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The Community-Conservation Conundrum: Is Citizen Science the Answer?

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Abstract: Public participation theory assumes that empowering communities leads to enduring support for new initiatives. The New Zealand Biodiversity Strategy, approved in 2000, embraces this assumption and includes goals for community involvement in resolving threats to native flora and fauna. Over the last 20 years, community-based ecological restoration groups have proliferated, with between 600 and 4000 identified. Many of these groups control invasive mammals, and often include protection of native species and species reintroductions as goals. Such activities involve the groups in "wicked" problems with uncertain biological and social outcomes, plus technical challenges for implementing and measuring results. The solution might be to develop a citizen science approach, although this requires institutional support. We conducted a web-based audit of 50 community groups participating in ecological restoration projects in northern New Zealand. We found great variation in the quality of information provided by the groups, with none identifying strategic milestones and progress towards them. We concluded that, at best, many group members are accidental scientists rather than citizen scientists. Furthermore, the way community efforts are reflected in biodiversity responses is often unclear. The situation may be improved with a new approach to data gathering, training, and analyses.

Keywords: ecological restoration; citizen science; monitoring; conservation volunteering; New Zealand; wicked problems

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1. Introduction

Public participation theory is the direct or indirect involvement of concerned stakeholders in policies, plans, or programs in which they have an interest [1,2]. It is assumed that public participation is beneficial to society in that empowering communities leads to enduring support for new initiatives, that those affected by decisions or actions should be involved in their implementation, and that communities that work together can achieve outcomes that are broader than those that can be achieved by individuals alone [1,3–5]. However, the kinds of decisions that might be appropriate, what is involved in participation and how best to implement it, are often unclear (e.g., [6]).

Conservation projects are regarded by many authors [4,7,8] as ideally suited to participation activities because they provide access to local knowledge, sustainable outcomes through on-going motivation, building of capacity through the acquisition of transferable skills, sharing of responsibilities, acceleration of change through growth of education, awareness and trust, economies of scale, and less costly enforcement through self-regulation [4,9]. Building on these advantages, community-based voluntary participation in ecological restoration (conservation) has shown global growth [10–12].

The motivations for voluntary participation in ecological restoration projects are well studied (e.g., [10,13–15]), and may be summarised as helping the environment, learning more about the environment (ecological literacy), social belonging (social networks), and personal growth. Although government agencies may be legally bound to restore degraded environments, many have taken advantage of this growth of interest in public participation, and have included increased engagement of communities in conservation as performance indicators (e.g., New Zealand Department of Conservation, DOC) [16].

The concept of public participation is implicit in the New Zealand Biodiversity Strategy (NZBS) [4,17] adopted by the New Zealand Government in 2000. The Strategy acknowledges that lack of understanding and awareness of biodiversity is a barrier to biodiversity conservation, and identifies the engagement of communities and individuals to conserve and enhance New Zealand's biodiversity as a potential tool. Citizen science, the engagement of non-professionals in scientific investigations [18], is not specifically mentioned in the NZBS, but the concept is certainly implied. For example, Goal 1 of the strategy ([17], p. 15) refers to communities having to share responsibility "equitably" for the conservation of New Zealand's biodiversity. This encompasses a breadth of potential outcomes of citizen science, including the gain of scientific literacy, fostering and strengthening of relationships between citizens and professional agencies, use of knowledge for advocacy, and to influence political decisions [19,20]. The action plan for Goal 1 advocates community involvement, using "participatory projects" ([17], p. 102) as a tool to resolve the threats to native flora and fauna, and to promote the sustainable use of natural resources. Over the last 20 years, community-based ecological restoration groups have proliferated in New Zealand [14,21], with more than 3500 ecological restoration projects [22] involving an estimated 4000 community groups [23–25].

There is general agreement that there are many levels of public participation. For conservation problems, a form of participation called adaptive co-management is advocated to address the socio-ecological complexities of environmental problems [26]. Here, the scale of the partnerships formed, the participants and type of arrangement formed, should reflect the complexity of problems being addressed. The complex nature of conservation problems is evident in New Zealand, where ecological restoration, especially on islands, almost always involves management of invasive species [17,27], and the translocation of species to refugia for conservation gains or to fill taxonomic gaps [28,29]. Both of these activities, increasingly undertaken by community groups, require numerous sequences of complex actions and decisions.

