Characterising rural resilience in Aotearoa-New Zealand: a systematic review

Sam Spector 1 · Nicholas A Cradock-Henry 2 · Sarah Beaven 3 · Caroline Orchiston 1

Received: 26 September 2017 / Accepted: 6 September 2018
© Springer-Verlag GmbH Germany, part of Springer Nature 2018

Abstract
The concept of ‘resilience’ has recently gained traction in a range of contexts. Its various interpretations and framings are now used to examine a variety of issues, particularly relating to the human dimensions of global change. This can pose challenges to scholars, practitioners, and policy-makers seeking to develop focused research programmes, design targeted interventions, and communicate across disciplinary boundaries. The concept of resilience is widely used in Aotearoa-New Zealand, where it informs both government policy and research programmes. Resilience is particularly relevant in this small developed nation, which is heavily reliant on primary production in rural areas and affected by a range of geological and climatic hazards. To understand the range and extent of application of resilience in the rural context, we use systematic review methods to identify, characterise, and synthesise this knowledge base. Currently, research applying the concept of resilience in the rural context is limited in areal extent, largely quantitative in nature, and led by a small number of researchers. There is limited evidence of collaboration. Research has focused on a small number of hazards, failing to capture the diversity of risks and hazards in addition to their impacts. The results of our analysis and methodology offer important insights for meta-analyses of risk and hazard scholarship. The findings provide a baseline to track the future progress and effectiveness of resilience interventions and help inform current and future research priorities targeting persistent vulnerabilities in rural New Zealand and elsewhere.

Keywords Rural · Primary industries · Agriculture · Tourism · Hazards · Risks · Resilience · New Zealand

Introduction
Aotearoa-New Zealand (hereafter ‘New Zealand’) is a developed, export-led country that is heavily reliant on primary economic activities such as forestry and farming for economic growth. Together, primary industries contribute 6.8% of real gross domestic product (GDP) and account for over 50% of export earnings (New Zealand Treasury 2016). Rural New Zealand occupies an important place in the social and cultural life of the nation. Local populations are dependent on the viability of agricultural production because it is the predominant economic activity for many regional areas and directly influences the viability of the service sector (Patterson et al. 2006).

Exposure to risks and hazards—including earthquakes, floods, snowstorms, and the current and anticipated impacts of climate change—has significant implications for rural New Zealand. The country’s trade-oriented agricultural economy is already sensitive to climatic variability and extremes (Stroombergen et al. 2006), floods (Lawrence et al. 2013), droughts (Harrington et al. 2014), climate variability (Kenny...
enhancing New Zealand. This decade-long investment in RNC is aimed at addressing priority topics for disaster risk reduction (United Nations International Strategy for Disaster Risk Reduction 2009, p. 24). Challenges established in 2015 to address priority topics for mainstreaming resilience thinking into local, regional, national, and international disaster risk reduction. This decade-long investment in RNC is aimed at enhancing New Zealand’s resilience to natural disasters through an inclusive and transdisciplinary approach in which social and natural sciences and stakeholders ‘co-create’ resilience solutions (Thompson et al. 2017). The RNC research programme has four co-creation laboratories, which focus on specific societal contexts (urban, rural, coastal, and Māori). The rural work stream is an empirically focused, interdisciplinary research programme that aims to enhance the resilience of New Zealand’s rural communities, enterprises, and regions by developing targeted interventions, tools, knowledge, and policies (Basher 2008; IFRC 2014).

A critical review of and reflection on work to date was necessary to identify and begin to address knowledge gaps and future research directions. We used systematic review methods to characterise research that applies the concept of resilience to rural New Zealand. ‘Systematic review’ refers here to a particular methodological approach for the synthesis of available scientific evidence. It is ‘a summary and assessment of the state of knowledge on a given topic or research question, structured to rigorously summarize existing understanding’ (Ford et al. 2011, p. 328). A strict methodology is utilised to collect, appraise, and compile all pertinent studies on a specific research question and to ensure that outputs are objective, transparent, traceable, and updateable.

While systematic reviews have long been integral in the field of health care, researchers have more recently begun to recognise their value in addressing questions in the social sciences (Green and Higgins 2008). In fields as diverse as climate change vulnerability, impacts, adaptation (Berrang-Ford et al. 2015; Ford and Pearce 2010; Lwasa 2014; McDowell et al. 2014), biodiversity and ecology (Bilotta et al. 2014; Pullin and Stewart 2006), and water management (Brisbois and de Loë 2016; Plummer et al. 2012), systematic reviews have been used to improve understanding of inconsistencies, commonalities, and gaps in diverse bodies of research in order to synthesise knowledge and define future research agendas (Haddaway and Pullin 2014). To date, there are few examples of systemic reviews pertaining to New Zealand (King 2015; McKim 2016) or to the risk and hazard literature (Jurgilevich et al. 2017; Smith et al. 2016).

Given the growing prominence of the resilience concept and the explicit focus of this research programme on rural areas, a systematic review was undertaken of research publications that apply resilience in the context of rural New Zealand. The research identifies, synthesises, and presents an up-to-date assessment of this literature. This is a crucial first step in understanding the state of knowledge on rural resilience in New Zealand and identifying the factors that shape resilience. The research develops a strong foundation from which to shape and inform research activities in the RNC Rural programme and to contribute to discussion on mainstreaming resilience thinking into local, regional, national, and international disaster risk reduction. It also contributes to the emerging body of literature that extends the application and development of systematic review methods to the field of disaster and hazard risk management.

Method

Systematic reviews have been used elsewhere to inform research programmes, identify targeted interventions, and derive an evidence base to inform management and policy (Bilotta et al. 2014; Cook et al. 2013). They are a vital tool for surveying large bodies of knowledge and providing a baseline from which to measure advances in understanding.

The current review is geographically bounded in that it is limited to rural areas. It relies on the 2014 Statistics New Zealand: Cradock-Henry 2017), and earthquakes (Stevenson et al. 2017). Such risks have flow-on effects for rural productivity, community wellbeing, and GDP. The 2010/2011 Canterbury earthquake sequence, for example, caused unprecedented damage to the city of Christchurch and its rural hinterland. More recently, the 2016 Kaikoura earthquakes had significant impacts on the largely rural district of Kaikoura, exerting immediate and far-reaching effects on related industries such as transportation and tourism. These events have focused national attention on disaster recovery, the importance of rural areas, and the factors that enhance or impede the ability of such areas to prepare for and respond to hazards.

This renewed attention on rural New Zealand’s vulnerabilities has been increasingly framed in terms of resilience. A vision of a ‘resilient New Zealand’ has underpinned government policy since the Civil Defence and Emergency Management Act 2002. New Zealand policy and planning documents at local, regional, and national levels rely heavily on this concept of resilience (Hayward 2013). They are informed by the growing global focus on resilience as evidenced, for example, in the recent admission of Christchurch and Wellington to the Rockefeller Foundation’s ‘100 Resilient Cities’ network.

