad & Hilchey 2011; Bonney 1996; Irwin 1995). There is growing recognition that volunteers can contribute valuable data for educational, ecological and environmental management purposes, and that the relationships between science and society can be strengthened in the process of doing so (Silvertown 2009). Although citizen science as a research method has been adopted by other sectors such as public health (Ottinger 2010), many definitions are specific to environmental contexts (e.g., Tweddle et al. 2012). Citizen science is therefore often used as an overarching term for CBEM activities, or alternately, citizen science and CBEM are regarded as complementary, overlapping or integrated concepts (Roy et al. 2012; Conrad & Hilchey 2011; Pfeffer & Wagenet 2008).

Citizen science continues to gather momentum, generating data for projects that are increasingly ambitious in scope and that engage an even greater diversity of community members (Silvertown 2009). The term citizen science is increasingly used around the globe by governments (Haklay 2015), including New Zealand recently (Ministry of Business Innovation and Employment 2013). The term also has begun to gain traction within the resource management and NGO sectors (Brumby et al. 2015), among the science community (Galbraith 2013; Spurr 2012; Sullivan 2012) and general public (Christian 2014, Blundell 2015), reflecting a distinct shift in how the role of the public in scientific enterprises is viewed and valued. In this study, framing CBEM (as carried out by community environmental groups) within citizen science is relatively novel. However, by emphasizing the synergies between citizen science and CBEM, greater consideration of, and practical support for sustaining and growing groups' science-based monitoring may be encouraged.

1.7 Rationale

The broad question of how community environmental groups in New Zealand measure the ecological success of their restoration projects inspired this study. Despite the proliferation of these grassroots groups in New Zealand and their increasingly important role in supporting biodiversity conservation (Brown et al. 2015; Phipps 2011; Campbell-Hunt et al. 2010), little is known about the characteristics of groups and their projects at a national level. In addition, information on how project partners work with these groups is somewhat lacking despite increased demands, in particular from resource management agencies, for groups to contribute more of their efforts to biodiversity conservation (Department of Conservation 2014).

Very few studies have investigated science-based monitoring activities carried out by community environmental groups. As a result, information on the particular requirements for supporting groups' monitoring activities within their projects as well as within the broader context of citizen science is sparse. Although community volunteers can collect scientifically valid data (Hoyer et al. 2014), it is not known how these efforts are viewed, for example, by resource management agency staff and scientists.

Without addressing these gaps in our knowledge, resource management agencies may not support groups as effectively as they could or develop policies and plans for doing so (Brown et al. 2015). Finally, the gradual evolution of the first National Policy Statement for Freshwater Management (New Zealand Government 2014), may encourage the collection of water quality data by community groups both for educational purposes and to support their expanding role in environmental decision-making. This study may help inform how this endeavour could best be achieved.

1.8 Research questions

Bearing the above rationale in mind, the following questions form the basis of chapters in this study:

Q 1 What are the characteristics of community environmental groups and their projects in New Zealand?

Q 2 How do community environmental groups determine whether they have met their project goals?

Q 3 How are community-generated environmental data perceived and used?

Q 4 Given the increasing focus on water quality decline in New Zealand, what scope is there for citizen science to assist with the provision of water quality monitoring data?

Q 5 What principles underpin long-term community environmental monitoring programmes?

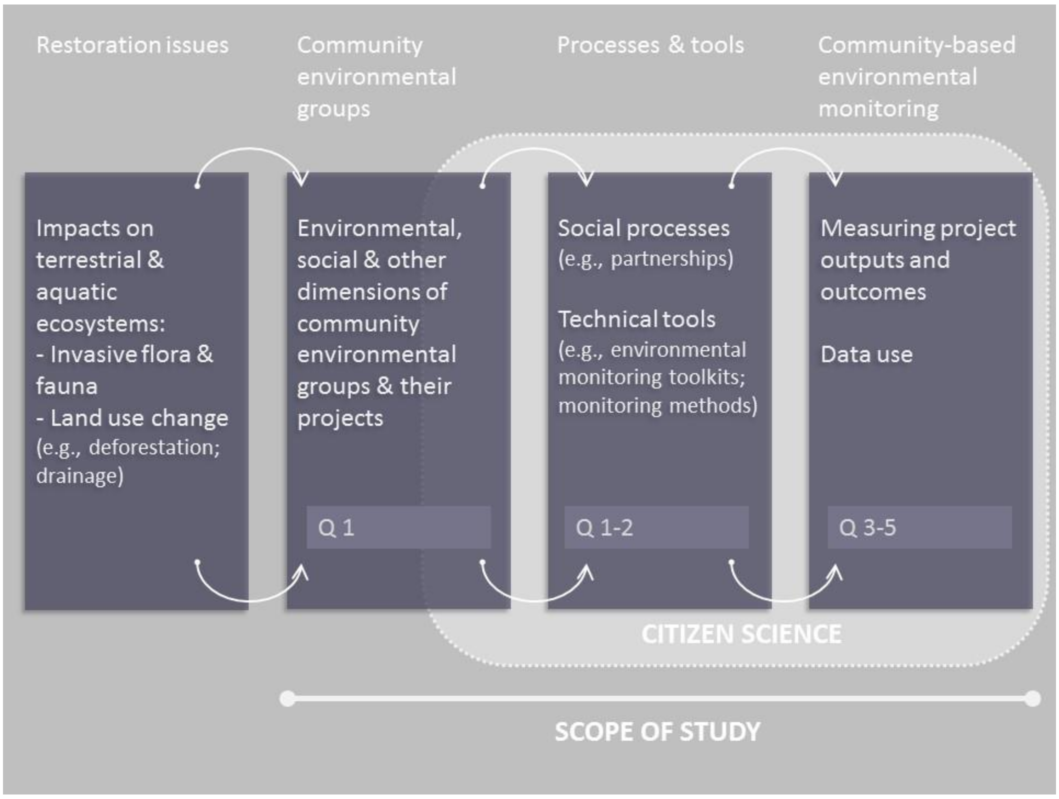
1.9 Thesis structure

In line with University of Waikato thesis requirements for a thesis which includes publications, a minimum of four chapters need to be based on material that has been published or has been submitted for publication in a peer-reviewed journal or for inclusion in a published book. Chapters 4, 5 and 6 have been peer reviewed by experts in the field of community-based environmental restoration and citizen science. Chapter 7 has been peer-reviewed by a New Zealand-based editor. Some repetition of concepts has occurred owing to the need for each publication to include sufficient detail in order to contextualise content. Each chapter, however, is distinct and uses one or more of the research questions listed above as a starting point for in-depth inquiry. Further material is brought together to provide a theoretical framework for the research (Chapter 2), to describe the approach to the research (Chapter 3) and to draw together the key findings (Chapter 8) along with the contribution to new knowledge.

1.9.1 Chapter outlines

The scope of the study is outlined in Figure 1.1. The relationship between environmental restoration, community environmental groups and community-based environmental monitoring and the five research questions is presented, along with the overarching nature of citizen science.

Figure 1.1. The scope of the study showing the ecological context for community environmental groups (i.e. restoration issues), and the relationship of these groups to the broad field of citizen science. Community groups, social processes occurring and tools used along with community-



based environmental monitoring are each linked to one or more research questions.

Chapter 2 comprises a literature review and investigates participation and engagement as they relate to environmental monitoring and the broad field of citizen science. Citizen science, as both a field of inquiry and research process, has in recent years expanded rapidly, leading to inconsistent use ofterminology and weak theorisation. The motivation to volunteer for environmental projects is included, followed by the range of definitions applied to citizen science.

Typologies that attempt to define the scope and nature of citizen science are examined, and possible outcomes relating to ways in which community members participate in citizen science are outlined. In addition, a theoretical framework is presented that draws together community environmental groups, their restoration activities and the monitoring they may carry out.

Chapter 3 details the methodological considerations for this thesis. The research paradigm, ontology and epistemology of constructivism are discussed, and a rationale provided for this approach. The positivist paradigm is also outlined given its relevance to conservation and environmental restoration-related research. An overview of the mixed method research design follows, and the qualitative and quantitative analyses carried out in the study are described. Methods for disseminating the research are summarized. An outline of the measures used to ensure trustworthiness is included as well as a summary of the study scope and limitations.

Chapter 4 draws on findings from the first half of an online questionnaire distributed to community environmental groups throughout New Zealand. The following question is addressed:

Q 1 What are the characteristics of community environmental groups and their projects in New Zealand?

Despite the proliferation of community environmental groups in recent years, no studies to date have investigated the diverse nature of these groups and their activities at a national level. This chapter builds a foundation for subsequent chapters by profiling groups, their restoration projects and their partnerships. Chapter 4 has been published in the *New Zealand Journal of Ecology*, as 'Action on the ground: A review of community environmental groups' restoration objectives, activities and partnerships in New Zealand' by Monica A. Peters, David Hamilton and Chris Eames (Volume 29, Issue 2, pp. 179-189). As the principal author, I carried out all of the data collection, and prepared the drafts and final version of the manuscript. My co-authors provided critical commentary on the content and edited the drafts.

Chapter 5 draws on findings from the second half of the online questionnaire distributed to community environmental groups throughout New Zealand and addresses the following question:

Q 2 How do community environmental groups determine whether they have met their project goals?

Little is known about how community environmental groups measure change within their restoration projects and how monitoring toolkits designed specifically for these groups are used. This chapter also investigates contextual factors shaping community-based environmental monitoring such as groups' characteristics and challenges faced by groups for developing monitoring programmes. Chapter 5 has been published in the *New Zealand Journal of Ecology* as 'The current state of community-based environmental monitoring in New Zealand' by Monica A. Peters, David Hamilton and Chris Eames (Volume 40, Issue 3, online only at the time of writing). As the principal author, I carried out all of the data collection, and prepared the drafts and final version of the manuscript. My co-authors provided critical commentary on the content and edited the drafts.

Chapter 6 draws on data from the second half of the online questionnaire and from interviews carried out with community environmental groups and their project partners. The following question is addressed:

Q 3 How are community-generated environmental data perceived and used?

Community environmental groups produce data from their monitoring activities, though how these data are used by the groups themselves and their project partners has been poorly studied. The diverse societal outcomes experienced by groups in the process of their monitoring activities are also investigated. Chapter 6 has been published by the *New Zealand Journal of the Royal Society* as 'The use and value of citizen science data in New Zealand', by Monica A. Peters, Chris Eames and David Hamilton (Volume 45, Issue 3, pp. 151-160). As the principal author, I carried out all of the data collection, and prepared the drafts and final version of the manuscript. My co-authors provided critical commentary on the content and edited the drafts.

Chapter 7 uses findings from the questionnaire data from community environmental groups to address the following questions:

Q 4 Given the increasing focus on water quality decline in New Zealand, what scope is there for citizen science to assist with the provision of water quality data?

Q 5 What principles underpin the development of long-term volunteer environmental monitoring programmes?

A strong culture of volunteer water quality monitoring exists in North America, with diverse programmes educating participants, and providing data for research and environmental decision-making. In contrast, few community members in New Zealand participate in monitoring freshwater resources though there is increasing interest in doing so. To progress combined community, scientist and government resource management agency participation in freshwater citizen science programmes, principles underpinning the development and implementation of long-term volunteer monitoring programmes are outlined. Chapter 7 will be published as 'Applying citizen science to freshwater ecosystem restoration' in Lake Restoration: A New Zealand Perspective, (eds.) D. Hamilton, K. Collier, C. Howard-Williams, and J. Quinn (Springer, to be published 2016). The different format of this chapter reflects publication in a book as opposed to a research article for a peer-reviewed journal. As the principal author, I carried out all of the data collection, and prepared the drafts and final version of the manuscript. My co-authors provided critical commentary on the content and edited the drafts. Mark Hoyer (University of Florida) contributed the feature box on ‘Florida Lakewatch’ (p 164), while Kathleen Weathers (Cary Institute) contributed the feature box on the ‘Lake Sunapee Protective Association’ (p 165).

Chapter 8 synthesizes key points drawn from Chapters 4-7 in relation to the literature and theoretical framework. Recommendations for further research and practical action are provided. The thesis concludes with the original contribution this study has made to building new knowledge in the fields of community environmental groups, community-led restoration and citizen science.

Chapter 2

COMMUNITY MEMBERS ENGAGING IN ENVIRONMENTAL MONITORING

2.1 Overview

Discourse on public participation in scientific investigations now pervades fields such as biological conservation and environmental restoration, management and policy development. Citizen science is one outcome of this debate and it describes both a field of inquiry where members of the public participate in scientific research, and a research practice that centres on collaboration with members of the public. In this review of the literature, particular attention is paid to the relationship between environmental monitoring and citizen science. Environmental monitoring carried out by community members has a lengthy history and is now integral to many citizen science projects designed to test hypotheses or contribute observations to environmental databases. Literature from the last two decades forms the basis of this review, as 1995 is considered to represent the formal conception of citizen science (Conrad & Hilchey 2011; Bonney et al. 2009a). Where possible, peer-reviewed articles are referenced in this chapter, but due to the recent advent and increasingly broad scope of citizen science, material from reports, conference proceedings and websites are also included.

The three strands of inquiry investigated in this review of the literature include (1) why and how community members participate in environmental projects; (2) the broadening scope and influence of citizen science, and (3) how citizen science is defined and projects are categorised. In order to lay the foundation for this chapter, the first section provides an overview of motivations that drive volunteer participation in environmental projects. Secondly, as citizen science represents a relatively new area for research, consensus among citizen science academics and practitioners on the scope and nature of what constitutes citizen science has not yet been reached. Terms used in association with, or as synonyms, for citizen science are reviewed and areas of consensus and divergence are highlighted. Thirdly, typologies to categorize citizen science projects that are based on differing levels of community participation are compared and contrasted, and the implications discussed in terms of volunteer empowerment. Lastly, a theoretical framework for this thesis as a whole is presented that links the concepts outlined in the general introduction (Chapter 1), namely, community environmental groups, their restoration activities and the monitoring they carry out, within the wider context of citizen science.

2.2 Environmental monitoring

Monitoring is a specific activity centering on the systematic measurement of phenomena over time, and is fundamental to understanding the integrity, ecology and conservation of ecosystems and their components (Lindenmayer & Likens 2010; Spellerberg 2005). Activities may include developing an inventory of biota within an area; measuring the status and trend of an organism or range of ecological features, or carrying out surveillance using specialised techniques for detecting presence (Lee et al. 2005). Monitoring has been carried out by members of the community for centuries, for example, with amateur ornithologists in Finland collecting data on the timing of migration from 1749 (Greenwood 2007). These long-term observations provide valuable insights into patterns and trends, and have contributed to studies on evolution and the effects of climate change on biota (Silvertown 2009).

Volunteer environmental monitoring efforts are characterised by their diversity, and range from projects led by individuals or small groups, to large-scale programmes reliant on thousands of volunteers to collect data. Skilled amateurs, such as American author, philosopher and naturalist Henry David Thoreau (1817-1862), have produced detailed accounts of the arrival dates of migratory bird species, as well as the first flowering and leaf-out dates (Miller-Rushing et al. 2012). In New Zealand, localised monitoring programmes have been developed by community groups, in partnership with scientists, to measure change within their environmental restoration projects (Galbraith 2013; Byrd 2008). In England, volunteers were instrumental in setting up bird-banding schemes and developed the first national bird atlas (Greenwood 2007). Volunteers participating in large-scale initiatives led, for example, by not-for-profit and non-government organisations, universities and government agencies, have collected data on weather patterns, the population sizes and distribution of flora and fauna, and environmental health (Chandler et al. 2012; Miller-Rushing et al. 2012; Silvertown 2009). Volunteer numbers in these programmes can be considerable. Tens of thousands of observers (primarily from the USA and Canada) participated in the 110th Annual Christmas Bird Count, documenting nearly 60,000,000 birds (Silvertown et al. 2013). Similarly large numbers of volunteers have contributed water quality data to inform environmental management across the USA (Firehock & West 1995).

Several factors underpin the growth of volunteer environmental monitoring initiatives. The challenge of collecting data in the long-term and across large areas, combined with the reduced capacity of organisations reliant on professional staff to do so, has created an environment amenable to increased volunteer input (Hyder et al. 2015; Lawrence 2006). At the same time, simplified techniques, standardized indicators and Web 2.0-based technology have facilitated community volunteers to collect environmental data, conduct analyses and share findings with relative ease, and have enabled large datasets to be more effectively managed (Hoyer et al. 2014; Newman et al. 2012). Along with increased opportunities for volunteers, societal shifts that have contributed to volunteer availability include increased participation in higher education; greater amounts of leisure time (particularly in industrialised nations), and higher numbers of retirees that are both educated and able-bodied (Haklay 2015). Pan-European and American surveys also indicate an increased level of public awareness of environmental issues, and of the role that members of the community may play in protecting the environment (Brulle et al. 2012; European Commission 2008).

Environmental monitoring carried out by members of the public forms a key component of citizen science, which is grounded in a philosophy of enabling and enhancing public participation in scientific studies (Bonney et al. 2009a). As such, citizen science simultaneously comprises a project or programme type, as well as a flexible tool that can be adapted to suit projects spanning different ecosystems as well as disciplines (Cooper et al. 2007). Initially regarded as a movement or even a global phenomenon (Haklay 2015), citizen science is now viewed as a paradigm (Cooper et al. 2007), and an emerging discipline (Jordan et al. 2015). With interest growing in studying citizen science processes and outcomes, Jordan et al. (2015) argue that the theory developed related specifically to citizen science, for example, on modes of volunteer participation, public engagement, learning, and socio-ecological systems, distinguishes citizen science from related fields e.g., of conservation, and science teaching and learning. As such, citizen science now forms the overarching framework for investigating the multiple ways in which the public participate in scientific investigations, and increasingly, the applications and outcomes of these investigations. The close relationship between environmental monitoring involving volunteers and citizen science is threaded throughout this thesis.

2.3 Why volunteer?

Community members are increasingly donating their time and resources to environmental projects. The basic tenet of volunteerism is willing participation, and though volunteers are generally unpaid, some form of reimbursement (e.g., a basic stipend) may be provided (Bushway et al. 2011). Voluntary action for the environment may occur on a one-time, casual basis, such as participating in a public planting day (Buchan 2007). At the other end of the spectrum, voluntary participation may be ongoing, and take place within a structured work programme, for example, coordinated by a land management authority or not-for-profit organisation (Bruce et al. 2014; Chandler et al. 2012; Jacobson et al. 2012). In well-established water quality monitoring programmes, volunteers have been known to participate on a regular basis for two or more decades (Maine Volunteer Lake Monitoring Programme 2012). Environmental activities carried out by volunteers include developing inventories of species (Becker et al. 2005; Lundmark 2003); reintroducing previously extirpated species; controlling weeds and animal pest species (Krasny et al. 2014; Reid et al. 2011; Hardie-Boys 2010); fundraising; political activism (McLean 2014), or advocacy and education about the natural world (Galbraith 2013; Campbell-Hunt et al. 2010). Collectively, these activities are integral to the environmental movement, and have the potential to provide significant social and environmental benefits to local communities by preserving; building and restoring their capacity, and by building civic identity (Overdevest et al. 2004).

Although predictors such as the level of income and education are closely linked to volunteering (Deutsch et al. 2009), to date, few studies have investigated the factors that motivate community members to volunteer specifically for citizen science projects (Raddick et al. 2010). However, insights can be drawn from the fields of volunteerism in general (Clary & Snyder 1999); ecopsychology (Stevens

2010); community psychology (McMillan & Chavis 1986), as well as from theories centring on experiential learning (Kolb et al. 2000). Understanding the diverse motivations of volunteers is necessary for designing programmes that are sensitive to volunteers' needs, while also assisting with volunteer recruitment and retention (Narushima 2005; Miles et al. 1998; Clary et al. 1992). Additionally, investigating volunteer motivation is pertinent given that providing robust evidence of programme capacity and sustainability is central to securing on-going support in an increasingly competitive funding environment (Bramston et al. 2011).

Community psychology recognises two broad, fluid, motivation-related categories, namely 'instrumental', where the aim is to carry out activities that have tangible outcomes; and 'expressive', which encompasses the need for belonging and sharing (Mannarini & Fedi 2009). When these categories are applied to environmental monitoring, volunteer motivation may be driven by practical conservation-based or socio-economic considerations (e.g., restoring ecosystem services to sustain livelihoods). In contrast, cultural, personal, and spiritual considerations for restoration may centre on (re)building connections to both the environment and society, and as such, include altruistic value orientations (Clewel and Aronson 2006, 2013). This acknowledges that people may volunteer for the same activity (e.g., environmental restoration), though for a range of different reasons (Clary & Snyder 1999).

An overview of the wider literature on volunteerism across the fields of gerontology (Bushway et al. 2011; Narushima 2005), conservation, environmental restoration and management (Krasny et al. 2014; Clewel & Aronson 2013; Measham & Barnett 2008; Gooch 2004; Miles et al. 1998), and social services (Yeung 2004; Omoto et al. 2000), reveals a suite of common motivations that add depth to Mannarini and Fedi's (2009) categories of instrumental and expressive. The suite of motivations described in the following sections are grouped as personal fulfilment; social connection; environmental action, and environmental connection.

2.3.1 Personal fulfilment

At its most fundamental, the act of volunteering can provide an opportunity for self-reflection, consolation and for cultivating peace of mind, while in the process strengthening personal confidence and enhancing a sense of self-worth (Gooch 2004; Yeung 2004; Ryan et al. 2001; Miles et al. 1998). Volunteering for the purpose of personal or spiritual enrichment, although rarely appearing as a primary motivation, may still rate highly. Cnaan and Goldberg-Glen (1991), for example, found in their study of social service volunteers that the motivation to increase self-worth was second only to 'doing something worthwhile'. For older volunteers, the act of contributing time and skills through volunteering may form part of the cycle of their lives. Additionally, older volunteers' motivation may be to leave a long-term legacy for future generations (Warburton and Gooch 2007).

The motivation to learn is a common theme in studies of volunteerism, serving both expressive and instrumental purposes (Jacobson et al. 2012; Bruyere & Rappe 2007; Ryan et al. 2001). For environmental volunteers, learning about flora, fauna and the natural environment often occurs through informal interactions between individuals, their surroundings and other project participants (Reid et al. 2011; Gooch 2004), and through activities such as nature walks and information nights on ecological subjects (Bramston et al. 2011). In contrast, more formal learning opportunities include volunteer training courses and workshops (Ashcroft et al. 2012; Jordan et al. 2011). Experiential learning is theorised to result from transforming experience into knowledge (Kolb et al. 2000) and can play an important role in volunteer learning processes. For example, Reid et al. (2011) demonstrated that volunteers in an environmental restoration project accrued an in-depth knowledge of harvesting and germinating seeds, and native plant establishment due to active experimentation and long-term observations of site responses to these experimental manipulations. Studies have highlighted that the provision of learning opportunities can encourage long-term volunteer commitment to a project (Ryan et al. 2001), empower volunteers, and engender a sense of inclusion among new volunteers (Gooch 2004). A functional aspect of accruing knowledge and experience is to gain skills that enhance employability (Clary & Snyder 1999), which may form a strong motive for younger volunteers (Jacobson et al. 2012; Omoto et al. 2000).

2.3.2 Social connection

The instrumental and expressive aspects of social connection overlap when socially-driven motivations are examined across studies. By providing a focal point for activities and social interactions, volunteering can play a powerful role in reducing social isolation, particularly among elderly and by rural residents (Bramston et al. 2011; Bushway et al. 2011). The motivation for social connection is expressed in other studies as the desire to have fun while participating in an activity with friends (Bramston et al. 2011; Clary & Snyder 1999), and meeting others with similar ideas and values (Bruyere & Rappe 2007).

The 'sense of community' model developed by McMillan and Chavis (1986), comprises a 'sense of belonging' (through shared social norms, rules, and interests); an 'emotional connection' between members (resulting in trust and collective identity); 'influence' (the ability to make change); and 'integration and fulfilment of needs' (where needs are met by resources received by the group), highlighting the confluence of practical and personal, instrumental and expressive concerns. Real life, however, is more nuanced, with categories such as the sense of belonging and emotional connection sharing many similar characteristics (Mannarini & Fedi 2009). The multi-faceted nature of community-building is highlighted in Gooch's (2004) study of Australian catchment care volunteers, where volunteering not only enhanced a sense of self-worth, and helped develop personal skills, but also enabled wider social changes within the group to occur. Although the latter was manifest as ability to participate meaningfully in local-level environmental decision-making, individual and group-level empowerment also resulted from this process (Gooch 2004).

The relative importance of social motivations compared with other motivations can be different across projects. Among young adults (e.g., college students), the primary motivation to volunteer for environmental organisations may be to enhance social networks, more so than to achieve learning-related outcomes (McDougle et al. 2011). Social outcomes may also be more important to highly committed volunteers, more so than other benefits derived from volunteering (Ryan et al. 2001).

2.3.3 Environmental action

Worldwide, human-induced transformations of the environment have resulted in significant, largely irreversible losses of biodiversity, coupled with the severe degradation of ecosystem services (e.g., climate regulation; the provision of food, fibre and freshwater; and habitats for migratory species) (World Health Organisation 2005). Ryan et al. (2001) underscore the importance of advocates for local natural areas to help avert degradation, as these typically do not receive the attention given to more 'glamorous' but distant ecosystems under threat, such as rainforests.

The increasing awareness of environmental degradation and the need for action blends both practical and personal considerations. In a study of volunteers from natural resource organisations, helping the environment emerged as the strongest overall motivation (Bruyere & Rappe 2007). Participating in restoration projects provides an opportunity to help the environment in a concrete manner, with the rewards to volunteers of being able to see the outcomes of their efforts (albeit sometimes not for a considerable length of time), and of greater worth than 'sending a cheque to a national environmental organization' (Ryan et al. 2001).

Motivations underpinning the desire to help the environment can relate to restoring ecosystem services (Clewel & Aronson 2013), but also occur as a responsibility toward nature in the face of ongoing threats to environmental integrity (DiEnno & Thompson 2013). Miles et al. (1998) found that the motivation to take 'meaningful action', was centred around altruistic notions of 'causing good things to happen' and 'being useful', which incorporated aspects of improving life for future generations. Similar altruistic notions were found by Bruyere and Rappe (2007), with volunteers participating as a way of paying back for the good things they had benefitted from over their lifetimes.

Basic motivations such as doing 'something physical' (Ryan et al. 2001; Miles et al. 1998) or simply getting outside (Bruyere & Rappe 2007) highlight the fundamental need to spend time either engaged in an activity or in an environment that is different to that experienced daily.

2.3.4 Environmental connection

Viewed from a social perspective, ecosystem services also include non-material benefits such as aesthetic values, spiritual nourishment, intellectual development, and recreation (World Health Organisation 2005). In this respect, the motivation to volunteer for environmental causes may result from biophilia, which according to naturalist E.O. Wilson, is an 'innately emotional affiliation with all living organisms' (Wilson 1984). A deeper, ecopsychological view is that human beings are intimately connected to the environment, which shapes notions of personal identity, health and well-being (Stevens 2010). The motivation to protect the environment is therefore not solely based on rational decision-making, but also in deep-seated emotions, that according to DiEnno and Thompson (2013), include feelings of guilt for not being more proactive, indignation at harm caused by others and a general affinity to nature.

Studies as diverse as reseeding oyster beds in New York (Krasny et al. 2014) and environmental care groups in Australia (Gooch 2003) demonstrate the importance of connection to place as a motivating factor for environmental volunteerism. The desire to return the landscape back to a state observed by participants in past times or to even earlier states is a powerful motivator that can drive the agenda of a volunteer program (Gooch 2003). The connection to the environment may also be expressed as a fascination with nature, with the related motivation simply to seek out and enjoy the wonders of nature (Miles et al. 1998).

2.3.5 Factors influencing volunteer motivation

In general, the factors influencing volunteer motivation are complex, interdependent and cannot easily be condensed into a unidimensional model (Mannarini & Fedi 2009). Furthermore, what prompts a volunteer to join a project may differ from that of continuing participation in the long-term. While the initial motivation may be to fulfil a personal need, practical considerations such as how well a project is organised and effectiveness of leadership may determine ongoing volunteer commitment (Bruyere & Rappe 2007; Ryan et al. 2001).

In a study of water quality volunteers in Alabama (USA), strong relationships were found between the variables of income, education and geographical location (Deutsch et al. 2009). In contrast, findings from three environmental stewardship programmes in Michigan (USA), found no relationship between participants' ages, the distance to the site, time availability or the specific activity and the commitment, frequency or duration of volunteers' participation (Ryan et al. 2001). Individual factors such as age and ethnicity may exert strong influences, with elderly volunteers motivated to 'pay back' to society (Narushima 2005), while cultural and religious notions of volunteerism may emphasize duty, rather than altruism or personal gain (Office for the Community and Voluntary Sector 2007; Yeung 2004).

Although few studies to date have investigated volunteer motivation in citizen science projects, the four basic categories discussed in this section form a common thread through projects ranging from conservation action (e.g. tagging wildlife), environmental monitoring, management, and environmental restoration to others within the social service sector. A full investigation of the motivations of community environmental groups in New Zealand voluntarily undertaking environmental restoration lies beyond the scope of this study. However, the four categories provide a psychological foundation for the groups this thesis centres on, as they undertake their restoration projects and monitor the environmental changes that occur (i.e., carry out citizen science).

2.4 Citizen science

Citizen science has emerged as a powerful means of democratising science by enabling diverse members of the community to participate in scientific investigations (Ely 2008). The term 'citizen science' was first used in 1989 to describe the collection of rain samples by volunteers in order to raise awareness of acid-rain in North America (Kerson 1989). In 1995, citizen science was used almost simultaneously in the United States and in England to refer to public involvement in science and science communication projects (Bonney 1996), and, more widely, to describe public engagement in science discourse and policy-making processes (Irwin 1995). Conrad and Hilchey (2011) have recognised this quasi-parallel evolution of citizen science terminology as contributing to the range of ways in which citizen science is currently conceptualised.

2.4.1 *The scope of citizen science*

The history of citizen science is being re-examined and extended, with Charles Darwin (1809-1882), for example, now being regarded as a 'citizen scientist'. Although Darwin existed in an era when the term 'scientist' had not yet been used, he was a highly regarded naturalist in his own right. The rationale for reframing Darwin as a citizen scientist is due to his role on the Beagle as a self-funded volunteer (in today's parlance), collecting environmental data in support of science (Silvertown 2009). In its broadest interpretation, citizen science may simply be scientific investigations where community volunteers collect genuine data that are analysed (either by, or in partnership with scientists/other professionals), and disseminated (Jordan et al. 2012). Such a broad definition has allowed a diversity of approaches and disciplines to be drawn into the discourse on citizen science, while at the same time, challenging boundary-setting for what constitutes citizen science. This is of particular importance for countries such as New Zealand, where the term 'citizen science' has only recently entered the vocabulary in the environmental management, community conservation and science sectors (e.g., Brumby et al. 2015; Spurr 2012). Understanding the current scope of citizen science enables New Zealand-based research, projects and programmes that involve volunteers collecting scientific data to be contextualized within the international citizen science movement. At the same time, there exists an opportunity to define citizen science in New Zealand in ways that are culturally acceptable and that connect to scientific and societal aspirations. In the course of doing so, the profile of activities underway in New Zealand can be raised, and programmes and projects developed that meet local needs, foster international collaboration (as already occurs with the E-bird database, http://ebird.org/content/ebird/), and contribute to citizen science scholarship.

2.4.2 Active vs. passive participation

Volunteers participate both actively and passively in citizen science projects and it is the nature of passive engagement that is debated among citizen science scholars (Haklay 2015; Roy et al. 2012; Parsons et al. 2011; Wiggins & Crowston 2011). According to Wiggins and Crowston (2011), active participation by volunteers is a distinguishing feature of citizen science, and ranges from the voluntary collection of specimens and observations for a single event in time, e.g., a BioBlitz (Lundmark 2003), to the other extreme, i.e. long-term monitoring sustained for decades by the same volunteer(s) (Maine Volunteer Lake Monitoring Programme 2012).

Others, however, extend citizen science to include passive projects, highlighting that participation is still voluntary, and that projects would not be feasible without volunteer input (Haklay 2015; Roy et al. 2012; Parsons et al. 2011). As such, volunteers are still perceived as participating, albeit in a less active capacity when compared with more active forms of citizen science involvement (Haklay 2013).

The following forms of passive participation are all described as citizen science (Haklay 2015; Misra et al. 2014; Raddick et al. 2010), namely, by donating computing power; providing space for equipment, and carrying around sensors. Resource intensive projects such as SETI@home (Search for Extra Terrestrial Intelligence), for example, rely on unused computing power. Volunteers download a programme to automatically analyse radio telescope data (http://setiathome.ssl.berkeley.edu/). In other projects, volunteers provide space (e.g., in their garden) for automatic sensing equipment (http://www.flightradar24.com/about), or drive around with sensors that automatically collect road condition data (http://www.streetbump.org/).

Haklay (2013) draws a distinction between being a participant and being a research subject, although the boundaries between these are blurred. Scassa and Chung (2015), argue that being a research subject and providing data in the form of written descriptions by participants, or DNA, bodily fluid or tissue samples, should be considered as citizen science. Their rationale lies in the potential for intellectual property rights issues around sharing personal data. The provision of bacterial swabs (as occurs in the Belly Button Biodiversity project, http://navels.yourwildlife.org/bbb-project/) is promoted as citizen science (Hulcr et al. 2012), highlighting the need for a finer-scale appraisal of project features such as purpose and research methods used to establish boundaries for what constitutes citizen science.

2.5 Terminology

Literature which focuses on voluntary participation in scientific projects (commencing from first usage of the term citizen science in 1989; Bonney 1996), includes a broad array of terms used either in conjunction with citizen science (such as Community Based Environmental Monitoring; CBEM), or interchangeably with citizen science (such as crowdsourcing). These increasingly varied applications of citizen science have led to confusion and inconsistent use of the term (Roy et al. 2012; Ely 2008; Clark & Illman 2001). Furthermore, the meanings of ‘citizen’, ‘citizen scientists’ and even ‘scientist’ are not value-free and have been called into question (Ely 2008; Wilderman 2007). The term ‘citizen’, for example, refers to both an inhabitant of a town or city as well as a ‘native or naturalized person who owes allegiance to a government and is entitled to protection from it’ (Merriam-Webster 2005). Wilderman (2007) points out the political connotations of ‘citizen’, as not all citizen science project participants may technically be citizens of the country in which the project takes place. Instead ‘amateur’ and ‘community’ are proposed as alternatives (Haklay 2015; Lawrence 2006). Defining professional scientists is generally straightforward (e.g., those specifically employed to carry out science-based activities or conduct investigations), however, citizen science participants may not describe or even identify themselves as ‘scientists’ despite the scientific nature of the work they carry out, preferring terms such as ‘birdwatcher’ or ‘volunteer weather observer’ (Haklay 2015).

Establishing a suite of standardized terms forms an essential foundation in any field of science (Salafsky et al. 2007). Terms that are both general but relevant to the local context are of particular importance in countries such as New Zealand, where increasing emphasis is being placed on community engagement in science and environmental decision-making (Ministry of Business Innovation and Employment et al. 2014; Ministry for the Environment 2013). Rather than producing an exhaustive list of synonyms, the purpose of this section is to provide an overview of current and trending terminology. By doing so, discrepancies in the use of particular terms are revealed, the close relationship between citizen science and monitoring reiterated, and the likely future direction of citizen science outlined. Synonyms for citizen science can be grouped into clusters according to four main characteristics, which (1) emphasize participation by non-professionals; (2) recognise other forms of knowledge; (3) highlight participatory processes, and (4) use locality as a defining feature. For the purposes of this review, these clusters are descriptive and overlapping rather than based on empirical testing.

2.5.1 Participation by non-professionals

Citizen scientists, though often educated to tertiary level, may not have a science background (Haklay 2015). Science skill levels in the citizen science project vary, with participants variously classed as neophytes (interested, but no formal background in the field studied), interested, or expert amateurs (Coleman et al. 2009). These individuals contribute their time, effort, and resources on a voluntary basis to collect and/or process data for scientific research projects, either in collaboration with professional scientists, or independently (Silvertown 2009). Participants may include school children (Mueller & Tippins 2012); low socio-economic or minority groups (Bone et al. 2012); tribespeople (Ansell & Koenig 2010); non-literate groups (Haklay 2015), or special interest groups such as recreational divers (Goffredo et al. 2010); holidaymakers (Chandler et al. 2012); foresters (Ballard & Belsky 2010) and birdwatchers (Cooper et al. 2014). Participants may also comprise inhabitants of localities such as urban areas (Krasny & Tidball 2009; Cooper et al. 2007); national parks (Ansell & Koenig 2010; Becker et al. 2005); watersheds (Conrad 2006; Whitelaw et al. 2003), or be located in areas affected by an event such as an oil spill (McCormick 2012) or air pollution (Ottinger 2010). These non-professionals are typically involved with data collection, though may participate in parts of the scientific processing or other aspects of the project.