Invasive plants can take some time to naturalise [30], and may require an equally lengthy time to eradicate or control [31], but invasive mammalian predators, even in low densities, can have an immediate and drastic impact on native biota [32,33]. For this reason, many restoration projects in New Zealand prioritise mammal control, even though such strategies seldom have definite end-points unless eradication is achievable [34] and even then, reinvasion may remain a perpetual risk [35]. If community groups aim to deal with introduced predators, they are confronted by significant and complex hurdles. The groups may face systematic removal (or control) of multiple species, which requires planning, logistics, technical requirements, and funds—elements that are acknowledged as a challenge for professional managers [36], and are potentially beyond most community groups working independently of other stakeholders [37,38]. For example, the eradication of rats from large islands involves the aerial spread of rodenticide using helicopters equipped with sophisticated Global Positioning Systems [39]. In New Zealand, there are restrictions on who can use the rodenticide, and many safety requirements must be met while the products are loaded and spread. There are also regulations about the discharge of toxins into the air and water that usually require resource consent from local authorities.

Like the management of invasive species, translocations of native species involve an array of complex hurdles for practitioners to address [40,41]. Translocation proposals must provide the rationale and justification for translocation, and consider logistics, viability of both source and transferred populations, habitat requirements, welfare needs during transfer, disease screening needs, and funding [42]. Increasingly, genetic issues need to be addressed as each translocation event is, potentially, a genetic bottleneck [43]. Furthermore, extended post-release monitoring of both source and transferred populations is often a required component of translocation events [44,45]. Community involvement in species translocations as part of the restoration process, whether wholly community-led or joint community/agency initiatives, is increasing [24,46]. For approved species translocations in New Zealand during the period of 2002–2012, community participation increased from 16% to 71% [46]. Community groups are unlikely to be fully aware of the complexity of undertaking translocations [47], although community participation in translocations is now considered to be an essential component of conservation advocacy [29,48].

These restoration activities have inherent, and potentially unforeseen challenges, which are typical of conservation management worldwide. For example, a fundamental part of halting the biodiversity declines identified in the NZBS is, of necessity, ecological restoration that includes pest eradication [17]. In a study of ecological restoration groups in New Zealand [24], at least 75% were involved in animal pest control. Should communities embark on ambitious habitat restoration projects that involve killing unwanted organisms, they will lurch unsuspectingly into the realm of "wicked" problems [49,50], which are those with complex and interconnected components, uncertain biological and social outcomes, which may operate over short or long time-scales, have ambiguous definition of scope and boundaries, and be subject to controversy and locally variable social constraints [38,51,52].

Reviews of the implementation of the NZBS [25,53,54] acknowledge the increase in community-sourced participants in conservation activities. Although the NZBS urges agencies to ensure that individuals and communities have the knowledge and technical skills to participate in biodiversity conservation activities [17], an initial review recognised that this community participation was dependent on considerable advice and support [54]. The challenges that communities and individuals face in addressing wicked problems may explain concerns raised in subsequent NZBS reviews that monitoring and reporting of biodiversity conservation activities are patchy or lacking [25,53].

Citizen science volunteer programs are not new to environmental monitoring (e.g., eBird [55]), and are being used increasingly for biodiversity assessment [56]. Citizen science is considered to be a developing field for the collection of long-term field data in ecological restoration [18,56–58]. There are numerous case studies of citizen science activities in "successful" ecological restoration projects (e.g., Tiritiri Matangi Island, New Zealand [59]), indicative of the potential for community-sourced participants to use empirical measures to assess progress towards restoration targets. In addition to the generation of ecological data, citizen science also increases science literacy and offers numerous social benefits as a result of members of the public being engaged collaboratively in research experiences [60–62].

The attributes expected of a restored ecosystem are frequently articulated, but there is little information on whether—or how—these attributes should be measured. The benefits of community participation in biodiversity management are well established (e.g., [4,7,8]), but, as of yet, the relationship between community group aspirations (their goals/aims) and their conservation achievements is unclear. Here, we review the extent to which community groups involved with selected ecological restoration projects in New Zealand define progress for their projects. Specifically, we ask:

1 What elements are covered in the goals and/or aims of the community groups?
2 What activities and strategic milestones do the groups identify?

