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Research Engagement after Disasters: Research Coordination Before, During, and after the 2010–2011 Canterbury Earthquake Sequence, New Zealand

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This article argues that active coordination of research engagement after disasters has the potential to maximize research opportunities, improve research quality, increase end-user engagement, and manage escalating research activity to mitigate ethical risks posed to impacted populations. The focus is on the coordination of research activity after the 22nd February 2011 Mw6.2 Christchurch earthquake by the then newly-formed national research consortium, the Natural Hazards Research Platform, which included a social science research moratorium during the declared state of national emergency. Decisions defining this organisation's functional and structural parameters are analyzed to identify lessons concerning the need for systematic approaches to the management of post disaster research, in collaboration with the response effort. Other lessons include the importance of involving an existing, broadly-based research consortium, ensuring that this consortium's coordination role is fully integrated into emergency management structures, and ensuring that all aspects of decision-making processes are transparent and easily accessed.

INTRODUCTION

The United Nations International Strategy for Disaster Reduction (UNISDR) defines disaster as the 'serious disruption of the functioning of a community or society involving

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widespread human, material, economic or environmental losses and impacts, which exceeds the ability of the affected community or society to cope using its own resources' (p.9 UNISDR, 2009). The levels of uncertainty and unknowns created by this level of disruption make major natural disasters literally definitive of chaotic decision-making environments (Van de Walle & Turoff, 2008; Schloss, 2014). It follows that the immediate response to such events requires a degree of top down management to provide 'emergency services and public assistance during or immediately after a disaster in order to save lives, reduce health impacts, ensure public safety and meet the basic subsistence needs of the people affected' (p. 24 UNISDR 2009). Research conducted in disaster impacted regions has not been routinely included in the activities managed as part of emergency response operations, although there are a few precedents for restricting research access during such operations (Quick, 1998; North et al., 2002; van Zijll de Jong et al., 2011).

There is increasing evidence, however, that high profile disasters can generate surges in research activity, creating a range of scientific opportunities and risks. Birkland (1998) has established that the politicizing effect of US earthquake disasters has triggered increases in research funding and activity, greater likelihood of effective policy/science collaborations, and greater uptake of science by policymakers. Equally, however, the focusing effect of disasters has also been found to escalate research activity at the expense of scientific quality, when large volumes of often duplicative research are produced for largely opportunistic or political ends (Rodriguez et al., 2007; Black, 2003; Birkland 2009). The convergence of researchers into a disaster zone, moreover, has been identified as a significant additional burden on regions struggling to cope in the aftermath of disaster (Brown & Donini, 2014; Walton-Ellery & Rashid, 2012; Sumathipala et al., 2010; Brun, 2009; Gill et al., 2007; Sumathipala & Siribaddana, 2005). The Belmont Report (1979) provided three principles that continue to mark ethical limits beyond which researchers are not free to collect scientific data. Research participants must be fully informed about the risks, implications and outcomes of participating, and have granted consent on that basis (the informed consent principle). Research activity must not only not do harm to participating individuals or groups – it should also actively provide benefits (the beneficence principle). Thirdly, the distributive justice principle dictates that research should not be conducted if it puts groups at risk of bearing "unequal burdens in research" because of their "ready availability in settings where research is conducted" (p. 1419, Sumathipala & Siribaddana, 2005; citing Belmont Report, 1979; see also Gill et al., 2007, and Brown & Donini 2014). Finding that increased research activity in disaster zones risks breaching both the beneficence and distributive justice principles, several ethicists have called for more active interventions to manage such activity, with a view to reducing this risk after disasters (Sumathipala & Siribaddana, 2005; Citraningtyas et al., 2010; Sumathipala et al., 2010).

The recent UN Sendai Framework for Disaster Risk Reduction 2015-2030 has noted that a 'steady rise' in disaster exposure and losses in all countries over the last decade lends urgency to the need for national organisational structures to coordinate disaster risk reduction, and support the science/policy interface for decision-making in this area (p.2, UNISDR 2015). In this article, research engagement after the 22nd February 2011 M_w 6.2 Christchurch earthquake is used to explore a particular instance in which a national coordinating organisation, the Natural Hazards Research Platform (NHRP), was used to support this interface, and manage the mix of scientific opportunity and risk generated by this disaster event. Two weeks after the Christchurch Earthquake a national directive required that social scientists refrain from contacting impacted populations during the two-month state of national emergency. Indexing the issue of escalating pressure from international researchers after disasters, this directive also raises the question of managing such pressure in accordance with the principles provided by the Belmont Report (1979).

The first section sets out the context, including the New Zealand hazard management and security environment, the establishment of the NHRP, and a broad outline of the 2010-2011 Canterbury Earthquake Sequence. The second outlines research collaborations facilitated through the NHRP during this sequence, and provides an account of the developments that led up to the decision to declare a social science moratorium on the 7th March 2011, two weeks after the Christchurch earthquake. An analysis of the issues arising out of both this larger collaboration, and the directive restricting access to local populations is provided in the third section. The article concludes with recommendations for the coordination of research in disaster zones, followed by conclusions.

MATERIALS

The article is largely based on secondary data. This includes a range of NHRP and other government documentation in the public domain, including the Ministry of Civil Defence and Emergency Management (MCDEM) review of the emergency response and the Royal Commission of Enquiry into the Canterbury Earthquakes Report (Mclean et al., 2012), material from the National Crisis Management Center (NCMC) Log during the state of national emergency (22nd February – 30th April 2011), and the Ministry of Business, Innovation and Economics (MBIE) review of the NHRP (Buwalda et al., 2014), as well as scientific and grey literature concerning the CES and its impacts, as available[2]. We also draw on observational and other data collected by the authors. All were involved in aspects of the larger response operation to this event, with some representing the NHRP on the science desk in the Christchurch Response Center (SB, TW, DJ) during the state of national emergency. Secondary data concerning the directive restricting research access to impacted populations included a number of emails and other personal communications. Due to sensitivities around this issue, these are not referenced individually, in order to protect the anonymity of those concerned. Note also that since this directive was not officially formulated, and so has no official title, we have chosen to term it the moratorium directive, for ease of reference, and reflecting common usage at the time.