2.5.1.1 Volunteer/community-based environmental monitoring

The non-professional, non-scientist status of citizen science participants is evident in terms such as volunteer (biological) monitoring (Engel & Voshell 2002), and community-based (ecological/environmental) monitoring (Conrad & Hilchey 2011; Conrad 2006). These terms generally describe individual members of a community or community groups carrying out monitoring in collaboration with researchers, local institutions, government agencies and industry (Whitelaw et al. 2003). In the freshwater domain, for example, water quality-centred projects are commonly referred to as volunteer monitoring programmes (Maine Volunteer Lake Monitoring Programme 2012), where volunteers supply data to a governing body such as a university, government agency or NGO.

2.5.1.2 Crowdsourcing

Crowdsourcing (also referred to as crowd-sourcing or crowd-sourced science), implies open participation to all members of the public who have access to the methods by which the data are collected. Crowdsourcing has become synonymous with large scale passive or active projects in citizen science that rely on Web 2.0 technology for harnessing data collected by geographically-dispersed participants (Lauriault & Mooney 2014). The expanding role of technology in citizen science has encouraged crowdsourcing by facilitating data entry, data analysis and sharing (Newman et al. 2012).

2.5.1.3 Community/civic science

Citizen science is variously regarded as a form of, or synonym for, community/civic science (Ahern et al. 2014; Bates et al. 2013; Haklay 2013; Tweddle et al. 2012). However, Carr (2004) argues that community science suggests a wider scope of social inclusion and stronger multi-disciplinary characteristics than citizen science, though activities such as mapping, monitoring, modelling and scientific discovery are common to both. This critique is understandable given the prevalence of citizen science projects utilizing individual, often geographically-dispersed, volunteers operating independently of one another as data collectors for scientist-led projects (Ely 2008).

Where citizen science has become the overarching term for volunteer monitoring, community science can in turn function as an overarching term for citizen science, in the same way public participation in scientific research (PPSR) was originally put forward by Bonney et al. (2009a). In the broadest sense, community science may include consultation as well as research between scientists and community members (Shirk et al 2012). A distinguishing feature of this approach is that community members may be empowered to take leadership and control of scientific investigations and use the science for problem solving (Cooper et al. 2007). This is similar to Haklay's (2015) 'Extreme Citizen Science' model, where citizens, often in projects situated in non-industrialised countries, set the research agenda. The concept and use of the term 'civic science' is also inconsistent and has been used to describe both practical scientific investigations and science communication efforts that are underpinned by a social agenda (Clark & Illman 2001).

2.5.2 Recognising other forms of knowledge

Western science forms the dominant research method for citizen science, though several authors argue that other forms of knowledge variously referred to as: traditional ecological knowledge (TEK; Mueller & Tippins 2012); indigenous knowledge (IK; Leach & Fairhead 2002), or lay, local and traditional knowledge (LLTK; University of the West of England 2013), can also be regarded as citizen science. Caution has been expressed in overemphasizing the difference between TEK and western science (Agrawal 1995), as key indicators may overlap (Berkes et al. 2007), and shared activities may include data collection, analysis and the co-production of knowledge (University of the West of England 2013). Ballard and Belsky (2010), for example, showed that local people drawing on their knowledge of place can help shape the research design by locating study sites and determining appropriate variables to measure. Although there are synergies between TEK and citizen science, the former may also be used to challenge conventional science (Leach & Fairhead 2002; Irwin 1995), underscoring the context-dependent nature of TEK when applied outside western science frameworks. The nature of the relationship between TEK and citizen science will continue to be debated, and this is likely to increase as citizen science is more strongly theorised.

In New Zealand, mātauranga māori is loosely summarised as indigenous cultural knowledge (Townsend et al. 2004), which when in the context of environmental policy and planning documents provides a very narrow interpretation. A richer understanding of mātauranga māori that captures the integrated nature of the concept, may in turn see citizen science viewed as a component of mātauranga māori rather than vice versa.

2.5.3 A focus on participatory processes

Participatory (action) research, participatory (biological) monitoring and participatory mapping have only recently been considered as citizen science terms (Singh et al. 2014; Haklay 2013; Roy et al. 2012; Bell et al. 2008; Lawrence 2006). Participatory research models can potentially offer volunteers greater opportunities to become involved with forming research questions, project design, data collection and interpretation (Bonney et al. 2009a). Cooper et al. (2007), however, delineate citizen science activities from participatory action research; the former typically taking place at larger scales, led by scientists and with research and educational priorities; the latter more localised, where the interest is generated by participants and an iterative approach is taken to adaptive management processes that are not present in citizen science projects. The difference in research processes highlights the development sector roots of participatory research (see Pretty 1995), and the newer application to citizen science, as the field expands and adopts new approaches to meet needs beyond preliminary data, such as for species conservation purposes.

2.5.4 The influence of locality

The professionalization of science over the last two centuries has occurred in tandem with increased specialisation, which has required more complex equipment and training than was previously available to amateurs (Greenwood 2007). This cemented institutions as centres of knowledge, and began the creation of a knowledge hierarchy distancing professionals from non-professionals (Vetter 2011). Emphasising both the location and practitioners lying outside formal institutions, as 'street science' does, highlights the alternative nature of citizen science when compared to science carried out by professionals within professional settings (Mueller & Tippins 2012). A feature of locally-based monitoring (Danielsen et al. 2008) is the use of local residents to study local issues such as water quality decline or pest incursions, as these issues may be too localised for investigation by professional scientists (Miller-Rushing et al. 2012). However, the distinction drawn between locally-based monitoring and citizen science is that the latter typically engages others to lead the project from outside the local community, sometimes from a considerable physical distance (Singh et al. 2014; Danielsen et al. 2008).

From the initial development in the environmental sector, the scope of citizen science has rapidly expanded to include projects in the fields of astronomy (Mendez et al. 2010) and public health (Khatib et al. 2011; Ottinger 2010). However, the most pertinent definition for Chapters 4-7 of this thesis was proposed by the United Kingdom Environmental Observation Framework, where citizen science refers to volunteers collecting data relating to biodiversity and the environment which contributes to enhancing knowledge of the natural world (Tweddle et al. 2012).

2.6 Typologies of citizen science

Having discussed the range of terms associated with, or as synonyms for citizen science, an examination of citizen science types follows. The citizen science typologies presented in this section were used as a tool for analysis in the study rather than for data collection purposes. Ultimately, applying typologies developed for citizen science to community environmental groups in New Zealand may assist with developing a model for hybrid forms of restoration and conservation that maximise outcomes for the groups themselves, their project partners (e.g., resource management agencies), and the environment.

The potential for volunteers to participate in one or more steps of citizen science project development and implementation activities has underpinned typology development both directly (Bonney et al. 2009b; Danielsen et al. 2008), and indirectly by reconceptualising volunteer participation into broader areas such as project activity type, intellectual property, and policy development (Haklay 2015; Scassa & Chung 2015; Haklay 2013; Wiggins & Crowston 2011). Typologies make explicit the relationships between community and professional scientists/project coordinators, and recognise the interplay between project organisational structure and leadership, as well as the differing skills and expertise required during each phase of the research process (Roy et al. 2012; Wiggins & Crowston 2011; Danielsen et al. 2008). This section outlines key typologies that seek to characterise citizen science project types, and provides an overview of alignment and variability of each. These typologies are then applied to a cross-section of citizen science and monitoring-related projects to highlight the diversity of project organisational models, as well as various ways they may be classified when different typologies are applied.

The first typologies to characterise citizen science were based on the level of volunteer participation (Bonney et al. 2009a). As such, they follow a similar structure to the ladder of citizen participation firstly proposed by Arnstein (1969), and further refined by Pretty (1995). Although 'participate' can simply be defined as to be involved with, or to take part in (Merriam-Webster 2005), the term 'participatory' has become highly contested (Goodwin 1998), symbolising a range of social and political ideals (Lawrence 2006). By opening participation potentially to all members of society, challenges to traditional top-down power structures have followed. Chevalier and Buckles (2013), for example, describe the ultimate goal of participation as precipitating social change that leads to improved individual and community wellbeing. The conceptualisation of participation as a ladder as both Arnstein (1969) and Pretty (1995) did, structured the debate around the nature of interactions between non-professionals/community members and professionals, as well as the expected outcomes of these interactions. The basic premise is that movement from no/low citizen participation to high citizen participation in activities such as decision-making changes the power relations between citizens and decision-makers. For example, the lower the level of citizen participation, the fewer the opportunities for empowerment exist, as communities are effectively excluded from the decision-making process. In contrast, high community member participation is synonymous with greater control of outcomes and therefore signifies a shift in power relations from decision-makers to communities (Pretty 1995; Arnstein 1969).

The ladder of participation serves a valuable purpose by exposing the power relations that can occur between professionals and non-professionals. In this respect, there is a strong link with citizen science project design. In the contributory (Bonney et al. 2009a) and contractual models (Shirk et al. 2012), the role of volunteers is mostly to provide data to professionally-led research, whereas at the community-led end of the spectrum, volunteers may participate in all parts of the research process. The ladder has been critiqued by citizen science scholars for failing to recognise that different models of participation can operate simultaneously within a program, and to the benefit of all participants (Shirk et al. 2012; Lawrence 2006). This awareness of the need for greater reciprocity, particularly within contributory programmes relations is now embedded as best practice within citizen science project design frameworks (Pandya 2012; Tweddle et al. 2012). Further discussion on these levels of participation within citizen science occurs later in this section.

Subsequent citizen science typologies reflect the growing complexity of projects driven, for example, by advances in technology (Haklay 2015; Haklay 2013; Roy et al. 2012; Wiggins & Crowston 2011), the implications of participating in citizen science projects with respect to intellectual property rights (Scassa & Chung 2015), and how citizen science projects can contribute to policy at scales from neighbourhood to continental (Haklay 2015). Both quantitative and qualitative methods have been employed in studies to cluster similar project types together. By examining 234 (mostly scientist-led) projects, Roy et al. (2012) found the number of participants and the level of (non-financial) investment by project coordinators (e.g., developing project resource material) and volunteers (level of input required) formed the key predictors of project type.

A similar, though more detailed study by Wiggins and Crowston (2011) using 80 different variables (e.g., project goals, research discipline and geographic scale), distinguished five separate project types, namely:

1. 'Action' projects: volunteers design and mostly implement projects with scientists in order to address local environmental concerns and issues.

2. ‘Conservation’ projects: mostly regional in scale and use long-term monitoring for environmental management, public awareness-raising and stewardship promotion.
3. ‘Investigation’ projects: range in scale from regional to international and have scientific research objectives that may include educational components.
4. ‘Virtual’ projects: participation is typically through online platforms.
5. ‘Education’ projects: primary objectives comprise education and outreach, with scientific rigour possibly of lesser importance.

The typology developed by Scassa and Chung (2015), highlights the need for informing volunteers of their intellectual property rights. Where citizen science projects include problem solving and data manipulation, copyright and patent issues may arise, while for projects requiring personal/medical information (e.g., samples of blood or tissue), intellectual property rights may apply depending on project design, methodology and sample use (e.g., Glasner 2000). The typology also acknowledges trade-offs between data privacy and increasing the value of data by making it more widely available (Scassa & Chung 2015).

A policy-oriented typology was developed by Haklay (2015), in response to the need for engaging the public in environmental decision-making, harnessing data for decision-making as well as maintaining a level of transparency for citizen science practitioners in the policy-development process. Policy domains are defined by increasing levels of geographical scale, with suitably designed citizen science projects corresponding to each level. Scientist-led biological surveys carried out by volunteers, such as the OPAL (Open Laboratories) Soil and Earthworm Survey can support environmental monitoring policy at a country scale (Bone et al. 2012). Similarly, public health and ecology policy can be supported by regional or country-wide surveys of disease vectors such as mosquitos (Kampen et al. 2015).

These typologies illustrate how citizen science challenges traditional approaches to how science is carried out, and by whom, to produce new knowledge (Haklay 2013). Citizens may be passive collectors of data (e.g., by using sensors), or participate fully in research design, data collection, analysis, interpretation and application. Typologies can guide the development of new projects by focussing attention on individual organisational models, or combinations thereof, that support desired project outcomes for the environment, project participants and stakeholders such as funders (University of the West of England 2013; Tweddle et al. 2012).

With the increasing diversity of citizen science projects, the boundaries between typology categories are mostly indicative rather than rigidly defined (Bonney et al. 2009b), and overlap depending on the variables used to define each category. In addition, different types of participation may occur within a single project, for example, where one group of volunteers has limited involvement while another group participates in many different aspects of the project (Tweddle et al. 2012). This approach results in projects appearing in more than one category. Applying these typologies to different project organisational models reveals the current scope of citizen science activities and the way in which each is conceptualised by different authors (Table 2.1).

Table 2.1 Participation-based typologies of citizen science by selected authors according to roles of community members and scientist including project examples.

Participation	Approximate synonyms	Roles	Project examples	Project type[1]	Project scale
HIGH - Community led	Autonomous local monitoring (Danielsen et al. 2008)	Research agenda set by community. Community carries out data collection, analysis, interpretation and application of results for management. Scientists can be facilitators and experts.	Lake Rotokare Scenic Reserve Trust (http://www.rotokare.org.nz/)	Action	Local
	Extreme citizen science (Haklay 2013)		Lake Sunapee Protective Association (http://www.lakesunapee.org/)	Action	Local
	Collegial (Shirk et al. 2012)		Traditional Ecological Knowledge (Shebitz 2005)	Action	Local
	Community (Conrad and Hilchey 2011)				
	Transformative (Goodwin 1998)				
	Bottom-up, grassroots (Conrad and Hilchey 2011)				

[1] Wiggins and Crowston 2011

MEDIUM - Hybrid science/ community led	Collaborative monitoring (Danielsen et al. 2008) Participatory science (Haklay 2013) Co-created (Bonney et al. 2009a) Collaborative (Bonney et al. 2009a)	Research agenda jointly set, or only by scientists. Community collect data and may participate in interpretation/ analysis, reporting, and management decision-making. Scientists provide advice and training, and lead the project, or facilitate local people to lead the project.	Participatory mapping (Haklay 2013) Friends of Organ Pipes National Park (Reid et al. 2011)	Action Action	Local Local
LOW – Scientist-led	Contributory (Bonney et al. 2009a) Contractual (Shirk et al. 2012) Instrumental (Goodwin 1998) Top-down (Conrad and Hilchey 2011)	Research agenda set by scientists. Community collects data. Scientists develop project design, analyse and interpret results; may conduct research at request of community	BioBlitz (Lundmark 2003) Wai Care (https://www.waicare.org.nz/Home.aspx) SETI@home (http://setiathome.ssl.berkeley.edu/) Project BudBurst (http://budburst.org/) Audubon Christmas Bird Count (http://www.audubon.org/conservation/science/christmas-bird-count)	Investigation Educational; Virtual; Investigation Investigation	Local Local / Regional National / Continental National / Continental

2.6.1 High community participation

In projects with a high level of participation by community members, varying degrees of collaboration and partnership occur. In 'autonomous local monitoring', for example, the entire research process including the application of results for management purposes, is carried out by community members with no direct involvement of external agencies. This suggests that little or no support for the research is received from professional scientists (Danielsen et al. 2008). In contrast, scientists may act both as facilitators and experts if required, following the 'Extreme' citizen science model, a locally situated, grass-roots practice designed to build participants' knowledge. However, as with autonomous local monitoring, the potential exists for full volunteer control and participation in all aspects of the investigation (Haklay 2013). A feature of these projects is that community members set the research agenda, and that projects are carried out at a local scale to address local issues. For this reason, this approach may also be described as 'grassroots' or 'bottom-up' (Conrad & Hilchey 2011), and may be 'transformative' on account of the potential for participant empowerment (Goodwin 1998). It can be argued that TEK is most similar to this community-led model, given the autonomous organisational structure, and local design and implementation carried out to suit local community needs (Leach & Fairhead 2002). According to the project types developed by Wiggins and Crowston (2011), a high level of community participation often results in practical action, as these projects typically take place on a local scale.

2.6.2 Medium community participation

In both 'co-created' and 'collaborative' projects, opportunities exist for volunteers to be engaged in different aspects of the research process (Bonney et al. 2009). In collaborative monitoring, community members collect data and may participate in management decision-making, while externally-located professional scientists, i.e., often located a considerable distance away from the study site, develop the project design and conduct analyses. Alternately, data may be locally interpreted and other parts of the research process carried out by local people, with the scientists' role being to provide advice and training (Danielsen et al. 2008). In both models, scientists either directly lead the project or facilitate local people to lead the project. In 'participatory science' projects, volunteers analyse data and interpret results (Haklay 2013). These may also be described as action-oriented projects, as they are often local in scale and are developed with input from scientists (Wiggins & Crowston 2011).

2.6.3 Low community participation

Scientist-led approaches, where the role of volunteers is largely 'contributory', form the most widely reported citizen science and community based environmental monitoring (CBEM) model, due to strong institutional involvement and the need for publishing outcomes for scientific research (Roy et al. 2012). To date, millions of volunteers have participated in diverse contributory projects (Bonney et al. 2014), requiring varying levels of commitment and expertise (Hobbs & White 2012). In these projects, externally-located professional scientists develop project design, and analyse and interpret results, while community members collect data, hence being described as 'top–down' (Mueller & Tippins 2012; Conrad & Hilchey 2011). Most examples of this model derive from Europe or North America, owing to the high level of infrastructure available to support the project (e.g., equipment required for recording observations), and accessible professional support (Danielsen et al. 2008). These types of contributory projects are often large-scale, and employ Web 2.0 technology as the primary means of communication between geographically-dispersed participants, scientists and project coordinators (e.g., Worthington et al. 2012), though Roy et al. (2012) found that a large number of projects operate at a local scale, particularly in the United Kingdom.

Further inclusions in the low participation-based continuum are ‘contractual’ projects, where professional scientists conduct research at the behest of the community (Shirk et al. 2012), and ‘virtual’ projects relying on ‘distributed intelligence’ (Haklay 2015; Wiggins & Crowston 2011). In these projects, the cognitive ability of trained participants is utilised, for example, to classify phenomena such as galaxies (Haklay 2015). According to Wiggins and Crowston (2011), the greatest diversity of project type falls into this category, namely, educational, virtual, conservation and investigation. This is primarily on account of the larger geographic scales achievable with institutionally-led projects and the ability to leverage substantial numbers of participants. However, projects in this category may also be local in scale, such as a BioBlitz, where the public participates in developing an inventory of flora, fauna and fungi within in a limited time frame and geographic area (Lundmark 2003).

2.7 Inclusivity, empowerment and control

Although the function of typologies is to reveal basic patterns, an investigation of the literature shows considerable complexity when typologies are examined against factors such as the nature of volunteers participating in citizen science projects, and whether or not empowerment is indeed an outcome.

Discourse on inclusivity pervades much of the citizen science literature (Bone et al. 2012; McCormick 2012; Ely 2008; Becker et al. 2005), however, participants in most projects appear to be white, educated, and possess discretionary wealth and time, although male to female ratios vary from project to project (Haklay 2015; Hobbs & White 2012; Deutsch et al. 2009). The desire to expand the diversity of participants in citizen science has resulted in the application of more socio-economically and culturally-sensitive approaches to volunteer recruitment and retention. The Open Laboratory programme, for example, successfully engaged deprived and other difficult-to-reach members of the community for inclusion in a biological survey project (Bone et al. 2012).

The future of citizen science will see increased use of technology with devices such as smartphones, sensors and tablets networked with interoperable databases (Crain et al. 2014; Newman et al. 2012). Web-based, game-style citizen science products may encourage younger, more culturally-diverse volunteers to participate (Newman et al. 2012), but could also create a 'digital divide' that segregates members of the public who have limited, or no access to technology (Haklay 2015).

Considerable debate has ensued when empowerment is assumed to result from greater community input and control, with empowerment referring to increased influence and capacity at a personal, group, or community level (Fawcett et al. 1995). However, community empowerment can occur in 'top down' settings, as learning can still take place that may significantly alter individual outlook and values, in particular where project coordinators' motivation centres on forming partnerships and sharing control of environmental management (Lawrence 2006). In contrast, Danielson et al. (2008) argue convincingly that top-down approaches, where project coordinators are externally located, do not translate into effective local management. The examples used in their work are mostly situated in non-industrialised countries, where the close link between local people and local decision-making becomes most apparent.

Participant empowerment can occur through medium-level participation where partnerships between volunteers and professionals are mutually negotiated, inclusive and transparent (Gooch 2004), confirming that the quality of participation can override other factors (Shirk et al. 2012), and that mutual respect is central to effective engagement (Haklay 2015). Galbraith (2013) demonstrates that greater empowerment for community members can eventuate when moving from a bottom-up, autonomous operational model to a partnership model. Other projects, however, highlight that bottom-up settings may also serve to protect local interests, leaving the power relations unchanged (Lawrence 2006).The achievement or non-achievement of empowerment at different levels of participation attests to the internal complexity both within communities themselves and within institutional settings. In addition, the contrasting nature of outcomes from projects using the same citizen science structural model, highlight the context-dependent nature of citizen science projects. Although the typologies are a useful structure for characterising project types and examining factors such as participation, caution should be exercised when inferring outcomes from the different top down to bottom up models.

Many scholars have pointed to the need for culture change within institutions, and by individuals, in relation to the greater need for social equity and for increased data to manage declining ecosystem integrity and biodiversity losses (Haklay 2015; Craig et al. 2013; Danielsen et al. 2007; Berkes 2004; Robertson & Hull 2003). With a greater emphasis on participatory and collaborative approaches, Haklay (2013) argues that the new role of scientists is as a 'mediator of knowledge and not as the sole authority of scientific truth'. In the same way, the deficit model of communicating science to the public has been discredited as overly simplistic (Miller 2001), as more effective ways of increasing public understanding centre on two-way public engagement (Ahteensuu 2011).

Uriate et al. (2007) underscore the need to create a scientific culture that welcomes public engagement in science, pointing to narrow definitions of academic success that limit incentives for, and acknowledgement of, the value of collaborative research with non-professionals. Instead, research success should include new metrics where engagement in outreach and educational activities is valued alongside data production and co-authorship (Goring et al. 2014). The multiple social, educational, environmental and scientific outcomes that can result from citizen science highlight the need for robust science that is integrated with a people-centred philosophy of meaningful engagement (Haklay 2015).

2.8 Theoretical framework

The context for this thesis centres on New Zealand-based community environmental groups carrying out environmental restoration projects. A particular area of focus of this thesis is groups' environmental monitoring activities, and contextualising these activities within citizen science. The meta-themes for this study (as outlined in Chapter 1, the general introduction to this thesis) comprise importance of public participation, meaningful engagement, and partnerships. The theoretical framework outlined below draws on the contextual information provided in the general introduction and rationale for this study (Chapter 1) and the literature review presented in this chapter. The following theoretical points, each linked to the thesis research questions guided the data collection processes (Chapter 3), and the analysis of findings that forms the basis of Chapters 4-7 of this thesis. References for key publications that informed the development of each theoretical point are included.

Research Question 1: What are the characteristics of community environmental groups and their projects in New Zealand?

- Community environmental groups' restoration activities contribute to agency-led conservation efforts throughout New Zealand (Hardie-Boys 2010; Buchan 2007);
- Community environmental groups' largely voluntary efforts are targeted towards environmental restoration (Phipps 2011; Cursey 2010);

- Community environmental groups and their projects are heterogeneous, although they tend to centre on groups of older people focussed on environmental restoration (Cowie 2010; Hardie-Boys 2010).

Research question 2: How do community environmental groups determine whether they have met their project objectives?

- Community groups measure change within their projects using both non-science and science-based methods (Cursey 2010; Byrd 2008);
- Community groups' environmental monitoring is a form of citizen science (Conrad & Hilchey 2011).

Research Question 3: How are community-generated environmental data perceived and used?

- Outputs and outcomes of groups' science-based activities are poorly understood but appear to be primarily used by the groups' themselves (Ritchie 2011; Hardie-Boys 2010);
- Data resulting from groups' science-based activities can contribute to increasing our understanding of regional and national environmental states and trends (Hoyer et al. 2014; Coates 2013).

Research Question 4: Given the increasing focus on water quality decline in New Zealand, what scope is there for citizen science to assist with the provision of water quality monitoring data?

- Increased engagement in biodiversity conservation and freshwater management is being called for from community environmental groups by resource management agencies in New Zealand (Ministry for the Environment 2013; Department of Conservation 2012).

Research Question 5: What principles underpin long-term community environmental monitoring programmes?

- Motivated volunteers, support provided through strong partnerships, the collection of robust and purposeful data that are integrated into long-term resource management programmes, are all required for partnering on ecosystem restoration (Hoyer et al. 2014; Hardie-Boys 2010).

Community environmental groups are becomingly increasingly visible in New Zealand, as greater attention being placed on their restoration activities by agencies and researchers (e.g., Phipps 2011; Hardie-Boys 2010). In addition, Web 2.0 tools (including online databases and social media platforms) provide new methods of raising awareness of groups and their projects (e.g., http://www.naturespace.org.nz/). Providing an overview of motivations for environmental volunteerism provides a foundation from which to investigate group activities. The major knowledge gaps this study addresses, centre on the characteristics of New Zealand community groups and their projects and activities related to their restoration projects. How environmental change is measured within groups' projects is investigated through the lens of the rapidly expanding citizen science movement. The methods used to investigate the research questions for this thesis are presented in the following chapter.

Chapter 3

METHODOLOGY

3.1 Introduction

This chapter describes the methodological approaches used to investigate community groups and their environmental restoration projects. To begin with, the positivist paradigm is briefly outlined, as it is commonly used in ecological research undertaken for conservation and environmental restoration purposes. The constructivist paradigm is then described, as constructivism is the lens through which this study was conducted. A discussion on the mixed method approach to data collection follows. The qualitative and quantitative data analyses are detailed as they relate to a questionnaire and semi-structured interviews carried out with members of community environmental groups. Measures used to ensure trustworthiness are outlined, as are ethical considerations used to guide the study. This chapter concludes with a brief discussion on the scope and limitations of the study, and a chapter summary.

3.2 Methodology

The methodology for any research study must cohere with a paradigm or worldview that explains the fundamental assumptions about reality and knowledge that underpin the study. A paradigm comprises a distinct set of practices that guide a researcher through the process of developing and conducting the study, and interpreting the findings (Lincoln et al. 2005; Fossey et al. 2002). In the current study, the primary study participants were community environmental groups, some of whom were known to use standardised science-based approaches to measure the outputs and outcomes of their restoration management interventions (e.g., Byrd 2008), or changes in environmental health (e.g., Coates 2013). The use of the positivist paradigm predominates within environmental restoration and biodiversity conservation research, and is underpinned by the belief that a single truth exists which can be objectively studied and measured (Lincoln et al. 2005). As such, positivism is based on the principle of falsification, where the results and findings are regarded as true until they are disproved (Merriam-Webster 2005). The use of positivist approaches, by members of community groups, in projects to restore the environment and improve environmental quality formed the starting point for this study. Community members undertaking their own scientific investigations or taking part in studies led by scientists is described as community-based environmental monitoring (CBEM; Conrad & Hilchey 2011) or, increasingly, as citizen science (Silvertown et al. 2013; Shirk et al. 2012).

As the focus in this study was on the group members' and their project partners' perceptions of their work rather than determining the actual outcomes of their work, a positivist approach was deemed inappropriate. The use of a socially-focussed research paradigm was necessary to understand how and why community environmental groups engaged in science within their restoration projects. This included the factors that influenced, for example, their choice of tools and methods for monitoring, and how their project partners viewed the science carried out by these groups.

A study utilising a constructivist approach enables a researcher to undertake detailed examinations of human experience as people live and interact within their own social worlds. The aim of this mode of inquiry is to understand the diversity of worldviews and the influence of contextual factors (Guba & Lincoln 1994). The philosophical foundations of constructivism differ from positivism, as the constructivist worldview is one of multiple realities, given the uniqueness of each individual's perspectives and experiences (Schwand 1994). A relativist ontology underpins constructivism, whereby the beliefs and principles of individual participants are neither timeless nor universal. Instead, they are applicable to a specific context (Appleton & King 2002), which is relevant for this study as the participants (i.e., community groups and their project partners) were investigated in relation to social factors (e.g., the nature of partnership arrangements), as well as socially-determined environmental factors (e.g., biodiversity loss through pest animal and weed incursions). Epistemologically, knowledge and reality in constructivism are developed through the personal experience of the researcher, as well as through interactions with others and their surroundings (Lincoln et al. 2005). In this respect, the researcher is closely linked to the research and must therefore carefully consider how to minimise any bias. The trustworthiness of the study design, process and outcomes are discussed later in this chapter.

3.3 Methods

In this study, quantitative methods were used to canvas community environmental groups in New Zealand. More than 600 of these groups are known to exist (Ross 2009), and such methods allow for breadth of data across large sample sizes, with statistical analysis providing a broad picture of the sample or population. Every possible effort was made to include a broad representation of community environmental groups working across all regions of New Zealand, major ecosystem types and urban, peri-urban and rural locations. Qualitative methods were primarily used to explore meaning and interpretation of responses by study participants, including both community groups and their project partners, at a more detailed level, to access reasons behind the questionnaire data. The collection, analysis and interpretation of both qualitative and quantitative data within a single study are described as mixed methods research (Leech & Onwuegbuzie 2009). The use of a mixed method study design is a pragmatic approach to research (Johnson et al. 2007), as the use of a single method in this study would not have met the objective of gaining both a broad picture and an in-depth understanding of community groups, their projects, activities and the views of their project partners. Mixed research methods enabled the strengths and weaknesses of each method to be offset (Bryman 2006), while also ensuring that data ranging from basic text or numerical responses to detailed narratives could be collected. The purpose of combining quantitative and qualitative methods was to seek complementarity, in other words to illustrate and elaborate upon findings from one method with the findings of another.

Of the 600 community environmental groups throughout New Zealand identified by Ross (2009), contact details for 540 were located. The two primary instruments for data collection comprised an online questionnaire sent to these 540 groups, as well as 34 interviews with project partners. This included nine interviews with members of four different community environmental groups. The use of a questionnaire enabled a large, geographically-dispersed population to be sampled with relative ease, and resulted in a wide-ranging, yet comprehensive overview of the community conservation and restoration sector. In contrast to the breadth possible through questionnaires, the interviews enabled in-depth investigation to take place, albeit with a smaller number of participants.

3.3.1 Online questionnaire

An online questionnaire was developed as a means for collecting data from diverse community environmental groups located in each of the 16 regions of New Zealand. This method enabled a more comprehensive overview of groups and their activities to be created than has previously been reported (e.g., Ritchie 2011; Campbell-Hunt et al. 2010; Hardie-Boys 2010; Byrd 2008). No previous studies were identified that had used an online tool in the context of community environmental groups in New Zealand. As groups included in the study were primarily located through online databases, and therefore had email contacts, an online questionnaire was considered the most practical tool for eliciting responses. Online tools, such as SurveyMonkey® (https://www.surveymonkey.net), offer numerous advantages to paper-based surveys, being both extremely cost-effective, and time-efficient (Dillman et al. 2009). A low-cost subscription to SurveyMonkey® was obtained for the two-month period of the data collection and this subscription was far below that of comparable costs for stationery and postage. In addition, digital responses captured by the software system saved considerable time that would otherwise have been associated with manually re-entering data from handwritten, individual questionnaires. Advantages for participants included the ability to complete the questionnaire from any location with computer access, and automatic functions (i.e. 'skip to'), which removed irrelevant questions depending on previous answers (Lauer et al. 2013). Participants were also spared the process of manually posting their responses. For the researcher, sophisticated back-end (e.g., database) capabilities enabled rapid analyses to take place.

The responses may be presented both as individual files and aggregated as frequency counts across respondents. In addition, the ability to adapt the user interface in increasingly diverse ways to suit respondent needs is a feature of newer online tools such as SurveyMonkey® (Lauer et al. 2013). A tracking function enabled the researcher to see which recipients had not responded or had only partially completed the questionnaire, and facilitated the process of improving response rates either by contacting individuals directly or generating an automatic reminder (e.g., every two weeks), to complete the questionnaire within a given timeframe (Dillman et al. 2009).

The factors that influence response rates to online questionnaires include access to technology, as well as income and level of education (Couper 2000). Contrary to expectations that older participants were less likely to engage with online questionnaires, Huyser de Bernado and Curtis (2012) found that once employment and income were accounted for, online questionnaires formed a viable option for studies that included populations over the age of 50, and senior citizens (65+ y). This finding highlights the potential utility of this approach for the current study as community groups are known to have a high proportion of participants aged 50+ y (e.g., Phipps 2011; Hardie-Boys 2010; Taylor 1997). Many of the technical issues summarised by Cohen et al. (2011), such as researcher and participant security, the corruption of content between devices, and questionnaire loading times, have largely been resolved by tools such as Surveymonkey®.

Although many survey functions are automated, an understanding of effective design principles is still required, including considerations of length; general structure (e.g., number of questions per web page); indicative rate of progress through the questionnaire; visual presentation; question format (e.g., the ratio of open to close-ended questions); and user interactivity such as prompts for missed responses (Lauer et al. 2013; Vicente & Reis 2010; Dillman et al. 2009; O'Rourke 2001).

3.3.2 Semi-structured interviews

An interview is a 'purposeful' dialogue between the researcher and the participant in order to generate detailed or 'thick' descriptions that allow the interview data to be contextualised (Lincoln et al. 2005; Geertz 1973). In this study, the interviews were used as a means for gaining a deeper insight into community-group/project partner relationships, while also creating the opportunity for related strands of inquiry to be explored with project partners as they arose.

The purpose of interviewing is to enter another person's perspective, and in the process, obtain their constructions of the present as well as their projections, reviews or verifications of these constructions (Lincoln et al. 2005; Patton 1990). Interviews may be structured through the use of set questions, semi-structured where thematic content guides are used, or unstructured conversations (Patton 1990). Semi-structured interviews were considered the most appropriate for the current study, enabling subject matter to be explored and expanded upon while still remaining within the bounds of the research topic. In contrast to unstructured interviews, semi-structured interviews anticipate and facilitate analysis by virtue of a thematic guide to assist with shaping interview content (Patton 1990).

Interviews generally elicit high response rates (Appleton 1995) compared with questionnaires (Dillman et al. 2009), and all potential interviewees contacted for this study agreed to be interviewed. As the facilitator, the interviewer can guide the respondent, for example, to elaborate on responses in order to provide richer content, or alternately, to move onto a new question when responses suffice. The interviewer can also answer questions the interviewee may have about the research, potentially strengthening content reliability by providing the interviewee with clarification (Appleton 1995).

Field-oriented research often uses non-probabilistic, purposive sampling based on criteria established by the researcher (Miles & Huberman 1994), as occurred in the current study. Although some authors have provided indicative numbers of interviews to carry out (e.g., Creswell 2006; Morse 1994; Bertaux 1981), others argue that a conceptual endpoint can be reached when key themes, topics and issues are repeated by different interviewees, and little new information emerges (Fossey et al. 2002; Morse 1995). Once this has occurred, the researcher is provided with greater certainty of having both adequately investigated the group in question, as well as having selected an appropriate sample size (Fossey et al. 2002). Guest et al. (2006), for example, found that almost all variation in thematic content occurred in the first 12 of the 60 interviews they conducted. However, endpoints may also be determined by operational factors such as the heterogeneity of the group being interviewed; the complexity of the interviews; researcher experience, and the level of resourcing available (Guest et al. 2006; Ryan & Bernard 2003). Overall, the relative degree of consensus and divergence in interview content required by the researcher rests on the objectives of the data collection and the strategy for analysis (Guest et al. 2006), highlighting the difficulty in predetermining numbers of interviews to be carried out.

3.4 Research design

An overlap in the timing of the online survey and interviews with project partners and selected community environmental groups, enabled multiple feedback loops to be constructed within and between data collection instruments, as well as between research instruments (Figure 3.1). Torrance (2012) highlights that the triangulation of data, i.e. from different sources and accessed over time, provides a more detailed, and informative account of what is being researched. In the study, the questionnaire and interviews were carried out over a 15-month period with project partners and community environmental groups, and as such, could be examined alongside each other. Areas of convergence confirmed consistency in the key messages, while areas of divergence underscored differences in the experiences and world views between respondents. The inclusion of engagement processes (e.g., ‘blog’ writing and attending community events), enabled continuity of two-way communication.

In this study, blog content and discussions with participants at community fora, for example, helped shape online survey and questionnaire content. As the study progressed, preliminary findings were shared with interviewees and a wider group of environmental stakeholders who had expressed interest in the study. The engagement processes used added richness to the study by enabling ongoing opportunities for discussion, elaboration, clarification and debate to occur.