Finally, we consider whether there are appropriate institutional frameworks in support of their endeavours.

2. Materials and Methods

The study focused on aims and goals of community groups participating in ecological restoration projects, and considered two key questions:

1 What are the key aspirations identified by community groups in their ecological restoration activities?
2 What progress are community groups making towards achieving strategic ecological restoration milestones?

Data about ecological restoration projects were gathered through online internet research. Internet-mediated research (IMR) [63] has the advantage of facilitating fast and efficient access to a broad selection of specialist information [64]. We reviewed ecological restoration projects with community participation through access to targeted websites. We consider that the disadvantages that may be attributed to IMR, (e.g., non-representative samples, ethical issues, and uncertain reliability [64–66]) do not apply to this study, as only text-based data about the targeted organisations was collected, not personal information. Furthermore, the information we accessed is publicly available. In New Zealand, participants in community conservation initiatives often form non-governmental collectives, such as incorporated societies or charitable trusts dedicated to specific conservation projects. This accords legal status to the groups, with an obligation to provide open access to their aims through the New Zealand Companies Office [67]. Groups are required to update their documents annually, so it is assumed that the available information is current and reliable.

The ecological restoration projects investigated covered a wide range of restoration types initiated and actioned by stakeholders at agency, community, and private levels. However, all involved a participatory community group. Seventy-eight New Zealand ecological restoration projects are listed or described by Sanctuaries of New Zealand Inc. [68]. Additional community-based projects were identified through a recent publication [23], the New Zealand Landcare Trust [69], and the authors' knowledge of restoration projects.

Fifty of these projects were reviewed in this study (Figure 1). Forty-one were selected for accessibility of project information through the umbrella websites Sanctuaries of New Zealand [68] and New Zealand Landcare Trust [69]. The websites of other known restoration projects (nine), not listed with the umbrella websites, were targeted individually. A further selection criterion was to limit the geographic range of the projects to the North Island of New Zealand where most of New Zealand's population, and hence the community-based restoration projects, are concentrated [70]. These locations include DOC reserves and other Crown land (71%), island (22%), and mainland sites. The abundance of island projects reflects concentrations of islands around northern New Zealand and their importance as refugia for native species [23,71,72].

The community groups participating in the projects included:

- Volunteer collectives with legal identity, with the project invariably located on public land (these examples include both agency- and community-initiated projects);
- Whānau or hapū (family or sub-tribe of Māori, the indigenous peoples of New Zealand [73]), with the project undertaken on family or tribal land (private);
- Private non-Māori individual(s) undertaking ecological restoration on their own land.

To establish the key elements of the community groups' aspirations, a corpus of comparable data was assembled from their collective goals and aims. This corpus was analysed using Wmatrix [74], a computer-based tool to calculate key-word frequencies. A word cloud visualisation of the dominant words in the corpus was generated using a web-based text analysis tool, Voyant Tools [75]. Word clouds show the frequencies of different words in the corpus as different font sizes, with words at higher frequencies being larger relative to other words. Function words that contribute to sentence syntax rather than meaning were excluded from the analysis. World clouds provide a quick visualisation of the common themes in texts, and are recognised as a supplementary tool for text analyses, particularly for corpora prior to any content manipulation [76].

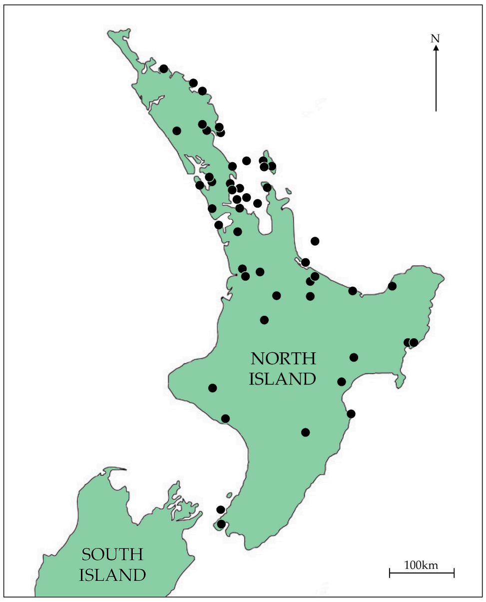

Figure 1. Ecological restoration projects with community participation considered in this study (North Island, New Zealand).