The increasing currency of this term has given rise to criticisms that it is loosely defined (Brown 2014; Miller et al. 2010; Turner II 2010) and a ‘fuzzword’ or open signifier that lacks an agreed-upon meaning (Alexander 2013; Olsson et al. 2015; Tanner et al. 2015). The growing social and political credence of resilience, however, makes it important for researchers to engage with this concept to produce ‘actionable information’ (Vogel et al. 2007) and inform policy and planning. This article defines resilience as ‘the ability of a system, community or society exposed to hazards to resist, absorb, accommodate to and recover from the effects of a hazard in a timely and efficient manner, including through the preservation and restoration of its essential basic structures and functions’ (United Nations International Strategy for Disaster Risk Reduction 2009, p. 24).

The systematic review has been funded and produced as part of Resilience to Nature’s Challenges—Kia manawaroa—Ngā Ākina o Te Ao Tūroa (RNC), one of 11 National Science Challenges established in 2015 to address priority topics for New Zealand. This decade-long investment in RNC is aimed at enhancing New Zealand’s resilience to natural disasters through an inclusive and transdisciplinary approach in which social and natural sciences and stakeholders ‘co-create’ resilience solutions (Thompson et al. 2017). The RNC research programme has four co-creation laboratories, which focus on specific societal contexts (urban, rural, coastal, and Māori). The rural work stream is an empirically focused, interdisciplinary research programme that aims to enhance the resilience of New Zealand’s rural communities, enterprises, and regions by developing targeted interventions, tools, knowledge, and policies (Basher 2008; IFRC 2014).

A critical review of and reflection on work to date was necessary to identify and begin to address knowledge gaps and future research directions. We used systematic review methods to characterise research that applies the concept of resilience to rural New Zealand. ‘Systematic review’ refers here to a particular methodological approach for the synthesis of available scientific evidence. It is ‘a summary and assessment of the state of knowledge on a given topic or research question, structured to rigorously summarize existing understanding’ (Ford et al. 2011, p. 328). A strict methodology is utilised to collect, appraise, and compile all pertinent studies on a specific research question and to ensure that outputs are objective, transparent, traceable, and updateable.

While systematic reviews have long been integral in the field of health care, researchers have more recently begun to recognise their value in addressing questions in the social sciences (Green and Higgins 2008). In fields as diverse as climate change vulnerability, impacts, adaptation (Berrang-Ford et al. 2015; Ford and Pearce 2010; Lwasa 2014; McDowell et al. 2014), biodiversity and ecology (Bilotta et al. 2014; Pullin and Stewart 2006), and water management (Brisbois and de Loë 2016; Plummer et al. 2012), systematic reviews have been used to improve understanding of inconsistencies, commonalities, and gaps in diverse bodies of research in order to synthesise knowledge and define future research agendas (Haddaway and Pullin 2014). To date, there are few examples of systemic reviews pertaining to New Zealand (King 2015; McKim 2016) or to the risk and hazard literature (Jurgilevich et al. 2017; Smith et al. 2016).

Given the growing prominence of the resilience concept and the explicit focus of this research programme on rural areas, a systematic review was undertaken of research publications that apply resilience in the context of rural New Zealand. The research identifies, synthesises, and presents an up-to-date assessment of this literature. This is a crucial first step in understanding the state of knowledge on rural resilience in New Zealand and identifying the factors that shape resilience. The research develops a strong foundation from which to shape and inform research activities in the RNC Rural programme and to contribute to discussion on mainstreaming resilience thinking into local, regional, national, and international disaster risk reduction. It also contributes to the emerging body of literature that extends the application and development of systematic review methods to the field of disaster and hazard risk management.
Zealand classification of rural areas into the following four categories, based on the degree of urban influence: highly rural/remote, low urban influence, moderate urban influence, or high urban influence.\(^1\) Second, the review relies on the use of the term ‘resilience’ in order to identify relevant literature. This criterion was set due to resilience having social and political credence in New Zealand and in order to allow focusing on studies that use resilience frameworks, concepts, and methodologies in order to investigate the commonalities, differences, and gaps within that body of literature. This has meant excluding studies that apply closely related concepts such as sustainability, adaptive capacity, and vulnerability but do not utilise the term ‘resilience’. The focus is on clearly defined risks associated with rapid or slow-onset geophysical, hydrological, or climatological hazards. We include within our analysis a consideration of climate change, which is already exacerbating the effects of climate-related risks in New Zealand, and which in turn may compound the consequences of other types of hazard (Lawrence et al. 2013).

The literature search was confined to peer-reviewed journal articles listed on databases that were selected in consultation with a research librarian. These included Web of Science, Scopus, Index New Zealand, ProQuest Central, and two EBSCO databases (GreenFILE and Academic Search Complete).\(^2\) To ensure maximum sensitivity, only two keywords were used: (Zealand*)\(^3\) and (resilien*). Many databases provide the option of culling items that are not articles. However, this feature was not used because databases are prone to having uncategorised records. A review of Scopus found that 3.8 million of its 27 million records were unclassified and might automatically—and potentially erroneously—therefore be excluded if the search were limited to articles (Dess 2006). Figure 1 summarises the search criteria and protocol.

Studies were excluded from the review if they were not (a) available in English, (b) peer-reviewed, (c) focused on rural New Zealand, and (d) concerned with community resilience to hazards. The first criterion did not result in any exclusions. Excluding non-peer-reviewed studies was necessitated by the large initial sample size. Berrang-Ford et al. (2015) note that ‘for a research question with a very large and diverse amount of information, the reviewer may need to identify ways of placing limits on the review so that it can be feasibly conducted’ (p. 762), and they suggest only including peer-reviewed works as one such method.

Criterion (c) resulted in additional exclusions. For example, a study of the Canterbury earthquake sequence that only addressed the city of Christchurch would be excluded, whereas one that also focused on non-urban areas of the Canterbury region would be included. Studies were excluded for two reasons under criterion (d): they did not focus on human communities or did not pertain to hazards. For example, studies in ecology commonly use the term ‘resilience’, but these were excluded due to their focus on animal or plant species. Similarly, exclusions occurred in fields such as medicine and psychology due to the lack of relevance to natural hazards. To ensure accuracy, the primary researcher (lead author) shared the list of included and excluded studies with the three co-authors during a peer review process.

A ‘realist review’ approach was used to analyse included articles. Realist reviews allow both qualitative and quantitative methods to be used and are better suited to complex and/or interdisciplinary research than purely quantitative methods (Berrang-Ford et al. 2015). The realist approach is ‘applicable when the aim of the research synthesis is to understand why and how a policy/practice works, for whom, and in what context it is effective or ineffective’ (Berrang-Ford et al. 2015, p. 758). Quantification, such as via the bibliometric analysis presented below, is used to complement thematic analysis where appropriate.

Findings and discussion

New Zealand’s research community is comparatively modest in size, with both contestable competitive funding and strategic non-competitive science investment from central government supporting the majority of research activity. The main research institutions include publicly funded universities and associated research centres, Crown Research Institutes (CRIs), and private research bodies such as multinational consulting firms, contractors, and individual researchers. Current science investment from central government is approximately 0.65% of GDP (NZ$1.5 billion p.a.) compared to 0.8% of GDP for other OECD countries (Ministry of Business, Innovation & Employment 2015).