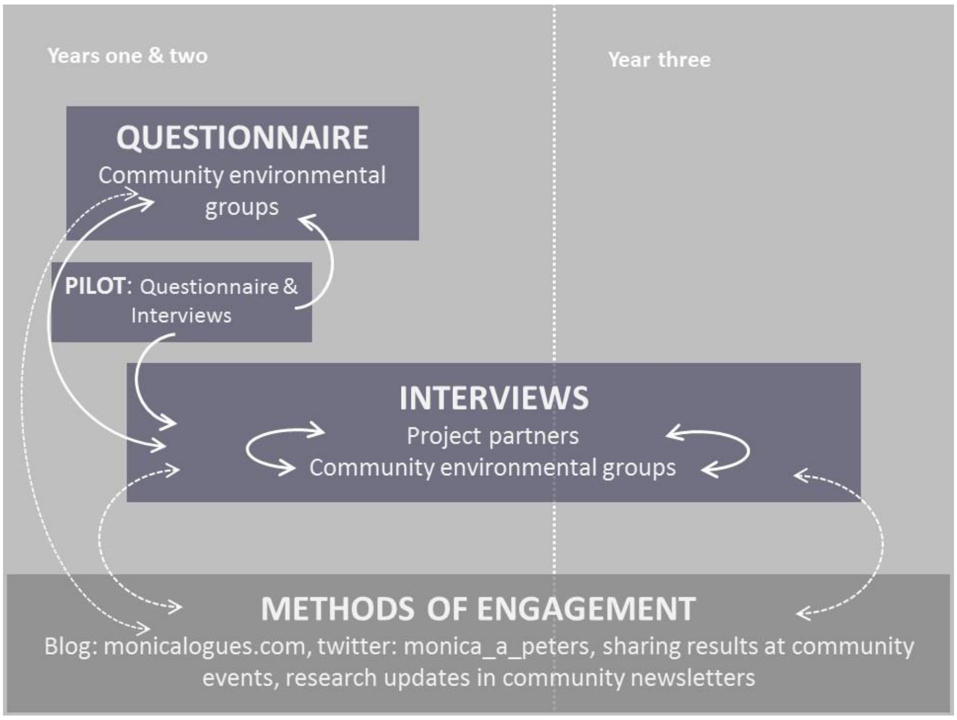


Figure 3.1. Primary methods used within the three-year study (including processes for engagement). Arrows indicate the direction of information flow within and between research methods and the processes of engagement. Broken arrow lines represent low engagement and unbroken lines represent strong engagement.

3.4.1 Online questionnaire

The online SurveyMonkey® questionnaire (Appendix 1) was developed following empirically tested design principles to minimise non-completion rates (see Lauer et al. 2013; Vicente & Reis 2010; Dillman et al. 2009; O'Rourke 2001). The questionnaire was therefore limited to 28 questions, and employed standard fonts and colours throughout. Upper-case letters were used for key instructions, and prompts were set for non-responses to questions. A progress bar at the base of each page indicated the proportion of the questionnaire completed compared with the proportion remaining.

The questionnaire comprised mostly closed-ended questions (e.g., multiple choice questions with fixed answers provided, matrices and Likert scales (Likert 1932). This enabled respondents to select the most appropriate answer more rapidly than writing their own response, and facilitated the categorisation and quantification of answers. Open-ended (free text) questions such as 'What are your group's main objectives…?' were also included, with others such as 'Please list other support received…' added to selected closed questions to enable elaboration on fixed answers. This broadened the scope of responses and enabled further categories to be developed during data analysis that were not included in the initial question choices provided. Presenting questions in different ways (e.g., closed, open, multiple choice) can help to maintain respondent interest and therefore decrease drop-out rates (Lauer et al. 2013). Matrices enabled two questions to be asked simultaneously, namely, 'What is the nature of support provided?', and 'Which project partner provided the support?' thus ensuring the efficient use of respondent time. 'Skip to' functions enabled respondents to skip sections that were not relevant to their group or project (Lauer et al. 2013), a further time-saving function. In addition, content was divided into subsections to help focus the respondent on particular themes, (O'Rourke 2001), as outlined below (questions 1-29).

Community group information (Q 1-7)

General information was requested including: the group name; status (e.g., formally established); aims/objectives; length of time established for; number and age of members/volunteers. These questions were designed to build a general profile of the groups in line with the type of information elicited from other smaller-scale studies of community groups (e.g., Phipps 2011; Hardie-Boys 2010). A suite of basic characteristics, such as length of time established and group size, provided data for multi-variate analyses e.g., to develop profiles of groups in relation to their monitoring activities (Chapter 5).

Partnerships and support (Q 8-9)

The nature of support (e.g., funding, project site visits) and the partner(s) currently providing the support were requested. Groups were also asked to identify further support needed from specific partners. Partnerships between community groups and agencies, scientists, iwi (tribal groups) and others are common (Harrison 2012; Ritchie 2011; Hardie-Boys 2010). An index outlining levels of support was developed that was used in multi-variate analyses (Chapter 5). Information on the status quo as well as the future expectations of support by groups may be required by government agencies and resource managers as greater community input into conservation and environmental decision-making is now required (Department of Conservation 2014; Ministry for the Environment 2013).

Restoration project characteristics (Q 10-16)

This section was intended to provide a description of groups' restoration projects and related activities by requesting the project's region and general location (e.g., urban); land tenure; ecosystem type and project area; and key activities including monitoring. As well as contributing to baseline data on groups' projects, the questions also provided data for multi-variate analyses (Chapter 5).

Monitoring; methods and toolkits; data and equipment use (Q17-29)

The final sections focussed more specifically on monitoring. Questions asked included: challenges for establishing monitoring programmes; other (non-science) based methods of monitoring environmental change being used; length of time monitoring had been carried out; monitoring priorities for groups; methods and toolkits used; groups' perceptions of toolkit layout and effectiveness; monitoring data use by groups; their desire to monitor in the future, and their use of technology in their monitoring work. The questions were designed to gain an insight into the role of monitoring in their projects, particularly as interest in strengthening the relationship between science and society has increased (Ministry of Business Innovation and Employment et al. 2014; Neilson 2014). Furthermore, the growing importance of citizen science and the need for robust data upon which to base environmental decision-making highlight the need for a more complete understanding of how science is understood and used within the community conservation sector.

Prior to sending the questionnaire to participants, a pilot study was carried out with six participants selected from existing personal and professional networks. The aim was to identify any anomalies and leading questions, and to provide feedback on the structure, design and timing of the questionnaire (Van Teijlingen & Hundley 2001). Pilot study participants included three community group members/coordinators (including one professional scientist), two academic staff members with social science expertise and one environmental contractor employed by a community group. Feedback generated by this group was minor, centring mostly on wording. Changes were incorporated into the final questionnaire design. It was anticipated that the final questionnaire would take 10-15 minutes to complete. The pilot study showed this to be a reasonably accurate estimation.

The opportunity to participate in completing the questionnaire was publicised through networks with national distribution, such as the New Zealand Landcare Trust's e-bulletin (Landcare Action; www.landcare.org.nz) and the Nature Space community restoration practitioner's website (www.naturespace.co.nz).

Regional networks such as the Waikato Biodiversity Forum e-newsletter (www.waikatobiodiversity.org.nz) and the New Zealand Landcare Trusts' regional newsletters were used to complement and reinforce the national channels used. Social media channels for information dissemination included a research blog (www.monicalogues.com) that contained supporting information on the questionnaire purpose and content, with *Linked In*™ and *Facebook*™ also used to promote wider inclusion in the questionnaire. In August 2013, an invitation to complete the questionnaire was then emailed to 540 community environmental groups throughout New Zealand.

As 'community environmental group' is a very broad concept, criteria listed in Table 3.1 were applied that combined definitions of community groups from Ritchie (2011) and not-for-profit organisations from Tennant et al. (2006).

Table 3.1 General criteria used in this study for defining community environmental groups
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Category	**Description**
Governance	Formal (e.g., charitable trust, Incorporated society) to informal
Funding	Not-for-profit
Primary environmental activities	Biodiversity restoration, enhancement or protection
Project structure	Volunteer base, though paid coordinator(s) and other staff acceptable
Partnership(s)	Strongly or weakly affiliated to existing (environmental) organisation (e.g., resource management agencies, NGOs, Māori tribal authority), or fully independent

Currently active community environmental group members and coordinators were recruited via publically accessible databases, namely Nature Space (Nature Space undated), the Department of Conservation (Department of Conservation undated-a), Sanctuaries of New Zealand (Sanctuaries of New Zealand undated), and funding providers such as the Waikato River Clean-up Trust (Waikato Regional Council undated) and Trustpower (Trustpower 2010; keyword search: environment). Additional non-public databases were accessed through the author's professional networks including organisations such as the Waikato Biodiversity Forum, WWF-New Zealand (Habitat Protection Fund recipients) and the NZ Landcare Trust. Groups present on these websites are located in the North, South and Stewart Islands of New Zealand. The Chatham Islands were excluded on account of lack of data. Efforts made to generate additional participants and increase the representativeness of community environmental groups from throughout New Zealand and across ecosystem types, included networks generated from attending public events such as biodiversity fora and community group workshops.

For emailing the questionnaire to community groups, a single email address per group was used, addressed where known to the lead coordinator. All individual emails containing a link to the questionnaire were personalised, as recommended by Dillman et al. (2009), in order to improve response rates. However, emails were not able to be personalised when sent via a third party (e.g., to funding recipients held in internal databases), and where only generic email addresses were available (e.g. 'info@'). In cases where the primary contact nominated another, more knowledgeable group participant to complete the questionnaire, the questionnaire was re-sent to the new email address supplied.

A feature of SurveyMonkey® is the ability to link individual questionnaires to individual emails, thus enabling responses from each of the emailed group contacts to be tracked, and reminders to be sent to non-responders. In this study, three-point contact (Dillman et al. 2009) was undertaken where the initial email to the primary group-contact was followed by two reminders to non-responders, each two weeks apart. Over half of the total questionnaire responses (56.8%; *n*=296) were received within the first two weeks following the initial email of the questionnaire. A further 22% and 21% of the total responses were received following the first and second reminders, respectively.

3.4.2 Semi-structured interviews

A guide comprising key questions was developed (Appendix 3) in order to provide a general structure for the interviews, though still enabling subject matter to be explored and expanded upon in a more spontaneous manner (Patton 1990). Three pilot interviews took place with project partners, to refine communication techniques and question themes (Baker 1999). These pilot interviews revealed no problems with responding and were therefore included in the overall interview dataset. In total, 34 in-depth, semi-structured interviews took place, ranging from 30 minutes to 2 hours. Interviews were mostly face to face, although Skype was used on two occasions when meeting with the interviewee was impractical. Questions were open-ended, and included how partners worked with groups; barriers and opportunities for using community-generated data, and means for better supporting community environmental monitoring.

Interview participants, mostly referred to as project partners in this study, comprised representatives from resource management agencies (*n*=14), Non-Government Organisations (*n*=5), environmental consultancies (*n*=1), and science providers (*n*=5). Each informant was identified by their strategic position within their respective organisations and by virtue of their ability to provide perceptive insights into the area of study (Marshall 1996). All interviewees engaged in conservation and environmental restoration and worked in some capacity with community environmental groups (Table 3.2). A snowball sampling method (Goodman 1961) was used to identify further interviewees. The total number of interviews enabled views from key project partners to be canvassed (i.e., resource management agencies and science professionals), with diverse regions and job types represented in the process. No new interviews were carried out when little new material appeared in responses.

Table 3.2 Criteria used for selecting community groups' project partners for semi-structured interviews.

Interviewee category	Number	Rationale for inclusion
Agency (e.g., Regional Council, Department of Conservation)	14	Collaborative project development; provides various forms of support to community groups; possible current and future user of community data, and project land owner.
Science provider	5	Collaborative project development; provides scientific support to community groups, and possible current and future user of community data.
Non-Government Organisation	5	Collaborative project development; provides various forms of support to community groups, and possible current and future user of community data.
Environmental contractor	1	Provides various forms of support to community groups, and possible current and future user of community data.

The total of 34 interviews with these project partners was considered an appropriate number for developing insight into a subject area, and was in line with similar studies (Gooch & Warburton 2009; Bell et al. 2008). In addition, interviews were required to fit the schedule of the study, precluding a larger sample.

Four New Zealand community environmental groups were selected for interviewing, to provide a greater insight into group activities, challenges faced within their environmental restoration projects and interactions with supporting organisations/partners. A total of nine interviews with different group members resulted so that a range of viewpoints could be obtained. Key questions included ways in which the group worked with project partners; whether data were provided to project partners; if yes, how these data were used; barriers for the use of community-generated data and how community environmental monitoring could be better supported (Appendix 3). The criteria for the groups' selection are outlined in Table 3.3. Groups selected fitted each criterion listed.

Interviews were mostly audio-recorded with additional notes made during and/or after interviewing in a field notebook. Transcripts were developed as soon as practical after interviewing and comprised a mixture of summaries and verbatim documentation depending on the style of communication and relevance to areas of questioning. Transcripts were returned to interviewees requesting that verification take place within two weeks to place a time limit on the process. In cases where interviews covered more general information on community environmental groups and their activities, notes instead of audio-recordings were taken, although the notes were also sent back to the interviewees for verification (again, with a two-week window for this to occur).

Table 3.3 Criteria used for selecting the four community environmental groups for semi-structured interviews

Criteria	Details
Well-established	≥ 10 years of operation.
Formalised structure	Incorporated Society, Trust or similar. Robust processes in place for documenting activities and achievements.
Governance	Comprises a range of local/regional representatives.
Engagement	Strongly engaged with local community.
Diversity	Diverse ecosystems and regions represented between groups.
Successes	Demonstrated successes.
Reciprocity	Willingness to participate in study; benefits identified to being a study participant.
Accessibility	Groups within existing personal and professional networks or easily contactable. Ability to participate in group events such as meetings and field activities.

3.5 Qualitative data analyses

The multiple instances of data collection which characterised this study required a method of analysis which was both iterative and reflexive in order to interpret and make sense of the data. If, for example, the process of collection is conceptualised as a spiral, then concepts and theories can evolve only after meanings have been constructed and then re-constructed (Bishop 1996). Therefore an inductive, iterative spiral of analysis was undertaken that allowed data resulting from open-ended questionnaire responses and transcripts from semi-structured interviews to mutually inform, contest and reinforce each other. In lieu of testing hypotheses a priori, this Grounded Theory approach is a process of continual comparison within and between the primary data and the wider literature (Glaser & Strauss 2009). Concepts and theories are then generated from, and effectively grounded within the data, having emerged through an iterative, cyclical process of coding. The qualitative data analysis software (NVivo 10; http://www.qsrinternational.com/products_nvivo.aspx) facilitated this analysis by enabling text to be manually tagged and coded into one or more categories drawn from passage content (Bazely & Jackson 2013). Category generation was an inductive process whereby recurring keywords and/or themes were aggregated to enable large bodies of text to be searched and interpreted in diverse ways.

Percentage counts of qualitative questionnaire responses were developed by aggregating instances where keywords and themes were repeated. Asking groups, for example, to describe their restoration objectives resulted in 1091 responses which were then tagged and indexed into three main categories inductively drawn from the data, namely, environmental, social, and economic. However, these broad categories also appear in other studies related to community environmental groups and their restoration activities (e.g., Phipps 2011; Hardie-Boys 2010; Buchan 2007). Additional reviewing of keywords (e.g., rat, pest) and themes (e.g., building relationships) in the main categories, resulted in further partitioning into subcategories (e.g. exotic fauna and community building, respectively). Once all objectives were tagged and indexed, a matrix ordering responses from each group across all the categories and subcategories was generated. Categorised objectives then were reduced from text to binary numbers to calculate percentages of categories and subcategories to each community group. These data were included in Chapter 4, which profiles community environmental groups and their projects.

NVivo 10 was used to determine the frequency of specific words occurring in open-ended responses. Results were generated as numeric frequency counts, but a process of visualisation of these data by means of a word cloud was used. The purpose of the word cloud was to visually display the most common words used by community groups to describe their project objectives (Chapter 4). This method allowed groups' main areas of concern to be highlighted. Word clouds link font size to word frequency, i.e., the more frequently a word is used, the larger it appears relative to other words. To determine the most frequently used words while avoiding repetition, settings were chosen to find the most commonly used 100 words; to aggregate words with a similar root (e.g., restoration = restore, restoration, restored, restoring); to exclude common words (e.g., and, the), and only to include words >3 characters long.

3.6 Quantitative data analyses

Several forms of quantitative data analysis were used in this study. The simplest was frequency counts of questionnaire responses to closed questions, for example, where groups were asked to indicate the type of ecosystem(s) being restored from a list provided (questionnaire question 13). Responses were presented as percentages of total responses received. Closed questions in the form of matrices (questions 8, 9, 21, 24 and 28) enabled frequency counts to be made for individual points (e.g., frequency of incidences of support provided by DOC for project site visits), as well as across categories of partners providing support or across the type of support being provided.

3.6.1 Determining the level of partner support

In order to determine the perceived level of support received by groups from their project partners, a general index of low, medium or high partner support was developed. This was inferred from the reported number of project partners per group added to the reported number of incidences of support provided by project partners per group (question 8). Project partners comprised the Department of Conservation, regional/district council, iwi, science providers, business and private contractor(s). Support comprised project site visits, technical support, data management, on-ground works, cultural advice, funding/sponsorship, administration, and equipment/venue loans. An open-ended question was included asking respondents to list other support received and its source. These data were summarised thematically (Chapter 4). The index acknowledges that a single partner with a broad mandate for working with community groups may therefore provide a range of support, e.g., site visits, assistance with on-ground works, equipment loans and so forth. In contrast, partners such as businesses are more likely to provide a narrower range of support and, for example, would be unlikely to provide cultural advice. 'Low, medium and high partner support were calculated as zero to two partners and incidences of support; three to eight partners and incidences of support; and nine and above partners and incidences of support respectively. One group, for example, reported technical support as being provided by four different partners; data management by two partners; cultural advice by one partner; and funding by three partners. The total incidences (i.e., ten), revealed this group to have had a high level of partner support.

3.6.2 Effects of individual predictors on groups' monitoring activities

To gain a greater insight into the characteristics of community environmental groups, a Pearson's chi–square test was carried out on seven group and project variables to determine the effects of individual predictor variables on groups' monitoring activities. These activities comprised groups currently carrying out their own monitoring, having monitoring carried out by others (e.g., resource management agencies), or not currently monitoring (question 16). Predictor variables comprised groups' reported interest in future monitoring (question 19); the number of years the group was established (question 4); group size (question 5) and individual participants' ages (question 6); perceived level of support from project partners (see above); project land tenure (question 12), and the size of the project area (question 14). The Pearson's chi-square test was carried out using the Statistical Package for the Social Sciences (SPSS; version 21.0) (IBM Corp 2012).

3.6.3 Testing interactions between predictor variables

To further test whether interactions between predictor variables might improve predictions, the regression tree approach 'Random Forest' was chosen as the modelling technique. This technique is commonly used for multinomial classification modelling, as it copes well with categorical predictors and efficiently models interactions between predictors (Breiman 2001). The Random Forest model comprises ensembles of randomly generated classification and regression trees.

Randomness is injected both at the data level, and at the model level. Firstly, the model builds trees from a random sample of the data. Secondly, the attribute by which each split in the tree is made is randomly selected. The purpose of this approach is to rapidly build a consensus model across a large number of trees, thereby decreasing error, and ultimately improving the accuracy of the prediction.

A model was constructed using all seven variables listed in the previous section, with the relative influence of each variable recorded within this model as the mean Gini decrease (a measure of how often a variable is used to divide the dataset in building regression trees). The independent effect of each variable was then assessed by calculating the change in classification error rates (i.e., the percentage of observations that the model assigns to the wrong class) when each variable was removed from the full model (i.e., the model containing all variables). Finally, models were built using all possible combinations of predictor variables (with a minimum of two predictors). The model with the lowest classification error rate was recorded. For all models, 500 individual trees were fitted. This combination of modelling approaches accounts for relatedness between predictors. It assesses which predictors (i.e. reported interest in future monitoring; number of years the group was established; group size and individual participants' ages; project partner level of support; project land tenure, and size of the project area) have the strongest influence on groups' monitoring activities (i.e. own monitoring carried out; no monitoring carried out; monitoring carried out by others such as resource management agencies). It also indicates which predictors add the most predictive power independent of the other predictors and which combination of variables gives the most accurate predictions of monitoring activity.

Classification error rate was assessed using cross-validation where the data were divided into subsets of training data (used to build the model) and evaluation data (used to assess classification error rate). For each cross-validation, one fifth of the data were removed at random as evaluation data and the rest of the data were used as the training set. Random Forest modelling was carried out using the 'randomForest' package in R (version 3.1.3) (R Core Team 2012).

3.7 Research engagement

The meta-themes of this study as outlined in the introductory chapter include public participation, engagement and partnerships. The philosophies that underpin each meta-theme include inclusivity and reciprocity, and became guiding principles for the study. Applying these principles entailed thinking more widely about means for strengthening the relationship between the researcher and research participants beyond initial data collection, as well as the eventual publication of findings. To this end, a variety of approaches was used to disseminate information about the study (e.g., study design) and its findings. The approaches included presentations at events such as Waikato Biodiversity Forum meetings and Landcare Networking days, as well as at conferences and symposia led by community groups, trusts and societies at locations throughout New Zealand. Research updates were provided for community newsletters produced by the NZ Landcare Trust, Waikato Biodiversity Forum and National Wetland Trust. Social media, in particular blogs, *Twitter*™, *Facebook*™ and *Linked In*™ were also employed as communication channels with questionnaire recipients, interviewees and other environmental stakeholders invited to join as followers.

3.7.1 The research blog

A blog (www.monicalogues.com) was developed within the first six months of the study. The three core functions of the blog were to: (1) create a forum for study participant and general public feedback on the study, (2) provide a channel for outlining the general structure of the study, progress and key findings, and (3) bridge disciplinary boundaries by minimising the use of discipline-specific terminology. The eight web pages included in the blog website are summarised in Table 3.4.

On occasion, informal ideas brought together in the process of the data analysis evolved into blog posts and as such, were used to test ideas and further explore the 'fit' between researcher positioning and the constructivist frame of reference (Maxwell 2012). A comments section was included after each post which resulted in occasional feedback from participants and interested parties. Although these data were not directly used in the study, the content was generally used to inform thinking.

Table 3.4 Research blog (www.monicalogues.com) web pages, contents and functions.

Research blog pages	Page contents	Page function
Blog and front page of the website	A series of 57 posts each c. 400 words long, generally appearing at fortnightly intervals. A comments field was included after every post.	To share preliminary findings; test ideas with blog post readers; highlight progress and enable feedback on blog content.
'About'	An outline of blog functions, and disclaimer for use of comments posted by site visitors in the study (see Ethical considerations).	To make explicit the link between the blog and study.
'Media'	You Tube clips of presentations; awards; articles in the popular press, and presentations delivered e.g., at conferences, symposia and community events.	To summarise and provide web links to the diverse means used to communicate the study findings.
'The research'	A summary of the original research proposal.	To provide an outline of the context for the study.
'Methodology'	A summary of the methodology.	To provide an overview of the key methods employed in the study.
'Outcomes'	A rationale for the study and a list of anticipated outcomes.	To provide a means for measuring the progress of the study.
'Community questionnaire'	An overview of the questionnaire process and contents.	To elaborate on the rationale and structure of the questionnaire.
'Contact'	A field for viewers to make contact.	To enable feedback on content or a channel for general enquiries to be made.

Study updates were published at 3-4 month intervals as 'Research Snapshots', and mostly comprised a summary of findings, research progress and next steps to be taken. A link to the snapshot post was emailed to c. 370 individuals from a (private) database comprising questionnaire respondents, interviewees and environmental stakeholders drawn from the researcher's professional networks. To avoid any issues arising from unsolicited emails, email recipients could opt out of receiving further snapshots and be removed from the database. To avoid cross-posting, existing blog followers were not emailed the link.

3.8 Data trustworthiness

The trustworthiness of qualitative and quantitative research is dependent on the systematic and rigorous approach taken to the three main phases of the research, namely, design and implementation; data collection and analysis, and the interpretation and reporting of findings (Fossey et al. 2002). As the study was informed by constructivism, criteria for trustworthiness were primarily drawn from the social science literature. Here, the notion of trustworthiness is multidimensional, and includes concepts of validity, confirmability, dependability, reliability or consistency, authenticity and credibility. These concepts form the principles that guide the research process as well as the criteria that determine whether the research results have addressed the research questions (Cohen et al. 2011; Lincoln & Guba 1985). The following points outline the strategies used in the study to enhance its trustworthiness, with reference to the key phases of the research. A section on ethical considerations also follows, with aspects such as the informed consent of participants forming another strategy to ensure the trustworthiness of the study design, process and outputs.

3.8.1 Study design and implementation

In the first phase of the study, a wide range of sources was accessed in order to develop a database of 540 community groups. This ensured coverage of the different regions throughout New Zealand as well as a diversity of ecosystem types being restored by groups. This process was designed to increase the representativeness of the sample, thereby strengthening the credibility of the study. A questionnaire was then developed, and piloted with six people deliberately selected to present a range of perspectives (three community group members/coordinators, two academic staff members with social science expertise and one environmental contractor; see section 3.4.1 on Online questionnaire). Feedback from each individual was incorporated into the final design of the questionnaire. Piloting ensured that questionnaire content was validated and any ambiguity in the questions was removed, thus strengthening the potential reliability of responses.

As the reliability of the data also strongly depends on the skills and expertise of the researcher (Appleton 1995), pilot interviews were carried out, transcribed and the content reviewed by the researcher. This was carried out in order to gain familiarity with the type of interviews required as well as the type of interviewees that would be encountered in the study. An interview guide (Appendix 3) was used to increase the overall consistency of interviewees' responses, along with verbal clarification of questions and responses with interviewees as required.

3.8.2 Data collection and analysis

The resulting sample of 296 groups (i.e., 55% response rate), suggests that the questionnaire responses provided a fair representation of community groups. A randomly selected set of ten responses was checked against group information on publicly accessible databases to test response authenticity.

The credibility of the research was enhanced through participant checking and peer review. Participant checking of all transcripts took place as all interviews were audio-recorded. The transcripts of these interviews were produced and returned to interviewees for verification, with interviewees' comments and amendments included in the revised version. In this case the content was checked and no interpretation was provided by the interviewee. For quantitative questionnaire data, academic staff from the University of Waikato and a statistician from Landcare Research provided assistance with the statistical analyses in the study. Results were re-examined by the same experts for accuracy and appropriateness of interpretation. Anonymous review (as required for publication of Chapters 4-6 in peer-reviewed journals) supported the appropriateness of the methods and interpretation in addressing the research questions presented. A similar review process occurred for Chapter 7, and was undertaken by an academic staff member at the University of Waikato (not supervising the thesis). The inclusion of detailed descriptions of the methods used for data collection and analysis can aid credibility and transferability of the findings. By being able to view all steps taken, other researchers can then determine how applicable data may be to other contexts.

To address both dependability and confirmability, a comprehensive audit trail (Lincoln & Guba 1985) of the research was developed. This comprised a spread sheet that documented the research process, including the activities undertaken, when, where and with whom. For example, a schedule detailing the semi-structured interviews included who was interviewed; confirmation of informed consent being signed; their position within their organisation; the interview date and location; interview length; whether it was audio recorded or whether notes were taken; when the data transcripts were sent, and if data transcripts were validated by interviewees within the two-week window required. A 'notes/follow up' section was also included, providing information on the sound quality of the interview, further contacts, and useful resources discussed in the interviews. The qualitative and quantitative analyses were all clearly described and related documentation such as the raw data and preliminary analyses were systematically filed. Additional information related to the study appeared on the blog site, providing further information as the study progressed.

3.8.3 Interpretation and reporting of findings

Guba & Lincoln (1981) state that credibility can be determined by returning data and interpretations to the source from which they were derived and receiving feedback on the plausibility of the findings. In the current study participants were invited (though not actively recruited or otherwise required), to voluntarily provide feedback on study findings through the research blog, and after presentations delivered by myself at community events and symposia.

The transferability of data forms another criterion for evaluating the rigour of projects and refers to the degree to which study findings can be generalised to contexts outside those studied (Cohen et al. 2011). The current study comprised detailed, thick description of all three phases of the research (design and implementation; data collection and analysis, and the interpretation and reporting of findings). This provides the necessary information base from which other researchers can determine the level of transferability of the study.

Lastly, study findings were presented in a manner appropriate to the diverse research stakeholders, e.g., academic writing was used for peer-reviewed journals, blog posts employed everyday language to make content clear to non-scientific readers.

3.9 Ethical considerations

Ethical considerations are vital from the design of the study until its conclusion (Fossey et al. 2002). The suite of approaches outlined in this section is interconnected with the abovementioned strategies employed to secure the trustworthiness of the study. The study group comprised adult members of the general public, which necessitated the development of procedures designed to minimise harm and ensure participant confidentiality (Appendices 4-6). An application for ethics approval was put forward to the University of Waikato Faculty of Science and Engineering Human Research Ethics Sub-committee, and formal approval for the study to progress was received on March 1, 2013 (Appendix 4).

For the questionnaire, an email was sent to all community environmental groups (Appendix 2) included on the database developed for the study. This email introduction contained a summary of information about the study including expected data use (e.g., for journal article, popular press, symposium presentation and blog posts); the expected time needed to complete the questionnaire; a link to the questionnaire; the contact details of the researcher and one of the supervisors; and a link to opt out of the study.

All interviewees received an information sheet (Appendix 4), and were required to sign an informed consent form (Appendix 6). The information sheet included a basic outline of the study; expected data use (e.g., for journal article, popular press, symposium presentation and blog posts), and considerations of participant confidentiality. Interviewees were given the right to withdraw all of their data up to two weeks after the interviews took place. The contact details of the researcher and lead supervisor were included, in the event of further information being requested or concerns being raised. A summary of this information was included on the informed consent sheet each interviewee was required to sign prior to the interview (Appendix 6).

The blog was an integral part of the study, and opportunities to comment on content were provided after each post, and on each of the web pages. The potential to use these comments in the thesis or other publications of the study meant alerting site visitors to this possibility. The following was therefore included (http://monicalogues.com/about/):

‘**Disclaimer:** As well as being for the research, this blog is part of the research too. Who knows what insights folk out there might post as feedback to my evolving research? I have no idea, but those insights might shed light on interesting themes to explore, things to read, sites to look at, people to talk to. For this reason I might end up using this community feedback in my research. If I do use any feedback in the form of quotes or ideas, it’ll be attributed without personal identifiers as e.g. ‘blog feedback [date]’.

3.10 Scope and limitations

Online searches and existing online databases were integral to recruiting potential questionnaire participants. Groups not included were most likely to be small, informal entities, operating mostly independently of agencies such as the Department of Conservation and Regional Councils; those not affiliated to virtual restoration or biodiversity networks (e.g., www.naturespace.org.nz); non-computer users, or those whose restoration objectives were small components within larger social or economically focussed projects.

Māori-led groups were also likely to be under-represented, as constructing a more complete picture of key study themes through an indigenous lens would have required a significantly different approach both to the study design and data collection. A study that successfully navigates a trans-cultural domain (the researcher in this case not being of Māori descent or having any Māori affiliation through marriage) must employ ‘cultural safety’ processes to guide the scientific process, and clarify the ownership and dissemination of knowledge (Moller et al. 2009). Furthermore, trust and respect must be gained from the research participants. With this in mind, it is obvious that an online survey from an unknown, unaffiliated researcher would not have been an appropriate instrument, and updating research participants via blog posts and not face to face, would likely have been considered inadequate.

3.11 Chapter summary

This chapter details the methodological considerations for this thesis. A constructivist paradigm was used to underpin the research and allow exploration of the meanings of participants' experiences in environmental restoration. A mixed method research design was used, with a questionnaire and semi-structured interviews both featuring as data collection instruments. A range of qualitative and quantitative analyses were carried out to construct a comprehensive picture of community groups, their projects, activities and the views of their project partners. A section on research engagement was included, highlighting the ways in which information about the study and study findings were shared. The inclusion of engagement processes (e.g., blog writing and attending community events) enabled two-way communication to occur throughout the study. Approaches to enhance trustworthiness of the data included developing a broad representation of community environmental groups from throughout New Zealand; piloting the online questionnaire and conducting pilot interviews; requesting that participants verify interview transcripts; seeking expert review of chapters, and providing rigorous documentation of the research process. The ethical considerations of the study necessitated obtaining approval through the appropriate channels at the University of Waikato, and then providing information sheets and consent forms to study participants. A disclaimer describing the possible use of data from comments to blog posts was also developed. Lastly, the possible lack of Māori-led community environmental groups included in the study was discussed in the final section on the scope and limitations of the study.

The following chapters (4-7) address the research questions outlined in the general introduction to this thesis. As Chapters 4, 5 and 6 were written as research articles for peer reviewed journals, descriptions of methods are less detailed than the information presented in the current chapter. No methods are outlined in Chapter 7, as this chapter took the form of a book chapter.

Chapter 4

A REVIEW OF COMMUNITY ENVIRONMENTAL GROUPS' RESTORATION OBJECTIVES, ACTIVITIES AND PARTNERSHIPS[2]

4.1 Abstract

More than 600 community environmental groups across New Zealand are engaged in restoring degraded sites, and improving and protecting habitat for native species. In the face of ongoing biodiversity declines, resource management agencies are increasing their reliance on these groups to enhance conservation outcomes nationally. However, little is known about community groups and their activities beyond local or regional studies. The aim of this study was to develop a profile of community groups and their projects through examining group and project characteristics, objectives, activities and the support provided by project partners. A total of 296 community groups from all mainland regions of New Zealand responded to an online questionnaire. Nearly 80% of these groups were established for ≥ 6 years and 72% operated with ≤ 20 participants (e.g., staff, members, and unpaid volunteers). For over half (54%) of groups, participants were mostly aged 51 - 65 yr. Small group sizes, combined with ageing participants, may threaten groups' longevity. More than 20% of groups' projects covered areas > 501 ha. Ecosystems represented within groups'

[2] A version of this chapter has been published as: Peters MA, Hamilton D, Eames C 2015. Action on the ground: A review of community environmental groups' restoration objectives, activities and partnerships in New Zealand. New Zealand Journal of Ecology 29(2): 179-189.

project areas included forests (64%), streams (42%) and freshwater wetlands (33%). Over one-third (37%) of freshwater wetland restoration projects occurred on private or Māori-owned land. Nearly 70% of groups carried out weed/pest animal control, native tree planting and advocacy/educational activities, highlighting the combination of social and ecological dimensions shaping most groups' projects. Over 90% of groups were supported by project partners (e.g., resource management agencies for site visits, funding and technical support), underscoring the interdependence between groups and their partners. Developing a more complete profile of New Zealand community groups and their projects will assist with improving the delivery of support to groups by project partners and developing an inclusive and cohesive sector based on meaningful partnerships. These two factors combined will ultimately enhance groups' environmental outcomes at the local level, while contributing to national biodiversity conservation goals.

4.2 Introduction

There are more than 600 community environmental groups in New Zealand (Ross 2009) with an estimated combined total of between 25 000 and 45 000 participants (Handford 2011). These groups form the backbone of the largely volunteer effort to restore biodiversity, and to protect and enhance habitat for native species. Under the New Zealand Biodiversity Strategy (Department of Conservation & Ministry for the Environment 2000), resource management agencies were tasked with supporting coordinated community actions to conserve biodiversity. With the overarching priority of maintaining and restoring the diversity of the country's natural heritage, the Department of Conservation (DOC) and regional councils now aim to enhance engagement in collaborative conservation by strengthening relationships with community members, including with iwi [tribal groups] (Department of Conservation 2014; Bay of Plenty Regional Council 2011; Auckland Regional Council 2007).

Environmental restoration can be defined as a range of activities designed to accelerate the recovery of damaged or degraded ecosystems (Reid et al. 2011). For the purposes of this study, the term environmental restoration is used in its broadest sense, as many community groups frame their restoration activities as conservation by also including biodiversity protection and enhancement (Nature Space undated). Community groups carrying out restoration projects in New Zealand typically comprise volunteers, some or all of whom may be subscribed members, though full- or part-time staff may also be employed (Hardie-Boys 2010). Group participants are often over 65 years in age (Callister 2013; Cowie 2010), but changes to the age-group structure of the New Zealand population (Bascand 2012) lend considerable uncertainty to the future make-up of community groups. Numbers of participants per group can vary widely, from less than 20 (Cursey 2010) to well over 100 (Hardie-Boys 2010), depending on how participants are defined.

Descriptors such as 'stewards of', 'friends of' or 'care' (e.g., beachcare, bushcare and streamcare), combined with a place name, often serve to identify groups. These names simultaneously connect groups' activities to a specific location while underscoring their ethic of environmental protection. Other groups may use 'trust' or 'society' as part of their name, reflecting their legal structure. A defining feature of community groups is that, in most cases, group participants lead the projects and contribute to project management decisions (Murphree 1994).

Participation and collaboration, both within the group and between project partners, are central tenets of effective group operation (Murphree 1994). Inter-group collaboration may also occur for example, where there are complementary restoration objectives, in order to increase efficiencies in resourcing and achieve greater restoration outcomes (New Zealand Landcare

Trust 2013; Whangarei Heads Landcare Forum 2010). Partnerships with external bodies such as resource management agencies are common (Hardie-Boys 2010; Curtis & Van Nouhuys 1999) and these agencies generally provide groups with goods and services such as training and technical advice (Handford 2011).