The top key words and multi-word expressions were also analysed for their association with attributes of restored ecosystems. Restoration ecologists have identified the expected outcomes for restoration projects, and empirical measures for the measurement of the progress (or "success") of a restoration process. These broad attributes (or criteria), derived from concepts of ecological integrity, conservation biology, and sustainability, were collated into nine broad groupings (Table 1).

Table 1. Broad attributes of ecological restoration success or progress.

Potential Ecological Restoration Attributes	Literature Sources
Ecosystem representativeness in comparison to reference ecosystem	[77–79]
Ecosystem composition in comparison to reference ecosystem	[77–85]
Maintenance of ecosystem processes	[77–86]
Integration into a larger ecological matrix	[77,79–82,85,86]
Prevention of extinctions and declines	[77–83,85]
Reduction of spread and dominance of alien species	[77–83,85]
Re-establishment of landforms and hydrology	[77,80,82,85]
Educational, scientific, social benefits	[77,82,83,85]
Sustainable management and use	[77,81,82]

Based on the information reported through the projects' websites, an evaluation of the progress made towards strategic ecological restoration milestones was carried out by scoring each project on an ordinal scale to characterise the status (Table 2). This evaluation included noting the nature of any ecological monitoring activities that were being reported.

Table 2. Scoring criteria for characterisation of the monitoring status of ecological restoration projects.

Project Status	Score				
	1	2	3	4	5
No project aims identifiable	✔				
Project aims identifiable		✔	✔	✔	✔
Evidence of monitoring of populations of invasive species			✔	✔	✔
Evidence of monitoring of populations of indigenous species				✔	✔
Evidence of monitoring of populations of indigenous species; evidence of ecological monitoring to show restoration progress					✔

3. Results

3.1. Projects' Aims and Objectives

The projects' objectives, where available, were collated into a corpus of 1490 words and are presented in visual form in Figure 2.

Figure 2. Visualisation of the dominant words in the goals and objectives of 50 community groups participating in ecological restoration projects. Word size reflects frequency of occurrence.

The key words in the corpus were: "native" (1.61%), "island" (0.87%), "natural" (0.87%), "restore" (0.87%), "provide" (0.81%), "conservation" (0.74%), "ecosystem" (0.60%), "education" (0.60%), "flora" (0.60%), "fauna" (0.60%), "species" (0.60%), and "birds" (0.54%). The two top multi-word expressions in the corpus, "endangered species" and "pest control", were equal in their occurrence (0.13%).

Words associated with the formal disciplines of conservation biology and restoration ecology were present, but at much lower frequencies: e.g., "indigenous" (0.27%), "habitat" (0.27%), "monitoring"(0.2%), "ecosystems" (0.2%), "research" (0.2%), "scientific" (0.13%), "populations" (0.13%), "reintroduction" (0.13%), "ecological" (0.13%), and "ecology" (0.13%).

The alignment of the key words and multi-word expressions with broad attributes of ecological restoration are shown in Table 3.

Table 3. Top 10 key words and top 2 multi-word expressions from community groups' aims and objectives aligned with attributes of restored ecosystems.

Potential Ecological Restoration Attributes	Literature Sources	Aims and Objective Key Words/Phrases
Ecosystem representativeness in comparison to reference ecosystem	[77–79]	native, natural, island, restore, ecosystem, flora, fauna, species, birds
Ecosystem composition in comparison to reference ecosystem	[77–85]	native, natural, island, restore, ecosystem, education, flora, fauna, species, birds
Maintenance of ecosystem processes	[77–86]	natural, provide, ecosystem, flora, fauna, species, birds
Integration into a larger ecological matrix	[77,79–82,85,86]	natural, island, restore, provide, ecosystem, species
Prevention of extinctions and declines	[77–83,85]	native, island, restore, conservation, flora, fauna, species, birds, endangered species
Reduction of spread and dominance of alien species	[77–83,85]	native, restore, provide, conservation, ecosystem, education, flora, fauna, species, pest control
Re-establishment of landforms and hydrology	[77,80,82,85]	restore, ecosystem
Educational, scientific, social benefits	[77,78,82,83,85]	conservation, education
Sustainable management and use	[77,78,82,83]	conservation, ecosystem, education

3.2. Project Milestones

The evaluation of the progress made towards strategic ecological restoration milestones, based on the information provided through the projects' websites, is illustrated in Figure 3. The project status is based on the scoring system described in Table 2. No groups demonstrated evidence of comprehensive ecological monitoring to indicate progress towards a pre-determined restoration state.