CONTEXT

In recent decades democratic governments have faced an increasingly complex and fragmented policy-making environment. This has driven growing reliance on non-state scientific, financial and other expertise for resources and cooperation, and an associated emphasis on the use of evidence as the basis of policy (Gluckman, 2013; Skogstad, 2003). Over the same period, calls for inter-disciplinary approaches which integrate end-users in all stages of the research process have become widespread in a range of domains (McNie, 2007). A concomitant body of research has focused on integrative research/end-user initiatives, establishing that inevitable tensions between researchers and policy makers need to be negotiated, especially around the concepts of scientific credibility and political relevance (Cash & Moser 2000). In addition, such initiatives have been found to be equally reliant on the perception that knowledge-generating processes have been legitimate, or fair and balanced, in the treatment of diverging and conflicting stakeholder views and interests (Clark & Majone, 1985; Sarkki et al., 2013; Cash et al., 2003). This balance can be difficult to maintain, as cross-sector collaborations can create new issues that require on-going decision-making about geographical, functional, structural and participatory parameters (Verweij et al., 2014). Decisions about these boundaries point back to the underlying judgments and expectations on which they are based, and can also create further issues as the relevant collaboration develops (Verweij et al. 2014).

[2] The 1999 Fourth International Conference on Grey Literature (GL '99) in Washington, DC defines grey literature as: "That which is produced on all levels of government, academics, business and industry in print and electronic formats, but which is not controlled by commercial publishers." (www.greylit.org; accessed 1 August 2014)

As yet, however, there is little research into the development of ongoing cross-sector collaborations in the hazard and disaster research field (Few & Barclay 2011). There is also little research focused directly on the collaborative management of research activity after disasters, although there have been significant advances in this area in relation to humanitarian and development activity after disasters (Brown & Donini, 2014; Walton-Ellery & Rashid, 2012). This lack of research focus is despite a longstanding recognition of the need for more integrated approaches to research and policy in the disaster risk management area. The need for such approaches now informs most government approaches to hazard and disaster research funding (UNISDR 2005, Few & Barclay 2011), as well as major scientific initiatives by international bodies such as the International Council of Science Unions (ICSU) and the International Social Science Council (ISSC) (ICSU 2008). A key tenet in official United Nations disaster risk reduction policy for the last decade (ICSU 2008; UNISDR, 2005, 2011), the drive to create an integrated DRR environment is the central plank of the 2015 Sendai Framework (UNISDR 2015).

NZ HAZARD MANAGEMENT

In New Zealand, a series of legislative changes has been designed to foster a more integrated national approach to researching and managing natural hazard and disaster risk. The Crown Research Institute (CRI) Act 1992 and the Earthquake Commission (EQC) Act 1993 both regulated the provision of hazards research in the national interest. In 2002 the Civil Defence and Emergency Management (CDEM) Act built on this and other legislative changes to shift national hazard management "from centralized, rules-based, response organisations towards more flexible arrangements based on principles, culture, mitigation and local knowledge" (p. 70, Helm, 2009). Devolving responsibility for risk to local and regional levels, with the goal of building networks at, and between, those levels, this policy was explicitly focused on increasing the overall resilience of the larger complex system that includes both hazards and society (CDEM Act, 2002; Helm, 1996; 2009; Smith, 2009).

Following the Act, collaborative arrangements were established between District, Regional and National levels of government during emergencies, which detailed engagements (at each level) between government and first response organisations (including the police, the army, and private lifeline providers) (MCDEM, 2005). The modular Coordinating Incident Management System (CIMS) introduced as a consequence of the subsequent Act was a nested framework, feeding from local through regional or group level to the national level (MCDEM, 2009). Providing the management structure used during emergency response situations, this system also required that those involved in such responses met regularly, to train, plan and conduct exercises together. In this way it incorporated a regular collaborative requirement, attempting to create networks and so lay the groundwork for future emergency responses (Helm, 2009).

THE NATURAL HAZARDS RESEARCH PLATFORM

In 2007 the New Zealand research-funding environment was identified as the most highly competitive in the OECD (Smith, 2009). Concern about the effects of this environment gave new force to initiatives aiming to develop hazard and disaster research clusters in the response structure (MCDEM, 2009; Smith, 2009), and informed the development of the Natural Hazards Research Platform (NHRP) (NHRP, 2009a). Launched in 2009, the NHRP was a pilot platform, set up to trial the national research platform concept (NHRP, 2009a). It was to work towards "a New Zealand society that is more resilient to natural hazards," and so further the Crown vision already articulated in MCDEM legislation (p.5, NHRP, 2009b). Designed to manage competitive behavior by providing a framework to integrate medium to long-term research and funding in areas of national interest, such platforms were expected to catalyse new, more collaborative networks between organisations, disciplines and agencies already involved in the relevant domain.

The NHRP brought together research organisations with existing hazard and disaster research capacity, but distinct existing priorities. The National Institute of Weather and Atmospheric Research (NIWA) and the NHRP host organisation, GNS Science, are Crown-owned companies required to conduct scientific research for the benefit of New Zealand (Sections 4 and 5.1(a), CRI Act, 1992). What was new about the platform was that it brought these CRIs together not only with Opus, a private research consultancy, but also with three of New Zealand's eight universities, the Universities of Canterbury and Auckland and Massey University. In addition to integrating research activities across these different organisations, the NHRP was required to integrate relevant disciplines into five broad thematic areas. Two of these, risk management and social resilience, were to cut across and so integrate the three themes more traditionally associated with hazard and disaster management: geological hazards models, weather and flood prediction and resilient buildings and infrastructure (NHRP 2009a).

The NHRP was guided by principles that prioritised research issues raised in particular government agency strategies, the endorsement of research programs by end-users, including government agencies, and (where possible) the involvement of such end-users in all stages of the research design process (NHRP, 2009a). Other principles referred to national and international networking and coordination, the prioritization of integration across organizational, disciplinary and sector boundaries, and research of high quality (NHRP, 2009a). The emphasis was to be on long-term research projects, and – through them – the development of an enduring and extensive network that would bring diverse research organisations and agencies together.

As well, however, the NHRP was to be responsive to changing government priorities and evolving science needs. This principle included responsibility for assisting the nation to respond to significant hazard events, and for capitalizing on the learning opportunities such events create (NHRP, 2009a). Responsibility for assisting the response had been subsumed in the existing responsibility of the host organization, GNS Science, to provide hazard and disaster advice to the Crown (GNS Science, 2011). The NHRP strategy document specified this role explicitly, meaning that coordination of research activity during and after the 2010-2011 Canterbury Earthquake Sequence fell within the remit of the NHRP.