Community environmental restoration projects are shaped by the intersection of the physical environment, social and economic factors (Clewel & Aronson 2013). In New Zealand, groups' projects are situated in a landscape dramatically modified by human-induced fire, logging and land drainage (Ewers et al. 2006; McGlone 1989). Forest cover nationally since AD 1314 ±12 has been reduced to one-quarter of its original extent (Ewers et al. 2006; Hogg et al. 2003), and wetland extent was reduced by 90% in only 150 years (McGlone 2009). Water quality is poor in nearly one-third of monitored lakes (Verburg et al. 2010) and is declining across all major rivers (Ballantine & Davies-Colley 2010). Non-point-source pollution from agriculture is degrading lowland freshwater resources (Parliamentary Commissioner for the Environment 2013).

While the value attributed to the flora, fauna and landscape features by New Zealanders is evidenced by descriptors such as 'iconic' and 'taonga' (Māori language for treasured), habitat loss, fragmentation and predation by introduced fauna remain major drivers for ongoing declines in indigenous biodiversity (Walker et al. 2006). It is against this background that early groups such as the Guardians of Lake Manapouri (established 1973) (Mark et al. 2001) helped crystallise what Young (2004) described as a 'conservation conscience' among the general public. This environmental awakening by wider society underpins restoration in New Zealand by highlighting the importance of human relationships with nature. At the same time, economic factors cannot be decoupled from community environmental restoration. Groups' largely voluntary efforts represent significant cost savings for work that would otherwise need to be carried out by paid professionals (Hardie-Boys 2010).

The global trend in the growth of collective action for natural resource management resulted in up to 478 000 community-led groups reportedly emerging in the decade before 2001 (Pretty & Ward 2001). In Australia, for example, the number of community Landcare groups addressing land and water degradation issues has more than tripled, from 2000 in 1996 (Farley 1996), to over 6000 in recent years (Department of Agriculture 2009). In the United States, more than 6000 watershed groups currently carry out projects to reduce non-point-source pollution (United States Environmental Protection Agency 2012). In New Zealand, the number of community environmental groups has grown in tandem with increased public awareness of the limitations of Resource Management Act (New Zealand Government 2014a) provisions for protecting the environment, underfunding of resource management agencies, and policies that have not adequately protected the social, economic, and ecological values of the New Zealand landscape (Ross 2009). A net population gain to rural areas (Statistics New Zealand 2013), combined with an annual average development of 5800 new lifestyle blocks (peri-urban or rural smallholdings) since 1998 (Andrew & Dymond 2013), may also have encouraged the formation of new groups connected to local ecosystems.

Examples of community environmental groups' contributions to the New Zealand environment and society are diverse. Groups have reforested an offshore island with native species (Galbraith 2013) , for example, and increased populations and ranges of wētā species (Orthoptera: Anostostomatidae and Rhaphidophoridae) (Watts et al. 2011). In the course of protecting brown kiwi (*Apteryx mantelli)* and enhancing their habitat in Northland, groups have developed integrated models for conservation across private and public land

(Blue & Blunden 2010). Community-led pest control has proved effective, and has led to innovative approaches for trapping black rats (*Rattus rattus*) by using ping-pong balls in conjunction with a scent lure instead of hens' eggs (King & Scurr 2013). Weeds targeted by community groups, such as Japanese walnut (*Juglans ailantifolia*) (Cursey 2010), also appear on councils' regional pest animal management plans (Waikato Regional Council 2014). Groups have also carried out environmental education programmes to raise awareness of their project activities and outcomes, as well as to highlight issues such as pest animal impacts on native biota (Moehau Environment Group 2013). Knowledge sharing is therefore an important component of groups' contributions to society, along with strengthening peoples' connection to place, and ultimately, promoting a stronger sense of community (Phipps 2011).

Currently no national-level review of community environmental groups in New Zealand or their restoration activities exists. Reports to date provide overviews of individual community group projects (Robertson 2012), projects occurring across a region (Harrison 2012; Ritchie 2011; Cursey 2010; Shaw 2003), and descriptions of community groups' activities affiliated to specific resource management agencies, NGOs or trusts (Dune Restoration Trust of New Zealand 2012; Hardie-Boys 2010; Buchan 2007). A national-level review of groups and their projects will enable project partners to design systems that better support groups, strengthen their own relationships with groups, as well as enhance networking and collaboration opportunities among groups. The ultimate outcome would be enhanced efficacy and efficiency of groups' collective restoration efforts.

The aim of this study was therefore to develop a detailed profile of community environmental groups and their projects in New Zealand through examining group and project characteristics, restoration objectives, group activities, and the support provided by project partners. To this end, answers were sought to four main questions: 1) What are the characteristics of community environmental groups and their projects? 2) What are groups' objectives and what activities are carried out? 3) What type of support is provided by which project partners? And 4) What further support is required by groups to meet their project objectives?

4.3 Methods

4.3.1 Online questionnaire

In order to reduce costs and the time associated with mailing and transcribing handwritten data, an online questionnaire (SurveyMonkey®) was used as the primary instrument for data collection in lieu of a paper-based mail-out questionnaire. An invitation to complete the online questionnaire (Appendix 1) was emailed to 540 community environmental groups throughout New Zealand in August 2013.

The questionnaire comprised mostly closed questions for which a set of fixed answers was provided, but also some open-ended questions requiring descriptive responses, such as 'What are your group's main objectives…?' Open-ended questions such as 'Please list other support received…' were added to selected closed questions to enable elaboration on fixed answers.

A list of email addresses was aggregated from websites housing publicly accessible databases of community environmental groups engaged in biodiversity conservation and/or environmental restoration. Websites accessed comprised the Department of Conservation (Department of Conservation undated-a), The Royal Forest and Bird Protection Society of NZ (Forest & Bird 2011), Sanctuaries of New Zealand (undated), Nature Space (undated), and funding trusts (Trustpower and the Waikato River Clean-up Trust). Access was also granted to internal community group databases at the NZ Landcare Trust, WWF-New Zealand (Habitat Protection Fund recipients) and the Waikato Biodiversity Forum. The Chatham Islands were excluded, owing to a lack of information on community environmental groups present. Groups not included in the aforementioned databases were most likely to be small, informal entities, operating mostly independently (e.g., of resource management agencies); non-computer users, or featured restoration objectives as very minor concerns within larger social or economic projects.

A single email address per group was used, and where possible addressed to the lead coordinator. All individual emails containing a link to the questionnaire were personalised unless sent via a third party (e.g., to funding recipients held in internal databases), or where only generic email addresses were available (e.g., info@). In cases where the primary contact nominated another, more knowledgeable group participant to complete the questionnaire, the questionnaire was resent to the new email address supplied. A feature of SurveyMonkey® is the ability to link individual questionnaires to individual emails, thus enabling responses from each group contact emailed to be tracked, and reminders to be sent to non-responders. In this study, three-point contact (Dillman et al. 2009) was undertaken where the initial email to the primary group contact was followed by two reminders to non-responders, two weeks apart.

Notice of the online questionnaire was widely publicised (through the NZ Landcare Trust's regional newsletters and Landcare Action e-bulletin, and the Nature Space website and Waikato Biodiversity Forum e-newsletters), before emailing the online questionnaire to groups' primary contacts. In addition, a research blog (www.monicalogues.com) was developed to share findings with questionnaire respondents and other interested parties, as well as to provide transparency to the research process. To maintain questionnaire respondent confidentiality, names identifying groups and locations were deleted from quotes included in the following pages.

The terminology used is as follows: 'active' participants were defined as taking part in at least 30% of all community environmental group activities (i.e., pest animal trapping, committee meetings or planting), a figure judged realistic from authors' (MP and CE) experience with community groups. 'Project partners' were defined as those who support groups to achieve their aims by providing goods and services; either paid for or in kind. A distinction was made between DOC-administered land and other Crown land (i.e. administered or owned by agencies other than DOC), the rationale being that groups identify the management agencies as in, 'working on DOC land' or 'working on council land'.

4.3.2 Analyses

Results from closed questions were summarised numerically and are presented as percentages of total responses received. Data from responses to open-ended questions are referred to as 'Group [number]' in order to maintain participant confidentiality. Open-ended responses were analysed using qualitative data analysis software (NVivo 10; www.qsrinternational.com/products_nvivo.aspx). The software enables passages of text to be manually tagged and indexed into one or more categories drawn from passage content (Bazely & Jackson 2013). Category generation is an inductive process whereby recurring key words and/or themes are grouped together to facilitate the interpretation of large bodies of text. For example, when all 1091 responses for group objectives were aggregated from questionnaire respondents (n=296; groups could list up to five objectives each), content was tagged and indexed into the three main categories that emerged as a result of the analyses, namely environmental, social and economic. Additional reviewing of keywords (e.g., rat, predator, pest) and themes (e.g., building relationships) in the main categories resulted in further partitioning into subcategories (e.g., exotic fauna and community building, respectively). Once all objectives were tagged and indexed, a matrix ordering responses from each group (*n*=296) across all the categories and subcategories was generated. Categorised objectives then were reduced from text to binary numbers to enable percentages of categories and subcategories per community group to be calculated.

NVivo 10 was also used to determine the frequency of specific words occurring in open-ended responses. Results were generated as numeric frequency counts, but in preference visualisation by means of a word cloud was used. Word clouds link font size to word frequency; i.e. the more frequently a word is used the larger it appears relative to other words. To determine the most frequently used words while avoiding repetition, settings were chosen to find the top 100 words; to aggregate words with a similar root (e.g., restoration = restore, restoration, restored, restoring); to exclude common words (e.g., and, the), and only include words >3 characters long.

4.4 Results

4.4.1 Questionnaire response rates

Just over half (55%, *n*=296) of the community environmental groups that were emailed the questionnaire link (*n*=540) responded over the seven-week period of online data collection. Over half of the total questionnaire responses (57%; *n*=296) were received within the first two weeks following the initial emailing of the questionnaire. A further 22% and 21% of responses were received following the first and second reminders respectively. The sample sizes reported varied from question to question as not all questions applied to all groups, and others chose not to answer some questions.

Numbers of community environmental groups included in the questionnaire email address database (*n*=540) were compared with questionnaire respondents (*n*=296). Responses were spread across all mainland regions of New Zealand (with Stewart Island included in Southland) (Fig. 4.1). Seven groups with projects spread over more than one region were also included in Figure 4.1. The greatest number of responses were from the Waikato and Auckland regions, reflecting factors such as the existence of local group databases, the level of support provided by project partners as well as the general population base.

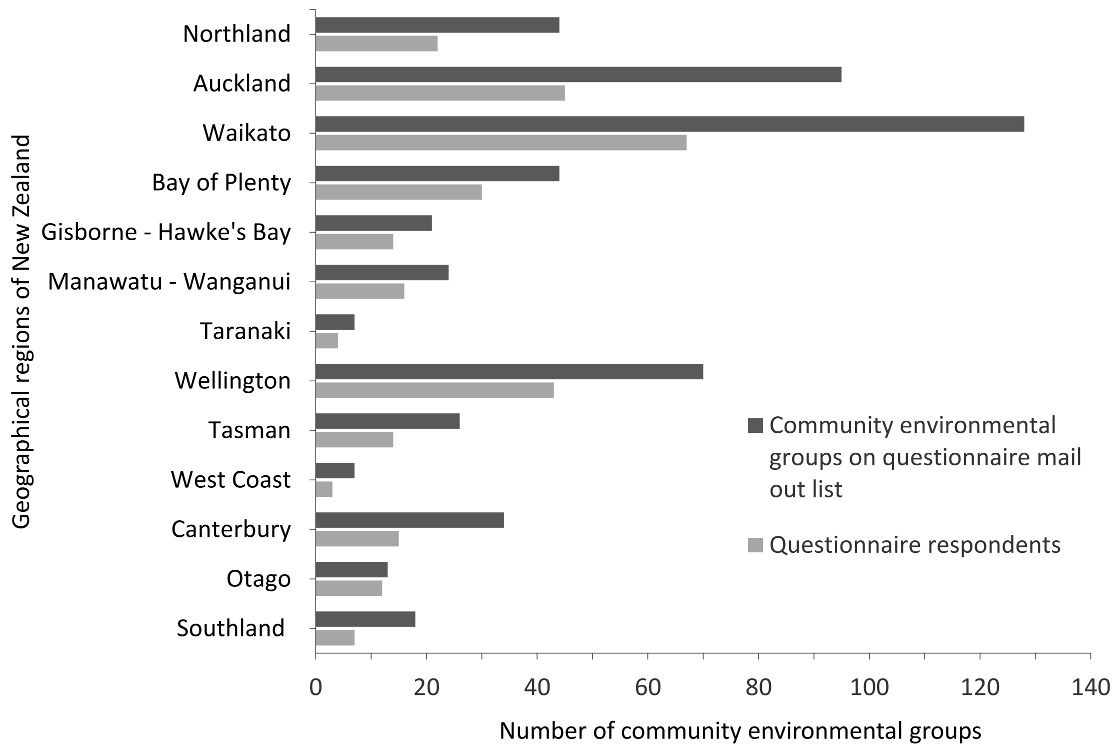

Figure 4.1. Total number of community groups involved in environmental restoration from the questionnaire database per region compared with numbers of questionnaire respondents per region.

4.4.2 Characteristics of community environmental groups

Two-thirds of the community environmental groups (67%) that responded reported their status as formal entities, i.e. as trusts or incorporated societies. Nearly 80% of groups reported being established for ≥ 6 years including time prior to formalisation (Table 4.1). However, groups were generally small, with nearly three-quarters (72%) operating with 20 or fewer active participants. When asked what age most group participants were, over half (54%) were reportedly in the 51–65 year age bracket, with those in the 31–50 year age bracket (26%) being nearly double that of the post-retirement age bracket, i.e. 66 years or over (13%). Open-ended responses highlighted the relationship between age and activities, e.g., 'Regular volunteers are between 40–65 years; casual volunteers are family groups and corporate groups' (Group 95).

Table 4.1 Number of years community groups were established both as formal and informal entities (*n*=296), number of members/volunteers participating in at least 30% of community group activities (*n*=296), and age of most community group members/volunteers (*n*=296).

Metric	**Category**	**% of groups**
Years established	< 1 y	1
	1 - 2 y	5
	3 - 5 y	14
	6 - 10 y	28
	11+ y	52
Participation	1 – 5	16
	6 – 12	32
	13 – 20	24
	21 - 50	16
	51 - 100	5
	101+	6
Age	≤18 y	3
	19 - 30 y	5
	31 – 50 y	26
	51 – 65 y	54
	66+ y	13

4.4.3 Project characteristics

Forests (64%), streams (42%) and wetlands (33%) formed the three most commonly restored ecosystems reported by community groups, noting that groups' restoration sites could cover more than one ecosystem type (Table 4.2). Other ecosystems (1%) restored included a limestone bluff, shingle pit, subalpine karst cave and lowland dryland (descriptions provided by questionnaire respondents). Overall, two-thirds (68%) of groups' projects took place on Crown land (DOC and other), and just over one-quarter on privately owned land (28%). Over one-third of groups restoring lakes (41%), freshwater wetlands (37%), coastal areas (37%), streams (37%) and forests (35%) had projects that took place on land in private ownership, including Māori-owned land (Table 4.2).

Table 4.2 Land tenure of project sites (*n*=290), and types of ecosystem restored: by community groups on public land (*n*=286) and on privately owned and Māori-owned land (*n*=280). Groups were able to specify more than one ecosystem type. *Crown land excluding DOC-administered land.

Metric	Category	% of groups
Land Tenure	Other Crown land*	44
	Private	28
	DOC	24
	Māori	4
Ecosystem type	Forest	64
	Stream	42
	Freshwater wetland	33
	Coast	24
	River	21
	Estuary	17
	Lake	11
	High country	4
	Other	1
Private & Māori-owned land ecosystem type	Lake	41
	Freshwater wetland	37
	Coast	37
	Stream	37
	Forest	35
	River	27
	Estuary	23
	High country	9
	Other	4

Groups' projects were spread across small (0.8 – 4 ha) to large (101 – 500 ha) sites, and just over one-fifth (21%) of groups reported projects covering > 501 ha (Table 4.3). Additional open-ended responses included six projects reportedly covering between 3000 and 6000 ha, with a further two projects reportedly covering > 18 000 ha. Over half (54%) of groups' projects were in a rural location and nearly one-fifth (18%) of groups reported their projects taking place on urban sites.

Table 4.3 Project location (*n*=288) and project size in hectares (*n*=286). Peri-urban projects occurred within a 10 km radius of a town or city centre.

Metric	**Category**	**% of groups**
Project location	Rural	54
	Peri-urban	28
	Urban	18
Project size (ha)	< 0.8	4
	0.8 – 4	17
	4.1 – 8	13
	8.1 – 40.5	18
	41 – 100	13
	101 – 500	15
	≥ 501	21

4.4.4 Project objectives

Groups were asked to list up to five main immediate and long-term project aims/objectives. A total of 1091 responses were received from all groups (*n*=296). Each objective was grouped thematically following qualitative analysis into one of three categories: environmental, social and economic, each with further subcategories (e.g., native flora, advocacy and funding) (Table 4.4). Indicative responses to each category and subcategory are included in Table 4.4 and range from broad visions to specific activities.

As expected, almost all groups (96%) reported environmental objectives. Despite the social and/or cultural focus of remaining groups' objectives e.g., '[The] retention of traditional practice' (Group 140), their activities all included an environmental component such as weed control or riparian planting. More than two-thirds of groups (73%) reported social objectives, though considerably fewer groups (10%) reported economic objectives. Within the main environmental category, all groups reported specific objectives focussed on flora and/or fauna.

Exotic-flora-focused objectives were reported by 14% of groups, and native flora by 19% of groups. Exotic-fauna-focused objectives were reported by 19% of groups, and native fauna by 18% of groups. Nearly one-half of groups (45%) reported education and awareness-focused objectives, with community building, and amenity and recreation-focused objectives reported by 28% and 24% of groups, respectively.

When main categories were combined, over two-thirds of groups (69%) reported a combination of social and environmental objectives, e.g., 'To have … Creek established as a green belt that includes multiple environs and uses, e.g. native forest, wetland, open space and walkway' (Group 41). Substantially fewer groups

(10%) reported a combination of environmental and economic objectives. A combination of all types of objectives i.e., social, environmental and economic, was reported by 8% of groups.

Objectives describing site-led biodiversity restoration projects (determined by the inclusion of place names or ecosystem type) were more common (53%) than species-led projects (7%). For the latter category, key fauna targeted for management included kiwi (*Apteryx* spp.) (2%), other native fauna including kōkako (*Callaeas wilsoni*) (1%), and native fish (1%). Weeds targeted for management included wilding pines (*Pinus* spp.) and old man's beard (*Clematis vitalba*) (1%). Native species such as Kauri (*Agathis australis*) and mistletoe (*Tupeia antarctica*) feature as other species-led projects (1%). The remaining 40% of objectives were very general, e.g., 'Protection of native fauna and flora' (Group 22).

Table 4.4 Percentage of groups (*n*=296) with objectives (*n*=1091) categorised as environmental, social or economic, and further sub-categorised. More than one main category and subcategory per group objective was possible. Indicative examples of objectives were draw from questionnaire respondents.

Group objectives: Main categories	**% of groups**	**Group objectives: Subcategories**	**% of groups**	**Indicative questionnaire responses**
Environmental objectives e.g., 'To preserve and protect indigenous flora and fauna' (Group 204)	96	Exotic flora	14	'Organise contractors and volunteers to kill wilding pines' (Group 246)
		Native flora	19	'Restoration of canopy trees which once would have been prolific in our valley (Rimu, Miro, Mangeo, Matai, Kauri, Puriri, Kahikatea)' (Group 92)
		Exotic fauna	19	'To achieve and maintain a RTC of less than 3% (for possums)' (Group 63)
		Native fauna	18	'Protection of native coastal bird life' (Group 57)
		Water quality	7	'Create a storm water cleansing nature preserve to raise awareness of the dangers of storm water pollution' (Group 127)
		Planning	9	'…to support Hapū [tribe or sub-tribe] and Iwi [tribal groups] to develop respective environmental plans' (Group 113)
		Other environmental objectives	6	'Remove inorganic rubbish' (Group 28)

Group objectives: Main categories	**% of groups**	**Group objectives: Subcategories**	**% of groups**	**Indicative questionnaire responses**
Social objectives e.g., ‘Gain community support for long-term project management’ (Group 17)	73	Advocacy	20	‘Act as a conduit and liaison for various community meetings and interactions with … other community groups’ (Group 47)
		Amenity and recreation	24	‘Create walkways to aid predator program and open public esplanade reserve for public’ (Group 97)
		Community-building	28	‘To increase local community pride, cohesion and environmental literacy’ (Group 42)
		Cultural and historic	11	‘To protect and preserve waahi tapu (sacred sites) of the tangata whenua (Māori)’ (Group 26)
		Education and awareness	45	‘Promoting education, awareness and appreciation of natural ecosystems within …’ (Group 46)
Economic objectives e.g., ‘To create employment opportunities for e.g., the Hapū of …’ (Group 291)	10	Funding	2	‘Secure funding for bio-control trial’ (Group 181)

Word frequency analysis of groups' project objectives (*n*=1091) provided an overview of the values, concerns and priorities that have shaped their projects (Figure 4.2). Though objectives with specific restoration end-points e.g., 'Restoration of valley to pre-human condition as far as possible' (Group 10), were only reported by 3% of groups; the use of 'native' emphasised the general objective of returning project sites to systems dominated by indigenous flora and fauna.

Figure 4.2. Visualisation of the 100 most frequently used words used by community groups (*n*=296) to describe their restoration objectives (*n*=1091). Word size reflects frequency of use.

The word 'plant' reinforced the two most prominent activities, namely weed control and planting of natives (Figure 4.2). 'Protect' was the fourth most commonly used word and the term 'community' was almost exclusively used by groups in a social as opposed to ecological context. 'Education' followed by 'predator' and 'controlling' were all within the ten most used words and underscore the congruence between groups' objectives (Table 4.4) and their activities (Figure 4.2).

4.4.5 Project activities

Weed control and planting of natives were reportedly undertaken by most groups (86% and 85% respectively, Figure 4.3). Three-quarters of groups carried out pest animal control (75%), with slightly fewer (71%) engaged in advocacy and educational activities. Over one-half of groups (57%) reported writing submissions to government agencies on environmental matters. Nearly one-half of groups (49%, *n*=282) carried out their own environmental monitoring while an additional 4% of groups used a contractor for this activity. When asked about other activities, open-ended responses (*n*=57) included rubbish removal (3%), plant propagation (2%), and attending Environment Court hearings (1%).

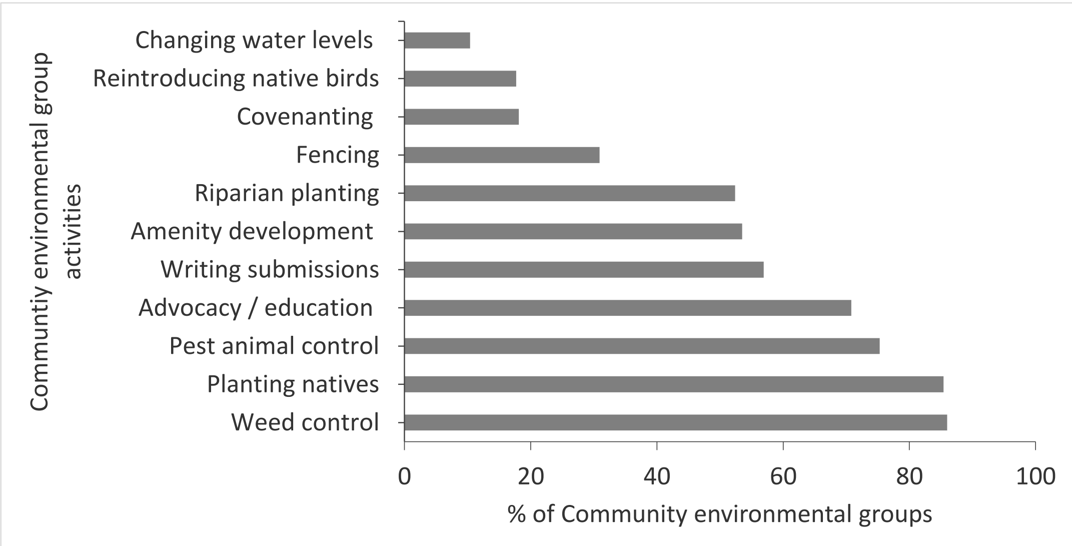

Figure 4.3 Community environmental groups' activities (*n*=288). Groups were able to specify more than one activity. Changing water levels e.g., refers to weir installation to re-wet wetland areas.

4.4.6 Current community group support

A total of 93% of groups (*n*=295) reported receiving some form of support from project partners. Overall, nearly one-third of the support received by community groups was reportedly provided by councils (31%), followed by DOC (21%) in line with the largest percentage of projects reportedly occurring on Crown land (44%) followed by DOC-administered land (24%; Table 4.2). Though nearly 80% of groups were reportedly established for ≥ 6 years (Table 4.1), support was still received from project partners for site visits (e.g., to discuss restoration options), technical support (e.g., assistance with species identification), on ground works (e.g., pest animal and or weed control), cultural advice and funding (Table 4.5). Councils reportedly supported groups by site visits (65%), technical support (46%), on-ground works (58%), and funding (62%). DOC reportedly provided groups with site visits (47%) and technical support (47%). Iwi were reported as providing 41% of groups with cultural advice.

Open-ended responses (*n*=151) elucidated reasons for the prevalence of groups reporting Not Applicable for individual support categories. Key themes included (1) an adequate skills base, described by one group: 'Our volunteers help with admin, data collection (monitoring), species ID [identification], predator control, advice, storage' (Group 52), (2) under-resourcing and therefore being unable to carry out desired activities, and (3) activities being no longer relevant, due (as one group described), to the completion of a monitoring contract.

Table 4.5. Current support provided to community environmental groups by project partners. Percentages of groups per category are recorded (*n*=271), with groups able to specify more than one support partner per support type. In categories where >100 (>37%) groups currently received support, bracketed numbers comprise percentages of groups (*n*=291) that reported needing further support in order to meet their project objectives. A "Not Applicable" category (N/A) was also included.

	Project partners supporting community environmental groups							
Support types	**N/A**	**DOC**	**Councils**	**Iwi**	**Scientists**	**Businesses**	**Contractors**	**Total % (excl N/A)**
Site visits	6	47 (19)	65 (18)	20	21	13	22	**22**
Technical support	10	47 (16)	46 (10)	5	26	3	14	**17**
Data management	32	14	17	1	9	4	1	**7**
On-ground works	9	31	58 (23)	4	4	9	24	**16**
Cultural advice	25	11	9	41 (22)	1	1	1	**7**
Funding	11	28	63 (25)	5	3	36	7	**17**
Administration	34	9	19	2	2	6	5	**5**
Equipment loans	21	24	34	3	4	10	6	**10**
Response %	**15**	**21**	**31**	**8**	**7**	**8**	**9**	

4.4.7 Further support needs

Nearly three-quarters (74%) of groups (*n*=291) reported a need for further support from project partners in order to meet their project objectives (Table 4.5). Overall, one-quarter of groups (25%) reported the need for further support from councils for funding. Support from councils was also reported as needed for on-ground works (23%), site visits (18%), and technical support (10%). Further assistance was reportedly required from DOC in the form of site visits (18%) and technical support (16%). More cultural advice from iwi was reported by 22% of groups.

When asked to describe other types of support needed to meet project objectives, open-ended responses (*n*=75) showed funding as a future concern for 36% of groups. Responses predominantly described the activities funding were required for, as well as the challenge of sourcing funding for administrative costs such as travel, stationery, and group meetings. Currently adequate or declining support needs were expressed by 8% of groups. Open-ended responses (*n*=49) also included the need for building groups' capacity by providing administrative support (34%), such as staff, website development, marketing, financial administration, and legal advice. Operational support required (22%) included weed control, predator bait, plants, and track development, and technical support required (8%) included geographic information system expertise, auditors for monitoring funded works, and remote sensing equipment.

Possible future support providers were reported as community volunteers (31%), adjoining landowners and churches (27%), charitable trusts, resource management agencies such as regional councils and DOC (18%), foundations and non-government organisations (14%), and schools or other education providers (4%).

Table 4.6 Percentages of responses from community groups (*n*=291) for further support needed from project partners in order to meet project objectives. More than one support partner possible per support type. A Not Applicable (N/A) category was also included.

	Project partners supporting community environmental groups							
Support types	***N/A***	**DOC**	**Councils**	**Iwi**	**Scientists**	**Businesses**	**Contractors**	**Response % (excl N/A)**
Site visits	38	19	18	9	17	7	4	**17**
Technical support	39	16	10	2	14	3	3	**11**
Data management	42	8	9	1	9	4	2	**8**
On ground works	34	15	23	5	3	10	9	**15**
Cultural advice	39	6	4	22	0.7	0.3	0.3	**8**
Funding	25	17	25	7	7	38	6	**24**
Administration	44	4	7	2	0.7	7	4	**6**
Equipment loans	37	10	14	3	3	11	5	**11**
Response %	**41**	**13**	**15**	**7**	**7**	**11**	**4**	

4.5 Discussion

4.5.1 Community group characteristics

Community environmental groups are present in every mainland region of New Zealand including Stewart Island. These groups carry out vital work on habitats and species that otherwise would not be restored, protected or enhanced to the same extent by resource management agencies, or at all, as much of community groups' work carried out is on a voluntary basis (Ritchie 2011). Three main features characterise the community groups in this study, namely extended periods of group operation (≥ 6 years), small group size (≤ 20 participants), and the ages of most groups' participants (51–65 years). Group longevity is reinforced by Hardie-Boys' study (2010), which reveals that half of the community environmental groups linked to DOC (*n*=198) have been active for more than a decade. This signals groups' ability to adapt to diverse circumstances such as changes to funding availability and fluctuating participant numbers. Furthermore, the ability to build relationships with external groups and organisations, negotiate project support from a range of sources over time (Allen et al. 2002), and develop effective strategies for recruiting skilled participants (Gooch & Warburton 2009), all underpin group longevity. Despite the established nature of most groups in this study, needs still included additional support from project partners (in particular agencies), greater numbers of group participants, and funding both for on ground works and project administration. According to Forgie et al. (2001), sourcing project funding is an ongoing task, though covering administrative costs remains a challenge (Ritchie 2011).

The age of most groups' participants varies between studies. In the current study, as well as those by Taylor (1997), and Phipps (2011), participants were mostly aged 51-65 years. Other studies show a higher percentage of retirement-age participants (Callister 2013; Cowie 2010). Group longevity may be threatened by the combination of small group sizes and ageing cohorts of participants. Demographic changes over the next 50 years may further alter community group composition. The percentage of retirees in New Zealand is projected to nearly double and individuals are expected to live longer (Bascand 2012). While this represents a larger pool of potential community group participants, their availability must be offset against factors such as the steady increase in post-retirement-age paid employment (Bascand 2012). By March 2014, for example, 27% of men and 15% of women remained in the workforce past the age of sixty-five (Statistics New Zealand 2014).

4.5.2 Objectives and activities

Community groups in this study and others in New Zealand typically carry out an extensive range of activities spanning pest animal and weed control, education, advocacy and administrative tasks (Cowie 2010; Hardie-Boys 2010; Ritchie 2011; Harrison 2012). This is reflected in groups' objectives, nearly three-quarters of which incorporated a social dimension despite most groups' affiliations to organisations with conservation and/or restoration as a primary focus (e.g., DOC). The synergy between groups' social and environmental dimensions can be explained by examining motivations for participation in community groups. These include the ability to contribute to the community; enhanced social interaction; opportunities for personal development; learning about the environment; being an environmental steward, and developing an attachment to a place (Measham & Barnett 2008).

For some groups, social objectives may be on a par with their environmental restoration objectives, as Campbell-Hunt et al. (2010) found in a study of groups managing fenced sanctuaries. In cases where groups' social objectives predominated, the study groups' focus on on-ground restoration activities (e.g., planting and pest animal control), provided the vehicle for environmental learning, or for reviving a cultural connection to the project area. A key role for groups was to generate and disseminate environmental information, evidenced by the predominance of groups' educational, advocacy-related and submission-writing activities. While positive project publicity, for example through groups' newsletters, assists in recruiting new members (Forgie et al. 2001), a further outcome is knowledge-building among project partners and the wider community (Phipps 2011).

Community environmental groups' practical, task-oriented approach to restoration supports both regional- and national-level conservation priorities. In this study, groups' focus on restoring forests, streams and wetlands acknowledged declines in the extent, condition and quality of these ecosystems (Verburg et al. 2010; McGlone 2009; Ewers et al. 2006). Wetland restoration (freshwater and estuarine), carried out on private and Māori-owned land, helps to mitigate further losses to an ecosystem that remains vulnerable given the lack of effective national policies and poor implemenation of regulation (Myers et al. 2013). At the same time, at-risk species associated with wetlands, such as pāteke (*Anas chlorotis*), have also benefited greatly from community groups' predator control and habitat enhancement activities, leading to increases both in population range and size (Department of Conservation 2014).

Weed and pest animal control carried out by most groups in this study is a direct response to the extent of exotic species invasion, as well as the significant threat pests pose to New Zealand's threatened native species, remaining habitats and ecosystems (Department of Conservation & Ministry for the Environment 2000). Although the majority of groups used a multiple-species approach for project area restoration, a small number centred on iconic, threatened or at-risk species such as mistletoe, kiwi and kōkako. These examples represent a small portion of species actively targeted by community groups within their projects, with DOC acknowledging the vital role played by community groups in supporting species recovery efforts (Department of Conservation 2011).

4.5.3 Project partner support

Almost all groups in this study relied on one or more project partners such as councils, DOC, iwi, science providers and business. Financial and practical support including site visits and assistance with on ground works were required, despite most groups being established for six or more years. According to Callister (2013), respect for groups' local knowledge accrued over time functions as a cornerstone for successful partnerships. The diverse skills of older group participants however, are often unacknowledged: 'We have witnessed examples of older volunteers being viewed as useful mainly for manual work, with outside consultants turned to for planning or scientific advice. This overlooks the professional backgrounds of many older volunteers as well as their often long practical experience in eco-restoration' (Callister 2013).

Handford (2011) challenges partners to extend their understanding of their function to include roles as community group mentors, facilitators and general supporters. This broader range of partner functions is pertinent given the proposed collaborative models for conservation put forward by DOC (Department of Conservation 2014), enhanced community biosecurity management roles envisaged for communities (Waikato Regional Council 2014) and the need for greater levels of engagement between scientists and communities (Ministry of Business Innovation and Employment et al. 2014).

4.5.4 Future support

Most groups in this study required technical, administrative and operational support in order to build group capacity and achieve their project objectives.

Effective partnerships are therefore critical for sustaining groups' activities in the long term. The need for training (e.g., pest animal and weed control, outcome monitoring, group and volunteer management) forms a common thread through studies of community environmental groups in New Zealand, highlighting groups' aspirations to grow their projects while empowering their own communities (Coates 2013; Harrison 2012; Handford 2011; Ritchie 2011; Cursey 2010; Sporle 2007). Similarly, groups in this study with socio-economic objectives viewed training as a pathway to paid employment in local communities.

New Zealand follows worldwide trends that have seen a continual rise in the reliance on volunteer input into the conservation and natural resource management sector (Bramston et al. 2011; Lee & Hancock 2011). The increased expectation from resource management agencies for greater community input to biodiversity conservation (Department of Conservation 2014) recognises the strong social and economic benefits that groups of volunteers can provide (Buchan 2007). As a large number of groups in this study carried out environmental monitoring, an expanded role for community volunteers may involve collecting and sharing environmental data with science providers and resource management agencies. Known as citizen science (Bonney et al. 2009), community involvement enables data to be collected at larger scales and at frequencies not feasible for many resource management agencies, representing further cost savings (Carr 2004), as well as opportunities to strengthen links between the community and scientists (Galbraith 2013).

4.6 Recommendations and further research

Agency partners face a challenge to develop models of engagement and support that are sensitive to the diversity of community environmental groups' objectives, activities and projects. A simultaneous challenge for groups is to develop new partnerships as their existing partners' ability to provide resources changes. For project partners, a flexible yet strategic approach would see targeted support for groups, while seeking opportunities to align groups' objectives with both regional and national biodiversity conservation objectives. To achieve greater efficiencies in resourcing, agency partners could, for example, assist groups where practical to form networks (see Whangarei Heads Landcare Forum 2010; Sobels et al. 2001). In addition, access to larger, more secure funds for restoration and related works (e.g., environmental education) would encourage greater collaboration between groups and lessen competition for limited resources.

Overall, the social dimensions of community-based restoration have been well explored, though gaps remain in the New Zealand literature. Internationally, environmental dimensions of community groups have been under-theorised and patchily investigated. Areas identified for future research therefore include (1) community environmental group governance and partnership models (2) factors contributing to groups' longevity and (3) groups' environmental outcomes. Little is also known about groups' monitoring and evaluation activities (Sporle 2007; Handford 2011), for example how monitoring data generated by community groups are used. Addressing these critical gaps will ensure that groups are adequately supported and their restoration efforts appropriately valued.