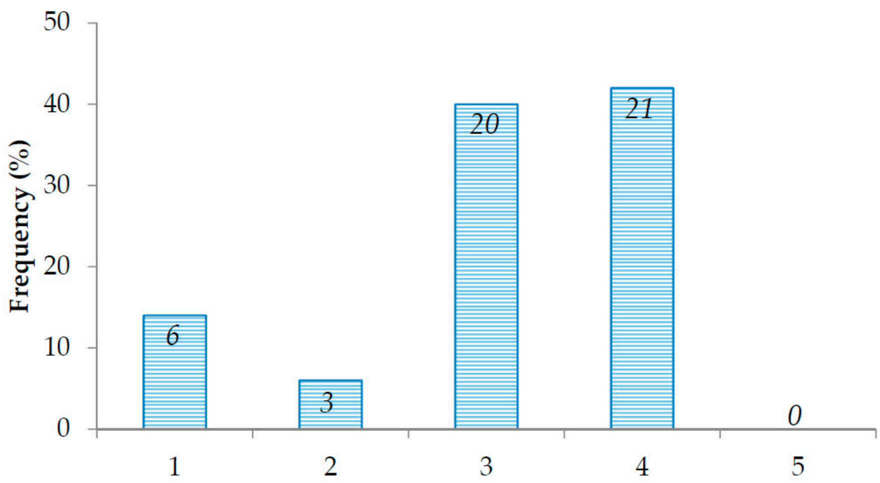

Figure 3. Proportion of projects achieving ecological restoration milestones (n = 50; italicised numerals within bars indicate the number of groups at each status).

The reporting of monitoring activities indicated that a majority of the groups (43) were engaged in control or monitoring of introduced mammals. Species reintroduction as a past, or intended, activity was identified by 31 of the groups. Of the groups that had actually completed species translocations (25), only 13 indicated that monitoring of the translocated species was being undertaken.

4. Discussion

4.1. Elements Covered in the Goals and/or Aims of the Community Groups

The goals and aims of the ecological restoration groups in the study varied greatly in the quality of information provided. The web-based information contained shortcomings in the use of restoration ecology terminology, and no groups identified specific strategic milestones for their participation and progress towards them. Our study confirms, however, that numerous community groups are involved in ecological restoration activities that fit the concept of "wicked" problems. Most groups are engaged in the management of mammal pests (84%), with species reintroduction either being carried out, or on the "wish list", for 62% of the groups. Both of these activities are complex, may have uncertain outcomes, and are potentially controversial.

The key words that emerged from the analysis of the aims and objectives of 50 community collectives reinforce studies identifying environmental gain as a significant motivational driver of volunteers participating in ecological restoration projects [81]. These key words and phrases were, however, of a relatively general nature, often with a local focus, and did not use the formal language more often associated with the science of restoration ecology. Examples of such generalised aims or objectives are:

- "to restore the natural and cultural landscapes" [87];
- "future generations will enjoy a forest alive with native birds, reptiles and insects" [88];
- "a natural environment of indigenous flora and fauna" [89];
- "a corridor of bush along a pristine stream; a place for birds to live and kids to play [90];
- "to preserve and enhance the natural beauty, ecosystems and biodiversity" [91];
- "to remove forever, introduced mammalian pests and predators" [92].

The generalised aims and objectives may reflect a gap identified in other studies (e.g., [52]) between a professional perspective of ecological restoration (e.g., that of a government agency, with a legislative obligation to focus on the scientific foundations of restoration), and a community perspective where general restoration objectives support social environmental benefits that avocational participants relate to. Avocational volunteers (or lay ecological restorationists [16,93]) have been shown to conceptualise restoration differently to ecological professionals [52]. However, we believe that, despite the general language used in the community groups' goals and aims, the key words and multi-word expressions can still be aligned to the broad attributes of ecological restoration (Table 3).