The following section begins with a discussion of the bibliometric analysis of the 51 included studies and of the institutional and disciplinary landscape. Thematic analysis of the articles is also presented in order to identify knowledge gaps and research priorities. The results suggest that there is a small community of rural resilience researchers who collaborate on multiple projects/studies in New Zealand. Research is

---

1 Note that rurality can be defined in a number of different ways—population density, political boundaries, or reliance on sources of primary production (e.g. McIntosh et al. 2008). For the purposes of this systematic review, the Statistics New Zealand (2014) classification was particularly apt, in that it uses residential and workplace addresses to demarcate a range of categories that reflect the diverse social characteristics of those currently living across the New Zealand urban–rural spectrum.

2 The initial search conducted on 19 December 2016 produced 2263 results. Databases were monitored for relevant additions until 27 March 2017. Five potentially relevant studies were added during this time for a total of 2268 records. Three of those were added to the systematic review.

3 The * search operator finds all words beginning with the preceding letters. ‘Zealand*’ thus also returns results for ‘New Zealander(s).’ ‘Resilien*’ returns results for resilience, resiliency, and resilient.
disproportionately concentrated in selected institutions, and there is limited co-citation.

**Bibliometric findings**

Of the 1531 non-duplicate studies reviewed, 51 consider rural New Zealand’s resilience to natural hazards. The included articles and their citation counts are shown in Table S1. Justification for the inclusion of each and its relevance is provided in Table S2. The majority of articles have not been frequently cited, with the four most cited studies having received nearly as many citations as the rest combined (see Table S1).

The articles are distributed across a range of journals, though most are disciplinary or thematic in nature. Five are published in *Natural Hazards*; three in *Disaster Prevention and Management* and *Australasian Journal of Disaster and Trauma Studies and Disasters*; two in *Journal of Sustainable Tourism*, *International Journal of Disaster Risk Reduction*, and the *Journal of Volcanology and Geothermal Research*. The remaining 31 studies constitute the sole piece of research on this topic in their journal of publication.

VOSviewer citation analysis software, which was used to analyse the included studies, shows that there is little evidence of co-citation. In other bibliometric studies of resilience, there is evidence of high numbers of co-citation and of papers from multiple knowledge domains serving as bridges between conceptual and methodological approaches (Janssen et al. 2006). This appears to suggest greater integration between applied and theoretical work on resilience and the need to consider sustainability and environmental challenges from multiple perspectives (Janssen 2007). In New Zealand, however, despite the relatively small size of the research community and the fact that many of the authors know one another, there are few examples of individuals referencing other New Zealand research in the same or similar field; most of the research in this area is ‘silied’ (Fig. 2). This lack of collaboration may result from the distributed nature of research, which is done by universities, CRIs, and private and quasi-public research centres and consultancies, in addition to the competitive nature of contestable funding in New Zealand. The lead author of one of the most frequently cited papers is based in Europe (Darnhofer et al. 2010).

VOSviewer was also used to identify influential prior research and co-authorship. No prior research was cited by more than two of the included studies, except an article by Smit and Wandel (2006) entitled *Adaptation, adaptive capacity and vulnerability* (cited by four studies). Analysis of co-authorship allows identifying key links between researchers. The authors of the majority of manuscripts are not connected to one another, with the exception of a few key nodes (e.g.
Wilson and Johnston) (Fig. 3). These research clusters reflect three loci of collaborative resilience research in New Zealand: the Joint Centre for Disaster Research (shown in blue), GNS Science and the University of Canterbury (in green), and the University of Canterbury and Resilient Organisations (in red).

Thirty-five (69%) of the studies were conducted by and funded through New Zealand universities, with the remaining ones being generated by independent research groups (13 studies; 26%) and government agencies (three studies, 6%). Four studies have primary authors based overseas. See Table S3 for further details about the organisations responsible for the included studies.

The application of resilience concepts to rural research in New Zealand is a relatively new phenomenon: one article is from 1997 and the rest were published in 2001 or later (see Fig. 4). There has been a steady increase in the number of studies on this topic, and three articles have been published in the first 3 months of 2017, indicating that this year could see substantially more research in this vein. This is in keeping with trends in the international literature, which shows an
increase in resilience-related publications year-on-year (Bunce and Ford 2015; Giupponi and Biscaro 2015; Olsson et al. 2015; Kelman et al. 2016).

Studies have used a diverse range of methods, including case study, quantitative, and mixed methods analysis (Fig. 5). There is a scope for further qualitative, exploratory research. The use of alternative methods, such as simulation games to explore emergency management situations (Huggins et al. 2015) or analyses of historical materials (Cashman and Cronin 2008; King 2015), is potential pathways for further methodological advancement.

Given New Zealand’s location on the Pacific Rim, earthquakes are the most frequently studied hazard (16 articles; Fig. 6). Hazards in general (10), climate change (8), and volcanoes (7) are also frequently studied. Floods, which are the most frequently occurring and costly hazard (Insurance Council of New Zealand 2017), require further study. There is also a scope for further investigation of rural resilience to hazards such as fires, storms, landslides, tsunamis, severe winds, snow, and droughts, as well as the cascading effects of hazards on distributed infrastructure (Officials’ Committee for Domestic and External Security Coordination 2007).

Studies are spatially distributed across the regions, with unequal attention on Canterbury (13 articles; Fig. 7). Eleven studies are New Zealand-wide. Westland, Bay of Plenty, Ruapehu, and Hawke’s Bay have also been studied more than once. Future studies could apply the Statistics New Zealand (2014) categorisation of rural areas to determine differences between those that have high, moderate, low, or minimal urban influence to investigate how to build resilience across different settings (see Whitman et al. 2013).

The papers analysed address a range of stakeholders, with many focusing on the general resilience of communities and community members (Fig. 7). Resilience has also been frequently studied in relation to farming and primary economic activities, with 14 papers addressing the topic. Nine papers...
discuss organisational resilience, and eight focus on disaster response agencies and emergency managers. Only four papers investigate the resilience of the tourism sector in rural areas. Due to the reliance of many rural areas on tourism (Stewart et al. 2016), there is a scope for further studies on this subject.

### Thematic analysis

The following section identifies and discusses key themes from the 51 studies: resilience of rural community members, rural organisations’ resilience, and recovery and response personnel’s role in fostering rural resilience.

#### Factors affecting the resilience of rural community members

Rural communities’ response to hazards varies due to their different values and perceptions of risk (Rouse et al. 2016). For example, Miller et al. (1999) suggest that physical threats are more salient immediately after a disaster, but that economic threats become more important during recovery. The most salient aspects of a hazard also vary within a community. Rural areas often have diverse stakeholders (e.g. farmers, tourism operators, international visitors), with each having different levels of risk awareness and preparedness. Likewise, Elms (2015) argues that flows between different communities need to be considered in order to understand resilience on a broader spatial scale.