4.7 Conclusion

There are more than 600 community environmental restoration groups throughout New Zealand, with numbers likely to be far higher if groups currently operating independently of agencies, organisations or web-based sites are included. There are increasing expectations by resource management agencies on groups to contribute more to conservation and biodiversity restoration. When considering factors such as group longevity, the diversity of activities carried out, participant numbers and project scale, a broad sphere of influence is suggested both environmentally and in society, though this remains largely unquantified. While the combination of small group numbers and ageing participants challenges group longevity, high numbers of groups operating for six or more years attest to their adaptability in the face of resourcing challenges. Ongoing financial and practical support is needed to ensure that community groups remain sufficiently resourced to carry out their mostly voluntary contribution to biodiversity restoration, protection and enhancement. The diverse nature of the groups and their environmental restoration objectives highlights the need for a pluralistic approach that acknowledges this diversity as well as the social and environmental contexts groups operate within. With citizen science entering the national vocabulary and wider opportunities for community involvement in scientific research evolving (Ministry of Business Innovation and Employment et al. 2014), there is a need for better understanding of how groups measure restoration success. An in-depth understanding of community groups and their projects will assist with improving support delivery by project partners, and in developing an inclusive and cohesive sector based on meaningful partnerships. Ultimately, a strategic approach to supporting community groups will enhance groups' environmental outcomes at the local level while also contributing to national goals for biodiversity conservation.

Chapter 5

THE CURRENT STATE OF COMMUNITY-BASED ENVIRONMENTAL MONITORING IN NEW ZEALAND[3]

5.1 Abstract

Volunteers engaged in community-based environmental monitoring (CBEM; a form of citizen science) can track changes in species abundance and distribution, measure ecosystem health, and provide data for local, regional and national environmental decision-making. A total of 296 environmental restoration-focused community groups throughout New Zealand responded to an online questionnaire, the objective of which was to investigate their CBEM activities as many are known to carry out some form of monitoring. Contextual factors shaping groups' monitoring activities were also investigated. Over one-half of groups reported using photopoints and 5-Minute Bird Counts (5MBC), with just over one-third (35% *n*=218) able to quantify their restoration project objectives through management outcome monitoring (e.g., 5MBC + predator control). Ecosystem monitoring toolkits specifically designed for community users were not widely used (19%; *n*=157). Groups managing larger areas (e.g., > 8 ha), with medium to high partner support and working on Department of Conservation (DOC) or private land were more likely to be conducting their own monitoring. The number of active members in the group and average age of active members did not significantly influence monitoring activity. 'Random Forest' modelling

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showed that total project area had the strongest independent influence on whether and how groups undertook environmental monitoring. Major challenges for establishing new monitoring programmes were reported as a lack of funding (45%; *n*=98), people (45%; *n*=98), and technical skills (31%). Overall, our results show that significant gains in CBEM could be made by targeting support towards groups managing small areas. The significant positive effects of partner support, and constraints imposed by resourcing and technical skills on monitoring activity, show that government agencies and science professionals could play a critical role in growing CBEM. Prioritising these collaborative partnerships to design and implement monitoring programmes will maximise the value of monitoring, by meeting groups' and potentially partners' information needs.

5.2 Introduction

In New Zealand, community volunteers are increasingly expected to contribute more toward achieving conservation outcomes throughout the country (Department of Conservation 2014). Although research indicates that community environmental groups make a sizeable contribution through weed and pest control, as well as in revegetation (Peters et al. 2015a; Phipps 2011; Hardie-Boys 2010), those efforts cannot be quantified due to a lack of fundamental data on their monitoring activities.

More than 600 community environmental groups carry out restoration projects across forest, wetland, freshwater and saline ecosystems (Peters et al. 2015a; Ross 2009). A greater public awareness of environmental declines in New Zealand (Hughey et al. 2013), as well as more people with discretionary time and wealth (Haklay 2015), may be contributing to increasing group and project numbers. The majority of groups are small, self-organising initiatives, primarily made up of volunteers, although some may employ one or more staff, and/or contractors e.g., to assist with weed and predator control (Peters et al. 2015a;

Hardie-Boys 2010). Groups' project partners typically comprise resource management agencies (e.g., regional councils and the Department of Conservation), and non-government organisations (NGOs) with some support also received from science organisations, iwi (tribal groups) and businesses (Peters et al. 2015a). Support is mostly provided in the form of funding, assistance with on-ground works such as pest animal control, and technical advice (Cursey 2010; Hardie-Boys 2010).

A sizeable portion of community environmental groups carry out some form of environmental monitoring to measure environmental change within their restoration projects (Peters et al. 2015a). Monitoring activities carried out by volunteers (often with no formal science education) may be termed 'participatory resource monitoring' (Van Rijsoort & Zhang 2005), 'volunteer biological monitoring' (Engel & Voshell 2002), or 'community-based environmental monitoring' (CBEM as used in this study; Conrad & Hilchey 2011). As such, CBEM can be an effective means for tracking changes in species abundance and distribution (Singh et al. 2014), and changes in ecosystem integrity (Hoyer et al. 2014). Monitoring carried out by volunteers forms a key component of citizen science, which has become a popular method of conducting large-scale, long-term ecological studies (Silvertown et al. 2013).

In New Zealand, diverse monitoring toolkits for forests, wetlands, streams, rivers and estuaries have been designed to assist community environmental groups to plan and implement monitoring programmes for their restoration project sites (Denyer & Peters 2012; Handford 2004; Tipa & Teirney 2003; Biggs et al. 2002). Toolkits that bring together recognised protocols can form a bridge between volunteers, the science community and environmental managers, by lending credibility and a recognisable structure to volunteers' data (Ottinger 2010).

There is potential for data generated through CBEM to contribute to regional and national-level monitoring programmes as well as international biodiversity-related agreements (Danielsen et al. 2014; Levrel et al. 2010). Substantial savings are possible when the investment in volunteer time to collect data is calculated against savings made in agency administration costs (Levrel et al. 2010). The social outcomes of volunteer participation in monitoring include improved scientific and environmental literacy, and greater community involvement in decision-making (Singh et al. 2014; Crall et al. 2012; Brossard et al. 2005; Trumbull et al. 2000). In addition, volunteers' field-based activities can function as a catalyst for enhancing stewardship, while interactions between participants can engender a stronger sense of community and shared purpose (Lawrence 2006). Encouraging volunteers to participate in environmental monitoring requires significant effort (Dickinson et al. 2012), therefore gaining a clearer understanding of challenges faced by volunteers can help inform programme design and implementation, as well as facilitate recruitment, upskilling and retention of volunteers for projects generally.

Recent studies of community environmental groups in New Zealand provide insights into CBEM by project type (Bellingham & McGlone 2013; Dune Restoration Trust of New Zealand 2012; Byrd 2008) or location (Harrison 2012). However, these study designs differ markedly, precluding the ability to achieve a countrywide overview of CBEM, let alone develop measures of restoration outcomes that in the future, could contribute to biodiversity conservation across groups regionally or nationally. Furthermore, little is known about how widely community environmental monitoring toolkits are used, and how effectively they facilitate the collection of data that support groups' restoration objectives.

To enhance our understanding of community groups' monitoring activities, and the wider potential for their monitoring programmes, this study addressed five questions. The first three relate to defining the current state: 1) How and why do groups measure environmental change within their restoration projects; 2) How useful are monitoring toolkits; and, 3) Which component(s) of groups' restoration projects do they wish to monitor in the future? A further two questions investigate the contextual factors shaping current CBEM activities: 4) Are there distinct characteristics that define groups carrying out their own monitoring compared with those not carrying out monitoring; and, 5) What are the major challenges for developing community based environmental monitoring programmes?

5.3 Methods

5.3.1 Online questionnaire

An invitation to complete an online questionnaire comprising both closed (fixed answer) and open-ended (free text) questions was emailed to 540 community environmental groups throughout New Zealand (Chatham Islands excluded). The questionnaire was accessible to community groups during August and September 2013 (Appendix 1).

To develop a list of questionnaire recipients, community environmental group email addresses were selected from the following online databases: the Department of Conservation (Department of Conservation, undated-a), Sanctuaries of New Zealand (undated), The Royal Forest and Bird Protection Society of NZ (Forest & Bird 2011), Nature Space (undated), and the Waikato River Clean-up Trust (Waikato Regional Council undated). Non-public databases administered by the NZ Landcare Trust, WWF-NZ (Habitat Protection Fund recipients) and Waikato Biodiversity Forum were accessed with permission by the respective database managers. Groups not present on databases were likely to operate mostly independently of resource management agencies, NGOs and others; small, informal entities; non-computer users; and/or predominantly without restoration-related objectives.

Prior to emailing the questionnaire, the study was widely publicised through various channels (e.g., NZ Landcare Trust newsletters and e-bulletins, the Nature Space website and Waikato Biodiversity Forum e-newsletter). One personalised email containing a link to the questionnaire was sent to each lead group coordinator. Where this address was not known, emails were sent via a third party (e.g., to funding recipients held in internal databases), or to the 'info@' address supplied by the group.

A research blog (www.monicalogues.com) was developed to share findings with study participants and interested parties as well as to provide transparency to the research process. In line with human research ethical approval criteria, names identifying groups and locations have been deleted from quotes included in the following pages to maintain research participant confidentiality.

5.3.2 Analyses

The questionnaire comprised mostly closed questions with a set of fixed answers provided. Open-ended questions such as 'Other monitoring methods used (please describe)' were added to selected closed questions to enable elaboration on fixed answers. Data from closed questions were summarised by frequency and are presented below as percentages of total responses received. Responses to open-ended questions were analysed thematically, with the emerging themes then grouped to enable frequency calculations.

Project partners of community groups comprised the Department of Conservation, regional/district council, iwi, science providers, business and private contractor(s). These partners provided diverse forms of support, namely project site visits, technical support, data management, on-ground works, cultural advice, funding/sponsorship, administration, and equipment/venue loans (Peters et al. 2015b). To develop an index of low, medium or high partner support per group, the number of project partners reported by each group was combined with the reported number of incidences of support provided to each group. A single partner with a broad mandate for working with community groups may therefore provide a range of support e.g., site visits, assistance with on ground works, equipment loans and so forth. In contrast, partners such as businesses are more likely to provide a narrower range of support, for example, and may be unlikely to provide cultural advice. Low partner support was defined as zero to two partners and incidences of support; medium partner support as three to eight partners and incidences of support, and high partner support as nine and above incidences of support.

A Pearson's chi–square test was carried out on seven individual group and project variables to examine effects on groups' monitoring activities. These activities comprised groups currently carrying out their own monitoring, having monitoring carried out by others (e.g., resource management agencies), or not currently monitoring. Predictor variables comprised groups' reported interest in future monitoring, the number of years the group was established, group size and individual participants' age, size of the project area, perceived level of support from project partners, and project land tenure (Peters et al. 2015a). The Pearson's chi-square test was carried out using SPSS (Version 21.0; IBM Corp 2012).

It is possible that the predictor variables were not independent and could interact with one another to influence the response (i.e., groups' monitoring activities). To account for this, we sought to model the response using multiple predictor variables. The regression tree approach 'Random Forest' was chosen because it accounts for categorical predictors (since it comprises 'trees' built by making bifurcating splits in the dataset), is commonly used for multinomial classification modelling, and efficiently models interactions between predictors (Breiman 2001).

The Random Forest model was constructed using all seven variables, with the relative influence of each variable recorded within this model as the mean Gini decrease (a measure of how often a variable is used to divide the dataset in building regression trees). The independent effect of each variable was then assessed by calculating the change in classification error rates when each variable was removed from the full model (i.e., the model containing all variables). Finally, models were built using all possible combinations of predictor variables (with a minimum of two predictors). The model with the lowest classification error rate was recorded. For all models, 500 individual trees were fitted. Classification error rate was assessed using cross-validation where the data were divided into subsets of training data (used to build the model) and evaluation data (used to assess classification error rate). For each cross-validation, one-fifth of the data was removed at random as evaluation data and the rest of the data was used as the training set. Random Forest modelling was carried out using the 'randomForest' package in R (Version 3.1.3; R Core Team 2012).

5.3.3 Terminology

'Science-based monitoring' was broadly defined in the questionnaire as the systematic measurement of change over time using science-based methods. While this definition left room for interpretation, it provided sufficient limits for questionnaire participants to distinguish formal methods (such as standardised bird counts) from informal methods (such as general impressions of birds seen or heard) used to gauge environmental change within community groups' projects.

‘Monitoring methods’ was used as an umbrella term to describe protocols such as 5-Minute Bird Counts (5MBC) and methods such as regularly photographing from photopoints and surveying vegetation plots. Photopoints are fixed locations (often marked by a post) from which repeat photographs are taken over time to visually track change (Handford 2004).

5.4 Results

Of the 540 community groups, contacted, 296 (55%) responded. Sample sizes reported here vary from question to question as not all questions applied to all groups, and some groups chose not to answer some questions. Responses to the question of what best describes the group's science-based environmental monitoring activities, from a set of answers provided, showed that nearly one-half (49%; *n*=282) of the questionnaire participants reported carrying out their own science-based environmental monitoring. A small percentage of respondents (4%) reported employing a contractor to carry out either all, or of part of, the group’s monitoring activities e.g., ‘Bat specific data is done by contractor. Pests and trapping (sic) tunnels done by us’ (Group 264). Over one-quarter of groups (27%) reported currently not monitoring, or that they had done so in the past. The remaining groups (21%) reported monitoring being carried out by others such as DOC and councils.

5.4.1 Monitoring methods used

When asked which monitoring methods were being used by their group or contractor, photopoints and 5MBC (Dawson & Bull 1975) were reportedly used by about one-half of the respondents (Table 5.1). Vegetation plots and Residual Trap Catch index (Warburton 1996) were reported as used by just under one-half of the groups. In open-ended responses asking for descriptions of other monitoring methods used (*n*=72), groups reported using both tracking tunnels (36%) and chew cards/wax tags for indicating the abundance and diversity of pest animals (14%). General flora and fauna surveys (methods used were unspecified) were reported by 29% of these groups. The same number of groups (29%) reported using methods other than 5MBC, such as counting birds using a ‘visual census’ (Group 203), while others reported using variations e.g., ‘One Minute Bird Count’ (Group 272), ‘20-minute bird counts every 6 months’ (Group 4), and, ‘One hour bird count’ (Group 41). One group reported combining methods that drew from differing cultural viewpoints e.g., ‘We have a mixture of mātauranga māori [cultural knowledge] and western science to help us understand our environment so that we can make better informed decisions on the future management of our resources’ (Group 291).

Table 5.1 Monitoring methods used by community environmental groups or their contractors. Groups could select more than one method (n=143).

Monitoring methods used by groups	% of groups
Photopoints	54
5-Minute Bird Counts	52
Vegetation plots	45
Residual Trap Catch Index	43
Stream invertebrate counts	22
Lizard counts	18
Foliar Browse Index	12
Don't know	6

Just over one-quarter of groups (26%; *n*=282) undertook tallies of litres of herbicide used, number of trees planted or pest traps laid out, or hours of volunteer labour carried out in order to track the effectiveness of their management actions. Monitoring to quantify the outcomes of management action was indicated by groups carrying out predator control (*n*=218) in conjunction with 5MBC (35%). For groups that carried out weed control (*n*=249), management outcome monitoring was indicated by the use of photopoints (31%) or by setting up vegetation plots (26%). When asked how long monitoring had been carried out nearly two-thirds (62%; *n*=157) of groups reported carrying out monitoring for ≥ 6 years, either by themselves or using a contractor. Nearly one-fifth of groups (19%) had carried out monitoring over 3-5 years, with 10% of groups in the 1-2 year category.

5.4.2 Monitoring toolkit use

When asked which monitoring toolkit was most used by the group or group's contractor, just under one-fifth of respondents (19%; *n*=157) reported using toolkits specifically designed for community group use. Of the available toolkits, 11 groups used the Forest Health Monitoring and Assessment Kit (Handford 2004), seven groups were using the Stream Health Monitoring and Assessment Kit (Biggs et al. 2002), five groups the Wetland Monitoring and Assessment Kit (Denyer & Peters 2012) and three groups the Cultural Health Index (Tipa & Teirney 2006). Open-ended questions highlighted a range of methods used by community groups prepared by different organisations, for example, 'NZ Dune Restoration Trust folder & WWF handbook' (Group 43), and 'DOC resources, field sheets, best practise method' (Group 60). Other respondents developed their own methods based on existing material e.g., 'Influenced by FORMAK [Forest Health Monitoring and Assessment Kit] methodology, but don't use them formally or frequently' (Group 269), or 'Cultural Health specific to [name of group] developed by our enviro-team' (Group 187).

When asked to rate responses on a 5-point Likert scale (Likert 1932), three-quarters of groups (18 out of 24 group) using toolkits reported either agreeing or strongly agreeing that overall monitoring priorities were able to be met by using their toolkit(s). Overall, 13 groups (out of 21) reported agreeing or strongly agreeing that toolkit design and layout was effective, though seven groups reported a neutral response. The same number of groups (13 groups out of 21) reported that technical terms and concepts were adequately explained, with 5 groups reporting a neutral response. A total of 12 (out of 21) groups reported that data entry was straightforward using the templates provided and six groups reported a neutral response. Most groups (*n* = 19 out of 24) reported either agreeing or strongly agreeing that onsite training in toolkit methods was necessary for collecting quality data. However, group responses for the ability of toolkits to enable scientifically robust data to be produced were varied. Seven groups (out of *n*=23) reported a neutral response, while 15 groups reported either agreeing or strongly agreeing. Nearly three-quarters of groups (n=17 out of 23) reported either agreeing or strongly agreeing to the need for ongoing technical support and training to maintain data quality.

5.4.3 Future monitoring

More than two thirds (70%) of all groups (*n*=296) wanted to continue or expand their monitoring programmes in the future. Of the total number of groups (*n*=239) that detailed the project components they wished to monitor in the future (Table 5.2), nearly two-thirds (62%) reported an interest in monitoring birds, followed by native plant establishment (54%). The desire to monitor water quality in the future was reported by 41% of groups.

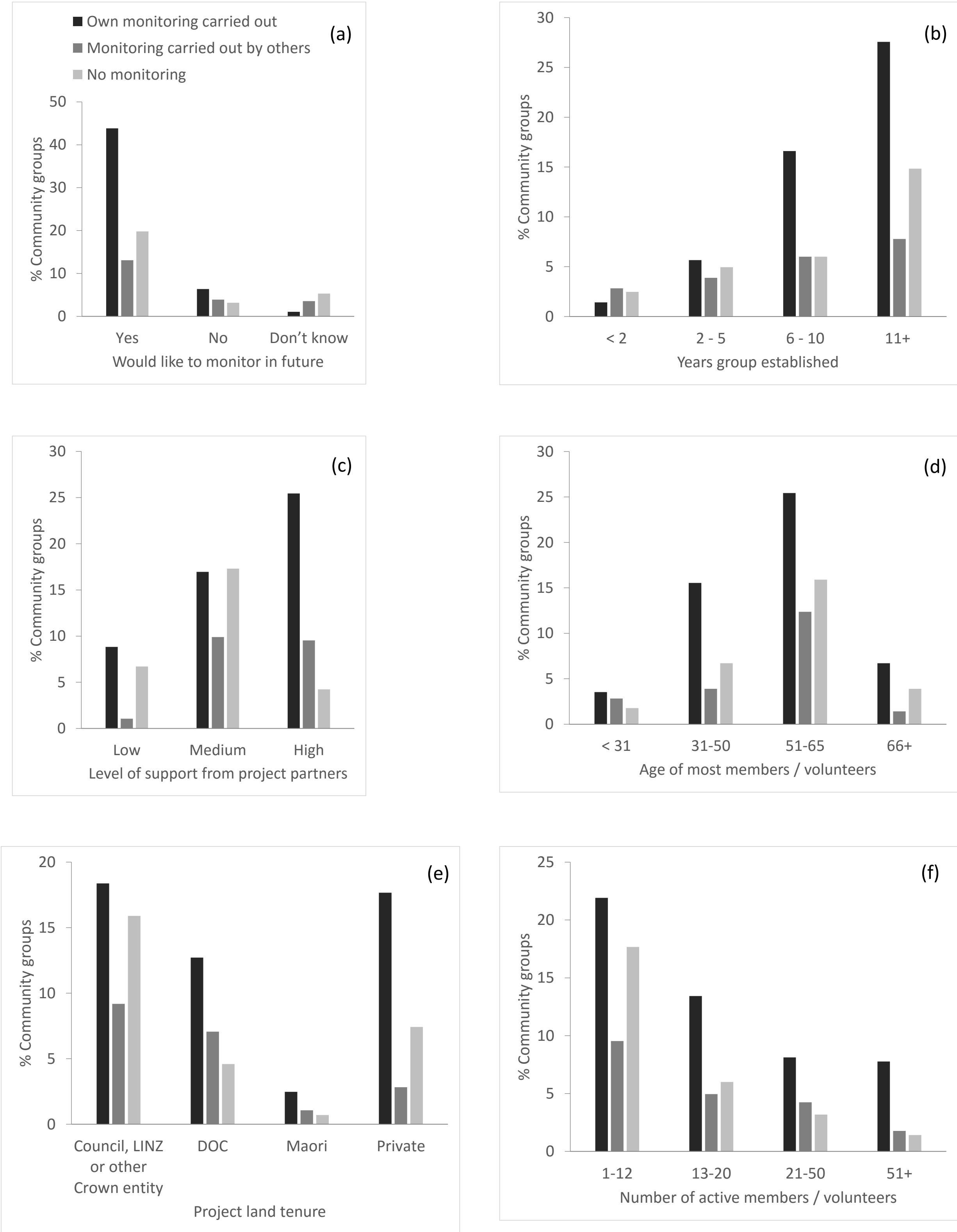
When asked which other project components groups wished to monitor in the future, open-ended responses (*n*=40) were diverse. An interest in invertebrate monitoring was reported by 23% of groups and bats by 10% of groups. Proposed qualitative studies included surveying walkway users, and investigating group effectiveness in changing community attitudes, while basic management-related components included visitor numbers, volunteer hours and the type of work undertaken.

Table5.2 Project components that community groups indicated they would like to monitor in the future. Groups could select as many components as were relevant to them (*n*=239).

Components of projects for future monitoring	**% of groups**
Type and number of birds	62
Establishment of native plants	54
Water quality	41
Type and number of lizards	39
Type and number of fish	37
Nothing else	14
Change in water level	9
Spread of weeds	3

5.4.4 Characteristics of groups monitoring or not monitoring

The views or attributes (seven selected variables from Peters et al. 2015a) of community groups that carry out their own monitoring, engage others (e.g., resource management agencies) to monitor for them, or do not currently carry out any monitoring are shown in Figure 5.1. Future monitoring intentions, the total project area and the level of support received by project partners each had a strongly significant effect on monitoring activity (Table 5.2). In general, groups planning to monitor in the future, managing project areas >8 ha or with high levels of partner support were much more likely to conduct their own monitoring or engage others to do so. The total length of time the group had been established, along with project land tenure were also significant, though to a lesser degree. Groups established for more than five years, or working on DOC, private or Māori land were more likely to conduct their own monitoring.



Own monitoring carried out
Monitoring carried out by others
No monitoring
(a)
% Community groups
Yes
No
Don't know
Would like to monitor in future
(b)
% Community groups
< 2
2 - 5
6 - 10
11+
Years group established
(c)
% Community groups
Low
Medium
High
Level of support from project partners
(d)
% Community groups
< 31
31-50
51-65
66+
Age of most members / volunteers
(e)
% Community groups
Council, LINZ or other Crown entity
DOC
Maori
Private
Project land tenure
(f)
% Community groups
1-12
13-20
21-50
51+
Number of active members / volunteers

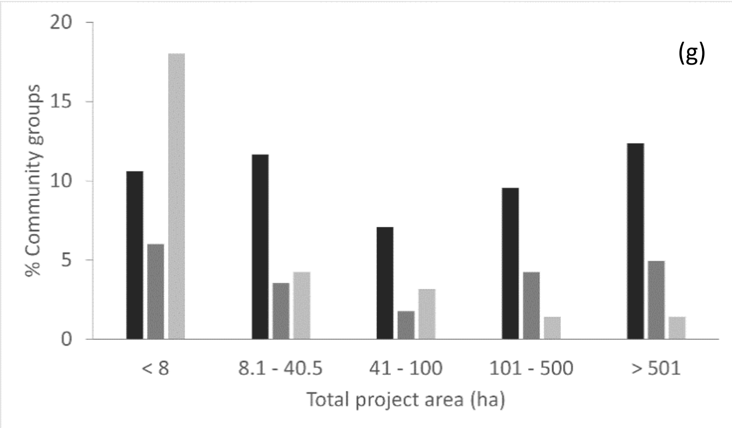


Figure 5.1. Characteristics of groups carrying out their own science-based environmental monitoring, groups that have monitoring carried out by others, and groups that do not carry out any monitoring measured against key group and project variables: (a) whether the group would like to monitor in the future, (b) number of years the group has been established for, (c) level of support provided to the groups from project partners, (d) age group of most members/volunteers, (e) project land tenure, (f) number of active members/volunteers in group participating in at least 30% of all activities such as pest trapping, committee meetings and planting, and (g) total project area in hectares. DOC-administered land and other Crown land (i.e. land administered or owned by Crown agencies other than DOC) are distinguished, since groups regard DOC and territorial local authorities as separate project partners.

Total project area had the strongest influence in the model containing all variables, followed by number of members and the length of time the group had been established (Table 5.3). The full model had a classification error rate of 45%, meaning that it misclassified the monitoring response of groups 45% of the time. Total area also had the greatest independent influence while the desire to monitor in the future had the second greatest independent influence. No variable had an independent effect greater than 4.2% (i.e., 4.2% increase in classification error when removed from the full model). This suggests that some of the variables are strongly related and may capture similar information. Only four variables (total project area, future monitoring, years group was established for, and number of members) had a positive independent influence on classification accuracy (i.e., classification error increased when they were removed from the full model). This suggests that the remaining variables (age of members, level of partner support, project site land tenure) do not add any useful independent information for explaining groups' monitoring activities. The model giving the lowest classification error rate (39%) included the two variables with the greatest independent influence (total area and future monitoring).

Table 5.3 Influence of individual variables within the Random Forest model containing all predictor variables (mean decrease Gini) and change in classification error rate (i.e. % groups misclassified) when each variable was removed from the full model (mean% decrease in error). Variables included in the model with the lowest classification error are highlighted in bold. The classification error rate of the full model was 45%, while the error rate of the best model was 39%.

Predictor variables	**Drop % change in error**	**Mean decrease Gini**
Total project area	4.2	20.6
Future monitoring	2.1	8.7
Length of time group established	1.4	11.6
Number of active members/volunteers	0.7	14.6
Age of members	-0.7	10.8
Level of partner support	-0.7	9.2
Project site land tenure	-2.1	10.4

Chi-square tests between all seven group and project predictor variables (Table 5.4) revealed that several predictor variables were strongly correlated, as expected from the Random Forest results. Partner support and total area were significantly correlated ($p<0.01$), as were partner support with both the number of active members/volunteers and length of time group established (both $p<0.05$). It is therefore possible that the small independent influence of partner support in the Random Forest model is due to the information it provides being captured by other variables, notably total area and future monitoring.

Table 5.4 Community groups' (*n*=283) environmental monitoring programs compared with group and project variables. P-values are for Pearson Chi-square tests. Symbols are as follows: p<0.05*, p<0.01**, p<0.001***.

Group and project variables	χ 2	Df	p-value
Would like to monitor in the future	23.397	4	<0.001***
Length of time group established	15.154	6	.019*
Number of active members/volunteers	11.889	6	.065
Age of members/volunteers	7.829	6	.251
Total project area	52.322	10	<0.001***
Level of support from project partners	33.370	4	<0.001***
Project land tenure	16.056	6	.013*

5.4.5 Monitoring challenges

When groups were asked to identify the range of challenges they faced for developing a monitoring programme, a lack of human resources (45%; *n*=98) and funds (45%) were most frequently reported. For one group, a lack of people resulted in, '…a toss-up between spending the effort on monitoring and spending it on actually dealing with a problem you are monitoring' (Group 101). Given these resourcing challenges, the relative value of monitoring was also questioned, '…you need to be quite clear that data you are spending effort in accumulating is going to tell you what you need to know' (Group 101). Nearly one third (31%) of groups reported a lack of technical skills necessary for setting up a monitoring programme. Just under one fifth (19%) reported monitoring as not being the role of the group, or monitoring not being necessary for their project as, for example, monitoring was already being carried out within their project area. Not knowing what to monitor was reported as a challenge by 17% of groups, and a further 10% of groups reported not knowing who to approach for assistance in setting up a monitoring programme.

Open-ended responses (*n*=28) to the same question provided additional insights into the challenges of setting up a monitoring program such as a lack of leadership, and the need for partnerships, 'All that we need is someone motivated to drive the set-up of a monitoring programme and get the relevant agencies on board' (Group 285). The lack of community-oriented tools and methods, e.g., for measuring invertebrates, along with the lack of ability to rescale methods to suit smaller project areas, were reported as further challenges. The overall value of monitoring was called into question by one group member, who argued that, '…too much time can be spent on monitoring and not enough on killing invasive introduced species'(Group 86).

5.5 Discussion

5.5.1 Monitoring methods used

The first research question addressed in this study was how and why groups measure environmental change within their restoration projects. The choice of monitoring methods is likely to be influenced by factors such as groups' scientific literacy (i.e., understanding of science), access to technical support and number of volunteers able and willing to carry out monitoring. Groups' lack of technical expertise and human resourcing were regarded as barriers for setting up new monitoring programmes, and are discussed later. The two most commonly used monitoring methods were photopoints and 5MBC, the former used to visually estimate the type and extent of vegetation change (Shaw et al. 2003), and the latter to determine the number and type of birds present in forests (Dawson & Bull 1975). A large number of groups carry out pest animal control (Peters et al.

2015a), as it has been well-documented that controlling ship rats (*Rattus rattus*), brush-tailed possums (*Trichosurus vulpecula*), or stoats (*Mustela erminea*) can reverse declines in populations of native birds (Spurr & Anderson 2004; Clout 2001; Brown et al. 1993). With nearly two-thirds of community environmental groups carrying out monitoring for six or more years, data sets are potentially available to supplement local, regional and national studies.

The results show that a sizeable minority of groups are monitoring the outcomes of their management actions, e.g., by combining pest animal control and 5MBC. This suggests an alignment between the restoration activities carried out, monitoring methods used and overall restoration objectives, i.e. protecting, restoring or enhancing native flora or fauna (Peters et al. 2015a). However, as outcome monitoring is resource intensive (Clayton & Cowan 2010), it is not surprising that major funders such as DOC primarily require management outputs (e.g., volunteer hours, area treated with possum control) to be reported (see Department of Conservation, undated-b). This is iterated by Byrd (2008), who highlights the lack of quantitative measures used in publicly funded projects to enhance biodiversity on private land. Although this relieves groups of detailed analysis and reporting and is practical considering typically short-term funding (e.g., 1-3 years) available, the design of groups' monitoring programmes risks being determined by funders' requirements rather than by measuring restoration management outcomes.

5.5.2 Monitoring toolkit use

The second research question considered the use of monitoring toolkits, designed to make science more accessible to community groups with little, or no formal science education. Despite the limited number of toolkit users in this study, most users reported being able to meet their monitoring priorities and produce robust data by using toolkits, providing evidence of the toolkits' utility.

Low use, however, may result from a perception that current toolkits will not meet groups' monitoring needs, a lack of awareness about available toolkits, or ongoing support (e.g., toolkit methods training and field support). Handford (2006) suggests that resource management agencies adopt toolkits and become points of contact for community users of them. With toolkits embedded in an institutional structure, more coordinated support in the form of technical advice and training could be provided. Additionally, adapting toolkit content to suit current technology may also improve uptake by enhancing efficiency (e.g., entering data online), improving toolkit accessibility (e.g., making content more widely available), providing real-time data, and facilitating data analysis both within and between projects (e.g., by being able to visualise results immediately) (Newman et al. 2012).

5.5.3 Future monitoring

The third research question asked which project components groups wanted to monitor in the future. More than two-thirds of all community environmental groups reported wanting to continue or expand their monitoring programmes. Bird monitoring is a priority, with the importance of birds overall demonstrated by an increased number of avian translocation proposals by community groups independently or as community-DOC partnerships (Cromarty & Alderson 2012). Species translocations to habitats where they are locally extinct or in low numbers is a recognized approach to ecological restoration and groups' desire to increase their bird monitoring activities may contribute to filling knowledge gaps concerning the post-release survival of translocated birds (Parker et al. 2013).

There was a sharp increase in groups numbers overall reporting a desire to monitor water quality in the future (41%; *n*=296) compared with those currently carrying out water quality monitoring (22%; n=143%). This change reflects a national focus on widespread declines in freshwater quality in New Zealand (Parliamentary Commissioner for the Environment 2013), and heightened public awareness of these issues (Hughey et al. 2013). The government has signalled efforts to improve freshwater management through legislation that includes processes for the community to participate in setting goals for freshwater quality outcomes (Ministry for the Environment 2013). Community environmental groups with a science-based understanding of water quality trends within their local area, may play a strong role in defining community values for freshwater (Ministry for the Environment 2013). Although a third version of the Stream Health Monitoring and Assessment Kit was in development at the time of writing (A. Wright-Stowe, NIWA, pers. comm.), toolkits supported by agencies and science providers for measuring the water quality of lakes and rivers (with the exception of the Cultural Health Index) are still required to facilitate wider community group involvement in freshwater data collection.

5.5.4 Group characteristics

The fourth question asked if specific characteristics defined groups carrying out their own monitoring compared with those not monitoring (i.e., where monitoring is carried out by others such as resource management agencies, or not at all). Determining key differences has implications for the type and level of support provided by project partners.

Few groups established for ≤5 years carried out monitoring, suggesting that the immediate demands, e.g., of weed and pest control, and revegetation (Peters et al. 2015a) were prioritised over baseline data collection. Developing monitoring programmes that begin with baseline monitoring are likely to require stronger support from project partners. A partnership approach from the outset may also create opportunities for designing monitoring programmes that meet both groups' and partners' information needs. In the USA, community-generated water quality data is used by resource managers to determine recreational use standards, thus creating a direct link back to community members, while science professionals use community data in meta-studies for investigating broader trends (Hoyer et al. 2014). Although Regional Councils and DOC already support groups for advisory and operational activities (Peters et al. 2015a), science professionals may play a stronger role given the direction from government to strengthen engagement between scientists and the wider public (Ministry of Business Innovation and Employment et al. 2014).

The statistical analysis of relationships between predictor variables drawn from group and project characteristics showed that groups carrying out monitoring were most likely to be those receiving a medium to high level of support from project partners, underscoring the necessity for this input to sustain groups' monitoring programmes. There were strong correlations between total area and partner support demonstrating that groups operating large-scale projects are likely to work with diverse partners and, equally, that partners are likely to prioritise large-scale projects. This highlights the scope for greater input into medium to smaller scale projects that collectively could yield useful data on species distribution and population numbers (Topia & Gardiner 2014).

5.5.5 Monitoring challenges

Finally, groups were asked to identify challenges for establishing monitoring programmes. In order for project partners to better utilise groups' monitoring data, e.g., to support conservation management decision-making, the lack of funds, volunteers and technical expertise must be addressed. The interdependent nature of these challenges highlight the difficulty groups have of understanding complex and diverse ecosystems, and of managing the factors that influence monitoring programme design and implementation. In a study of community environmental stewardship groups in urban New York, Silva and

Krasny (2013), also reported limited monitoring activities, due for example, to the added workload of doing so, and the challenges of engaging in partnerships with researchers.

Nearly two-thirds of groups had been monitoring for ≥6 years, clearly demonstrating that groups view their projects as long-term undertakings and that achieving their project objectives requires ongoing commitment. Although groups' data is primarily used in situ, e.g., for managing their own projects (Peters et al. 2015a), providing more cohesive evidence that outcomes from CBEM activities across community groups demonstrate improvements in biodiversity may also strengthen the case for more secure, longer-term funding.

Groups typically have a small core of active participants, which requires monitoring to be prioritised. Ageing participants may struggle with the physical demands of monitoring, for example, operating long pest monitoring lines in rugged terrain (Peters et al. 2015a). Although new technology such as self-setting traps may save labour, groups may also benefit from strategic collaboration with local groups to pool limited resources and share expertise (Whangarei Heads Landcare Forum 2010). An alternative model is where the coordination of monitoring efforts is provided by project partners, enabling data to be used by all parties (Topia & Gardiner 2014; New Zealand Landcare Trust 2013). Groups' lack of technical skills may signal the need for improved access to training programmes, that training programme content requires modification to better suit groups' information needs, or that the frequency of training opportunities needs to be increased. While context-specific training for community members has been shown to improve participants' scientific literacy (Crall et al. 2012), increasing opportunities for informal knowledge exchange, for example where groups can share practical knowledge and experience gained through their own monitoring programmes, may also benefit groups (Fernandez-Gimenez & Ballard 2011).