THE CANTERBURY EARTHQUAKE SEQUENCE (CES)

On 4 September 2010 the M_w 7.1 Darfield earthquake occurred 10 km deep and ~35km west of Christchurch, New Zealand's second largest city (pop. 390,300[3]). This was the first event in a sixteen-month sequence of earthquakes that trended eastwards across Christchurch, punctuated by a further three large events which caused significant additional damage (Bradley et al., 2014) . The second, and most damaging of these larger events occurred on 22 February 2011, when the M_w 6.2 Christchurch Earthquake led to 185 deaths and more than 6,500 injuries (Johnston et al., 2014). Originating 5 km under the city's southern suburbs, only 6 kilometers away from the city's central business district (CBD), unusually high vertical accelerations caused extensive liquefaction and associated ground and building damage (Chang et al., 2014). The Darfield earthquake had been coordinated at the regional level. The scale of the disaster caused by the Christchurch earthquake, and the magnitude of the required response and recovery operations, led to the declaration of the first state of national emergency in New Zealand, on the 23rd February 2011, which lasted until the activation of the Canterbury Earthquake Recovery Authority (CERA) on the 1st May 2011

[3] Estimated as at June 2010. Source: Subnational Population Estimates: At 30 June 2010. Statistics New Zealand. http://www.stats.govt.nz/.

(see Appendix 1 for a more detailed outline of this disaster's impacts). A purpose-built central government agency of limited duration, CERA was tasked with managing the overall recovery strategy, and given a range of powers designed to reduce obstacles to recovery decision-making (Johnson & Mamula-Seadon, 2014). This article uses Canterbury Earthquake Sequence (CES) when referring to the larger, cumulative earthquake disaster. It is largely focused, however, on the state of national emergency period that followed the Christchurch Earthquake.

THE CES: SCIENCE COORDINATION

The CES created a range of new science requirements and opportunities. Although mandated to coordinate research in response to both, the NHRP was newly formed and lacked detailed protocols for response coordination (NHRP, 2009b). As a result the development of the NHRP coordination effort over this period was largely organic, responding to developments in the wider environment. After the initial Darfield Earthquake local Christchurch scientists self-activated within hours, conducting assessments and gathering fault, seismic, liquefaction, building and infrastructure data across the city and surrounds. In support of the response, much of this activity was also for more basic research purposes (Quigley et al. 2012). Within days, it had developed into the series of broadly themed research operations that was to characterize the ongoing collaborative research effort coordinated by the NHRP during the CES (see Table A1, Appendix A).

The response operation to the Darfield earthquake was coordinated at the regional level by the CDEM Group based in the Canterbury Regional Council (ECAN) (Johnson & Mamula-Seadon, 2014). For this reason, the wider research effort was loosely coordinated through daily NHRP briefing sessions also held at ECAN. Attended by representatives from the NHRP, member organisations, key research operations, response agencies and others, this forum provided updates concerning the previous day's research and ongoing research priorities and issues; representatives were then able to brief others. Raising awareness across the wider research effort, these daily sessions provided a crucial channel of two-way communication, both within the post-disaster research collaboration and with responding agencies.

The much greater devastation caused by the M_w 6.2 Christchurch earthquake on 22 February 2011 prompted New Zealand's first ever declaration of a state of national emergency, and – in a major deviation from existing MCDEM procedure – the co-location of district, regional and national response levels of operation on site, run by the National Controller from a single Christchurch Response Center (CRC). Also for the first time, this operations center explicitly included a Science Liaison function (McLean et al. 2012). This function was managed by the NHRP, which also staffed the Science Desk that was centrally positioned in the CRC. Reflecting both the gains made after the Darfield earthquake, and the politicizing effect of this second, more destructive event, this explicit acknowledgement of the role of science in the response helped the NHRP cement the gains in end-user engagement made after the earlier event.

As the organic development of the NHRP's coordination role adapted to incorporate the new science liaison function, new challenges emerged. McLean et al. (2012) found that confusion arising out of the new structure, regional political tensions within the response operation, and a lack of appropriate information technology made communication difficult within the CRC. This meant many relied on face-to-face communication, which in turn required physically finding others located in the CRC (McLean et al., 2012). The NHRP's ability to negotiate these issues was improved by its new location at the Science Desk, and by the NHRP manager's participation at daily high-level CRC briefings. These gains were somewhat offset, however, by the speed with which the new science function was introduced, which meant there was no time to officially incorporate it into the modular CIMS structure, or add a science section to the Situation Report format informed by this structure (NCMC Log). The introduction of such a section would have improved the NHRP's ability to communicate with the agencies involved in the response operation, since this was another significant channel of communication within the wider response operation (NCMC Log, McLean et al., 2012).

A science section in the Situation Report would also have helped improve communication across the wider research operation coordinated by the NHRP. Although the engineering response operation held its own briefing sessions, as did some of the geotechnical research programs, the NHRP did not conduct daily research briefing sessions, as it had done after the Darfield Earthquake. This was largely due to the much greater scale and complexity of this second science effort. The loss of the wider daily science briefing session, however, removed the forum that, during the Darfield response, had fed into functional and structural NHRP decision-making, and informed response agencies, as well as raising awareness across disparate research programs. These communication issues were compounded by a structural issue, which arose out of the crossover between the new NHRP coordinating role, and the more familiar advisory and support responsibilities of its host organization GNS Science (Buwalda et al., 2014). Assumptions as to the demarcation of tasks and responsibilities between the CRI and the larger consortium tended to default to GNS Science. Although the NHRP was officially responsible for science coordination, those representing this consortium were routinely understood by most agencies to be working for GNS Science, for example. Similarly, the Science Liaison desk was often described as the "GNS desk". Later, this would be continued in an ongoing lack of reference to the NHRP in most official review documents, which like the NCMC Log, referred only to GNS Science in relation to science coordination in the CRC (e.g. Cooper et al., 2012; Mclean et al., 2012; OAG, 2012). This meant that the NHRP's coordinating role remained largely behind the scenes.

RESEARCH PARTICIPATION DECISIONS AFTER THE CHRISTCHURCH EARTHQUAKE

A significant aspect of this role involved allocation of existing and additional research funding to earthquake-related projects. Allocation decisions made by the NHRP management group enabled a range of research activities that were not being directly coordinated by the NHRP, including engineering and geotechnical programs, and so extended the reach of its coordinating influence. The government provided an additional NZ$1 million in research funding after the Darfield earthquake, and a further NZ$3 million after the Christchurch earthquake (Berryman, 2012). Some of this was allocated retrospectively as reimbursement for projects initiated immediately after these events, particularly those in support of the response operation, as well as for major new research programs. Calls for proposals (including retrospective applications) made funding conditional, however, on a letter, or letters, proving endorsement of the relevant research project by an agency or organization involved in the response and recovery operations in Christchurch. This requirement clarified a fundamental NHRP expectation: that research into these events should integrate the needs of end-users, and so increase the uptake of research in policy decisions. In addition, it forced researchers to engage with agencies and organisations involved in the response, and so to this extent brought current and potential research activity to their attention, further opening the possibility of cross-sector collaboration.