Self-efficacy and problem-solving coping strategies demonstrably reduce vulnerability to volcanic hazards (Miller et al. 1999; Paton et al. 2001), though Miller et al. found that ‘sense of community’ does not affect it. Their findings may be due to the seasonal nature of the population in their study area—winter tourism in Ruapehu. Conversely, Sampson and Goodrich (2005) found that the resilience of two Westland communities who lost their primary source of income (forestry) was a function of a strong community identity, in addition to resourcefulness and place attachment. This supports Marshall and colleagues’ findings from rural Australia on the positive relationship between place attachment and climate change adaptation and resilience (Marshall 2011; Marshall et al. 2013a,b). Resilience to wildfires, such as the Mount Somers fires in 2003 and 2004 (Jakes and Langer 2012), was also enhanced by attributes such as strong community ties and local knowledge that were in place pre-disaster. The extent to which factors such as community ties and place attachment contribute to resilience therefore may vary depending on the specific characteristics of the community, particularly the transience of its population. This has significant implications for hazards resilience in New Zealand since rural regions have high proportions of seasonal (e.g. holiday home) and transient (e.g. tourist and farm worker) residents. This presents a significant gap in current knowledge and requires further study.

Other themes identified in the literature include the significance of workshops and other forms of knowledge exchange to provide support services to community members before and after disasters (Britt et al. 2011; Cooper-Cabell 2016; Finnis et al. 2010; Orchiston et al. 2013; Paton et al. 2001; Tipler et al. 2016). Workshops were shown to help individuals’ process hazards (Britt et al. 2011; Cooper-Cabell 2013; Orchiston et al. 2013), and participants become more resilient in terms of preparedness and hazards awareness (Finnis et al. 2010; Tipler et al. 2016). Workshops and similar events help rural communities cope with disasters, but recovery is not a linear progression. For example, Britt et al. (2011) showed that residents experienced more than one ‘disillusionment dip’ after the Canterbury earthquakes. While there was a slight decrease in emotional stability for those most affected by the earthquakes, other personality-related traits remained stable (Milovjev et al. 2014). Building resilience thus requires awareness of the long-term implications of disasters.

The tension between different aspects of centralised (local or national government) and community or stakeholder participation was also evident in the reviewed research (Espiner and Becken 2014; Mamula-Seadon and McLean 2015). The need for expert advice and national guidance to help rural communities to prepare for and respond to disasters (Glavovic et al. 2010) must be balanced against the importance of local knowledge and practices (Jakes and Langer 2012; Rouse et al. 2016). Community response plans can...
build resilience, but the planning process is just as important (Mitchell et al. 2010). Clarification and justification of the role of public participation in post-disaster recovery, either substantive or procedural (Vallance 2015), has also been studied, though to a more limited extent.
Finally, a small number of studies have investigated students’ resilience and hazard perceptions (Beaglehole et al. 2017; Finnis et al. 2010; Thomson et al. 2016). Evidence from these studies highlights that rural areas can build resilience by implementing measures to allow students to maintain a semblance of their normal routines after disasters (Beaglehole et al. 2017; Thomson et al. 2016).

Factors affecting organisational resilience

Organisational resilience, which focuses on the ability of organisations to recover from sudden disruptions, is the focus of several studies. This includes work on characterising resilience at multiple scales (i.e. at the institutional level and across value chains) and the resilience of organisations in particular industries, such as farming and tourism. The characteristics of resilient organisations include good communication, an absence of silos, flexibility, and relationships with stakeholders (McManus et al. 2008). Managing risks along supply chains (Kachali et al. 2012) and the identification of keystone vulnerabilities and strengths within an organisation can be a useful process for learning how to leverage those areas to build resilience (McManus et al. 2008).

Organisations’ recovery post-disaster is positively correlated with how quickly utilities are repaired (Kachali et al. 2012; Wilson and Cole 2007; Whitman et al. 2013, 2014), and backup provisions for such services can enhance resilience (Whitman et al. 2013). Policy to enable rapid reinstatement of infrastructure—bypassing the usual public consultation requirements—could help in this regard (Rotimi and Wilkinson 2014). Another key component of organisational resilience is staff wellbeing and inter-personal relationships (Brown et al. 2017; Kachali et al. 2012; Whitman et al. 2014). Training staff to respond to disasters is particularly important in rural areas with high numbers of tourists, since visitors may not know the correct procedures (Leonard et al. 2008; Orchiston 2013).

Contrary to other research, Brown et al. (2015) found that the size and age of an organisation were not associated with earthquake resilience in Canterbury; rather, the sector of operation was the key. This suggests the need for region-, sector-, and organisation-specific research on resilience. Work by Kelly and Smith (2012) showed that farmers who had previous experience with damaging snow storms were able to recover more quickly. This suggests that when organisations have some degree of control over their resilience and recovery, those in harder-hit areas will not necessarily take longer to recover.

The resilience of primary economic activities is also the focus of several studies, including some more recent work. Research on resilience of primary industries emphasises the importance of learning and adaptability to cope with a range of shocks and stressors (Kenny 2011; Pomeroy 2015; Tanner et al. 2015). In one of the most widely cited papers in our analysis, Damhofer et al. (2010) propose that learning and adaptability—not production and efficiency—are the most important factors in farm resilience. In a case study of the New Zealand kiwifruit industry, Cradock-Henry (2017) characterised the tactical and strategic adaptation strategies used by growers to manage risks associated with climate variability and change, urbanisation, and market risks. Tactical adaptations include short-term methods (such as farmers burning hay to heat crops during unusually cold periods), whereas strategic responses involve medium- to long-term options (such as altering pruning methods as the climate changes). Future studies could evaluate how rural communities can utilise both strategic and tactical adaptive strategies to build resilience to hazards.

Beyond the scale of individual farmers, the resilience of primary industries nationally is enhanced by its adaptability, complexity, and diversity (e.g. various relative proportions of sheep and beef, differing levels of irrigation and intensification, various paid and unpaid labour sources, and engaging in off-farm work) (Hunt 2015; Nettle et al. 2015; Pomeroy 2015). As a whole, the farming sector may be more resilient due to diversity in individual approaches to risk, production methods, and labour sources. For example, some pastoral farmers can potentially convert some land to plantation forest. This initiative can enhance farmers’ resilience (such as their ability to cope with market uncertainty and potential future environmental regulations) and also contribute to national resilience.
emissions reductions (Monge et al. 2016). However, there is more broadly a shift towards intensification—rather than diversification—which is creating new exposures and vulnerabilities (Cradock-Henry and Mortimer 2013).

Opportunities to enhance farm-level resilience may be realised through greater collaboration with researchers (Kalaugher et al. 2013) and by capitalising on farmers’ knowledge (Nettle et al. 2015). Evidence from eastern New Zealand shows that some farmers are already adopting resilience-enhancing adaptive strategies to cope with climate change (Kenny 2011). Researchers can play a role as knowledge brokers to facilitate peer-to-peer learning, bringing ‘smart farmers’ together with others to communicate adaptive land management practices, much like the successful ‘Climate Adaptation Champions’ programme in Australia (Meijerink and Stiller 2013). Likewise, scientists’ findings on developing resilience to hazards (e.g. Wilson and Cole 2007) need to be more effectively communicated and implemented.