5.6 Future research

As groups' restoration project objectives have been previously studied (Peters et al. 2015a), a more detailed investigation of the alignment between groups' monitoring methods and their project objectives is warranted. Monitoring needs to be carefully targeted, with adequate power (precision) for its purpose, while still being cost-effective. Given the complexity of science-based monitoring for community volunteers with little or no formal science training, opportunities for strengthening groups' technical skills and overall scientific literacy may need to be explored. Further research could also explore drivers influencing community groups' selection of monitoring methods, for example, illuminating how and why methods such as bird counts are modified by groups. This would enhance our understanding of groups' monitoring priorities as well as assist with designing appropriate forms of support that ensure that data are robust and meet data users' needs.

5.7 Conclusion

This study provides a national overview of CBEM and demonstrates that a large number of community groups have well-established, and highly varied monitoring programmes in place to measure change within their environmental restoration projects. The characteristics that distinguish groups undertaking monitoring from those not monitoring have implications for the type and level of partner support provided. Although ongoing support for groups is vital particularly for large scale projects, encouraging groups currently not monitoring to do so should also be considered. In this respect, toolkits form a useful means for promoting the importance of monitoring and guiding programme development by providing standardised methods suitable for community use.

Investing in content design and delivery upgrades as well as training and support for users would ensure that methods are understood and applied with rigour. Prioritising long-term funding to enhance collaboration between groups, scientists and environmental managers would also ensure that study design is robust, the monitoring meets group and project partners' needs, and that data use may be maximised through better integration with agency data sets.

Chapter 6

THE USE AND VALUE OF CITIZEN SCIENCE DATA IN NEW ZEALAND[4]

6.1 Abstract

There has been significant growth worldwide of citizen science projects involving community members collecting environmental data. The following study is based on questionnaire responses from 296 community environmental groups and interviews with 34 project partners (e.g., resource managers and scientists), and examines the use and value of citizen science data in New Zealand. Frequency counts and inductive thematic analysis were used to examine the quantitative and qualitative data respectively. Groups reported using their data to support funding applications (63%; *n*=151), inform restoration management decision-making (60%; *n*=151) and for educational purposes (48%; *n*=157). Outcomes such as relationship-building with project partners and increasing environmental knowledge highlighted the transformational nature of groups' citizen science activities. Although groups reported providing data to project partners (60%; *n*=151), concerns were expressed by project partners over data quality and a lack of institutional systems for using the data. Project partners, however, proposed novel solutions for enhancing collaboration with groups to produce useful data, underscoring the value they attributed to groups' citizen science efforts.

[4] A version of this chapter has been published as: Peters MA, Eames C, Hamilton D 2015. The use and value of citizen science data in New Zealand. Journal of the Royal Society of New Zealand 45(3): 151-160

6.2 Introduction

An increasing amount of scientific data about changes in the world around us is being gained through citizen science (Silvertown 2009). The term citizen science has been used to describe a broad range of ways that individuals and communities participate in scientific studies, with environmental monitoring forming a key activity (Bonney et al. 2009). Internationally, community volunteers have contributed to large-scale studies in ecology and evolution (Silvertown 2009). Danielsen et al. (2014) have suggested that there is further potential for citizen science data to contribute to environmental monitoring for the Convention on Biological Diversity as well as other international environmental agreements, such as the Convention on Migratory Species and the Convention on Wetlands of International Importance.

A major advantage of citizen science is the ability to provide data beyond the collection capabilities of most organisations (Carr 2004), as well as from under-researched areas such as private gardens (Spurr 2012), playing fields, allotments and inner city areas (Open Air Laboratories 2013). Citizen science data may be used directly by natural resource managers to identify problems, define baseline conditions and determine management actions (Miller-Rushing et al. 2012; Savan et al. 2003). In contrast, watchdog groups may generate data suitable for educational purposes and volunteer empowerment, leaving the collection of management-related data to agencies who have greater expertise and specialist equipment (Savan et al. 2003).

Despite the wide-scale use internationally of data generated by community volunteers, questions remain about data quality (Conrad & Hilchey 2011). Studies using parallel testing between professionals and community volunteers have diverged strongly on key indicators (Gillett et al. 2012; Kremen et al. 2011), or shown close alignment (Canfield Jr et al. 2002; Fore et al. 2001), highlighting a suite of factors impacting on data quality. Many are context-dependent, such as the technical difficulty of monitoring protocols, or the nature of the variable being studied (e.g., cryptic species), while other factors are more general such as the level of training provided to community volunteers.

Citizen science is gaining momentum in New Zealand. At a government level, a proposal to build biodiversity management partnerships by using a citizen science framework (Ministry of Business Innovation and Employment 2013) simultaneously acknowledges the necessity for wider public engagement in science, while legitimising and mainstreaming community science activities. Furthermore, the new Science in Society Strategic Plan proposes building stronger links between scientists and the public by developing a platform for collaborative research projects (Ministry of Business Innovation and Employment et al. 2014).

Current citizen science projects have been developed and led by New Zealand-based organisations such as universities (New Zealand Marine Studies Centre 2012), science providers (Spurr 2012), and not-for-profit organisations such as Fish and Game New Zealand (www.fishandgame.org.nz). A different form of citizen science is carried out by a loose network of community environmental groups engaged in projects to restore, enhance and protect habitat for native species (Peters et al. 2015a). More than 600 of these groups are active throughout New Zealand (Ross 2009), and at least 137 report carrying out their own monitoring (i.e. engaging in citizen science activities) to investigate change occurring within their projects (Peters et al. 2015). Community environmental groups typically work with a range of government agency, non-government and science organisation partners that may support technical aspects of environmental restoration such as assisting with species identification. Funding for group administration and operation may be accessed through these partners as well as from other sources including private businesses and funding trusts (Peters et al. 2015a).

Typologies derived from the level of volunteer participation in citizen science activities provide a useful starting point for understanding the diverse character of community environmental group projects in New Zealand. Three commonly used models (Bonney et al. 2009a) comprise:

- Contributory scientist-led projects where community members contribute data;
- Collaborative scientist-led projects where community members contribute to one or more of project design, data collection, analysis and dissemination of findings;
- Co-created projects designed by scientists together with community members, with some of the latter involved in all aspects of the project.

A further model, 'Transformative projects', proposed by Conrad and Hilchey (2011), follows on from 'Co-created projects', and differs on account of being community-led with varying levels of input from partners. In transformative projects, group participants (often volunteers) take a leadership role, gather and analyse data, and apply findings (Conrad & Hilchey 2011), with scientists functioning as guides, advisors and mentors (Handford 2011; Ely 2008).

The notion of environmental monitoring functioning as a transformative activity highlights the potential for enhanced project outcomes (Conrad & Hilchey 2011). Community monitoring connected to local management and action, for example, can lead to community empowerment (Danielsen et al. 2005), stronger partnerships between community groups and their project stakeholders, including scientists (Carr 2004), and re-invigorate cultural connections between indigenous peoples and their project areas (Townsend et al. 2004). At the same time, participants may broaden their skills in field work and increase their environmental knowledge (Open Air Laboratories 2013). Ely (2013) argues persuasively that there are greater opportunities for a democratisation of science to take place within community-based volunteer monitoring programs. In this setting, participants may be empowered to carry out scientific studies in contrast to contributory forms of citizen science where participation is mostly limited to the provision of data.

While research has provided useful insights into community groups' monitoring activities in New Zealand (Peters et al. 2015a; Harrison 2012; Jamieson 2010; Byrd 2008), questions still remain around the role monitoring plays within community groups' restoration projects, as well as the perceived value of groups' citizen science activities both within and beyond the scope of groups' individual restoration projects. This study therefore asks: (1) How are groups' monitoring data used, (2) What outcomes result from groups' citizen science activities and, (3) What value do project partners place on groups' citizen science activities?

6.3 Methods

6.3.1 Online questionnaire

In August 2013, an invitation to complete an online questionnaire was emailed out to 540 community environmental groups throughout New Zealand (excluding the Chatham Islands). The questionnaire comprised both closed questions (with a range of fixed answers provided), and open-ended questions (for narrative responses). A list of questions relating to this study is included in Appendix 1.

A list of questionnaire recipients (one email per group) was developed from community environmental group databases publicly available on the following websites: NZ Department of Conservation (DOC) (Department of Conservation undated-a), The Royal Forest and Bird Protection Society of NZ (Forest & Bird 2011), Sanctuaries of New Zealand (undated), Nature Space (undated) and the Waikato River Clean up Trust (Waikato Regional Council undated). Non-public community environmental group databases were accessed (with permission) from the NZ Landcare Trust, the World Wide Fund for Nature (New Zealand) and the Waikato Biodiversity Forum. It is important to note that these databases are unlikely to include groups which are small, informal entities, independent of resource management agencies and other major partners, non-computer users or those that have few environmental restoration objectives.

Prior to emailing the questionnaire, the study was publicised widely through newsletters, e-bulletins and websites (NZ Landcare Trust, Nature Space website and Waikato Biodiversity Forum). All individual emails containing a link to the questionnaire were personalised unless sent via a third party (e.g., non-public databases), or where a generic email address was provided such as info@. A research blog (www.monicalogues.com) was developed to track progress and provide transparency to the research process as well as to share findings with questionnaire respondents and other interested parties. To maintain questionnaire respondent confidentiality, names identifying groups and locations were deleted from data reported below and replaced with generic identifiers.

6.3.2 Interviews

A series of semi-structured, face to face interviews (*n*=34) was carried out with key representatives from resource management agencies (referred to in the results as A-01, A-02….; *n*=14), Non-Government Organisations (NGO-01, NGO-02…; *n*=5), environmental consultancies (CON-01; *n*=1), science providers (SCI-01, SCI-02…; *n*=5), and leading participants from four well-established (> 10 years) community environmental groups (CEG-01, CEG-02…; *n*=9). These expert sources of information, known as key informants (Marshall 1996), were drawn from the lead author's professional networks and expanded through the snowball sampling technique (Morgan 2008), where informants recommended other suitable interviewees. Interviews were mostly audio-recorded with additional notes made during and/or after interviewing in a field notebook. Interviews ranged from 30 minutes to two hours and transcripts were returned within two weeks to interviewees for verification. A list of interview themes is included in Appendix 3.

6.3.3 Analyses

From the responses to the questionnaire, data from closed questions were summarised by frequency and are presented below as percentages of total responses received. Responses to open-ended questions were analysed thematically using codes that primarily emerged inductively from the data, and were compared to categories drawn from the interview data as below. Data from responses to these open-ended questions are referred to as Group [number] when presented in conjunction with interview data.

Interview data were analysed using qualitative data analysis software NVivo 10 (www.qsrinternational.com/products_nvivo.aspx). The software enables passages of text to be manually tagged and indexed into one or more categories drawn from passage content (Bazely & Jackson 2013). Categories were inductively generated, i.e., recurring key words and/or themes were grouped together to facilitate interpretation of the text.

6.4 Results

6.4.1 Citizen science data use

A total of 296 community environmental groups (55%) responded to the online questionnaire (*n*=540). Of the groups carrying out monitoring, questionnaire responses indicated that the primary use for the monitoring data (Table 6.1) was reporting back to funders (63%; *n*=151), followed by informing restoration planning, sharing results with resource management agencies and supporting funding applications (all 60%).

Table 6.1 Community environmental groups' reported use of their monitoring data (*n*=151). More than one answer is possible per category.

Groups' reported use of their monitoring data	% of groups
Reporting back to funders	63
Informing restoration management planning in line with project aims/objectives	60
Providing general results to e.g. DOC, Councils, Science providers	60
Supporting funding applications	60
Measuring the effectiveness of new methods, equipment (e.g. traps) or materials (e.g. herbicide or bait)	53
Supporting submissions on environmental matters	29
Contributing to larger research projects led by e.g., science providers, universities	19
Don't know	5

In an open-ended question asking groups to detail how their monitoring data supplied to councils, DOC or science providers was used, more than one-third (35%; *n*=55) reported that they did this for compliance or accountability reasons e.g., 'To see that we are following 'best practice' at all times in our predator control; to see if the Project is successful enough for the re-introduction of native bird species; to see if we are using funding how it was intended' (Group 230). Though not specified as a high monitoring priority overall (Figure 6.1), one33% of groups reported through the open-ended question the data they provided to councils and other organisations as contributing to larger-research project led, for example, by science providers and universities. A further 29% of groups reported their data being used for advocacy purposes, such as promoting group activities to others.

When groups were asked to award a priority (low, medium, high) for using their monitoring data, the main priorities (Figure 6.1, *n*=157) were reported as using data to guide restoration management decision-making (61%), followed by using data for educational purposes and for supporting funding applications (48% and 48%, respectively). The lowest priority (23%) was reported as making contributions to wider research projects such as those coordinated by science providers.

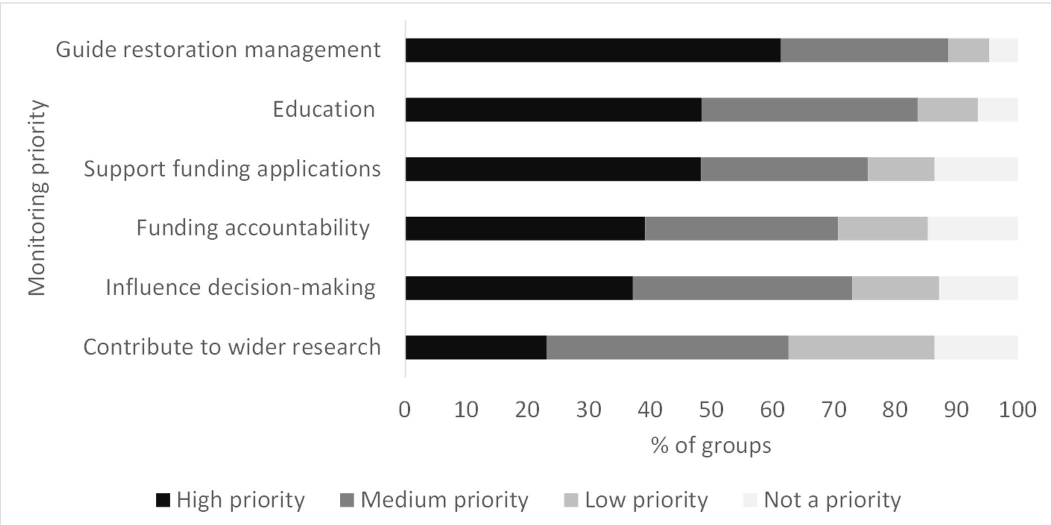


Figure 6.1 Low, medium, high priority or not a priority reported by community environmental groups for monitoring aspects of their restoration projects (n=157).

6.4.2 Monitoring outcomes for community groups

Qualitative analysis of open-ended responses to the questionnaire (*n*=27) and interviews (*n*=34) highlighted the broad social dimension inherent in the process of community environmental monitoring. The ability to strengthen relationships between individuals, their communities and local landscapes, was described by one community group member, 'The best thing about Five Minute Bird Counts I think is engagement… we do the bird counts together and I've really got to know him and his family… [it's] to do with actually caring... the elements of community – they're back again' (CEG-10). One community group member also highlighted the benefits of sharing monitoring outputs, '…there's nothing like a good tracking paper with no [pest animal] prints on it to lift everybody's morale…' (CEG-06). Relationships between groups and project partners were also enhanced, with one agency staff member commenting that using community data, '…creates a mutual dependency between everyone involved in the project…' (A-06).

Monitoring as a means to learn more about the environment was reported by one community group member, as s/he explained '…we had no idea about the bittern [*Botaurus poiciloptilus*] until… suddenly in the middle of our monitoring they started booming….'(CEG-06). The use of monitoring toolkits that combined mātauranga māori (cultural knowledge) and western science was seen to enable simultaneous engagement and empowerment for iwi, as one scientist described, '… people say we have lost a lot of [mātauranga māori]… so the CHI [Cultural Health Index] is being used to build up that knowledge base so that people are a lot more informed when they go into any decision-making' (SCI-02).

6.4.3 The value of groups' citizen science activities

In the interviews (*n*=34), staff from agencies and science providers put forward arguments both supporting and challenging the value of community citizen science activities. One scientist suggested that, '… [community environmental groups] are probably the best people on the ground to monitor and understand changes to that place and also tie in any activities in those areas with their own aspirational targets…' (SCI-02), highlighting the multiple functions of community monitoring. Agency staff described groups' citizen science activities as '…an opportunity to add value…' (A-06) to agency-led monitoring programs. One agency staff member described how community data could be used when combined with species distribution data available through other agency and online public databases, arguing that, '…then I've got a good understanding of where those species have been recorded historically … when we write a key native ecosystem management plan [or] restoration plan, we basically want to understand what species are there… [and] how we should be managing [them]…' (A-12).

Barriers for using citizen science data centred on data utility and data quality. One agency staff member, for example, highlighted a suite of conditions that s/he felt needed to be met before using community data, such as whether it was, '… meaningful, whether resource-wise it can be achieved, and makes sense in terms of our core business, our business functions, and the agreements we've made through our Long-Term Plan' (A-02). Issues concerning data quality were discussed both by agency staff and community group members. One agency staff member commented that, 'People who are distrusting… think… you need professionals to be collecting the data before you can pay any attention to it...' (A-06). While the challenges of setting up processes for improving community data quality were not 'insurmountable' (A-02) according to one agency member, even community group members felt that their data quality was 'an obvious concern' (CEG-10).

Factors identified by agency staff contributing to poor data quality included not defining monitoring purpose (A-02), a lack of understanding of experimental design (A-05) and a lack of project control sites (A-05). A further factor was claimed by an agency member to be the skill set and consistency required, '…it takes a lot of practice and not everyone's very good at monitoring; individual variation can actually undermine any other value in the data you collect…' (A-05).

However, another agency member regarded groups' participants as potentially highly competent, noting that, '… [some were] professional accountants, professional ecologists in their day… I don't see any reason why you can't trust the[ir] data' (A-06). This view was echoed by one experienced community group member, stating '…it's not as if we're dipsticks out in the wops who need DOC to tell us how to do things; we've gone over that hump and… gone a lot further' (CEG-05).

6.4.4 Solutions

The lack of a wider context for supporting groups and using community data, as one agency staff member described, '… is where we've fallen down… not [just] providing the template but providing an entire system for [groups] to be able to feed [their monitoring data] back and who… they feed it back to' (A-13). This had detrimental effects for groups, as outlined by an agency member, '…[stream monitoring data was] never used for anything and never fed back to the groups, so it was quite disheartening, so a lot of the groups… don't see the benefit [of monitoring]… as they do from putting plants in the ground … ' (A-13).

A range of practical solutions for developing and implementing robust monitoring programs was proposed by interviewees (*n*=34), beginning with, as one agency staff member suggested, '…some serious discussion… so that we can meet in the middle [with community groups] and find something that is going to be worthwhile, but also that's going to be achievable for the groups and for us to sell to the groups...' (A-13). Progress would require suitable structures for supporting groups, as explained by one community group member, 'I see a real potential…for frameworks, guidance… mentoring even – somebody who is like a science advisor to groups…' (CEG-10). This general idea was reiterated by an agency staff member who suggested, '…having a science structure [around groups, to] …give [community groups] credibility around what they're doing…'

(A-06). In addition, more collaborative approaches to working with the community that respected groups' local knowledge were emphasised by an environmental consultant, '…let's not come in as scientists that know everything…' (CON-01).

Building capacity amongst community groups was also proposed. One agency staff member suggested two ideas: (1) '…a satellite group of experts among the community group…' could be trained, '…so maybe a community group doesn't have to do its own monitoring…'; (2) 'For the amount of [monitoring] training [required by groups], would it be worth us all [i.e. agencies] pooling in and getting somebody to go in and do the monitoring for the groups once a year or whenever…' (A-13). Similarly, a proposal for 'specialist teams' made up of professionals with both technical and social skills was put forward by one community group member, '… [they] would be highly trained and really good communicators…' (CEG-10). Ultimately, the need for national leadership in citizen science was summarised by one agency staff member as '…encouraging people to… standardise to be part of a big picture… it could happen… someone needs to take the bull by the horns and lead it…' (A-05).

6.5 Discussion

6.5.1 Data use

Community environmental groups' priorities for carrying out monitoring were generally aligned with how they used their data. For example, groups' highest monitoring priority was to guide their restoration management decision-making, and this appeared as one of the four main uses of groups' data. Monitoring priorities and data uses were also well aligned with funding: both for supporting applications and for reporting results back to funders. These results underscore groups' reliance on funding bodies for sustaining their projects as well as the need to justify expenditure on outcomes of key restoration activities such as weed and animal pest control (Peters et al. 2015a). The use of data for educational purposes was also regarded as a high priority. This combination of environmental and social dimensions typifies community environmental groups' activities in New Zealand (Peters et al. 2015a; Hardie-Boys 2010) and underscores the dual purpose of community monitoring, namely as a social activity embedded within a scientific enquiry (Byrd 2008).

Groups also reported providing their monitoring data to project partners (e.g., councils, DOC and science providers). Resource managers may use citizen science data as background information (in the absence of other data); to assess environmental health; to 'raise a red flag' (e.g., for pollution events), for special studies (e.g., determining the effects of management) and to support evidence-based policy making (Haklay 2015; Hoyer et al. 2014; Brown et al. 2000). Project partners, however, described a lack of systems in place within New Zealand agencies for integrating community data into environmental reporting. In addition, data provided by the community may be incomplete or in formats not readily used by environmental managers (Conrad & Hilchey 2011). An explanation may lie with the grass roots nature of community group development where projects have been developed in response to local environmental issues (Ross 2009). The results demonstrate that groups' citizen science activities primarily serve the needs of the group first, with data supplied to others such as agencies and science providers as a secondary consideration.

The potential exists in New Zealand for community data to contribute to larger monitoring programs given current shortfalls in agency-led monitoring (Clayton & Cowan 2010). For example, limited outcome monitoring being conducted on brush-tailed possum (*Trichosurus vulpecula*) control operations by resource management agencies (Clayton & Cowan 2010) could be supplemented by data from community groups, as large numbers of groups trap possums and other animal pests on council-owned land (Peters et al. 2015a). Additionally, Lee and Allen (2011) point out that community group weed or animal pest control data combined with population studies of native species could be used to develop meaningful indicators of community engagement in biodiversity protection.

Several interviewees expressed concerns about data quality arising, for example, from observer error and flawed experimental design, or from a belief that community data are inherently untrustworthy. Although community stream water quality monitoring data have shown significant differences to professionally collected data, differences in equipment and protocols were revealed as the sources of error (Coates 2013). Biases regarding species distributions have been documented in open access platforms where community members can log their species observations (e.g., www.naturewatch.org.nz), hence the importance of understanding data limitations (Ward 2014) and designing studies to minimise potential biases (Ashcroft et al. 2012).

In New Zealand, critical evaluation of groups' performance when using common protocols such as Five Minute Bird Counts is needed to provide a wider context for interviewees' observations and assumptions. While the use of recognised protocols serves to legitimise community generated data (Ottinger 2010), applying a framework to assess groups' methods for quality assurance and quality control (QA/QC) could provide empirical evidence to guide future decisions around community data use (Wiggins et al. 2011).

6.5.2 Monitoring and transformation

The results of this study show that monitoring within community-led projects can act as a catalyst for enhancing environmental knowledge and relationship building with other group members, local communities and project partners. Community-led projects in the study are therefore most closely affiliated to a transformative model of citizen science, although Lawrence (2005) argues that scientist-led projects may also enable participant's perspectives and values to become transformed despite a lesser level of engagement in project activities. Monitoring tools such as the Cultural Health Index (Tipa & Teirney 2003) that situate cultural indicators of ecosystem health alongside western science methods provide fertile ground for extending the transformative reach of community monitoring. By producing data that are both culturally relevant and useable by resource managers, groups are able to participate more credibly in environmental decision-making (Townsend et al. 2004).

6.5.3 The way forward

Current government initiatives are targeted at contributory and collaborative citizen science projects (Ministry of Business Innovation and Employment et al. 2014; Ministry of Business Innovation and Employment 2013). In contrast, support for transformative projects is left largely to individual project partners, hence the lack of a more strategic approach across resource management agencies to drive, for example, more effective community data use, and the development of QA/QC frameworks suited to New Zealand community groups' projects. Interviewees put forward solutions for progressing community monitoring that centred on cohesive long-term support from resource management agencies by increasing groups' capacity for carrying out science, or by providing monitoring services across groups. These solutions emphasised the relationship-building between science professionals and community members that is central to the Science in Society Strategic Plan (Ministry of Business Innovation and Employment et al. 2014). The democratisation of science through greater public participation in scientific studies and more accessible science designed to meet community needs is a critical step towards creating a scientifically literate society, as well as one that can contribute important data to agencies charged with environmental management (Pandya 2012; Conrad & Hilchey 2011).

6.6 Conclusion

Monitoring by community environmental groups in New Zealand forms an integral part of many environmental restoration projects. Community groups' data remains a valuable though under-utilized resource with potential to contribute to environmental reporting led by agencies and science providers. The value of groups' citizen science data lies with informing groups about the management of their environmental restoration projects, educating project stakeholders about project outcomes, building environmental knowledge and enhancing relationships with project partners. The range of outcomes therefore distinguishes community environmental groups' monitoring activities as transformative in character, though diverse social outcomes may also occur in other types of citizen science projects. The optimism and caution expressed by project partners for using citizen science data highlight fundamental challenges around data quality combined with the lack of institutional or other supporting frameworks. However, the rapid growth internationally of citizen science demonstrates that effective methods can be developed that address data quality concerns. As groups' individual monitoring programs have often evolved independently from larger agency or scientist-led research, bringing cohesion and shared objectives for monitoring at greater spatial scales presents a significant challenge. For community data to contribute to wider research objectives, further leadership and ongoing support are needed by project partners as well as from central government.

Chapter 7

APPLYING CITIZEN SCIENCE TO FRESHWATER ECOSYSTEM RESTORATION[5]

7.1 Abstract

Interest in citizen science is growing globally as environmental degradation continues, information needs increase, and the value of stronger relationships between the science community and public is recognised. How community volunteers participate in citizen science ranges from solely collecting environmental data to being fully engaged in project design and delivery. In New Zealand, community groups lead diverse environmental restoration projects. Responding to an online questionnaire, 137 groups reported carrying out their own monitoring to measure environmental change. While many of these groups (41%, *n*=239) reported an interest in monitoring water quality in the future, there was limited reporting of freshwater monitoring (22% of groups, *n*=143), and this monitoring centred mostly on stream macroinvertebrate counts. Three case studies are presented that outline how community groups have engaged in collecting water quality data. In contrast, a strong culture of volunteer water quality monitoring exists e.g., in the USA, where programmes are designed to educate participants while also providing data for fundamental research, and for government agency-led environmental decision-making. To encourage wider participation of communities, professional scientists and government agencies in

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[5] A version of this chapter has been accepted for publication as: 'Applying citizen science to freshwater ecosystem restoration' Monica A. Peters, David Hamilton and Chris Eames. In: 'Lake Restoration: Perspectives from New Zealand', eds. D. Hamilton, K. Collier, C. Howard-Williams, and J. Quinn (to be published 2016 by Springer). This chapter includes contributions in 'Feature Boxes' from Mark Hoyer and Kathleen Weathers that are part of the accepted book chapter.

citizen science, principles underpinning the development and implementation of long-term volunteer monitoring programmes are outlined. Stronger community participation in monitoring has the potential to improve both scientific and environmental literacy, while building more complete data sets describing trends in freshwater resources. Furthermore, in New Zealand an informed and engaged public is in line with goals of local, regional and national government to increase public involvement in freshwater through participatory decision-making.

7.2 Introduction

A major issue facing humanity in the twenty-first century is the global decline in the quality of freshwater resources (United Nations Educational 2012). Recognising the need to protect and maintain water body health, volunteer water quality monitoring programmes have proliferated across the USA and Canada over the past 40 years. Hundreds of thousands of community volunteers now monitor streams, rivers and lakes in order to understand trends and identify issues (Kebo & Bunch 2013; United States Environmental Protection Agency 2012). Many of these volunteer initiatives began from environmental watchdog programs where members of the community became advocates for their local freshwater resources (Firehock & West 1995).

These volunteer water quality monitoring programmes now form part of a wider movement known as citizen science. Broadly defined as public participation in scientific investigations (Bonney et al. 2009a), monitoring carried out by community volunteers underpins an increasingly diverse range of studies across terrestrial and aquatic ecosystems (Silvertown 2009). Data generated by volunteers may be used to raise public awareness of environmental issues (Savan et al. 2003); contribute to scientific research (Hoyer et al. 2014), or to inform environmental management and policy (Haklay 2015). As participants carry out field-based activities in citizen science projects, stewardship of the environment may be encouraged, and participants may also increase their knowledge of ecology (Dickinson et al. 2012). In addition, the potential also exists for increasing participants' knowledge of scientific processes, i.e., scientific literacy (Crall et al. 2012; Jordan et al. 2011; Brossard et al. 2005; Trumbull et al. 2000).

The increasing popularity of citizen science projects and volunteer monitoring programmes can be attributed to a range of factors. With government agency capacity to carry out environmental monitoring reduced due to declining budgets (Kebo & Bunch 2013), trained volunteers have proved cost-effective, particularly for collecting long-term data over large areas (Hoyer et al. 2014). As a result, key scientific questions can be addressed that would otherwise lie beyond the resourcing capability of professional organisations and their staff (Carr 2004). Over time, access to simplified methods and training materials developed for volunteers have encouraged wide participation, notably for water quality monitoring (Firehock & West 1995). The growth of Web 2.0-based tools has driven the expansion of citizen science, with smartphone apps and sensors enabling rapid data collection and dissemination (Teacher et al. 2013). Haklay (2015) also identifies increasing levels of higher education, leisure time, and numbers of able-bodied retirees as factors, though also points out that few project participants comprise minority groups unless specifically targeted.

7.2.1 Participating in citizen science

Citizen science projects and volunteer monitoring programmes can be categorised according to level of participation by volunteers. In contributory or scientist-led projects, the primary role of volunteers is to collect data (Bonney et al. 2009a). This approach typically underpins studies where long-term data are required across large distances, such as 'The Great Secchi Dip-In' (http://www.secchidipin.org/). In this programme, more than 2,000 waterbodies (mostly across the USA and Canada) have been monitored for five or more years by volunteers for trends in transparency. A feature of the contributory approach is that it builds on what community members may already enjoy doing, for example, regular recreational users of water bodies may also collect samples for water quality monitoring or amateur bird watchers may join in on an annual bird count (Silvertown 2009).

Co-created or collaborative approaches enable greater volunteer participation in key activities such as study design, data collection, analysis and reporting (Shirk et al. 2012). An example is researchers working with local communities neighbouring a contaminated site to co-create a project that responds to community information needs (Ramirez-Andreotta et al. 2015).

Full participation by community volunteers in developing and leading projects/programmes, as well as collecting and managing the data, may be labelled as community-led, grass-roots or transformative citizen science (Conrad & Hilchey 2011). In this approach, scientists and land managers provide technical input, but the monitoring agenda is primarily directed by the volunteers. These types of projects are widespread in New Zealand, among community groups carrying out environmental restoration-centred projects across a range of ecosystems including freshwater (Peters et al. 2015a).

7.2.2 Data quality

Despite the widespread use of volunteer data and the longevity of water quality monitoring programmes such as Florida Lakewatch and the Lake Sunapee Protective Association (Feature Boxes 1 and 2), the quality of data collected by volunteers is frequently questioned. Sources of error commonly include poor study design, inconsistent use of methods, or not using uniform/standardised monitoring equipment. Further errors may stem from volunteers' lack of experience, which can lead to over or under-estimation of size and/or abundance, or inadvertent bias stemming from volunteers' preconceptions (Wiggins et al. 2011; Danielsen et al. 2005).

Quality assurance and quality control (QA/QC) planning procedures specifically designed to assist volunteer water quality monitors in the USA, were developed to address these issues (United States Environmental Protection Agency 1996). At the same time, an increasing number of studies have been carried out to determine the concordance between volunteer and professionally collected data. Both the Florida Lakewatch programme and the Lakes of Missouri Volunteer programme, for example, showed that results for variables measured (total phosphorus (TP), total nitrogen (TN), chlorophyll *a* and Secchi disk depth), were strongly correlated between professionals and volunteers (Hoyer et al. 2012; Obrecht et al. 1998). Further studies have shown similar levels of concordance for measurements of the average cyanobacterial toxin microcystin in samples (Sarnelle et al. 2010), and for determining macroinvertebrate taxon richness (Fore et al. 2001).

Wiggins et al. (2011) pinpoint three stages at which QA/QC interventions can take place, namely before, during and after participation by volunteers. Common solutions include pre-monitoring participant training and certification (Hoyer et al. 2012); the inclusion of tests during online data entry to validate data; replication by multiple participants, and expert review of data to highlight anomalies (Worthington et al. 2012; Wiggins et al. 2011). Effective monitoring programmes also acknowledge limitations by using protocols that match volunteers' skill and equipment, with authorities then alerted when more detailed monitoring using specialist equipment and expertise is required (Savan et al. 2003).

FEATURE BOX 1: Florida Lakewatch[6]

Florida LAKEWATCH is a successful long-term volunteer water quality-monitoring program. LAKEWATCH (est. 1986) began when citizens from Lake Santa Fe and Lake Broward (Alachua County, FL) contacted the University of Florida seeking answers on how to best manage their lakes. After training these volunteers to collect water from their lakes, they began monthly surface water sampling and measuring water clarity (Secchi depth), delivering samples back to the University to be analyzed for nutrients (phosphorus and nitrogen, key limiting factors for biological production), and chlorophyll (an indicator of algal biomass). These first citizens gave university professionals an idea and an opportunity to use volunteers to address these three original LAKEWATCH objectives: 1) How is the limnology of Florida lakes impacted by changing geologic gradients everywhere apparent in Florida. 2) What variance is exhibited among and within Florida lakes, and 3) Are there trends in the water quality of Florida lakes?

Professional and public interest with citizen involvement flourished to such a degree, that continued requests for state funding were heard, and the Florida Legislature officially established Florida LAKEWATCH in 1991 (Chapter 1004.49 F.S.). The evolution of the program lead to the organisational model of a Land Grant University with aspects of teaching, extension and research.

University professionals coordinating graduate students (teaching) and thousands of dedicated citizen scientists have resulted in the collection of reliable long-term water quality data for over 1100 lakes, 175 coastal sites, 120 rivers, and 5 springs. LAKEWATCH has used the results to create information circulars (extension) to address lake management issues in an understandable format while maintaining scientific credibility. At the same time, committed researchers maintained a steady stream of publications in peer-reviewed journals (research) showcasing the quality of data collected by volunteers.

Two major (of the many) hurdles to the early and continued success of LAKEWATCH are: 1) demonstrating to professional groups that trained volunteers are capable of collecting credible data, and 2) maintaining consistent long-term funding. Studies comparing data collected by volunteers with those collected by professionals have ensured LAKEWATCH’s accreditation to meet various national standards. Funding is especially critical because trained and committed core staff is needed to work alongside volunteers. Continued successes of the program make it easier for funding agencies to move money into the program. There is a vast army of citizen scientists waiting to get involved, and the hope is that the Florida LAKEWATCH experience assists other groups develop successful monitoring programs (Hoyer et al. 2014).

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[6] Feature Box contribution by M.V. Hoyer, University of Florida, USA

FEATURE BOX 2: Lake Sunapee Protective Association[7]

The Lake Sunapee Protective Association (LSPA) is one of the oldest lake associations in the United States, with a more than 110-year history of preserving and enhancing the environmental quality of the Lake Sunapee watershed and beyond. Located in southern New Hampshire, Lake Sunapee is an oligotrophic lake whose watershed is 80% forested and whose shoreline is rimmed with private cottages. LSPA relies on volunteers supported by 4.5 staff and an annual budget derived from membership and donations to conduct watershed restoration activities and deliver education and outreach programs to 4,000 to 5,000 people per year.

Citizen science volunteers have gathered over 20 years of water quality monitoring data, and their critical observations have contributed to a better understanding of the ecosystem. One example is when cyanobacteria blooms began to appear in the lake in 2004. Lakeshore residents and monitoring volunteers were the first to notice the appearance of an unusual bloom and different kind of algae in Lake Sunapee. They went looking for help to understand changes underway and found serendipity on their side. The author (Weathers) was on sabbatical with LSPA in 2004 and a student passionate about algae was looking for an internship in the area. It was the start of what has become a major, multi-year, regional study involving many citizens and students working with researchers from area universities and colleges (e.g., Carey et al. 2014).

The LSPA research program also involves the use of high frequency data from sensors mounted on a buoy in the lake and collaborations with researchers as part of the Global Lake Ecological Observatory Network (GLEON). The research has not only contributed to an improved understanding of the surprising algae blooms in Lake Sunapee – the kind of sound science that underpins management decisions – but also to an understanding of how these blooms may affect nutrient-poor lakes worldwide (Cottingham et al. 2015).