Words associated with long-term monitoring of ecological attributes, however, were few, and, if present, were at particularly low frequency. Although monitoring featured in a minority of objectives, words that might be expected of community-based restoration projects, such as "citizen", "science", and "measure", were absent. This low focus on ecological science likely reflects the avocational status of the community participants who generally lack technical skills and science literacy, particularly where their contribution focuses on practical contribution under the direction of an agency body [94].

4.2. Activities and Strategic Milestones Identified by Community Groups

Environmental monitoring is a globally common participatory action (e.g., [4,7,8,94]). However, although it is evident that some degree of monitoring is undertaken by the community groups we studied, none provide a comprehensive framework of strategic milestones to demonstrate restoration progress. Other studies [94] have found similarly that only a minority of groups monitor the outcome of their actions.

Analyses of reports from restoration projects that we studied indicated long term monitoring activities dominated by assessment of ecological status (e.g., populations) and impacts (e.g., invasive mammals). Aspects of ecological integrity, such as ecosystem composition, structure, and processes, do not feature in the analyses. Ecological status assessment is dominated by vegetation measures, attributed to the relative speed and ease with which such measures can be completed [95,96]. Recent publications suggest that this is a common characteristic of restoration monitoring [94,96]. The milestones that were used by the groups in our study focussed on the monitoring of invasive mammal pests (see also [24]). This form of monitoring reflects the impact of invasive mammals in New Zealand, and that their management is now a routine activity and acknowledged as a crucial first phase (and potentially long-term activity) of restoration projects [97]. Of the more specific restoration activity of species translocation, only half of the groups that had carried out, or participated in, such events indicated that these species were monitored (despite this being a condition of all translocation permits issued by the Department of Conservation).

There is evidence that many ecological restoration projects do exhibit positive progress in improving ecological integrity and/or achieving conservation gains [98], and this appears to be generally assumed for a large number of New Zealand projects [23,99]. Despite such proclamations of successful ecological restoration projects worldwide, however, there is international debate over what constitutes "success" in the context of ecological restoration [98,100–104], with some authors criticising the wide use of the word "success" (and other value-laden terms, for example, "desirable", "degraded", and "intact") to describe ecological restoration outcomes (e.g., [98,100,103]). An additional complication, further reducing clarity for community participation in particular, is that different stakeholders will likely have differing expectations of restoration outcomes [105], so it is inevitable that perceptions of restoration success will be based on their respective experience and values [98,100,105].

If the measurement of restoration progress and/or success is a desired and expected component of restoration outcomes, then the need to assign value to the actions of community participation is paramount. Accountability is particularly important where restoration projects are on public lands and restoration outcomes are accountable to society (taxpayers) in general, and/or where parties using outside funding may be held financially responsible for restoring a damaged ecosystem [106]. Effective and meaningful evaluation of the progress of an ecological restoration project requires a framework for systematic ecological monitoring to be in place [83]. Such a framework is deemed to be a necessary pre-requisite for evidence-based review of restoration actions [107].

4.3. Citizen Science

New Zealand has international recognition for the participation of volunteers in conservation projects [38,59], with the growing trend of volunteers seen by the Department of Conservation and other territorial authorities as a pathway to greater engagement of the public in conservation activities and to increase business partnerships for conservation gain (DOC 2013). This trend addresses the goals of the NZBS [17], and is consistent with current government priorities [16]. Since communities may already be engaged in some level of monitoring, albeit at a low scale, the targeted training of interested individuals as citizen scientists may prove a way to obtain comprehensive measures of restoration outcomes against community effort. However, citizen science is not listed anywhere in the NZBS [17], nor in the index of a comprehensive published account of New Zealand sanctuaries [23]. Nevertheless, the Strategy emphasises the need to improve the technical knowledge and capacity for communities to become involved in biodiversity management.