The results of the analysed studies also highlight the important contextual differences in resilience between rural farming and non-farming organisations. Whitman et al.’s (2013) study of responses to the 2010 Darfield earthquake, for example, showed that stress was a major organisational challenge for farmers, whereas for non-farmers, the primary concern was maintaining cash flow. Likewise, farmers’ relationships with neighbours were critical for ensuring labour, food, water, and animal husbandry could be attended to. For non-farming organisations, insurers and lenders were of vital importance. Studies of both floods and snowstorms conclude that neighbourhood and community relations were integral factors in determining farmers’ resilience; however, outside help is also needed to restore basic infrastructure following a disaster (Kelly and Smith 2012; Smith et al. 2011). Post-disaster initiatives to provide psychological support to farmers and pre-disaster efforts to build community ties may contribute to farmers’ resilience as well (Whitman et al. 2013).

Technology is also an important influence on resilience for farming systems. Enhancing production during ‘business as usual’ has the potential to exacerbate vulnerabilities during crises and recovery (Smith et al. 2011; Kelly and Smith 2012). For example, a lack of cell-phone coverage following snowstorms in southern Canterbury hindered recovery as farmers had come to rely on it for communications (Kelly and Smith 2012). Likewise, if disaster events destroy or impair technology-intensive agriculture systems, farmers will not necessarily have the skills or resources to maintain the level of production required to remain viable (Smith et al. 2011). While New Zealand farms are larger than they used to be, many are still family-owned (Smith et al. 2011) and carry high levels of debt, which must be serviced (Cradock-Henry and Mortimer 2013).

Resilience has also been applied to the tourism sector (Espiner et al. 2017; Espiner and Beeken 2014; Orchiston 2013; Stewart et al. 2016), and research emphasises the importance of community participation and diversification (Espiner et al. 2017). For instance, glacial recession of the Fox and Franz Josef Glaciers has prompted operators to offer increased air access and to build new tracks to allow visitors to view the glaciers (Stewart et al. 2016). Nearby communities have also capitalised on new prospects being created by marketing the opportunity to witness glacial recession (Stewart et al. 2016). Espiner and Beeken (2014) found that most stakeholders in the Fox and Franz Josef Glacier areas were unaware of the fragility of the region’s tourism sector. The authors argue that the ‘hardened’ attitude of many residents in the area results in a willingness to cope with living in a remote environment. This attitude may contribute to resilience, but may also result in a blind spot in terms of recognising their vulnerability to hazards that threaten the region’s economic livelihood. Community-based disaster training and response plans may be particularly useful for tourism operators in peripheral areas due to their pre-existing strong community ties (Orchiston 2013).

The role of recovery and response personnel and agencies

The final theme identified in the analysis emphasised the role of recovery and response personnel and agencies. Information-sharing between organisations and to improve warning systems and disaster management technologies can enhance resilience and speed recovery (Huggins et al. 2015; Dantas and Seville 2006; Leonard et al. 2008, 2014; Wilson et al. 2014). This includes better communication of research findings to industry (Glavovic et al. 2010); involving end-users in disaster risk-reduction technologies (Dantas and Seville 2006); and encouraging infrastructure managers, scientists, and governments to collaborate to design hazard education materials (Wilson et al. 2014).

To ensure more effective responses, organisations should work together prior to a disaster (Johnston et al. 2012). Pre-disaster collaboration could be used to develop a shared understanding of roles during an emergency (Johnston et al. 2012) and to build relationships between outside experts and local stakeholders (Leonard et al. 2014). The need for coordination between national and local groups is evidenced, for instance, by the importance of four-wheel drive clubs in assisting disaster response authorities after a series of snowstorms in southern Canterbury (Kelly and Smith 2012).

Conclusions and suggestions for future research

The results of our research—commissioned as part of a larger programme on rural resilience in New Zealand—demonstrate the value of conducting a systematic review to inform multi-year, multidisciplinary research projects. The 51 included studies address a diverse set of hazards, geographic areas,
and stakeholders. The review systematises a diverse body of research and identifies key research gaps.

Systematic reviews provide researchers with a rigorous and robust method for characterising available published information about a particular topic. While systematic reviews are methodologically rigorous, they are not without their limitations. As this study has shown, limiting the search criteria to ‘rural’ and ‘resilience’ may preclude inclusion of some related studies. However, the sample captures studies that apply the concept of resilience in the context of rural New Zealand and, as such, provides the basis for investigating how this concept is operationalised in the literature, the determinants and antecedents of resilience, and fruitful areas for future study. Notably, while some of the reviewed articles discuss Māori (the indigenous people of Aotearoa-New Zealand), the results reveal considerable gaps in the fields of traditional ecological knowledge, emergency management, and rural resilience from an indigenous perspective. There has been work on indigenous perspectives on tsunami risk in Aotearoa-New Zealand (King 2015) as well as Māori experiences with urban earthquake hazards (Phibbs et al. 2015), but there is lack of research specifically on the relationship between rural resilience and Māori. This is significant as Māori have management responsibility for large areas of rural land as well as commercial agribusiness and forestry interests which are likely to be exposed to a range of hazards.

The ‘fuzziness’ of resilience can encompass a number of other related topics including adaptability, flexibility, coping capacity, sustainability, and transformation (Rodriguez and Sadras 2011; Berman et al. 2012; Cowan et al. 2013; Marshall et al. 2013a). Furthermore, some scholars may be disinclined to use the term (Olsson et al. 2015), for example due to conceptual, theoretical, or ontological differences between disciplines (McEvoy et al. 2013; Nelson 2011). A comprehensive review of the resilience, vulnerability, adaptation, and transformation literatures might reveal even more about the characteristics of the risks, opportunities, and management strategies used to cope with hazards, but such a project is beyond the scope of the present study.

The key finding of the review is that while resilience is increasingly used in relation to rural New Zealand, there is not yet a cohesive body of work investigating the determinants and outcomes of resilience in this specific geographic area. In part, this is due to the nature of funding, which has historically been short-term in nature and distributed amongst universities, CRIs, and non-government organisations. A small number of researchers, largely allied along disciplinary or institutional lines, have led work in this field. The current RNC programme of work is developing and applying new ways of working across various domains in an effort to develop new solutions (Thompson et al. 2017).

Drawing on the results of the analysis, it is clear that perceptions of hazards vary temporally and spatially across rural communities. Determining the extent to which place attachment and community ties enhance resilience (Miller et al. 1999; Sampson and Goodrich 2005; Jakes and Langer 2012) could provide new insights into solutions-focused pathways specific to rural contexts (Miller et al. 1999; Rouse et al. 2016). For example, workshops and educational events can enhance resilience both pre- and post-disaster (Finnis et al. 2010; Britt et al. 2011; Orchiston 2013; Tipler et al. 2016).