7.3 New Zealand: the freshwater policy context

Examples discussed thus far have included volunteer water quality monitoring programmes primarily from the U.S.A. This restricted geographic focus raises the question of which types of programmes exist in other parts of the world. New Zealand provides a useful case study, as water quality monitoring is likely to evolve into a collaborative activity in the future. The drivers for this change are legislated changes to government agency-led management of freshwater and a greater emphasis on community participation in natural resource management (Department of Conservation 2014; Ministry for the Environment 2013).

[7] Feature Box contribution by K.C. Weathers, Cary Institute, USA

At present, there is a pressing need for more effective freshwater management. Although point source pollution has largely been controlled through tighter regulation and enforcement, non-point source pollution (stemming mostly from agriculture), continues to have a major impact on freshwater quality (Parliamentary Commissioner for the Environment 2013). Water quality declines have been recorded across all major rivers (Ballantine & Davies-Colley 2010), and nearly one-third of monitored lakes are classed as eutrophic or of higher (degraded) trophic state (Verburg et al. 2010). Public awareness of these declines has increased such that water pollution is regarded as a critical environmental issue (Hughey et al. 2013), especially for rivers and lakes (Horizon Research 2013).

Water quality programmes vary widely between local authorities. This is partly due to programmes having been inherited from management structures such as catchment boards, which pre-dated the formation in 1989 of regional councils as territorial management authorities (Derby 2012; Office of the Auditor-General 2011). The need for guidance on freshwater management from central government has resulted in the new National Policy Statement for Freshwater Management (NPS-FM), the primary function of which is to maintain or improve overall freshwater quality within a region (New Zealand Government 2014a). The NPS-FM National Objectives Framework will enable local authorities and communities to plan for freshwater objectives (i.e., the desired state of freshwater relative to the current state), through a participatory process involving members of the wider community (Ministry for the Environment 2013). The NPS-FM recognises the environmental, social, economic and cultural values of freshwater resources in line with the range of iwi [tribal group] and community interests. In this respect, the policy enlarges upon existing, world-leading approaches centering on the specific inclusion of Māori in negotiated arrangements for resource management.

Although the date for NPS-FM implementation by local authorities has been established as December 2015, full implementation may be achieved through a staged process to meet a final deadline of December 2030 (New Zealand Government 2014b). This will allow time to define the manner in which community members, including iwi, will be involved in setting water quality objectives. The NPS-FM includes a suite of variables that community groups may be encouraged to monitor in the future. These variables are similar to those commonly measured in freshwater volunteer programmes in the USA, namely water temperature, periphyton abundance, sediment, discharges, connectivity, total nitrogen (TN) and total phosphorus (TP), fish, invertebrates and riparian margin condition.

7.3.1 Lake water quality monitoring

Standardised protocols used by local authorities and science organisations for measuring lake water quality (e.g., TN, TP, chlorophyll *a* and Secchi depth) have not been widely adopted by New Zealand community environmental groups and Non-Government Organisations. Contributing factors are diverse and are likely to include a low population density, for example, relative to North America (World Bank 2014), lake ownership, and a lack of accessible monitoring toolkits that bring together basic protocols, educational support material, equipment and necessary training. Limited funding is available for setting up and sustaining monitoring programmes, let alone for meeting laboratory costs for specialist analysis of TP, TN and chlorophyll *a.*

A further explanation may lie with who ultimately takes responsibility for water quality monitoring. In New Zealand, this activity is carried out by local authorities who are obliged to do so under the 1991 Resource Management Act (New Zealand Government 2014a). These authorities are also required to provide data to the Ministry for the Environment for national state of the environment reporting (Hilliard & Breese 2010). Although communities may not perceive a need for developing their own water quality monitoring programmes, equally, local authorities have not widely considered the potential of community volunteers to greatly enhance their capacity to collect useful data. The lack of water quality monitoring programmes that are reliant on volunteers to collect data for educational, scientific and environmental management purposes contrasts greatly with the two case studies from the USA presented in Feature Boxes 1 and 2.

7.4 Community freshwater ecosystem restoration

More than 600 community environmental groups largely made up of incorporated societies and trusts, are estimated to exist in New Zealand (Ross 2009). These groups represent a sizeable labour force of up to 45 000 volunteers (Handford 2011). An online questionnaire was sent to 540 of these groups and results showed that almost two-thirds (63% n=286) were actively engaged in restoring, enhancing and protecting native habitat associated with freshwater ecosystems (Peters et al. 2015a). Of this number, 32 groups (11%) carried out lake and catchment restoration. An overview of groups' freshwater restoration projects reveals a broad suite of activities within water bodies, in the riparian zone and extending into the catchment. Common activities undertaken by volunteers include pest animal and weed control, and re-vegetating with native species. Public education programmes and advocacy in the form of preparing submissions on environmental matters are also common, underscoring the diverse ways in which groups address issues around environmental degradation (Peters et al. 2015a). Groups' efforts are generally poorly documented in the peer reviewed literature, however sources such as group newsletters and reports highlight various freshwater ecosystem-related outcomes. Stream-based groups have controlled invasive aquatic weeds (Friends of Waiwhetu Stream 2013); improved habitat for native fish by manipulating the instream environment;

restored riparian vegetation (Collier et al. 2008); and improved waterway health after best practices were adopted on adjacent farms (Allen et al. 2014). Internationally recognised protection for wetlands has been secured (Ravine 2007), and partnerships with researchers developed to investigate sediment traps and floating wetland effectiveness (New Zealand Landcare Trust 2013). Large-scale lake catchment projects have resulted in pest-proof fencing, intensive pest animal control and the reintroduction of native fauna (Rotokare Scenic Reserve Trust 2014; Campbell-Hunt & Campbell-Hunt 2013).

Questionnaire results also showed that 137 community groups carried out their own science-based monitoring as a component of their restoration projects (Peters et al. 2015a. Despite increased public awareness of water quality declines, groups' environmental monitoring activities were predominantly focused on terrestrial ecosystems in support of objectives to control/manage pest animals and weed species (Peters et al. 2015a). Although 41% of community groups (*n*= 239) reported an interest in monitoring water quality in the future, most groups currently only carried out stream invertebrate counts (22%) (Peters et al. 2015b). The use of freshwater monitoring toolkits such as the Stream Health Monitoring and Assessment Kit/SHMAK (Biggs et al. 2002), and Cultural Health Index/CHI (Tipa & Teirney 2003) has therefore been very limited (8%; *n*=157), despite these tools being developed specifically to assist community groups and iwi (Māori tribes) to quantify water body health.

7.4.1 *Lake 'care' groups*

The following case studies provide insights into the diverse ways that volunteers have mobilised around their local lakes. Despite the absence of volunteer toolkits and wider programmes to support the collection, analysis and management of volunteer data for lakes, public concern over water quality declines has motivated some community groups and individuals to collect their own data.

Other group efforts have centred on building a better knowledge base about water quality declines in order to improve local authority lake management, as well as inform policy.

CASE STUDY 1: Lakes Water Quality Society

The Rotorua Lakes comprise 11 volcanic lakes ranging in size from 79.8 km^2 (Lake Rotorua) to 1.4 km^2 (Tikitapu/Blue Lake), and are situated in the central North Island.

From the late 1990s, lakeside inhabitants had begun witnessing cyanobacterial blooms occurring annually in several of the Rotorua lakes. The Lakes Water Quality Society (LWQS; http://lakeswaterquality.co.nz/) evolved in response to these ongoing water quality declines and the lack of remedial action taken by local authorities. Over 12 years, the LWQS ran a series of eight Symposia, triggering interest in the science, and disseminating scientific knowledge to decision-makers and the wider community. The LWQS has also been extremely effective at strategic policy change. In 2000, a Regional Water and Land Plan was proposed by the regional resource management agency, Environment Bay of Plenty. The Plan included Rule 11 which prohibited any additional land use intensification that could increase nutrient discharge to five lakes (including Lake Rotorua) with the overall objective of maintaining water quality above, or at, the level it was in 1960. Action Plans were developed to support remedial works for these five lakes. The LWQS successfully fought for further Action Plans to be developed for the seven remaining lakes, with works to be initiated when their water quality declined below a threshold level. The LWQS has also played a key role in securing major funding from central government (a total of NZD$79.3 million), and encouraged action by local authorities resulting in improved sewerage reticulation, in-lake engineering works, land use change from farming to forestry, more effective on-farm nutrient management and the precipitation of phosphorus from some lakes and streams (summarised from McLean 2014).

CASE STUDY 2. Lake Tarawera Ratepayers Association

At 51.0 km², Lake Tarawera forms the second largest of the Rotorua Lakes group in the central North Island.

In 2005/6 a summer student from the University of Waikato, Hamilton, was employed by the Lake Tarawera Ratepayers Association (LTRA) to determine nutrient concentrations of the lake and tributary inflows as well as to measure tributary discharges. Local resident Terry Beckett, a LTRA member and avid fly-fisherman, recognised the value of continuing the monitoring. He has continued the monitoring quarterly (following protocols used by the University), to now provide a long-term (10-year), continuous dataset. The samples, collected on behalf of LTRA, are supplied to the University of Waikato for analysis of ammonium, soluble reactive phosphorus, nitrate, TP and TN, complementing data from the regional council state of the environment monitoring which is restricted solely to the lake itself. Surface water discharges also continue to be measured by the LTRA. This comprehensive dataset has revealed the linkage of Lake Tarawera to other lakes by outflows, and the marked differences in composition between geothermal and cold-water spring inflows. This citizen science work has led to a realisation that a wider view than just the immediate lake catchment needs to be taken into consideration when investigating ways in which anthropogenic nutrient inputs can be reduced. The dissemination of data via newsletters has resulted in an informed and supportive community whose annual donations support costs associated with data collection and analysis (Terry Beckett, Pers. Comm.). Donations also help support a monitoring buoy that forms an important source of 'live' information for local residents (Environment Bay of Plenty, undated).

CASE STUDY 3. South Wairarapa Biodiversity Group

The Oko(u)rewa/Onoke Lagoon covers 6.3 km^2 and is part of a heavily modified system linked to Lake Wairarapa (78 km^2) at the southern end of New Zealand's North Island.

The vision of the South Wairarapa Biodiversity Group is '…a healthy coastal lagoon within the Wairarapa Moana Complex [Lake Wairarapa] supporting indigenous flora and fauna, for the education and enjoyment of the NZ public.' (http://swbg.weebly.com/okorewaonoke-lagoon.html). To achieve this vision, the group is re-vegetating the lagoon margins and has conducted baseline monitoring to develop a report of current lagoon health. In 2013 funding was received for the group to sample invertebrates and to collect water for laboratory analysis. A group member with a science background conducted her own research into suitable methods to use – a challenge given the lagoon's variable flushing regime, fluctuating salinity, and soft, sticky substrate. As a well-established group, strong partnerships have evolved with government agencies and others. For example, university staff and students provided technical assistance while sampling and carried out analyses of water quality samples. The group is considering whether to continue monitoring, though will need to source additional funding as well as verify the best protocols to use for this complex system (Jane Lenting and Heather Atkinson pers. comm).

7.5 Developing long-term volunteer monitoring programmes

A common thread running through each of New Zealand case studies is the desire for knowledge, environmental stewardship of the local area, and engagement in activities that lead to positive environmental as well as social outcomes. There is a big step between these individual community group initiatives and the large-scale, long-term water quality monitoring programmes commonly encountered in the USA such as Florida Lakewatch, and the Lake

Sunapee Protective Association initiatives. However, the shifting focus of water management in New Zealand from agency-only to multi-stakeholder collaborations has created a political environment amenable to an expanded role for community volunteers in freshwater science and monitoring.

With an abundance of well-established programmes to reflect on, in particular across the USA, Canada and Europe, a suite of interdependent management, science and social principles can be brought together to guide the development of new, long-term volunteer monitoring programmes. The principles listed here are neither intended to serve as a complete checklist, nor are they presented in any hierarchical order. Instead they contribute to a growing dialogue on citizen science best practice (e.g., Shirk et al. 2012). Comprehensive frameworks, describing the practical steps for developing, implementing and evaluating citizen science projects (that can also be applied to volunteer monitoring programmes), have previously been produced for the UK Environmental Observation Framework (Tweddle et al. 2012), as well as for Canadian community monitoring networks (Conrad & Daoust 2008).

7.5.1 Defined objectives and outcomes

Citizen science objectives commonly include education and public engagement; contributing to scientific research on ecosystems and phenomena; enhancing community capacity for decision-making; providing data for environmental management, or supporting policy development (Shirk et al. 2012). Defining volunteer monitoring programme objectives as well as outcomes from the outset has major implications for who will participate, and how they will participate. The scope and nature of data collected will also be affected, an example being that an educational or public engagement monitoring programme may not prioritise data quality to the same level as a programme designed to collect data for research or management purposes (Savan et al. 2003). Additionally, the way in which information is communicated and results are shared will also reflect the project purpose, as the target audience will vary, and how data are used will be programme specific. Further details on these key priorities are outlined in the following sections.

7.5.2 Fit-for-purpose programme structure

Three primary approaches that characterise the structure of citizen science programmes are described in this chapter as consultative/scientist-led, co-created and community-led or grass-roots. Each approach has evolved in response to factors such as differing information needs, the level of resourcing available and the type of participants targeted for the programme (Tweddle et al. 2012). The increased complexity of data management in programmes spanning wide temporal and spatial scales typically require a consultative approach (i.e. led by scientists and resource-managers) (Ely 2008), Florida Lakewatch being an example (Feature Box 1). In contrast, programmes with a more restricted geographic focus may rely on community volunteers to provide leadership and management roles as demonstrated by the LSPA (Feature Box 2), and by New Zealand community environmental group initiatives. The three approaches outlined above may be combined in order to achieve programme outcomes. For example, the main body of volunteers participating in the programme may collect primary data, while a core group of more engaged volunteers may participate more fully in the research process, e.g., developing new research questions and analysing data (Tweddle et al. 2012).

7.5.3 Robust monitoring design and appropriate protocols

Citizen science monitoring programmes are commonly designed to test hypotheses or contribute observations to environmental databases (Miller-Rushing et al. 2012). In both instances, long-term data sets can provide unique insights into ecosystem function particularly if programmes are guided by research questions and not by 'mindless data collection' (Lindenmayer & Likens 2010). Posing good research questions is undoubtedly challenging, however adapting the programme to suit emerging questions can contribute to programme longevity (Lindenmayer & Gibbons 2012). Firehock and West (1995), for example, highlight how stream monitoring programmes have evolved over decades owing to increased understanding of freshwater ecosystems, changing management needs, and the availability of new, user-friendly monitoring equipment. Pilot studies can determine the suitability of protocols for volunteer use, while also determining whether the quality of volunteer-generated data meets programme objectives (Tweddle et al. 2012; Lindenmayer & Likens 2010).

7.5.4 Ethical data use and ownership

The question of who owns and has access to the data produced has implications both for disseminating the research, as well as the how the research outputs are used (Scassa & Chung 2015). Intellectual property rights come to the fore when considering the ways in which volunteers can participate in programmes and agreements (contractual or otherwise), made between volunteers and programme coordinators. Copyright may apply to volunteers' photographs, videos and text-based contributions. However, programme designers that seek intellectual, innovative or creative input from participants, such as app design or improved methods, may need to consider the possibility of copyright infringements as well as patents (Scassa & Chung 2015).

7.5.5 Adequate resourcing

With an abundance of volunteer monitoring programmes to learn from, the first step is identifying successful models of funding from other projects (including those from outside the environmental sector), most likely to suit the objectives and structure of the new programme (Lindenmayer & Gibbons 2012). Sourcing long-term funding for monitoring has proved challenging, due to the lack of importance attributed to the sustained collection of environmental data (Hoyer et al. 2014; Lindenmayer & Gibbons 2012; Conrad & Hilchey 2011).

The cost-saving nature of citizen science compared with professional monitoring is often emphasised (Levrel et al. 2010), although this risks not adequately funding other aspects of the programme. Set-up costs, for example, can be substantial when considering the monitoring equipment required, along with programme infrastructure development (e.g., Smartphone apps, website and database design). Volunteers also require ongoing support following initial monitoring training, and specialist analyses necessitating skilled scientific personnel (often using expensive analytical equipment and specialist labs), which also contribute to costs (Tweddle et al. 2012).

Many successful programmes rely strongly on institutional support (Tweddle et al. 2012), as well as funding from diverse sources including private donations, memberships and government funding (Maine Volunteer Lake Monitoring Programme 2012). Other means toward enhancing the scope of programmes while contributing to their longevity include leveraging off existing monitoring programmes and monitoring-related events such as 'BioBlitzes' (Lundmark 2003). Lindenmayer and Gibbons (2012) stress the importance of informing programme partners and funders of programme outputs and outcomes, while also underscoring the importance of monitoring, as well as the costs of <u>not</u> monitoring.

7.5.6 Engaged participants

Citizen science would not exist, were it not for the willingness of volunteers to donate their time, knowledge, skills and, at times, personal resources. Volunteers may comprise members of the general public, school children, indigenous groups, or special interest groups such as recreational anglers (Open Air Laboratories 2013; Ansell & Koenig 2010; Goffredo et al. 2010).

Although an ethic of inclusivity underpins much of citizen science discourse, Haklay (2015) points out that middle-class white men continue to be over-represented in projects. Encouraging the participation of disadvantaged communities, as has occurred through the Open Laboratories Programme (Open Air Laboratories 2013), requires a purposeful approach so that volunteers may be meaningfully engaged in the programme (Haklay 2015). Meaningful engagement relies on understanding volunteers' motivations for participating in the monitoring programme (e.g., widening social networks; contributing to science or society; educational), and therefore understanding their expectations (e.g., social engagement; purposeful collection of data; quality communication) (Clary & Snyder 1999). Powell and Colin (2008), however, warn that few professionals attempting to 'engage in engagement' are clear about specific programme objectives and outcomes relating to engagement, and whether the means used to facilitate engagement will achieve these ends. This underscores the need for considering the complex nature of programme social dynamics from the beginning.

7.5.7 Effective communication

The skills required for developing and implementing volunteer monitoring programmes are considerable, and include scientific expertise, project management and volunteer facilitation. The ability to communicate effectively, as well as promote the programme is becoming increasingly important as communication channels diversify and information is sought across different media. Communication in the development phase of the programme is typically targeted at establishing the programme team and at volunteer recruitment (Tweddle et al. 2012). During programme implementation, regular communication that acknowledges volunteers' input, staff and partner roles as well as funders' support, helps to build a sense of community and shared purpose (Dickinson et al. 2012). Communication outputs may include informal updates or points of interest for the wider community using tweets, blog posts, newsletters, radio, television or other media. Formal channels include peer reviewed journals or reports mainly designed for partners and funders. An alternative example of the latter are citizen State of the Environment reports that share programme outputs and outcomes with volunteers, programme staff, resource managers, researchers and other stakeholders (Open Air Laboratories 2013; Maine Volunteer Lake Monitoring Programme 2012).

7.5.8 Ongoing evaluation

Although volunteer monitoring programmes have been conceptualised as a series of steps with feedback loops at specific junctures (e.g., Bone et al. 2012; Tweddle et al. 2012), the actual process of implementing volunteer monitoring programmes is most likely to be repetitious and discursive (Pollock & Whitelaw 2005). The dynamic and multi-faceted nature of volunteer monitoring programmes heightens the need for a considered approach to evaluation that captures the range of social educational, scientific or environmental management-related outcomes sought. With a defined set of outcomes to guide the evaluation of programme effectiveness, iterative testing by users should also be viewed as part of a wider, ongoing process of evaluation that can be adapted in line with programme evolution (Tweddle et al. 2012).

7.6 Future prospects

Citizen science and the related activities of volunteer monitoring are continuously evolving. Advances in Web 2.0-based technology have enabled large-scale initiatives to flourish (e.g., Worthington et al. 2012), achieved by simplifying data collection and management, automating quality control, and facilitating communication between stakeholders (Newman et al. 2012). Wireless sensor networks and smartphones are rapidly emerging as powerful tools for data collection. The latter function as mobile, internet-enabled computers that provide access to geographical information systems (GIS), and contain global positioning systems (GPS), scanners, microphones, camera and video (Teacher et al. 2013). Over half (54%) of New Zealanders now own a smartphone; very close to ownership in the USA (56%) (Ipsos MediaCT 2013a; Ipsos MediaCT 2013b). It is estimated that in New Zealand, smartphone penetration could reach 90% by 2018 (Research New Zealand 2015). Although few (10%, *n*=205) community environmental groups in New Zealand currently download smartphone software applications (apps), future interest in using apps is high (57%), indicating a willingness to trial new, and potentially more efficient methods of data capture.

Smartphone apps related to water quality monitoring are becoming increasingly diverse. Volunteers can now log sightings of harmful algal blooms (Xiao et al. 2011), or determine the likelihood of algal bloom occurrence in shallow lake waters (University of Wisconsin Parkside 2014). Apps such as Creekwatch allow users to enter qualitative data on water quantity, rate of flow, and level of pollution, as well as upload images of the waterway evaluated (California State Water Resources Control Board 2012). More comprehensive tools currently in development include a Global Lake Ecological Observatory Network app that will allow users to enter diverse geo-referenced data, including quantitative values of dissolved oxygen, water temperature, pH and Secchi depth, as well as aquatic vegetation (http://gleon.org/node/4370). In the future, inexpensive sensors attached to smartphones may enable measurements to be made of nitrate and phosphate concentrations. Such analyses are mostly currently conducted by highly trained personnel utilising specialist equipment and laboratories.

The greater volumes of data generated from wireless sensor networks and mobile technology will necessitate better data management. Newman et al.

(2012) create a vision of future database inter-operability, where computer-to-computer interaction will occur automatically, generating metadata and tracking changes to datasets, thus broadening the scope of data use and function.

7.7 Summary

Contributory citizen science projects e.g., led by resource management agencies and scientists are well underway in New Zealand (e.g., Brumby et al. 2015; New Zealand Marine Studies Centre 2012; Spurr 2012). At the same time, community-led initiatives include efforts by community environmental groups monitoring environmental change within their restoration projects (Peters et al. 2015b). Many useful lessons can be learned from well-established international examples of large-scale, long-term volunteer monitoring programmes that can be adapted to suit New Zealand and other countries where similar programmes are yet to be developed. Formulating a coordinated approach between all stakeholders and designing the infrastructure required to support citizen science programmes – particularly if data are to be used by agencies and researchers – are undoubtedly challenging. Yet, as a steadily increasing number of citizen science initiatives demonstrate, programmes with a long-term vision, effective data collection, storage, sharing and retrieval mechanisms, a focus on participation and collaboration, effective leadership and sufficient resourcing can result in mutually beneficial outcomes for volunteers and their wider communities, resource managers and researchers.

Chapter 8

SYNTHESIS

8.1 Overview

A history of pest and weed incursions in New Zealand, along with land use changes have significantly degraded ecosystem integrity and threatened indigenous biodiversity (Craig et al. 2013; Walker et al. 2006). This has set the scene for a wide range of grassroots initiatives to restore, enhance and protect remaining terrestrial and aquatic habitats. More than 600 community groups have mobilised throughout New Zealand with an estimated 25 000 – 45 000 participants (Handford 2011; Ross 2009). Projects are driven by practical environmental actions, with wider socially-oriented activities often included (Phipps 2011; Ritchie 2011; Cowie 2010;). Their largely unpaid input to on-ground works and project management can be significant (Phipps 2011; Campbell-Hunt et al. 2010). Thus, the overarching question this study sought to address was how these groups measured the ecological success of their restoration projects. In New Zealand, existing research on community-led biological conservation and environmental restoration has previously been limited to regional studies (e.g., Ritchie 2011), and projects associated with specific partners or organisations (e.g., Dune Restoration Trust of New Zealand 2012; Hardie-Boys 2010). A national-level study was undertaken to gain a comprehensive understanding of community environmental group and project characteristics; the nature of their partnerships, and to investigate groups' monitoring activities (i.e. grassroots citizen science).

This chapter re-examines the five key research questions presented in Chapter 1 (General Introduction) against the theoretical framework for the thesis introduced in Chapter 2 (Literature Review). Study findings from Chapters 4-7 provide the basis for discussion about the importance of public participation, meaningful engagement, and partnerships within the context of the research questions and theoretical framework underpinning this thesis. These three interrelated themes were chosen as the guiding principles for the study as: (1) Public participation in environmental restoration and biodiversity conservation is required to help halt the ongoing decline of New Zealand's biodiversity (Brown et al. 2015; Department of Conservation 2014); (2) Meaningful engagement between professionals and volunteers may enable concepts of reciprocity to be embedded in conservation practice (Phipps 2011; Buchan 2007); and (3) Effective partnerships can enhance environmental and social outcomes resulting from groups' project activities (Department of Conservation 2014; Handford 2011).

The study findings comprised three peer-reviewed journal articles and one book chapter that responded to one or more of the five research questions (Chapter 1). Briefly, the key characteristics of community environmental groups and their restoration projects are identified, along with the type of support provided by their project partners (Chapter 4). The nature of the monitoring activities carried out by these groups (Chapter 5), and how their data are used and perceived by their project partners (Chapter 6), are also identified. Chapter 7 gives key priorities for developing long-term volunteer monitoring programmes and comprises USA-based volunteer freshwater monitoring programmes with community-led activities in New Zealand. .

To conclude this synthesis, a suite of key recommendations for further research and practical action to enhance community groups' restoration activities are drawn from the study findings. Lastly, contributions this study has made to the fields of community environmental group-led restoration, community-based environmental monitoring, and citizen science are presented.

8.2 Community environmental group and project characteristics

Research question 1. What are the characteristics of community environmental groups and their projects in New Zealand? (Chapter 4)

To provide a broad foundation for the study, a database of 540 community environmental groups from throughout New Zealand was developed. These groups were then invited to respond to an online questionnaire, with a total of 296 groups participating. In addition, 34 in-depth, semi-structured interviews were carried out with groups' project partners to gain a deeper insight into the relationship between groups and their project partners. A further four community groups were interviewed to provide greater depth, for example, on key factors influencing their restoration activities. Each of the groups interviewed coordinated projects within different ecosystems (i.e. wetland, forest, river and lagoon), had been established for more than 10 years, and had demonstrated measurable environmental outcomes.

Study findings confirm that these groups aim to contribute to environmental restoration, enhancement and protection in New Zealand through their activities (Hardie-Boys 2010; Buchan 2007). The emphasis on environmental restoration is aligned with the importance and value these groups attached to indigenous flora and fauna and ecosystems such as wetlands, forests, streams, rivers and lakes they inhabit (Cursey 2010). Projects were mostly situated on publicly-owned or administered land, with the remaining one-third on privately or Māori-owned land. Groups reported addressing threats posed to indigenous biota by introduced flora and fauna, as well as land use changes (e.g., wetland drainage). In most cases, groups not only actualised their project objectives through environmental actions (i.e., riparian planting, pest animal and weed control), but also through environmental education and advocacy. These socially-oriented activities highlighted the position of groups as nodes within their local communities through which information on project progress as well as conservation-related issues were disseminated (e.g., Moehau Environment Group 2013).

Although quantifying the outcomes of groups' project activities lay beyond the scope of this study, major benefits to the environment and to groups' local communities could be inferred from group and project characteristics. The study showed that community groups were distributed throughout all regions in New Zealand, with the majority of groups reportedly in operation for more than six years. Although groups' projects ranged from very small areas (< 0.8 ha) to very large areas (> 501 ha), one-fifth of projects fell into the very large category. Groups supported both regional- and national-level conservation priorities through their task-oriented approach to restoration. For example, some pest control efforts were directed toward protecting native birds such as the pāteke, (*Anas chlorotis*; classified as 'at risk-recovering'), and North Island brown kiwi (*Apteryx mantelli*; classified as 'nationally vulnerable') (Department of Conservation 2011). The majority of groups also revegetated areas with native species after controlling weeds, some of which were listed in Regional Pest Management Strategies (Waikato Regional Council 2014; Cursey 2010). Political activities with longer-term, less direct outcomes included writing submissions on environmental matters. This highlights the diversity of scales groups operated at along with the diverse range of approaches to biodiversity conservation employed.

This study clearly demonstrated the importance of partnerships with professional organisations and other environmental stakeholders, for enhancing the activities carried out by community environmental groups (Callister 2013; Handford 2011; Ritchie 2011; Hardie-Boys 2010). Nearly all community groups reported being in partnerships (primarily with resource management agencies and non-government environmental organisations), underscoring their sourcing of external input to maximise ongoing impact. Partners provided groups with publically accessible databases where project summaries and contact details could be housed, e.g., Nature Space (Nature Space, undated), Department of Conservation (Department of Conservation, undated), and The Royal Forest and Bird Protection Society of NZ (Forest & Bird 2011). Resource management agency partners in particular, conducted site visits, provided technical support, assisted groups with on-ground works and made funding available. This is also reflected in the large number of projects reported by groups as taking place on agency-owned or administered land (Hardie-Boys 2010).

Specialist support such as cultural advice was provided by iwi [tribal groups], underscoring the range of project land tenure types and groups' awareness of the need for appropriate protocols to be followed when working with Māori (Moller et al. 2009). Nearly three-quarters of groups reported a need for further support from project partners in order to meet their project objectives. Expectations, however, of who would provide the support revealed a shift towards science providers and businesses, the latter regarded as an increasingly important potential source of funding. This is in line with enhanced agency collaboration with businesses in order to achieve greater conservation gains (Department of Conservation 2014).

This study shows that community environmental groups and their projects are of diverse character (Campbell-Hunt & Campbell-Hunt 2013; Phipps 2011; Cowie 2010; Hardie-Boys 2010). With 296 groups around New Zealand responding to the questionnaire, it was not surprising that considerable diversity was shown between groups as well as projects. Although most groups were small (≤ 20 regular participants) and relatively long-lived (≥ 6 y), questionnaire and interview findings suggested that a complex, interdependent range of factors determined group and project characteristics. These included groups' motivations for undertaking their restoration projects (inferred from the project objectives they reported), the age range of participants, physical aspects of the project (e.g. ecosystem type and geographical location) and the nature of partner support provided.

A wide range of motivations is known to drive voluntary participation in environmental activities (Ryan et al. 2001). Community groups' environmental objectives relating to the restoration of ecosystems (e.g., freshwater, wetlands), suites of species (e.g., 'birds') or individual species such as mistletoe (*Tupeia antarctica*), or kōkako (*Callaeas wilsoni*) reflect major declines in habitat condition and availability as well as threats to iconic species (Craig et al. 2013). More than two-thirds of groups also had social objectives such as raising environmental awareness, providing places for recreation and building community cohesion. This suggests that community groups' motivations may include a mix of practical considerations (i.e., to restore ecosystem integrity), altruism (i.e., to 'give back' to nature and society), and personal drivers (i.e. to experience fulfilment though restoration-related activities). These findings are consistent with international studies (Krasny et al. 2014; Bruyere & Rappe 2007; Ryan et al. 2001). Detailed research on what motivates volunteers to participate (and continue participating in the long-term) in community-led environmental restoration projects is lacking in New Zealand.

Chapter 4 showed that volunteers of different ages participated in projects for specific activities (e.g., public planting days), but the core group of participants mostly fell into the pre-retirement age bracket (51-65 y). This finding contrasts with studies of other New Zealand community environmental groups where participants were mostly retired (Cowie 2010; Taylor 1997), though still raised potential issues of group succession and participants' ability to carry out physically-demanding tasks (e.g., managing long pest-trapping lines) in the longer term.

The physical locations of groups' projects were diverse. Projects were situated in all regions of New Zealand, and within all major ecosystem types: from terrestrial to aquatic; lowland to highland, and freshwater to saline. Projects ranged in size from very small areas (0.8 ha) to very large areas (> 501 ha), across rural, peri-urban and urban locations. This suggests that declines in ecological integrity are widespread and that many different communities throughout New Zealand are willing and able to take leadership in restoration activities.

The diverse characteristics of groups and their projects have implications for the type and frequency of support provided by project partners, although the longevity of most groups demonstrated their resilience to numerous challenges, such as sourcing funding, and recruiting and retaining volunteers. Study findings suggest that wider conservation outcomes, or at least conservation outcomes that are easier to quantify, are likely to result from collectives of communities collaborating with project partners. Existing examples centre on initiatives to protect kiwi (New Zealand Landcare Trust 2013), though studies that relate conservation outcomes to group governance models are currently lacking for New Zealand.

8.3 Meeting project objectives

Research question 2: How do community environmental groups determine whether they have met their project objectives? (Chapter 5)

In the online questionnaire, groups were asked to identify five key objectives for their restoration projects, and which types of monitoring methods they used to measure change in their projects. Study findings support the theory that community groups measure change within their projects using both non-science and science-based methods (New Zealand Landcare Trust 2013; Dune Restoration Trust of New Zealand 2012; Harrison 2012; Byrd 2008). Groups' methods reportedly ranged from undocumented observations (i.e. non-scientific methods), to those routinely used by professional scientists such as photopoints, 5-Minute Bird Counts (5MBC; Dawson & Bull 1975) and vegetation plots (McNutt 2012). The diversity of these methods demonstrate a spectrum of skill levels from minimal (for photopoints), to substantial (i.e. flora and fauna species identification). Groups relying on non-science based methods (e.g., comparing the present project site condition with that obtained from historical documents), reported being mostly confident that they were meeting their project objectives. Factors put forward by groups for not monitoring included a lack of need for using science-based methods. While this included groups where monitoring was also carried out by others, it underscores the importance of determining groups' level of scientific literacy to support their restoration management decision-making.

Of the groups carrying out monitoring, just over one-third combined pest animal control with 5MBC to measure the outcomes of their management actions (i.e. outcome monitoring). Others were mostly limited to output monitoring (e.g., tallies of pest animal trap catches), a commonly used method by groups for tracking project progress (Nature Space, undated; New Zealand Landcare Trust 2013). Groups' monitoring objectives may change in the future given the high interest reported in monitoring water quality. This activity was reportedly carried out by few groups, with the limited availability of toolkits designed specifically for freshwater ecosystems forming one of the barriers to more widespread volunteer water quality monitoring initiatives.

Chapter 5 showed that groups carrying out their own monitoring generally had large-scale projects on privately-owned land, or land administered by the Department of Conservation, with medium to high partner support. The impediments to developing and implementing monitoring programmes identified by groups included a shortfall of funds, people and/or technical skills. These interdependent factors highlight the difficulty non-specialist community groups have in understanding complex and diverse ecosystems, managing short-term funding cycles and securing participants with an interest in science-based monitoring. These impediments are mirrored within the professional science and environmental management sectors, where long-term outcome monitoring may not be prioritised, and consequently may be under-valued and under-funded (Lindenmayer & Gibbons 2012; Clayton & Cowan 2010).

Study findings support the theory that groups' community-based environmental monitoring (CBEM) is a form of citizen science (Shirk et al. 2012; Conrad & Hilchey 2011), as citizen science projects commonly feature volunteers collecting data for scientific studies. Nearly half of the groups reported carrying out their own monitoring, instead of relying on contractors or agencies to do so on their behalf. Groups' focus on monitoring the outputs of their restoration management activities (e.g., numbers of pests trapped), and/or management outcomes (e.g., changes in bird populations) is consistent with citizen science projects that measure changes in ecosystem condition and trend (Hoyer et al.

2014), and changes in populations and distributions of species over time (Sullivan et al. 2014).

In order to cement groups' CBEM activities within citizen science scholarship, typologies were examined that categorise citizen science projects based on the nature of volunteer participation in the scientific process, and on project characteristics such as scale and activities undertaken (Roy et al. 2012; Wiggins & Crowston 2011; Bonney et al. 2009). These typologies are noticeably oriented toward projects where volunteers' primary activity comprised data collection for projects designed and coordinated by science institutions (contributory or crowdsourced citizen science). Consequently, few community-led citizen science projects feature in the peer-reviewed literature. However, Conrad and Hilchey (2011) include a category of 'grassroots' citizen science that can be applied to community environmental groups in New Zealand. This form of citizen science describes community volunteers setting the research agenda (either by themselves or in partnership with science professionals), collecting data, as well as participating in other aspects of the research process (e.g., monitoring programme design, data analysis and reporting).

The term 'transformative' can also be applied to community groups, as the outcomes of their CBEM activities may include enhanced social cohesion and improved environmental literacy (Open Air Laboratories 2013; Conrad & Hilchey 2011; Byrd 2008). The social nature of environmental monitoring (e.g., the importance of being with, and learning from others), was touched upon by community group interviewees and has been documented in other New Zealand-based studies (Coates 2013; Byrd 2008). Further studies investigating outcomes of this nature could enhance the understanding of volunteer motivation, and in the process, reveal factors underpinning group and project resilience.

8.4 The perception and use of community-generated data

Research Question 3: How are community-generated environmental data perceived and used? (Chapters 5 and 6)

This study supports the theory that community-generated data can contribute to scientific research and environmental decision-making (Hoyer et al. 2014; Coates 2013). The methods described by community environmental groups for meeting their project objectives included both science-based and non-science-based methods (Chapter 5). In Chapter 6, groups reported their data being used to support applications for further funding, inform project restoration management decision-making and being provided to resource management agencies. Studies of public participation in scientific research show an increasingly broad range of uses for volunteer data within ecology and environmental management (Haklay 2015; Miller-Rushing et al. 2012; Silvertown 2009).