Decisions involving participation can also clarify less explicit underlying assumptions (Verweij et al., 2014). This NHRP agency endorsement requirement effectively excluded researchers disinclined or unable to engage with response agencies from these funding rounds. Existing hazard and disaster researchers and teams were most able to fulfill the requirement, since they were likely to have already developed links with agencies and other researchers in this field. To some extent this reflected the original NHRP focus on the maintenance of existing hazard and disaster research capacity. Although this was represented, at that time, by member organizations, it is clear that the NHRP's coordinating role extended well beyond research activities involving these organisations. International research teams contributing to this collaborative effort after both events included researchers from organisations such as Geotechnical Extreme Events Reconnaissance (GEER), the Earthquake Engineering Research Institute (EERI) and the Technical Council on Lifeline Earthquake Engineering (TCLEE), a branch of the American Society of Civil Engineers (ASCE). In addition, research funding decisions brought other local and national research providers into the larger coordinated science effort, including Lincoln, Victoria and Otago Universities, as well as a range of private geological and geotechnical science providers. This did not lead, however, to the expansion of NHRP membership in response to the new opportunities generated by the earthquakes (Buwalda et al., 2014).

The second implicit assumption that constrained the NHRP's coordinating role concerned scope. Most of those involved understood that the scope of this role did not extend beyond the larger research effort funded and/or coordinated by the consortium. This assumption was shared well beyond those directly or indirectly involved with the NHRP. It was likely to have been informed on the one hand by widespread respect for research autonomy, and on the other, by the urgent, larger focus on response-related activities.

In addition to the large, loosely networked research collaboration with agencies coordinated by the NHRP, however, the CES also attracted the attention of local and national researchers with little or no prior engagement in the field, and of international researchers excited by the research opportunities offered by these events. The pronounced geotechnical impacts of these earthquakes in a city where development had been required to meet high-seismic building codes made these opportunities particularly attractive to hazard and disaster researchers. That this disaster zone was in a developed, English speaking nation with a well-networked research community may also have increased its appeal as a research destination. By the time the Christchurch Earthquake occurred, international research interest generated in the wake of the Darfield event was already well in excess of the hosting, collaborative capacity of New Zealand researchers who were engaged with the response.

The high profile generated by the more destructive Christchurch earthquake appeared to immediately escalate this research interest. Senior local researchers were contacted within a day of this event by a number of international research teams seeking to arrange new data gathering visits within weeks. Consulted at that point, NHRP management confirmed that all science conducted in the region came under the aegis of the state of national emergency, and that for this reason the issue of research pressure on impacted communities was being discussed with the National Controller. Over the following week several senior CDEM personnel independently asked the National Controller to clarify the issue of international researcher visits, after persistent requests for research access from international researchers reluctant to accept advice, from these staff, to wait until the response period was over (NCMC Log). The National Controller consulted with other CDEM personnel, the international desk in the CRC, and the NHRP. During the same period, increasing numbers of uninvited international researchers were arriving daily at the CRC. Requesting support from the response to access CBD, most were interested in liquefaction and building structural performance data. The volume of these visitors caused problems not just for staff in the CRC, but also for those engineers and others already engaged in research projects in collaboration with the response (Social Science Situation Report 2011; McLean et al., 2012). By Monday 7 March, almost two weeks after the Christchurch earthquake, visiting researcher numbers had reached 100 per day, forcing the introduction of a new CRC access protocol designed to restrict their entry (Engineering Situation Report 2011). It should be noted that these numbers refer only to those researchers who made contact with the CRC; overall visiting researcher numbers are likely to have been much higher.

RESEARCH PARTICIPATION AND THE (SOCIAL SCIENCE) MORATORIUM DIRECTIVE

On the same day, the National Controller's consultation over this issue culminated in a directive, issued under the state of emergency, requiring that all international researchers should postpone data-gathering visits to the city until the state of national emergency was lifted, or until 1 May, whichever came earlier (NCMC Log). Social scientists, in particular, were to be held off until 1 of May. MCDEM did not have the resources required to host visiting researchers while engaged in the response, and the consensus opinion was that local communities should be given space before being interviewed by researchers. Geoscience and engineering fact-finding missions that did not include a community focus were to be the exception, as long as they were coordinated through NHRP, and so contributed to the science response (NCMC Log).

This directive was necessary, in order to address the escalation of research interest in the days after the earthquake. It was made by the National Controller, using the powers available to him under the state of national emergency, and informed by networking and advice from within the New Zealand hazard and disaster research community, NHRP management, and within MCDEM. The directive was not, however, officially formulated, widely promulgated, or accessible on any official websites. It was communicated by the National Controller's office to CDEM and other response personnel through the Coordinated Incident Management Structure (CIMS) structure. It did not feature prominently in the situation reports, which were an important communication mechanism within the wider response operation. This meant that although it was discussed with the international desk in the CRC (NCMC Log), it was not as widely disseminated as it could have been within the wider response operation.

The decision was also communicated informally to NHRP management. Those staffing the science desk were responsible for explaining the directive to visiting researchers arriving at the CRC. In hindsight, it is likely that the difficulties of this task would have been reduced if it had been possible to refer visiting researchers to an officially worded and authorised version of the directive, on a relevant government website. NHRP researchers were also required to disseminate this directive through local and international hazard and disaster networks. There was no obvious mechanism for communicating the moratorium decision to local and international hazard and disaster scientific communities, however, and even less possibility of reaching the rapidly burgeoning local research community inspired by the earthquake to enter the hazard and disaster field for the first time. The moratorium decision was made early after the Christchurch earthquake, a day or so before contact and collaboration was established between the NHRP and the office of the Chief Science Adviser (CSA), with a view to demarcating science communication tasks (NCMC log). Since a large part of this role is science communication with the public (Gluckman 2014), the CSA might have been well placed to help publicize both the moratorium directive, and the rationale behind it.

Later in March, local education organisations concerned about international research pressure contacted the University of Canterbury, and were informed about the moratorium directive by university management. Information about the moratorium was subsequently made available to pre-school, primary and secondary schools through the Ministry of Education. The NHRP collaborated with this Ministry to provide ethical guidelines for research conducted with education organisations after the moratorium was lifted, which included requiring all such research to have applied for and received ethics approval, and that all projects be registered with the Ministry.