A balance must be struck between respecting local knowledge, and ensuring ‘expert’ research on resilience is put into practice (Mitchell et al. 2010; Mamula-Seadon and McLean 2015; Vallance 2015). Case study research could be instrumental in developing a framework for effective coordination between experts and rural community members. Rural communities often have pre-existing strong community ties (Smith et al. 2011; Kelly and Smith 2012; Whitman et al. 2013), so effectively harnessing existing relationships, collaborative groups, and social capital to build resilience could provide new pathways for disaster risk reduction.

Further research on how to accelerate the recovery process for rural communities (with their own particular set of infrastructure-related difficulties) is also critical. Such work could examine the vulnerability of daily routines dependent on distributed and built infrastructure—roads, electricity, and school attendance, for example—and ensure that they are sufficiently robust to resume functioning as soon as possible (Elms 2015; Beaglehole et al. 2017; Thomson et al. 2016). At an organisational level, testing insurers to determine their capacity to expedite claims in the event of a crisis would also be useful (Brown et al. 2015; Kelly and Smith 2012; Wilson and Cole 2007; Rotimi and Wilkinson 2014).

Rural commodity production is a key economic driver for New Zealand, and ensuring the resilience of supply chains—from pasture to port—is vital. Interconnectedness between organisations (McManus et al. 2008; Kachali et al. 2012) and staff resilience within organisations was also shown to be an important feature of rural resilience (Leonard et al. 2008; Orchiston 2013; Brown et al. 2015). Guidance on enhancing employee resilience specifically for rural contexts may reveal new or different stressors and opportunities from their urban counterparts. Further research is also needed on the resilience of rural areas’ primary income sources—farming and tourism. The increasing reliance of those systems on technology poses an interesting area for research in terms of how technologies might contribute to and hinder resilience (Smith et al. 2011; Kelly and Smith 2012). Longitudinal studies of how individuals and organisations progress through the recovery process would also be particularly useful (Paton et al. 2001; for a similar argument in the context of vulnerability to climate change and the use of cohort and trend studies, see Fawcett et al. 2017).

Finally, while resilience was originally focused on establishing a return to normal, critical scholarship has promoted a normative shift in resilience studies to draw greater attention
to the role of agency, power, and social justice using livelihoods frameworks (Brown and Westaway 2011; Olsson et al. 2015; Tanner et al. 2015) and highlighted the need to consider uncertainty and surprise in planning for the future (Welsh 2014). This is particularly relevant for rural regions which face the compounding effects of multiple socio-cultural and economic stressors (Burton and Peoples 2014; Pomeroy 2015) in addition to climate change and natural hazard events (Leichenko and O’Brien 2008; McCubbin et al. 2015). Gaining insight into the ways in which antecedent conditions, social processes, and political and economic considerations influence post-disaster outcomes in rural settings can help inform new tools, processes, and practices to ensure resilient rural futures (Cradock-Henry et al. 2018). This should be prioritised in future research, particularly as the effects of climate change are already being felt in New Zealand (Harrington et al. 2014) and have the potential to interact with and compound the effects of natural hazard events.

Rural resilience research in New Zealand is still inchoate. The reviewed studies have produced numerous indications of how to foster resilience in this context, but further research is needed in each of these dimensions to inform policy and enable local resilience-building initiatives. Bespoke resilience solutions for rural regions must account for the differences in the availability of critical lifelines, infrastructure, community ties, and place attachment. Such research is particularly important in New Zealand as rural communities, via the farming and tourism sectors, form the social, economic, and cultural backbone of the country. These rural areas face an increasingly complex and interrelated set of future challenges.

Acknowledgements This study was supported by the Resilience to Nature’s Challenges National Science Challenge (funded by the NZ Ministry of Business Innovation and Employment) as part of the Rural Co-Creation Laboratory. We would also like to thank Simon Homer from Manaaki Whenua-Landcare Research for his expert job designing the Fig. 6 infographic.

References

Alexander DE (2013) Resilience and disaster risk reduction: an etymological journey. Nat Haz Earth Syst 13:2707–2716. https://doi.org/10.5194/nhess-13-2707-2013

Basher R (2008) Disaster impacts: implications and policy responses. Soc Res 75:937–954

Beaglohole B, Bell C, Frampton C, Moor S (2017) The impact of the Canterbury earthquakes on successful school leaving for adolescents. Aust NZ J Publ Heal 41:70–73. https://doi.org/10.1111/1753-6405.12625

Berman R, Quinn C, Paavola J (2012) The role of institutions in the transformation of coping capacity to sustainable adaptive capacity. Environ Dev 2:86–100. https://doi.org/10.1016/j.envdev.2012.03.017

Berrang-Ford L, Pearce T, Ford JD (2015) Systematic review approaches for climate change adaptation research. Reg Environ Chang 15:755–769. https://doi.org/10.1007/s10113-014-0708-7

Bilotta GS, Milner AM, Boyd I (2014) On the use of systematic reviews to inform environmental policies. Environ Sci Pol 42:67–77. https://doi.org/10.1016/j.envsci.2014.05.010

Brisbois MC, de Loë RC (2016) Power in collaborative approaches to governance for water: a systematic review. Soc Natur Resour 29:775–790. https://doi.org/10.1007/s10814-015-080339

Brit E, Dorahy M, Carter J, Hoggath P, Coates A, Meyer M, Naswall K (2011) Promoting recovery and building resilience for individuals and communities. New Zeal J Psychol 40:76–78

Brown C, Seville E, Vargo J (2017) Efficacy of insurance for organisational disaster recovery: case study of the 2010 and 2011 Canterbury earthquakes. Disasters 41:388–408. https://doi.org/10.1111/dis.12201

Brown C, Stevenson J, Giovannazzi S, Seville E, Vargo J (2015) Factors influencing impacts on and recovery trends of organisations: evidence from the 2010/2011 Canterbury earthquakes. Int J Disast Risk Re 14:56–72. https://doi.org/10.1016/j.jldr.2014.11.009

Brown K (2014) Global environmental change I: a social turn for resilience? Prog Hum Geog 38:107–117. https://doi.org/10.1177/0309132513498337

Brown K, Westaway E (2011) Agency, capacity, and resilience to environmental change: lessons from human development, well-being, and disasters. Annu Rev Environ Resour 36:321–342. https://doi.org/10.1146/annurev-environ-052610-092905

Bunce A, Ford J (2015) How is adaptation, resilience, and vulnerability research engaging with gender? Environ Res Lett 10:123003. https://doi.org/10.1088/1748-9326/10/12/123003

Burton RJF, Peoples S (2014) Market liberalisation and drought in New Zealand: a case of ‘double exposure’ for dryland sheep farmers? J Rural Stud 33:82–94. https://doi.org/10.1016/j.jrurstud.2013.11.002

Cashman KV, Cronin SJ (2008) Welcoming a monster to the world: myths, oral tradition, and modern societal response to volcanic disasters. J Volcanol Geoth Res 176:407–418. https://doi.org/10.1016/j.jvolgeores.2008.01.040

Collaboration for Environmental Evidence (2013) Guidelines for Systematic Review and Evidence Synthesis in Environmental Management. Version 4.2. www.environmentalevidence.org/Documents/Guidelines/Guidelines.4.2.pdf