The limited use of data beyond the scope of groups' own projects underscored the largely autonomous nature of groups, and their priorities for addressing the environmental issues on their own project sites (Ritchie 2011; Hardie-Boys 2010). Interviews with project partners (Chapter 6) showed that while most supported the use of community generated data in the future, the type and format of the data often did not fulfil agency requirements, hence the low or non-use of groups' data. Study findings showed that community groups were confident that the data they collected (e.g., using monitoring toolkits), supported their own project objectives, although differences in objectives between agency-led and community group-led monitoring formed a major barrier for using groups' data. This was compounded by the lack of frameworks such as databases, which enable community-generated data to be integrated into agency data sets, or to be used as standalone data to support agency-led environmental management decision-making.

However, species recovery efforts (e.g., for kiwi protection) rely on a strongly collaborative model, where groups across a region use standardised monitoring methods to produce data for land management agencies and science professionals (New Zealand Landcare Trust 2013; Holzapfel et al. 2008). This suggests that shared objectives, particularly around the protection of iconic native species, can be a powerful driver for enhancing collaboration between multiple groups and their project partners, as well as generating data of sufficiently high standard to meet research needs. In the future, measuring trends in water quality may also function as a shared objective between multiple groups across a region as is demonstrated in many examples from the USA (Hoyer et al. 2014; Obrecht et al. 1998; Firehock & West 1995). Methods to ensure data are of sufficient quality to meet end-user needs are a key consideration for volunteer monitoring programmes (Wiggins et al. 2011), yet no studies investigating data quality control and quality assurance procedures used by community environmental groups in New Zealand have to date been carried out.

8.5 Citizen science and water quality monitoring

Research Question 4: Given the increasing focus on water quality decline in New Zealand, what scope is there for citizen science to assist with the provision of water quality monitoring data? (Chapters 4 and 5)

There is increasing concern about decline of water quality in New Zealand, with non-point-source pollution from agriculture continuing to degrade lowland freshwater resources (Parliamentary Commissioner for the Environment 2013). Currently, nearly one-third of monitored lakes in New Zealand have water quality which is classified as poor (Verburg et al. 2010), and declining biodiversity is being recorded across both terrestrial and aquatic ecosystems (Elston et al. 2015; Craig et al. 2013).

This study supports the theory that there is scope for increased engagement by community environmental groups in biodiversity conservation and freshwater management. Enabling factors include an increased need by resource management agencies in New Zealand to work more closely with communities, along with development of an increased range of environmental monitoring toolkits specifically designed for community groups (Ministry for the Environment 2013; Department of Conservation 2012; Townsend et al. 2004; Biggs et al. 2002). Findings presented in Chapters 4 and 5 reveal a high level of participation in environmental restoration, enhancement and protection by community volunteers. In Chapter 5, few groups reported monitoring water quality, though a high level of interest was reported. This growth in interest may reflect greater knowledge of the degree and impact of water quality declines in New Zealand (Hughey et al. 2013; Parliamentary Commissioner for the Environment 2013), and the desire to measure outcomes relating to works carried out, such as riparian planting (Collins et al. 2013).

A broad discourse on the nature of science in society is now evident among Government ministries and resource management agencies, which also comprise key sources of funding for community groups. Goals have centred on enhancing conservation outcomes through closer engagement with the community (Department of Conservation 2014), involving members of the public in decision-making for freshwater resource management (Ministry for the Environment 2013), and building better relationships between scientists and members of the community generally (Ministry of Business Innovation and Employment et al. 2014). How individual members of the public and community environmental groups may participate in the new National Policy Statement for Freshwater Management (NPS-FM) (Ministry for the Environment 2013) is yet to be determined, along with how groups may be supported for doing so, by resource management agencies (Department of Conservation 2014). Examples of projects from the USA and Europe show that well-developed citizen science programmes can achieve a wide range of environmental and social outcomes that align with these government and agency goals (Hoyer et al. 2014; Open Air Laboratories 2013).

To assist New Zealand community groups with collecting standardised data using science-based methods, various toolkits for quantifying ecosystem changes, e.g., in wetlands, forests and streams, have been developed (Denyer & Peters 2012; Tipa & Teirney 2006; Handford 2004; Biggs et al. 2002). At present there are no such toolkits for measuring lake ecosystem change in New Zealand, in contrast to well-established programmes in the USA (Carey et al. 2014; Hoyer et al. 2014).

Few groups in the study reported using monitoring toolkits, despite their perceived utility for collecting data to enable increased understanding of their project ecosystem(s) (Townsend et al. 2004). Discussion by project partners of barriers for wider toolkit use centred on the lack of integration with partners' own monitoring programmes, along with the need for developing support and delivery frameworks (Handford 2006). These findings underscore the benefit of viewing community groups' monitoring activities within a broader conservation context rather than as individual, localised group efforts. Ultimately, it is important for agencies to quantify conservation outcomes relating to increased community participation in conservation activities (Department of Conservation 2014). This creates a strong case for promoting toolkit use as well as supporting toolkit users so that both community group and agency data needs may be met.

8.6 Developing long-term community-based environmental monitoring programmes

Research Question 5: What principles underpin long-term community environmental monitoring programmes? (Chapters 2, 4-7)

The lenses through which the following section is explored comprise community-based environmental monitoring as carried out by the community groups in this study, and contributory/crowdsourced citizen science programmes. Large-scale, long-term citizen science programmes are common in Europe and the USA, with volunteers collecting data for studies on an increasingly diverse range of species (e.g., avifauna, ocean mammals), ecosystems (e.g., lakes, forests and streams), and various phenomena (e.g., weather patterns) (Miller-Rushing et al. 2012; Silvertown 2009).

This study posited that requirements for long-term community environmental monitoring programmes include motivated volunteers, support provided through strong partnerships, and the collection of robust and purposeful data that are integrated into research and resource management programmes (Hoyer et al. 2014; Hardie-Boys 2010).

Studies on motivations for participating in community environmental groups are sparse (Byrd 2008), and a specific examination of this motivation was outside the scope of this study. However, recognising volunteers' motives forms a cornerstone of programme development and underpins the success of ongoing project operation (Narushima 2005; Miles et al. 1998; Clary et al. 1992). In this study, there was likely to be a strong alignment between the groups' environmental, social and, occasionally, economic project objectives and the motivations that drive project planning and implementation. These diverse objectives can be divided into categories similar to those found in the environmental volunteerism and restoration literature (Chapters 1 and 2). These categories comprise practical conservation (e.g. flood control), socio-economic considerations (e.g., reinstating a food source), and the fulfilment of cultural, personal, and spiritual needs (e.g., networking with like-minded others and reconnecting with nature) (Clewel & Aronson 2013; Bramston et al. 2011).

The critical nature of partnerships was underscored in Chapter 4, as the majority of community environmental groups reported relying on resource management agencies, or others for assistance with project delivery (e.g., on ground works, project administration, providing funding, baits, and pest animal traps) and enhancing group capacity (e.g., by providing technical advice). Robust partnerships are equally important for large-scale citizen science projects that seek to engage volunteers and provide educational experiences alongside data collection (Tweddle et al. 2012). For larger projects, the role of the partner may also be as a coordinator or facilitator, while community environmental groups coordinate their own projects and set their own objectives (Blue & Blunden 2010; Hardie-Boys 2010).

A key role identified in the study for project partners included 'science mentors' to help groups overcome technical issues relating to monitoring, encourage ecological learning and ensure the collection of robust data (Handford 2011). This highlights the importance of Including opportunities for empowering volunteers (Gooch 2004) and supporting volunteers to share and grow their knowledge, as this can encourage long-term commitment to a project (Ryan et al. 2001).

To date, the most comprehensive studies on data quality have appeared in the volunteer monitoring and citizen science literature (Bonter & Cooper 2012;

Hoyer et al. 2012; Wiggins et al. 2011), which is extensively referenced throughout this thesis. Studies comparing professionally collected data with that of volunteers have identified the importance of appropriate study design, equipment and monitoring methods that are suitable for volunteer use and for fulfilling research needs, as well as the need for specialised training and support (Moffett & Neale 2015; Ashcroft et al. 2012). Findings in Chapter 6 showed that some of the community groups carrying out monitoring reported customising scientific methods (e.g., 5MBC) to suit their project and group needs. This led to several project partners voicing their concerns (during research interviews) about the validity of groups' data. However, partners also highlighted that appropriate use of the data as well as strong technical support could alleviate this problem. Community groups themselves identified a need for improving their technical skills, as well as the need for ongoing support from project partners (Cursey 2010).

Generally, validity emerges as a significant barrier for using volunteer-generated data (Conrad & Hilchey 2011). There are increasing numbers of studies comparing volunteer and professionally collected data (Moffett & Neale 2015; Hoyer et al. 2012), along with investigations of methods used in citizen science programmes for ensuring data validity (Wiggins et al. 2011). Specific guidelines for volunteers to strengthen their quality assurance and quality control procedures have also been published (United States Environmental Protection Agency 2002), but similar guidelines are currently lacking in New Zealand.

Study findings showed that groups' data were primarily used to support funding applications and to guide restoration management decision-making (Byrd 2008). The limited use of groups' data beyond the scope of groups' own projects (Chapter 6) is reinforced by monitoring toolkits that exist as stand-alone modules, i.e. are not integrated with resource management agency monitoring programmes (Handford 2006). In contrast, crowdsourced citizen science is typically used to address a specific research need, such as the abundance and distribution of a particular species (Spurr 2012). With quality assurance and quality control in place, data can then be used for its intended purpose.

Further features identified in Chapter 7 and applicable to ecosystem restoration include the need for clearly defined restoration project objectives that result in strongly connected outcomes. Shirk et al. (2012) suggest beginning with desired outcomes, and then developing project objectives as part of a 'deliberate design' process.

Ethical data use and clarity over data ownership have recently been emphasised in the literature, owing to the multiple ways that data can be generated and shared e.g., through Web 2.0 technology such as smartphones (Scassa & Chung 2015). Community groups, their project partners and contractors will increasingly need to consider who owns the data, who the data may be used by, as well as how they may be used.

The need for a suitable project governance structure relates directly to the objectives of the project. Crowdsourced citizen science, for example, relies on geographically dispersed volunteers to collect data for studies (e.g., to measure the effects of climate change on biota), where using professional participants would not be feasible (Levrel et al. 2010). This approach typically relies on strong collaborations between institutions and a high level of resourcing (e.g., Worthington et al. 2012), in contrast to community groups that are largely internally governed, and whose project objectives mostly centre on their own project sites (Ritchie 2011). The emergence of hybrid models where multiple community groups work together acknowledges that individual group identity can still remain strong, while overarching objectives such as kiwi protection, may be shared (New Zealand Landcare Trust 2013; Whangarei Heads Landcare Forum 2010). In these projects, partners may adopt the primary coordinator role, given the necessary organisational structure required to support larger-scale and longer-term collaborative initiatives.

Adequate resourcing to meet project objectives emerged as a challenge for community groups (Chapter 4), despite most groups continuing operation beyond the time-frames of project funding provided by resource management agencies and government ministries (i.e., 1-3 years). The diversity of project partners reported by groups, and the multiple partners typically required for crowd-sourced citizen science projects attest to the need for building project resilience by accessing a wide variety of funding sources (Tweddle et al. 2012).

Lastly, the need for effective communication of project progress and key findings amongst project participants underscore both the social nature of monitoring (Byrd 2008) and the need to account for funding received. Ongoing evaluation encompassing social and environmental aspects was also identified as integral to measuring the effectiveness of a programme or project (Tweddle et al. 2012).

8.7 Conclusions

Community environmental groups, largely made up of volunteers, are involved in a diverse range of projects to restore, enhance and protect the environment in New Zealand. The large numbers of groups, the size, distribution and length of time their projects have been underway indicate that, collectively, their actions are likely to make major contributions to conservation nationally. Groups' project objectives primarily centre on environmental restoration, although social and (on occasion) economic dimensions are also included. Alongside groups' practical on-the-ground restoration efforts (e.g., pest animal and weed control), groups may also share their knowledge and experience with the wider community through advocacy and educational activities. Therefore, to fully comprehend community groups’ achievements, a holistic approach is required as groups’ restoration activities cannot be separated from the social and economic context in which they take place. In addition, detailed studies are needed to understand the many internal dynamics within individual groups that influence how personnel issues such as succession, volunteer recruitment and retention are resolved.

Groups carry out a wide range of monitoring programmes (i.e. ‘grassroots citizen science’) to quantify their management outputs (e.g., numbers of possums and rats trapped), and the outcomes of their restoration management activities (e.g., increases in bird numbers resulting from predator control). Anecdotal methods (such as undocumented observations) were also used, but the reliance on scientific methods highlights the value of finding measures of project progress that have currency with funders, and credibility with project partners.

Arguably, community-generated data could exist for the sole purpose of meeting groups’ own needs, and in many cases appears to do so, as groups may use their data to support funding applications and for guiding restoration management decision-making. However, the current emphases on enhancing partnerships between agencies and communities, and increasing public engagement in science and environmental decision-making, provide compelling reasons for re-examining community groups’ current monitoring activities, how their data may be more widely used, and how this may be achieved. Particular attention will need to be focussed on quality assurance and quality control procedures to better understand the nature of data produced and how these data could also meet partners’ needs.

Volunteer-collected data is rapidly growing in importance as a means for supporting scientific research, environmental management and evidence-based policy, and as a process for enhancing participants' scientific and ecological literacy. Study findings showed that monitoring toolkits using protocols and equipment suitable for community users can enable standardised data to be collected. However, the need for training and technical support cannot be underestimated, and furthermore, without toolkit integration into agency-led or science provider-led programmes, groups' data may have limited utility beyond the scope of their own projects.

Groups face many challenges to maintain effective project operation and to carry out long-term environmental monitoring. But there are many groups that obetain goods and services from multiple project partners. Agency-led environmental restoration, protection and enhancement initiatives would achieve far fewer conservation gains were it not for the sustained efforts of community environmental groups. This underscores the need for long-term partnerships that are able to evolve in response to groups' needs over time. If groups can realign their project objectives to agencies' needs, it will be possible to develop more strategic, collaborative approaches to biodiversity conservation.

Community environmental groups' strong ethic of stewardship over the unique flora, fauna and landscapes of New Zealand is evidenced by the scope and nature of their projects. There are no single answer to New Zealand's biodiversity crisis and the ongoing declines in environmental integrity across terrestrial and aquatic ecosystems, however, community groups' efforts highlight the necessity of using diverse approaches for conservation: leadership and action by concerned communities are required in tandem with government agencies fulfilling their statutory obligations to protect and enhance biodiversity.

8.8 Recommendations for further research

The following recommendations are primarily oriented toward scholars, e.g., from a university or crown research institute, and have a combined socio-cultural and ecological focus. Specific expertise in ecology will be required to compare volunteer and professionally collected data (Section 8.8.3) and to find measures of community groups' outcomes for biodiversity conservation (Section 8.8.4). Research findings presented in Chapters 4–7 form the basis of these recommendations and limitations of this study identified in Chapter 3 (Methodology) are also addressed.

8.8.1 Investigate volunteer motivation, engagement and group resilience

Studies are required on volunteers' motivations for joining groups, developing environmental restoration projects and for making long-term commitments to these projects. Aspects of NZ community environmental groups to be examined include social, cultural and environmental motivation in relation to the make-up and functioning of these groups. Attention should also focus on participants' ages and their expectations, as well as the nature of the ecological issues their projects seek to address. Methods for evaluating the effectiveness of processes for enhancing community engagement that includes volunteer recruitment and retention is required to support current programmes and future initiatives. Additionally, an in-depth investigation of factors that contribute to groups' resilience may assist partners in targeting their limited resources for groups more efficiently. This is integral to developing a more nuanced understanding of the socio-cultural and economic factors that drive community-led conservation in New Zealand.

8.8.2 Examine the relationship between groups' project governance models, project delivery and outcomes

This study has highlighted a range of governance models from independent, mostly autonomous projects to groups that work collaboratively with one another across regions on diverse projects, though with shared restoration objectives. The advantages of this approach are evident when viewed through an ecological lens, however, examining the relationship between groups' project governance models, project delivery and outcomes also requires a social focus. Understanding factors that underpin successful large-scale collaboration between multiple groups and their project partners may ultimately lead to more efficient use of resources and skills, and better outcomes for biodiversity conservation. Existing models that centre on threatened species recovery (e.g., http://www.kiwicoast.org.nz/) could provide a foundation for a study of this nature.

8.8.3 Determine the quality of groups' environmental data

The scepticism that exists among some scientists and managers around the quality of volunteer-generated data forms a major barrier to its use. Critical areas deserving attention include the drivers influencing community groups' selection of monitoring methods, for example, how and why methods such as bird counts are modified by groups, and groups' quality assurance and quality control processes for their monitoring programmes. In addition, further studies comparing volunteer and professionally collected environmental data are warranted as studies in New Zealand are currently limited to freshwater monitoring (Moffett & Neale 2015; Coates 2013).

8.8.4 Quantify community group outcomes

The contribution made by community environmental groups to biodiversity conservation in New Zealand is significant but currently unquantified. More accurate knowledge may help to apportion and target funding more effectively for community-led conservation initiatives. Furthermore, the need to quantify groups' contributions is pressing given the declining state of the environment (Ministry for the Environment and Statistics New Zealand 2015).

8.8.5 Investigate iwi-led restoration

Many iwi-led restoration projects fell outside the scope of the current study. The conservation and restoration-centred databases accessed, for example, may have excluded iwi-led groups which, although carrying out weed control and replanting with native species, were doing so as part of a larger, socially-oriented project. Investigating the socio-cultural and environmental dimensions of iwi-led restoration will shed light on how mātauranga māori [traditional knowledge] guides decision-making. In addition, findings are likely to highlight best practice for partnering with restoration-focussed iwi in order to maximise outcomes for biodiversity, water quality and the communities that depend on these resources. The structure for research of this nature exists under the current Vision Mātauranga framework (Ministry of Business Innovation and Employment 2014).

8.8.6 Definine citizen science for New Zealand

As citizen science continues to gather momentum in New Zealand, questions are likely to be raised about what constitutes citizen science and the relationship of mātauranga māori to citizen science. There exists an opportunity to define citizen science for the New Zealand context given the newness of the term and the unique range of scientific activities carried out by community members and tangata whenua [māori].

8.9 Recommendations for practical action

The following recommendations call for practical action to strengthen both environmental and social outcomes of community-based environmental restoration. Diverse input is required to implement these recommendations. Firstly, professional scientists (from crown research institutes, agencies and universities) can contribute by enhancing groups' technical skills (Section 8.9.1). Secondly, to assess the potential for volunteer monitoring in New Zealand (Section 8.9.2), collaboration is required between scientists, environmental managers and project coordinators skilled in translating technical material to non-scientific audiences. In addition, the identification of appropriate methods for community group to collect robust and reliable data are required. Lastly, it seems most appropriate that the development of a framework for growing citizen science in New Zealand (Section 8.9.3) is led by a non-government organisation. The broad range of stakeholders likely to be engaged in framework development (e.g., professional scientists, environmental managers, policy developers, community conservation and restoration practitioners) will require considerable skilled facilitators with an ability to maintain independence given the possibility of conflicting stakeholder needs.

8.9.1 Enhance groups' technical skills

Groups may benefit from access to cost-effective learning opportunities to enhance their technical skills, particularly with monitoring programme design and implementation. Input from professional scientists would enable greater confidence in data collected both by groups and other data end-users.

8.9.2 Assess the potential for volunteer water quality monitoring

Long-term volunteer water quality monitoring programmes, particularly in the USA, provide successful models for engaging the community in scientific research. Similar approaches could be trialled in New Zealand as the use of volunteers to collect water quality data that contributes to scientific research and management in New Zealand has not yet been widely considered.

8.9.3 Develop a framework for growing citizen science in New Zealand

A high degree of commitment is required by central government, resource management agencies and other environmental stakeholders to both support and grow citizen science in New Zealand. In Europe, the USA and in Australia, citizen science associations comprising practitioners, scholars and diverse professional institutions have been established (e.g., http://citizenscienceassociation.org/). These associations present a new model for New Zealand to evaluate that may assist with the development of a strategic direction for citizen science nationwide, as well as formulating best practice guidelines for designing and implementing citizen science projects.

8.10 Contribution to research

To date, both international and New Zealand-based studies of community environmental restoration have mostly centred either on single groups (e.g., Krasny et al. 2014; Reid et al. 2011), groups within a region (e.g., Blue & Blunden 2010; Gooch & Warburton 2009), or groups affiliated to a particular organisation (e.g., Hardie-Boys 2010; Buchan 2007). The findings of the study reported here provide more comprehensive insight into the social and environmental setting of community-led restoration across New Zealand, as well as opportunities and barriers for enhancing community contributions to conservation across terrestrial and aquatic domains. As such, new perspectives have been provided on the current state of community group-led environmental restoration as well as the scope and nature of the environmental and social activities that support their restoration. A detailed breakdown of which partners provide groups with what type of support is included, underscoring the interdependent relationship between groups and their project partners. Insights into the future needs of groups are provided to assist groups' project partners to provide appropriate forms of support.

Positioning groups' community-based environmental monitoring programmes within the broader field of citizen science is a novel approach. This recognises that projects in New Zealand are largely led by community members, and that are distinct from large-scale professionally-led projects that dominate the international citizen science literature (e.g., Sullivan et al. 2014; Bone et al. 2012; Worthington et al. 2012). Furthermore, the nature of community environmental restoration emerges as distinct when compared to other countries. Although, for example, stewardship groups exist in the US (Krasny & Tidball 2012), initiatives are dispersed and appear to lack both regional and national support networks as occurs in New Zealand. Although grass-roots initiatives exist in Australia, over 4 000 have been brought together under 'Landcare' a national NGO which provides a far greater level of coordination and support for groups than occurs in New Zealand (Ferraro 2013). In contrast, groups in New Zealand to a large degree have self-mobilised and are largely autonomous, despite support from multiple partners and the existence of national group databases.

This study situates groups' monitoring activities in the small, but growing body of New Zealand-based citizen science scholarship (e.g., Brumby et al. 2015; Spurr 2012), and sets the scene for investigating the effectiveness of grass-roots, bottom-up citizen science.

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APPENDICES

Appendix One: Online questionnaire

PART ONE: Community Group and Project Information

1. What is the name of your community environmental group? If your group doesn't have a name, write the name of your restoration project(s):
2. Is your group formally established (e.g., Incorporated Society, Trust)?
   Yes; No; Don't know
3. What are your group's main aims/objectives in the immediate and long-term? Please list up to 5
4. How long has your group been in existence for? (Add TOTAL years if group existed prior to becoming a Trust or Inc. etc)
   Less than 1 yr; 12 yrs; 35 yrs; 610 yrs; 11+ yrs
5. How many group members and/or volunteers participate in at least 30% of all activities (e.g., trapping, committee meetings, administration, planting)?
   1–5; 6-12; 13-20; 21-50; 51-100; 101+
6. What age are MOST group members and/or volunteers?
   18 yrs and under; 19-30 yrs; 31–50 yrs; 51–65 yrs; 66+ yrs
7. Does your group have any partners/ supporters (e.g., DOC, Councils, Iwi, Businesses)
   Yes; No; Don't know

Group partners / Support

Partners and supporters help groups achieve their aims by providing good s and services, either paid for, or in kind.

8. Which partners currently support your group's needs? Please click any that apply

Matrix column headings: *Not applicable; DOC; Regional/District Council; Iwi; Scientists e.g., NIWA or Landcare; Business/Corporate; Private contractor*

Matrix row headings:

PROJECT SITE VISITS (e.g., discuss restoration options);

TECHNICAL SUPPORT (e.g., species ID);

DATA MANAGEMENT (e.g., analyses, storage);

ON GROUND WORKS (e.g., pest/weed control);

CULTURAL ADVICE;

FUNDING/SPONSORSHIP;

ADMINISTRATION;

EQUIPMENT/VENUE LOANS.

Please list OTHER SUPPORT needed and WHO may provide it:

9. If NOT currently supported, or FURTHER support is needed, who could help fulfil your group's aims/objectives? Please click any that apply

   Matrix column and row headings as above

   Please list OTHER SUPPORT needed and WHO may provide it:

Restoration project outline

10. In which region(s) are your project(s) located?
11. Which best describes where MOST of your project(s) are located?

    Urban, Periurban (within a 510km radius of a town or city centre), Rural
12. Who owns MOST of the land your project(s) are on?

    Private, DOC, Council/LINZ or other Crown entity, Maori, Other
13. Which ecosystems are your group restoring?

    Forest; High country; Stream; River; Freshwater wetland; Lake; Estuary; Other
14. What is the TOTAL AREA covered by ALL of your group's current restoration project(s)?

Less than 0.8 hectares (1 acre); 0.8–4 hectares (2–10 acres); 4.1–8 hectares (11–50 acres); 8.1–40.5 hectares (51–100 acres); 41–100 hectares (101250 acres); 101–500 hectares (251 1240 acres); More than 501 hectares (1240+ acres)

Unsure about ACRES or HECTARES? Please specify total area in m2 or km2

15. Which activities has your group (or contractor) carried out? Click any that apply

    Planting natives; Weed control; Riparian planting; Pest animal control; Advocacy/education (e.g. school/community visits); Writing submissions; Fencing; Reintroducing native bird species; Changing water levels (e.g. building weirs); Covenanting (e.g. Council, QE2); Amenity development (e.g. walkways, signage); Other activities (please specify)

PART TWO: Environmental Monitoring

16. Which BEST describes your group's science-based environmental monitoring activities?

    Our group doesn't do any environmental monitoring;

    Our group currently does its own environmental monitoring;

    We used to do environmental monitoring, but don't currently;

    We contract out our environmental monitoring to a contractor;

    Environmental monitoring is already being done by others. (e.g., DOC, Councils)

    OTHER (please describe)

17. If NOT currently part of your project(s), what are the main challenges for setting up a monitoring programme? Please click any that apply

    Monitoring is not necessary for our project;

    Monitoring is not the role of our group;

We don't know what we should be monitoring;

We don't have the technical skills to set up a monitoring programme;

We don't know who to approach to help us set up a monitoring programme;

We don't have enough people to carry out a monitoring programme;

We don't have the funds to set up a monitoring programme.

Other (please describe)

18. If NOT currently monitoring, how does your group know that its aims/objectives are being met? Please click any that apply

    We are unsure if we are meeting our aims/objectives;

    Our group and others have observed e.g., increases in bird numbers, decreases in weeds, native plant growth;

    We add up e.g. litres of herbicide used, trees planted, pest traps laid out, volunteers hours

    We contrast what the site looks like now with old photos/historic documents;

    Our restoration has resulted in a management response from e.g., DOC, Council.

    Other (please describe).

19. Would your group like to monitor any aspect of your project(s) in the future?

    Y/N; Don't know

20. How long has your group or contractor been monitoring your restoration project?

    Not applicable; Less than 1 yr; 1-2 yrs; 3-5 yrs; 6-10 yrs; 10+ yrs

21. How much of a priority are the following for monitoring your restoration project?

    Matrix column headings: *Not a priority; Low priority; Medium priority; High priority*

Matrix row headings:

Education: Learn more about the ecosystem, share findings;

Management: Guide restoration site management;

Accountability: Monitoring required by funders;

Research: Contribute to wider research outside of project;

Decision-making: Influence decisionmaking e.g. by DOC, Councils; Funding Support funding applications

22. Which methods has your group/contractor used for monitoring? Please click any that apply

    Don't know; 5-Minute Bird Counts; Foliar Browse Index; Residual Trap Catch Index; Stream invertebrate counts; Vegetation plots; Lizard counts; Photopoints.

    Other monitoring methods used (please describe)

23. Which toolkit is USED MOST by your group or contractor for project monitoring?

    None; FORMAK Forest Health Monitoring and Assessment Kit; SHMAK – Stream Health Monitoring and Assessment Kit; CHI Cultural Health Index; WETMAK –Wetland Monitoring and Assessment Kit.

    Other toolkits used by your group/contractor

24. To what extent do you agree/disagree with the following statements about the toolkit used MOST OFTEN by your group?

    Matrix column headings: *Strongly disagree; Disagree; Neutral; Agree; Strongly agree*

    Matrix row headings:

    Overall, the toolkit/ methods enable monitoring priorities to be met;

    Onsite toolkit methods training is necessary for collecting quality data;

    Data collected using this toolkit are good quality and scientifically robust;

    Testing toolkit users after training would ensure quality data are collected;

Ongoing technical support and training is required for maintaining data quality;

The kit layout enables information to be easily found;

Technical terms are clearly explained;

Enough diagrams, graphs etc. are used to explain concepts;

The toolkit is appropriately designed for field use;

*Data entry is straightforward using the templates provided.*Any other comments on toolkit usability? (please describe)

25. How are the monitoring data collected by your group/contractor used? Please click any that apply

    Providing general results to e.g. DOC, Councils, Science providers; Measuring the effectiveness of new methods, equipment (e.g. traps) or materials (e.g. herbicide or bait); Informing restoration management planning in line with project aims/objectives; Reporting back to funders; Contributing to

    larger research projects (e.g. NIWA, University, Landcare Research); Supporting submissions on environmental matters; Supporting funding applications; Don't know

    How else are your data used? (please describe)

26. If you provide YOUR DATA to Councils, DOC or science providers etc. what do THEY use your data for?

27. What would your group like to monitor in the future? Please click any that apply

    Nothing else; Change in water level; Spread of weeds; Establishment of native plants; Water quality; Type and number of birds; Type and number of fish; Type and number of lizards

    Other (please describe)

28. Which do you currently do, and which might you do in the future (after training if required)? Please click any that apply

Matrix column headings: *Not applicable; Do now; Interested for future*

Matrix row headings: *Enter and store data online (e.g.,*

Naturespace.org.nz);

Access online forums (e.g. project blogs, project Facebook pages);

Attend monitoring training workshops;

Use Google maps;

View monitoring training videos/DVDs;

Download Smartphone applications (Apps) e.g. for species ID;

Identify flora and fauna\ using books;

Use web ID guides (e.g. NZPCN, Landcare Research);

Use GPS (handheld unit or smartphone application);

Take photos with phone/Smartphone;

Take photos with digital camera

OTHER (please describe)

29. Any further comments you would like to add?

END OF THE QUESTIONNAIRE

Appendix Two: Email accompanying online questionnaire

[Email subject]: Community groups and environmental restoration: A questionnaire

Hi [name of group contact]

My name is Monica and I am researching community groups and their environmental restoration project(s). The questionnaire will take 10-15 minutes and is aimed at group leaders who are knowledgeable about their group and project(s) being carried out. As little is known about the challenges faced by groups restoring their local environments, the information you provide will go towards developing better support for community groups throughout NZ.

I would greatly appreciate it if you could follow the link to the questionnaire [link]

PLEASE NOTE that this link is uniquely tied to your email address so cannot be forwarded to someone else. If you are not the right person, please let me know whom I should contact instead.

Filling out the questionnaire is voluntary and all data you provide are confidential. Questionnaire results will be used for my PhD thesis, scientific journal articles, reports and presentations. No groups or respondents will be individually identified in any of these media.

I will regularly post research updates on my blog: www.monicalogues.com - your comments are welcome. The site also contains more information about the research.

Thank you in advance for your participation!

Any questions? Please don't hesitate to contact me:

Yours sincerely

[Signature]

Monica Peters

[contact details included]

For any concerns or further questions about this questionnaire, please contact my supervisor:

Dr. Chris Eames

[contact details included]

Please note: If you do not wish to receive further emails about the questionnaire, please click the link below, and you will be automatically removed from the mailing list [link].

Appendix Three: Themes for guiding interviews

Themes for guiding interviews with project partners[8]

- How do you work with community groups?
- Are environmental data collected by community groups used by your organisation in any way?
- What are the barriers for using community generated environmental data?
- How can community data be integrated into existing reporting?
- How can community environmental monitoring be better supported?

Themes for guiding interviews with community environmental groups

- How do you work with your project partners?
- Do you provide environmental data to your project partners, and if so, how are they used?
- What barriers do you think there are for using community generated environmental data?
- How can community environmental monitoring be better supported?

[8] Government resource management agency staff including regional council and Department of Conservation; non-government organisation staff, scientists and environmental contractors

Appendix Four: Human research ethics approval

Faculty of Science and Engineering

Human Research Ethics Sub-committee

12 Feb. 2013

Monica Peters

Department of Biological Sciences

Re: Ethics approval – '*A framework to evaluate the effectiveness of community environmental monitoring toolkits to meet end-user needs*'

The Faculty ethics committee has now considered your above-named proposal. It is approved subject to you addressing the points noted below. Please make appropriate revisions and send me a final copy signed by you and your supervisor.

1. Under 3b 'Participant observation – case study community groups' indicate here whether or not people will be photographed. You do mention this later, but it is useful to note it here too. Also mention this under the next section 'Focus group';
2. You mention under 4a that the CEO of Landcare has given permission for you to access the database. However, those that are on this database would not necessarily be happy for him to take such a step. It is suggested he or another organizational official send out a message to those on the database that he has been asked by you to allow such access, and ask if they have any objections;
3. Under 4b please state explicitly if only one questionnaire will be used for all participants;

4. Under 5b, do you think there could be a need to inform a given participant's employer?;
5. Under 5e it might be better to say participants have the right to withdraw anytime before data analysis begins (same applies to 7b);
6. Under 5f, did you consider if some participants may not be able to access these summaries as they do not have Internet access? If so how might they get information about the project?;
7. Please indicate in the appendices how letter is to be headed for various groups of participants;
8. Under appendix 5 second bullet, you need to note who owns and what will happen to any data;
9. In terms of process, the initial information letters need to accompany the consent form. After that, the instruments can be distributed -there seems to be some confusion in this process.
10. There is no mention of consent and confidentiality re the taking of pictures, this needs to be described, and included in the information letter and consent form.

Appendix Five: Research information sheet

PhD Research Topic: “A framework to evaluate the effectiveness of community environmental monitoring toolkits to meet end-user needs” [working title]

Study outline

I am writing to invite you, as a member/affiliate of a community environmental group, or as a project partner to participate in a study. A 30-60 minute interview is the first step toward understanding how your community group operates, what type of monitoring is carried out, and how the resulting data are, or could be used. I will either take notes or will ask your permission to record the interview. If recorded, I will send you a transcript so that the contents can be verified and amendments made (if required).

Why get involved?

The information you provide will fill important knowledge gaps, as little is known about community groups and environmental monitoring, monitoring toolkit use or how the resulting data are used. While toolkits are useful resources and a valuable way to make science available to the public, how effective they are in meeting the needs of community groups and other data end-users is currently unknown.

Results and confidentiality

Outputs from these data will comprise a chapter in a PhD thesis as well as a journal article. Additional outputs may include reports, blog posts (www.monicalogues.com), NGO magazine articles or presentations, for example, at community workshops, symposia and conferences. Your feedback on blog posts are welcome, though note that these too may be used for the study.

To maintain confidentiality individuals will not be identified, and your name and that of your organisation will NOT be used in any publications, presentations or blog posts unless permission is given prior. All information gathered from you will be securely stored.

I would appreciate your consent to be involved as outlined above. If you would like more details about the project, or have any questions or concerns about the project and your involvement in it, please don't hesitate to make contact. If I am not able to resolve any concerns you may have about the study, you can contact my research supervisor, Professor David Hamilton.

Yours sincerely

[Signature]

Monica Peters

[contact details included]

Prof. David Hamilton, PhD Supervisor

[contact details included]

Appendix Six: Informed consent sheet

PhD Research Topic: "A framework to evaluate the effectiveness of community environmental monitoring toolkits to meet end-user needs" [working title]

If required, please seek permission from your employer before completing this consent form.

I have read the attached research information sheet.

I understand that:

- My participation in the study is voluntary.
- I have the right to withdraw up to 2 weeks after interviews/observations have taken place
- I will own the raw information (data), though Monica Peters will own the interpretation and analysis of the information (data).
- Information may be collected from me in the ways specified in the accompanying letter. All information will be kept confidential and securely stored.
- Information (data) obtained from me during the research project may be used for a PhD Thesis and related publications along with reports, articles in the popular press, the www.monicalogues.com blog site study updates, the WETMAK Facebook page in the case of monitoring training workshops and for making presentations about the project. All information (data) will be reported without use of my name or the name of my group / organization.

- I am free to decline to have my photo taken. If I allow photographs of myself to be taken either individually or in a group, I will be re-contacted and asked for my permission for the photograph(s) to be used. My name will not be used to identify myself, group or organisation in the photo unless I provide permission for this.

Monica Peters

[contact details included]

Prof. David Hamilton, PhD Supervisor

[contact details included]

I give consent to be involved in the project as outlined above

Name:__________________________

Signed:_________________________

Date:___________________________

Please return this signed form to the researcher via email, or post a printed version to Monica Peters at the address above. Alternately, you can give your consent by email.