Citizen science, however, has its problems. It requires willing engagement of participants in science. This is a likely barrier, as, according to published accounts (e.g., [10,108]), most community volunteers are involved in the projects for reasons other than an interest in obtaining data. In addition, volunteers' experiences must be enjoyable to be sustainable [21], and the imposition of science-based activities may counter this need, particularly for avocational participants. The divide between avocational participants and formal science is well recognised [109], and may have developed through the marginalisation of amateur naturalists as a by-product of the professionalisation of science [18]. Furthermore, the quality of data collected by avocational volunteers has often been questioned [58], although recent approaches tend to suggest that citizen science data is useful and important if the research methodologies are well-designed [60,110].

The involvement of avocational volunteers in the measurement of ecological attributes of restoration, measures that are essentially an applied science focus, has implications for both achieving and measuring project outcomes. For many participants in restoration projects, social and recreational motivations may be as important as environmental stewardship [111], and are often included in the goals of citizen science projects. Their participation in ecological science, therefore, may be unintentional, and develop as a result of a project's management requirements and/or devolution of management by governing agencies to communities. In this situation, the participants may be considered as "accidental" scientists rather than citizen scientists [112], and raises questions of the desire, and hence capacity, of community groups to engage in ecological science.

5. Conclusions

This study considered 50 community-based ecological restoration projects in New Zealand to gauge the relationship between the aspirations of the participants as collectives (their goals/aims) and their conservation achievements. We found that goals tend to be generalised, and do not identify strategic milestones to gauge project success. Although many groups are undertaking environmental monitoring and, at least at some level, are engaged effectively in scientific activities, it appears that monitoring of restoration outcomes is given a lower priority than might be expected given the need to provide measures of long-term results, which perhaps is indicative of the avocational nature of most participants.

The consequence of poorly defined criteria of restoration "success" is the difficulty of evaluating benefits, leading to subjective assertions of the outcomes of ecological restoration, particularly as they are often based on anecdotal measures. This difficulty can be compounded when projects lack predetermined goals, criteria for measuring milestones, and fail to monitor appropriate project outcomes [98]. Evidence-based approaches would justify restoration as an option for natural resource management through demonstrated conservation gains, development of best practices in the field, facilitated prioritisation of restoration actions, justified funding and allocation of resources, and clear accounting for funds committed to do the work [98,104,113–115].

Citizen science is accepted as an excellent opportunity to progress ecological restoration, where the participants increase their scientific literacy and skills, and gain social benefit. Such activities can certainly meet the needs of effective monitoring for restoration success. However, although most studies of community groups identify the need for increased technical training for volunteers, including methods for outcome monitoring, such training is not necessarily a priority of the groups themselves [24,116].

The implication from the NZBS [17] is that improved capability through training and technical support would derive from professional agencies such as the New Zealand Department of Conservation (DOC) and regional councils. Many community groups do receive assistance and advice from staff of government agencies or tertiary educational institutes [24], sometimes with scientists as members or even instigators of the community groups. Such collaborative processes have been shown to greatly enhance the outcomes for conservation [117]. However, studies of community participation in ecological restoration do not mention the collaborative approach as a motivation for involvement, although it is perhaps buried within the objective of education and learning about the environment [24]. Furthermore, two events have conspired to make collaboration increasingly difficult to achieve. First, the number of community groups is now so large it is potentially beyond the agencies' abilities to help them all. Second, technical assistance from DOC has declined as funding has progressively reduced [23]. In an attempt to improve linkages with the community, DOC has bolstered partnership staff, but in compensation further reduced its technical capacity. These two events are mirrored globally (e.g., [10,62,118,119]).

Ecological restoration involving community groups thus faces a conundrum: participation is an essential component of the goals of conservation agencies. Restoration participants, however, may engage in citizen science if they are already interested in science. If not, many participants, at best, are "accidental" scientists rather than citizen scientists. There are important implications for managers of existing and future citizen-science projects. Given the "wicked" problems associated with ecological restoration activities—technical, ethical, and financial—community groups will need more than intermittent technical advice from government agencies. These groups will require substantial training in data gathering and analyses for citizen scientists, with support from institutions and innovative tools, in order to generate the long-term resilience necessary for sustainable ecological restoration projects.

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Abbreviations

The following abbreviations are used in this manuscript:

DOC	New Zealand Department of Conservation
IMR	Internet-Mediated Research
NGO	Non-Governmental Organisation
NZ	New Zealand
NZBS	New Zealand Biodiversity Strategy

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