Cook CN, Possingham HP, Fuller RA (2013) Contribution of systematic reviews to management decisions. Conserv Biol 27:902–915. https://doi.org/10.1111/cobi.12114

Cooper-Cabell N (2016) Mind the gap: post earthquake community wellbeing at Aoteaoroa New Zealand Soc Work 25:27–34. https://doi.org/10.11157/anzswj-vol25iss2id78

Cowan L, Kaine G, Wright V (2013) The role of strategic and tactical flexibility in managing input variability on farms. Syst Res 30:470–494. https://doi.org/10.1007/s10763-013-9217-7

Cradock-Henry N, Mortimer C (2013) Operationalising resilience in dairy agroecosystems. Ministry for primary industries, Wellington, NZ

Cradock-Henry NA (2017) Kiwifruit growers’ vulnerability to climate and other stressors. Reg Environ Chang 17:245–259. https://doi.org/10.1007/s10584-018-2270-7

Dantas A, Seville E (2006) Organisational disaster recovery: case study of the 2010 and 2011 Canterbury earthquakes. Disasters 41:388–408. https://doi.org/10.1111/dis.12201

Dann C, Seville E, Vargo J (2015) Factors influencing impacts on and recovery trends of organisations: evidence from the 2010/2011 Canterbury earthquakes. Int J Disast Risk Re 14:56–72. https://doi.org/10.1016/j.jldr.2014.11.009

Danns A, Seville E (2006) Organisational disaster recovery: case study of the 2010 and 2011 Canterbury earthquakes. Disasters 41:388–408. https://doi.org/10.1111/dis.12201

Darnhofer I, Fairweather J, Moller H (2010) Assessing a farm’s sustainability: insights from resilience thinking. Int J Agri Sustain 8:186–198. https://doi.org/10.3763/ijas.2010.0480

S. Spector et al.
Characterising rural resilience in Aotearoa-New Zealand: a systematic review

Nelson DR (2011) Adaptation and resilience: responding to a changing climate. Wiley Interdiscip Rev Clim Chang 2:113–120. https://doi.org/10.1002/wcc.91

Dess HM (2006) Database reviews and reports: Scopus. Issues Sci Technol Librariansh. https://doi.org/10.5062/F4X0650T

Elms D (2015) Improving community resilience to natural events. Civ Eng Environ Syst 32:77–89. https://doi.org/10.1080/10286608.2015.1011626

Esponer S, Becken S (2014) Tourist towns on the edge: conceptualising vulnerability and resilience in a protected area tourism system. J Sustain Tour 22:646–665. https://doi.org/10.1080/09669582.2013.855222

Espiner S, Orchiston C, Higham J (2017) Resilience and sustainability: a complementary relationship? Towards a practical conceptual model for the sustainability–resilience nexus in tourism. J Sustain Tour 0:1–16. doi: https://doi.org/10.1080/10286608.2017.1281929, 25

Fawcett D, Pearce T, Ford JD, Archer L (2017) Operationalizing longitudinal approaches to climate change vulnerability assessment. Glob Environ Chang 45:79–88

Finnis KK, Johnston DM, Ronan KR, White JD (2010) Hazard perceptions and preparedness of Taranaki youth. Disaster Prev Manag 19:175–184. https://doi.org/10.1108/09653551011037986

Ford JD, Berrang-Ford L, Paterson J (2011) A systematic review of observed climate change adaptation in developed nations. Clim Change 106:327–336. https://doi.org/10.1007/s10584-011-0045-5

Ford JD, Pearce T (2010) What we know, do not know, and need to know about climate change vulnerability in the western Canadian Arctic: a systematic literature review. Environ Res Lett 5:014008. https://doi.org/10.1088/1748-9326/5/1/014008

Giupponi C, Biscaro C (2015) Vulnerabilities—bibliometric analysis and literature review of evolving concepts. Environ Res Lett 10:123002. https://doi.org/10.1088/1748-9326/10/12/123002

Glavovic BC, Saunders WSA, Becker JS (2010) Land-use planning for natural hazards in New Zealand: the setting, barriers, ‘burning issues’ and priority actions. Nat Hazards 54:679–706. https://doi.org/10.1007/s11069-009-9494-9

Green S, Higgins JPT (2008) Preparing a Cochrane review. In: Higgins JPT, Green S (eds) Cochrane handbook for systematic reviews of interventions. Wiley-Blackwell, Chichester, England, pp 11–30

Haddaway NR, Pullin AS (2014) The policy role of systematic reviews: past, present and future. Springer Sci Rev 2:179–183. https://doi.org/10.1007/s40364-014-0023-1

Harrington LJ, Rosier S, Dean SM, Stuart S, Rosier A (2014) The role of anthropogenic climate change in the 2013 drought on the North Island, New Zealand. Explaining extremes of 2013 from a climate perspective. Special Supplement of the Bulletin of the American Meteorological Society 95:S45–S48

Hayward BM (2013) Rethinking resilience: reflections on the earthquakes in Christchurch, New Zealand, 2010 and 2011. Ecol Soc 18. https://doi.org/10.5751/ES-05947-180437

Higgins TJ, Hill SR, Peace R, Johnston DM (2015) Assessing displays for supporting strategic emergency management. Disaster Prev Manag 24:635–650. https://doi.org/10.1108/DPM-05-2015-0100

Hunt L (2015) The challenge of economic growth for sustainable production landscapes. Sustain Sci 10:219–230. https://doi.org/10.1007/s11625-014-0276-2

IFRC (2014) New Zealand country case study report: how law and regulation support disaster risk reduction. International Federation of Red Cross and Red Crescent Societies, Geneva, Switzerland

Insurance Council of New Zealand (2017) Cost of disaster events in New Zealand. In: Cost of disaster events in New Zealand. http://www.iczn.org.nz/statistics-data/cost-of-disaster-events-in-new-zealand/. Accessed 16 May 2017

Jakes PJ, Langer ER (2012) The adaptive capacity of New Zealand communities to wildfire. Int J Wildland Fire 21:764. https://doi.org/10.1071/WF11086

Jansen MA, Schoon ML, Ke W, Börner K (2006) Scholarly networks on resilience, vulnerability and adaptation within the human dimensions of global environmental change. Glob Environ Chang 16:240–252. https://doi.org/10.1016/j.gloenvcha.2006.04.001

Janssen M (2007) An update on the scholarly networks on resilience, vulnerability, and adaptation within the human dimensions of global environmental change. Ecol Soc. https://doi.org/10.5751/ES-02099-120209

Johnston D, Becker J, Paton D (2012) Multi-agency community engagement during disaster recovery: lessons from two New Zealand earthquake events. Disaster Prev Manag 21:252–268. https://doi.org/10.1108/09669582.2011.122120034

Jurgilevich A, Räsänen A, Groundstroem F, Juhola S (2017) A systematic review of dynamics in climate risk and vulnerability assessments. Environ Res Lett 12:013002. https://doi.org/10.1088/1748-9326/aa5508