Under the state of national emergency, the National Controller was authorized to exercise powers of compulsion. The moratorium directive was voluntary, however, as far as members of the science community were concerned. As a directive, its primary force was in requiring responding agencies and researchers involved in the collaboration with the response to decline requests for access and assistance from visiting researchers who were not contributing to that collaboration. International media crews wishing to document the activities of international researchers were also declined access (Social Science Situation Report 2011). Note that although the directive applied to research activity in the Greater Christchurch region after the earthquake, it was only possible to deny access to the cordoned off CBD. While all visiting researchers attempting to engage with this local collaboration were asked to respect the directive, there was no way to ensure that they did so. There was also no way to communicate the directive to visiting researchers that did not attempt to contact local research and response operations, or indeed, to assess numbers of visiting researchers overall; as a proportion of overall research activity in the city at the time, those that did make contact indicated that these numbers were very high.

Those made aware of the moratorium by were largely supportive, although some researchers were reluctant to accept the authority of the National Controller in this domain, or the rationale for his decision, or both.

ANALYSIS

The NHRP's ability to coordinate the larger research effort in collaboration with the response was constrained by several factors. The initial parameters evidenced in the contract and strategy documents created a focus on existing capacity, and failed to distinguish clearly between the roles of the larger consortium and its member organizations during emergency responses. The NHRP had not had time to develop when the CES began. It was trialing a new consortium approach to research funding and coordination, and so had no precedent to follow. Despite these constraints, the NHRP played a significant role in the production of a coordinated range of scientific outputs of high quality (Buwalda et al., 2014), many of which fed directly into policy and practice decisions (Table A1). The inclusion of a new science liaison function in the CRC, like the provision for the NHRP to coordinate emergency research support in future events in the new, draft CDEM plan (MCDEM, 2014) testified to the new levels of collaboration with agencies achieved during and after these earthquakes. As a pilot consortium, despite significant constraints, the NHRP demonstrated that it is possible to bring a large section of the hazard and disaster research community into collaboration with the response operation. It also established that such consortiums have the potential to coordinate research activity after major disaster events in such a way as to increase the uptake of research opportunities, including the opportunity to engage end-users, and the provision of scientific evidence as the basis of decision-making, while also decreasing the risks to science quality documented after other disasters.

On-going decision-making about the structural, functional, geographic and participatory boundaries of collaborations of this kind have been found to create new issues as the collaboration unfolds (Verweij et al., 2014). Looking more closely at boundary decisions concerning the larger collaboration between the response operation and the NHRP helps to clarify some of the issues arising out of the management of research activity after disasters. Many of these issues are best illustrated by the moratorium directive, which can be seen as a flash point. Driven by rapid developments after the disaster, this directive was the result of assumptions and swift decision-making concerning the distribution of tasks between the response operation and NHRP, the scope of NHRP function and responsibility, and participation in research activity into the disaster and its impacts. The directive is also important because it indexes the research pressure that Birkland and others have identified as a secondary effect of the high profile generated by major disasters (Birkland 2009, Rodriquez et al., 2007, Citraningtyas et al., 2010; Brown & Donini, 2014; Gill et al., 2007). In addition to (scientific) risks to research quality, this pressure carries more immediate risks of particular concern to the response operation. As in the CRC, the volume of arriving researchers can compromise the ability of such operations – already overwhelmed by the disaster – to provide basic services to the impacted population. As well, the convergence of researchers into a disaster zone collectively risks creating a cumulative research burden on already stressed, impacted communities disproportionate to any benefits they may gain, in contravention of the Belmont Report's (1979) distributive justice principle (Brown & Donini, 2014; Sumathipala et al., 2010; Citraningtyas et al., 2010). These immediate risks meant that the rapid escalation of research pressure after the Christchurch earthquake required active management, and rapid decision-making. Since it is a consequence of major disasters, this kind of increase in research activity will always require some form of active management if these risks are to be addressed (Brown & Donini, 2014; Walton-Ellery & Rashid 2012; Gill et al, 2007).

THE MORATORIUM DIRECTIVE, VISITING RESEARCHERS AND SOCIAL SCIENTISTS

As a necessary intervention designed to reduce these risks after the Christchurch Earthquake, however, the moratorium directive introduced a new research participation restriction that affected research activity in the impacted region. This restriction also marked a participation boundary in the larger collaboration between the response operation and activities coordinated by the NHRP. Participation boundary decisions of this kind carry the risk of creating the perception that the interests of a particular group have been ignored (Verweij et al., 2014). It has been well established that such perceptions risk bringing the legitimacy of the relevant collaborative activity into question, and so can put the larger collaborative enterprise at risk (Cash et al., 2003; McNie, 2007; Parker & Crona, 2012).

Possibly due to sensitivity around these and other issues, the moratorium directive was not officially formulated, or promulgated through the media. The speed with which this decision was forced by rapidly unfolding developments in the high-pressure post-disaster environment is also likely to be a factor here. As entered in the NCMC log, the National Controller's directive allowed only visiting researchers who joined programs coordinated by the NHRP to engage in research activity in the Greater Christchurch region, which was directly impacted by the disaster. This was in effect already the case. The vast majority of researchers arriving at the CRC were geotechnical and structural engineers, who were being declined access to red zones and support from the response and/or other researchers unless required by existing collaborative research projects. Overall, far more visiting engineers requested and were declined research access during this period than visiting social scientists. However because this log entry also specified holding off social scientists in particular, and because there was no official formulation to refer to, the directive was widely perceived and described as the social science moratorium. While the bluntness of this description was effective in reducing immediate pressure on impacted populations, it was not strictly accurate. All visiting researchers not involved in local collaborations were subject to the directive, irrespective of discipline. And many agencies were conducting or engaging with social science initiatives that were gathering data to inform response decision-making; most, although not all, did not involve direct contact with impacted communities (such as statistical studies of existing data streams, literature searches and modeling of likely demographic effects, for example).

Restricting research contact with impacted populations during disaster response after disasters will always carry the risk of alienating the sectors of the research community that rely on such contact. In retrospect, however, phrasing this directive as a social science moratorium exacerbated this risk, by appearing to exclude an entire branch of science. To the extent that this indicated that the requirements of this section of the research community were not being considered, it also risked compromising the legitimacy of the larger collaboration. In hindsight, it is likely that these risks could have been reduced if this directive had been expressed as a collaboration requirement, in terms of its rationale (limiting the research burden on impacted populations) and effect (facilitating access to all researchers involved in the larger research effort being coordinated in collaboration with the response effort). This phrasing would still have required responders and researchers to refuse access to visiting researchers not required by this effort, but without appearing to single out social science. Phrasing the directive in terms of participation, rather than exclusion, would also have directed interested researchers to participation options, while clarifying the rationale would have been likely to have increased perceptions of the legitimacy of the coordinated research effort (Cash et al., 2003; McNie, 2007; Parker & Crona, 2012).

STRUCTURAL BOUNDARY DECISIONS (AND THE SCIENCE/POLICY INTERFACE)

Senior researchers and CDEM staff had requested clear direction from the National Controller concerning visiting international researchers. Such a directive was only possible under the powers granted to this office under the state of national emergency. Lending the authority of that office to a directive of this kind had other advantages. Making it easier for responders to decline access to visiting researchers, this authority also to some extent shielded local and national researchers from negative fall-out from sectors of the research community following the directive. A significant disadvantage, however, was that the directive was in effect a participation decision that directly affected the interests of the research community, and it appeared to have been made only by senior emergency managers (and so a government agency).

Effectively placing a moratorium on all research activity not part of this collaborative effort, this government directive risked alienating newly interested members of the local New Zealand research community, as well as sectors of national and international hazard and disaster research communities. Again, in hindsight this risk might have been better managed with a joint directive, issued officially by the National Controller and the NHRP, making research activity conditional on collaboration with the response and specifying minimal contact with impacted populations. Direct responsibility for this directive, even when shared with this much more powerful entity, may have increased the exposure of the NHRP and member organisations to fall-out from research communities. But as a large research consortium, including several major national universities and Crown Research Institutes, the NHRP had the potential to spread this risk across institutions, and in this way reduce it. The official involvement of the NHRP as an equal partner in the moratorium decision would have clarified the breadth of support for the collaboration requirement across New Zealand research organisations. Ensuring that government agencies were not perceived to be making uninformed political decisions about research participation, this kind of joint directive would also have demonstrated that the research collaboration with the response coordinated by the NHRP reached to the highest levels. These potential benefits would have been greater, however, if the NHRP had been free to move rapidly to include new member organisations, and had also been more able to generate a much higher, more official profile over this period, both generally, and as distinct from GNS science in particular.

As a CDEM directive, the moratorium decision also clarified structural assumptions at the time concerning the distribution of responsibility for research activity in the disaster zone. Within hazard and disaster research networks, and across responding agencies, the NHRP was understood to be responsible for – and largely limited to – coordinating activities either actively driven and/or funded through this consortium. Research activity outside this larger collaboration thus fell under the aegis of the response, along with other activities in the disaster zone. Reflecting cultural expectations concerning research autonomy, these assumptions were also informed by the urgency and magnitude of the task facing the response, which tended to narrow the focus of all concerned onto the collaborative effort. They were in any case implicit in the consortium's initial parameters: the NHRP was set up to sustain and increase existing hazard and disaster networks, and so national capacity, not to actively manage the larger surge in research interest and activity that follows major disasters.

Newly interested local researchers, however, did not always share these assumptions. While private providers of psychosocial support to businesses and other organisations were in demand after the disaster, for example, those that attempted to ensure their activities were coordinated with and contributed to the larger response effort were unsuccessful (pers. com.

J. Black, organisational psychologist). There were other instances in which local researchers, upon hearing of the NHRP, assumed this consortium was responsible for immediately acting to engage all local scientists interested in research after the disaster (many of these subsequently contributed to the research effort coordinated and funded by the NHRP). While opportunism is a factor in increased local research interest after disasters (Rodriguez et al., 2007, Birkland, 2009), the desire to contribute research skills and time to the response and to the local community is at least as significant a motivating factor. As well as marking another instance of perceived exclusion, then, the initial disappointment created by mismatched assumptions about the scope of the NHRP's role underlines the peculiar relevance research into a disaster event carries for those researchers living in the impacted region. This issue arises out of the intersection of the boundaries defining the participatory and geographical extent of the coordinated post-disaster research effort. Although a factor in NHRP research participation and funding decisions, it remained implicit, and did not appear in calls for research proposals, or other NHRP documents.

TRANSPARENCY AND COMMUNICATION (AND THE SCIENCE/COMMUNITY INTERFACE)

Two broad themes can be seen running through the issues that arose out of decisions involving the geographical, functional, structural and participatory boundaries of the post-disaster research effort coordinated by the NHRP. Firstly, these issues all involved risks arising out of the perception that individuals or groups were being unfairly excluded by the relevant boundary decisions, which in turn posed risks to the legitimacy of the wider research effort. Secondly, these risks were all highlighted and exacerbated by communication and awareness issues. Difficulties formulating and promulgating the moratorium directive, for example, led to poor dissemination and impact with possible alienation of some research groups. Since the consultation process informing this and other decision-making remained behind the scenes, like the wider networks that informed NHRP activity, the directive was open to being misinterpreted as a government intervention that curtailed academic freedoms, while NHRP activity risked being misconstrued as that of a single member agency. And finally, misunderstandings about the scope of the NHRP's coordinating role contributed to feelings of disappointment and unfair exclusion in sectors of the wider research community living in the disaster zone

It follows that if communication issues and lack of awareness exacerbated these issues, improvements in these areas are likely to mitigate them. It has been established in the wider literature concerning complex cross-sector collaborations in high pressure environments that both communication and transparency contribute to perceptions of legitimate process, even among groups who have been excluded (Cash et al., 2003; McNie, 2007; Cummings & Kiesler, 2007; Parker & Crona, 2012). Measures to improve the transparency of research coordination processes, and that of collaborative engagements with the response operation would have increased awareness of the NHRP's role, and significantly diminished confusion around decision-making criteria for research funding and participation. Formalizing this information, and providing it in an accessible format on an open platform from the outset may have made the subsequent moratorium directive unnecessary. By diminishing the associated risk of alienating sectors of the research community, this would also have limited potential compromise to the legitimacy of the wider collaborative operation.

The widespread dissemination of decision-making criteria for research participation is arguably even more important when it comes to addressing the risks research pressure can pose to the response operation, and impacted populations. In the first instance, observance of the moratorium relied on dissemination to relevant researchers, who were more likely to adhere to it if the rationales for decisions made concerning research participation, and the exclusion of a proportion of interested researchers were clearly articulated.