Kachali H, Stevenson JR, Whiteman Z, Seville E, Vargo J, Wilson T (2012) Organisational resilience and recovery for Canterbury organisations after the 4 September 2010 earthquake. Australas J Disaster Trauma Stud:11–19

Kalaugher E, Bornman JF, Clark A, Beukes P (2013) An integrated biophysical and socio-economic framework for analysis of climate change adaptation strategies: the case of a New Zealand dairy farming system. Environ Modelling Softw 39:176–187. https://doi.org/10.1016/j.envsoft.2012.03.018

Kelly S, Smith W (2012) Marginality, adaptation and farming in the New Zealand high country. J Alp Res 100:1–10. https://doi.org/10.4000/nga.1711

Kelman I, Gaillard JC, Lewis J, Mercer J (2016) Learning from the history of disaster vulnerability and resilience research and practice for climate change. Nat Hazards 82:129–143. https://doi.org/10.1007/s11069-016-2294-0

Kenny G (2011) Adaptation in agriculture: lessons for resilience from eastern regions of New Zealand. Clim Chang 106:441–462. https://doi.org/10.1007/s10584-010-9948-9

King DN (2015) Tsunami hazard, assessment and risk in Aotearoa–New Zealand: a systematic review AD 1868–2012. Earth-Sci Rev 145:25–42. https://doi.org/10.1016/j.earscirev.2015.02.004

Lawrence J, Reisinger A, Mullan B, Jackson B (2013) Exploring climate change uncertainties to support adaptive management of changing flood-risk. Environ Sci Pol 33:133–142. https://doi.org/10.1016/j.envsci.2013.05.008

Leichenko R, O’Brien K (2008) Environmental change and globalization: double exposures. Oxford University Press, New York, USA

Leonard GS, Johnston DM, Paton D, Christianson A, Becker J, Keys H (2008) Developing effective warning systems: ongoing research at Ruapehu volcano, New Zealand. J Volcanol Geoth Res 172:199–215. https://doi.org/10.1016/j.jvolgeores.2007.12.008

Leonard GS, Stewart C, Wilson TM, Procter JN, Scott BJ, Keys HJ, Jolly GE, Wardman JB, Cronin SJ, McBride SK (2014) Integrating multidisciplinary science, modelling and impact data into evolving, syn-event volcanic hazard mapping and communication: a case study from the 2012 Tongariro eruption crisis, New Zealand. J Volcanol Geoth Res 286:208–232. https://doi.org/10.1016/j.jvolgeeres.2014.08.018

Lwasa S (2014) A systematic review of research on climate change adaptation policy and practice in Africa and South Asia deltas. Reg Environ Chang 15:1–10. https://doi.org/10.1007/s10133-014-0715-8

Mamula-Seadon L, McLean I (2015) Response and early recovery following 4 September 2010 and 22 February 2011 Canterbury earthquakes: societal resilience and the role of governance. Int J Disast Risk Re 14:82–95. https://doi.org/10.1016/j.ijdrr.2015.01.005

Marshall NA (2011) Assessing resource dependency on the rangelands as a measure of climate sensitivity. Soc Nat Res 24:1105–1115. https://doi.org/10.1080/08941920.2010.509856
Meijerink S, Stiller S (2013) What kind of leadership do we need for sustainable marine resource use? Environ Res Lett 8:034016. https://doi.org/10.1088/1748-9326/8/3/034016

McNamara K, Md N, Henly-Shepard S, Thomalla F (2015) Economic and social reconnaissance: Kaikōura earthquake, New Zealand. New Zealand Journal of Social Sciences Online 10:72–89. https://doi.org/10.1080/1177083X.2015.1066401

Orchiston C, Manuel C, Coomer M, Becker J, Johnston D (2013) The resilience of the South Island region of New Zealand to volcanic hazards. Nature 496:434–438. https://doi.org/10.1038/nature12047

S. Spector et al.
Livelihood resilience in the face of climate change. Nature Clim Change 5:23–26. https://doi.org/10.1038/nclimate2431

Thompson MA, Owen S, Lindsay JM, Leonard GS, Cronin SJ (2017) Scientist and stakeholder perspectives of transdisciplinary research: early attitudes, expectations, and tensions. Environ Sci Pol 74:30–39. https://doi.org/10.1016/j.envsci.2017.04.006

Thomson J, Seers K, Frampton C, Hider P, Moor S (2016) Sequential population study of the impact of earthquakes on the emotional and behavioural well-being of 4-year-olds in Canterbury, New Zealand. J Paediatr Child Health 52:18–24. https://doi.org/10.1111/jpc.12988

Tipler KS, Tarrant RA, Johnston DM, Tuffin KF (2016) New Zealand ShakeOut exercise: lessons learned by schools. Disaster Prev Manag 25:550–563. https://doi.org/10.1108/DPM-01-2016-0018

Turner II BL (2010) Vulnerability and resilience: coalescing or paralleling approaches for sustainability science? Global Environ Chang 20:570–576. https://doi.org/10.1016/j.gloenvcha.2010.07.003

United Nations International Strategy for Disaster Risk Reduction (UNISDR) (2009) 2009 UNISDR terminology on disaster risk reduction. UNISDR, Geneva, Switzerland

Vallance S (2015) Disaster recovery as participation: lessons from the Shaky Isles. Nat Hazards 75:1287–1301. https://doi.org/10.1007/s11069-014-1361-7

Vogel C, Moser SC, Kasperson RE, Dabelko GD (2007) Linking vulnerability, adaptation, and resilience science to practice: pathways, players, and partnerships. Global Environ Chang 17:349–364. https://doi.org/10.1016/j.gloenvcha.2007.05.002

Welsh M (2014) Resilience and responsibility: governing uncertainty in a complex world. Geogr J 180:15–26. https://doi.org/10.1111/geoj.12012

Whitman Z, Stevenson J, Kachali H, Seville E, Vargo J, Wilson T (2014) Organisational resilience following the Darfield earthquake of 2010. Disasters 38:148–177. https://doi.org/10.1111/disa.12036

Whitman ZR, Wilson TM, Seville E, Vargo J, Stevenson JR, Kachali H, Cole J (2013) Rural organizational impacts, mitigation strategies, and resilience to the 2010 Darfield earthquake, New Zealand. Nat Hazards 69:1849–1875. https://doi.org/10.1007/s11069-013-0782-z

Wilson TM, Cole JW (2007) Potential impact of ash eruptions on dairy farms from a study of the effects on a farm in eastern Bay of Plenty, New Zealand: implications for hazard mitigation. Nat Hazards 43:103–128. https://doi.org/10.1007/s11069-007-9111-8

Wilson TM, Stewart C, Wardman JB, Wilson G, Johnston DM, Hill D, Hampton SJ, Villemure M, McBride S, Leonard G, Daly M, Deligne N, Roberts L (2014) Volcanic ashfall preparedness poster series: a collaborative process for reducing the vulnerability of critical infrastructure. J Appl Volcanol 3:10. https://doi.org/10.1186/s13617-014-0010-x