No matter how widely voluntary measures are disseminated to researchers, however, there will always be those disinclined, for a variety of reasons, to accept the criteria for participation, and correspondingly reluctant to refrain from activity that does not meet those criteria. For this reason directives like that issued after the Christchurch Earthquake need to be communicated to those groups most likely to come under direct pressure as a result of increased research activity. Researchers, and the organisations they represent, can wield considerable authority. During the CES, a number of individuals and agencies sought clarification from local researchers, research organisations and the NHRP after being contacted by international researchers. Many were unaware not only of the moratorium directive, but also of their rights to refuse to consent to research participation detailed in the Belmont Report (1979). Concerns expressed included the expectation that research participation might be required of them, or of vulnerable populations in their charge, stress at the prospect of refusing researcher requests, and anxiety about the repercussions of refusals. These groups welcomed the moratorium directive, as it empowered agencies, researchers and potential research participants who so wished to decline requests from interested researchers.

The empowering effect of this directive was only available, however, to those potential research participants who were aware of it. To effectively reduce the risk of research pressure exacerbating the other stressors affecting impacted populations, research participation criteria and the participant rights provided in the Belmont Report need to be as widely disseminated as possible, through a variety of public channels. Given that some regions were without power for a considerable period, these channels should always include communication measures that do not rely on electricity, like door knocking and leaflet drops, which McLean et al. (2012) found to have been an effective means of communication after the Christchurch Earthquake. At the other end of the spectrum, including interactive and crowd-sourcing platforms wherever possible would allow generation of wider debate about the issue. Allowing those feeling pressured by research participation requests to contribute to and seek clarification from those coordinating research activities in the disaster zone, such platforms would also provide pathways for those wishing to take part in research activities (as either researchers or participants). Conversely, interactive data from agencies, researchers and potential and actual participants would also have the potential to help clarify the extent and nature of research activity in the impacted region, making it possible to develop new management measures in response to this developing picture.

RECOMMENDATIONS

The following broad recommendations for research coordination during and after disasters can be extrapolated from this analysis.

EXISTING/CONTINUING RESEARCH CONSORTIUM:

Research coordination after hazard events will be most effective if it is conducted by a permanent research consortium, with existing, closely related business as usual research coordination functions which facilitate the ongoing development of relevant national research and end-user networks, and of networking skills. If such a consortium is not already in place, establishing it should be the first step.

RECOMMENDATIONS BEFORE DISASTERS:

Planning: The research consortium responsible for post-disaster research coordination should work with agencies responsible for emergency management to develop a detailed, collaborative disaster research coordination plan. The research plan should be fully integrated into the relevant response management structure. Resources should be allocated to research management activities. The research consortium should made explicitly responsible for a distinct science function in the response structure, and provision should be made requiring consortium representatives to engage in regular emergency response training at local, regional and national levels with response agencies and other relevant organisations.

The research coordination plan should make provision for measures designed to facilitate a focus on - and the coordination of - as much research activity as possible in the relevant impacted region after hazard events. The aim should be to anticipate and plan to manage a surge in research interest that is roughly parallel to the profile of the relevant hazard event. Objectives should include mitigating the risks posed by this increased research activity, while also taking advantage of the possibilities it offers in terms of contribution to the wider effort, and the development of local research capacity and international research networks.

RECOMMENDATIONS AFTER DISASTERS:

Integration With Response: Research coordination should be fully integrated with, and conducted in collaboration with the response operation.

Proactive Communication: As soon as possible after the event those responsible for research and emergency management should issue joint statements detailing research coordination responsibilities, processes, participation pathways, research participant rights (to require proof of ethics approval, and to refuse consent) and measures to mitigate the risks associated with research pressure (such as collaboration and/or registration requirements). These statements should be officially formulated, and provide clear, accessibly phrased information. Relevant agencies should be included in ensuring that this information is as widely promulgated as possible – available on relevant open access websites, and included in media releases, leaflet drops, public meetings, interactive platforms and other communication channels used by the response operation.

Transparency: If possible, all research coordination decisions should be accessible on an up to date, monitored and appropriately resourced open website. Material provided should continue to include all broad decisions about research participation and the demarcation of tasks as they are made, as well as more specific information including research funding decisions, and relevant current and completed research projects and outputs in the impacted region.

Monitoring: All information gathered (from interactive websites, registration requirements, and agencies as well as through research funding decisions) should be used to monitor the wider research effort, with a view to responding to evolving research trends in order to maintain research quality, respond to emerging requirements and opportunities, and mitigate the risks associated with research pressure.

Building Local Capacity: Consideration should be given to involving highly qualified researchers from the impacted region with new interest in the hazard and disaster field, as much as possible, in order to develop local and national research capacity by bringing in new expertise.

CONCLUSIONS

The Sendai Framework (UNISDR 2015) has called for government organisations and increased coordination of disaster risk reduction, including support for the policy/science interface for decision-making. Research activity after the Christchurch earthquake bears out this call, as well as findings from other disasters concerning the convergence of researchers into the disaster zone, and significant escalation of research activity. Within this increase in overall research activity, research needs and opportunities were revealed in this post-disaster environment to be in tension with the risks posed to research quality by this increase, and to local agencies and populations. Active management of these tensions was necessary in order to address needs and maximize opportunities, while also reducing negative impacts on the larger response operation, local populations and research quality. However such management necessarily involved decisions about participation in research activity, which carried secondary risks associated with perceptions that groups had been excluded from participation. When not addressed, such perceptions have the potential to significantly compromise the legitimacy and the longer term validity of the larger research enterprise, and so can threaten gains made when it comes to addressing research needs and taking up opportunities created by the disaster. This allows us to conclude with five broad points about research coordination after disasters – all follow from the larger contention that such coordination is necessary.

In the first instance, research organisations are unlikely to be able to coordinate research activity in disaster zones without the involvement of disaster response agencies and organisations. This involvement is critical in order to address the research needs created by the disaster effectively, which often requires the engagement of these end-users. It is also required to minimize negative impacts of research activity on the wider response operation, and to facilitate researcher access to disaster zones. Conversely, response agencies are neither sufficiently qualified nor networked to effectively manage post-disaster research activity without support from the research community. To the extent that they are perceived to be doing so, they risk creating the perception that decision-making has ignored scientific considerations, and that the scientific community has been excluded from contributing to decisions that affect it directly. The first point, then, is that the risks and opportunities associated with post-disaster research activity can only be managed effectively to the extent that they are jointly managed, through as full and equal a collaboration as possible between the response operation and research communities.

This kind of joint, collaborative management of research activity will rely in turn, however, on the range and relevance of the networks represented by both response and research operations, and which are thereby able to feed into decision-making in the chaotic and high pressure post-disaster environment. The New Zealand CIMS system is a purpose-built project management structure designed to effect this after disaster events by bringing together (and connecting back into) relevant government and other networks, at local, regional and national levels. The NHRP was barely established when this disaster struck. The extent to which it was able to organically develop a similar representative and networking function relied heavily on its ability as a national consortium to represent the research organisations demonstrating the greatest collective existing hazard and disaster research capacity at the time of the CES. Although not prepared for the post-disaster environment, the NHRP structure made it possible to bring this range of organisations together to effect collective decision-making about the coordination of research activity, by linking back through them into wider hazard and disaster research networks. Thus the second broad point we can draw from the Christchurch experience concerns the advantages of using a research consortium or platform structure to coordinate research activity after disasters. The more such a consortium draws on and represents the interests of wider research communities, the greater its capacity to ensure high quality research outcomes, and the less likely it is to create the perception that the interests of particular groups or organisations are being excluded as a result of decision-making about participation.

Thirdly, the corollary of this logic can be applied to the scope of research coordination after disasters. The wider this scope is, the less likely it is to generate perceptions of exclusion, even when a significant proportion of researchers wishing to participate are not able to do so. Including all research activity in the impacted region would also increase the possibility of monitoring the amount and nature of research activity in the impacted region, and so of managing it effectively.

The fourth point concerns the profile of the coordinating research consortium. The NHRP management group included internationally networked senior scientists who represented – and relied on – expertise from all six member organisations. This group was responsible for all major NHRP decision-making concerning the coordination of research activity during and after the CES, including structural decisions about the demarcation of tasks and responsibilities, functional decisions concerning the scope and nature of research programs, and broad participatory decisions concerning engagement in research into this disaster and its aftermath. The extent to which collaborative research activity after the Christchurch Earthquake was informed by this larger decision-making body remained behind the scenes, however, due to the widespread collective assumption that attributed NHRP activity to GNS science. This attribution significantly limited the consortium's ability to demonstrate the extent to which it in fact represented and was informed by the wider New Zealand (and international) hazard and disaster research community. To the extent that it increased the perception that a single organization was making decisions that influenced a range of sectors and organisations, it risked creating the impression that some of those directly affected by these decisions were excluded from both research management decision-making, and participation in research activities. The fourth point that emerges from the Christchurch earthquake experience relates to the extent to which research coordination arrangements are widely disseminated, transparent, and understood to at least some degree by all involved.

The fifth point to be drawn from the experience of research engagement after the Christchurch earthquake comes back again to the situation of the NHRP at the onset of the CES. Barely established, this consortium had not had time to develop extensive research networks, or generate a profile among researcher and end-user communities. As a pilot platform, it had no precedent to follow; with no resourcing for management, and without protocols and guidelines concerning coordinating research activity after disaster events, the NHRP was forced to evolve organically in response to this challenging environment. This situation can also be used, however, to make the obvious reverse point. Consortium status, collaborative decision-making relationships and structures, and links into wider networks were already in place when the NHRP was required to respond to this disaster event. There is no doubt this played a major part in this consortium's considerable achievements after the disaster, which relied heavily on its ability to bring a wide range of expertise into decision-making around research coordination and into research programs and activities. It was also a major factor in the NHRP's ability to network across agencies at local and national levels to coordinate this research effort in collaboration with the response operation. The fifth point, then, which we can draw from the coordination of research during and after the CES, builds on the second. The advantages of using a consortium or platform structure to coordinate such research activity, in other words, will be significantly increased if this is an existing, well-established structure, with a relevant permanent research coordination function. The extent to which such a structure is able to fulfill its research coordination potential after disasters is likely to rely on the extent to which it is already engaged in the collaborative relationships – both within research communities, and with agencies and other relevant organisations – that become so crucial after disasters.

Finally, it is important to end by reiterating the point that has already been made in relation to other disasters, concerning the intense research pressure that follows such events, and the effects of this pressure on local research and emergency management communities, and on impacted populations. This pressure was considerable and difficult to manage after the Christchurch Earthquake, which, although a major disaster by New Zealand standards, was not a catastrophic event. After a catastrophic disaster, requesting that ambitious, senior researchers from prestigious institutions and organisations respect the need to defer data gathering visits becomes an infinitely more demanding task, and this level of difficulty increases exponentially again for researchers and response agencies in developing countries, due to North/South power relations (Sumathipala et al., 2010; Brown & Donini 2014; Citraningtyas et al., 2010). Increased awareness and discussion of this issue among hazard and disaster research communities is essential to ensure that visiting research teams respect moral and ethical research principles, and recognize the importance of being guided by the needs of local response operations, researchers and impacted populations when conducting research after disasters.

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APPENDIX A

SUMMARY OF THE 2010-2011 CANTERBURY EARTHQUAKE SEQUENCE (CES)

On 4 September 2010 the M_w 7.1 Darfield earthquake occurred as a result of a fault rupture 10 km deep and ~35km west of Christchurch, New Zealand's second largest city (pop. 390,300[4]). Ground shaking resulted in widespread liquefaction in eastern Christchurch, and caused ground, building and infrastructure damage (Cubrinovski et al. 2010; Bradley et al. 2014). This was the first event in a sixteen-month sequence of earthquakes that trended eastwards across Christchurch, punctuated by a further three large events which caused significant additional damage (Bradley et al., 2014) . The second, and most damaging of these larger events occurred on 22 February 2011, when the M_w 6.2 Christchurch Earthquake led to 185 deaths and more than 6,500 injuries (Johnston et al., 2014). Originating 5 km under the city's southern suburbs, only 6 kilometers away from the city's central business district (CBD), unusually high vertical accelerations caused extensive liquefaction and associated ground and building damage (Chang et al., 2014). Partial or total building collapse during this event caused 175 of the 185 deaths; 133 resulted from the collapse of two large multi-story buildings in the CBD (Cooper et al., 2012). The Darfield earthquake had been coordinated at the regional level. The scale of the disaster caused by the Christchurch earthquake, and the magnitude of the required response and recovery operations, led to the declaration of the first state of national emergency in New Zealand, on the 23rd February 2011. Granting the National Controller "all the powers that are reasonably necessary or expedient" to enable the performance of his functions (Section 9[1], CDEM Act, 2002), the state of national emergency lasted until the activation of the Canterbury Earthquake Recovery Authority (CERA) on the 1st May 2011. A purpose-built central government agency of limited duration, CERA was tasked with managing the overall recovery strategy, and given a range of powers designed to reduce obstacles to recovery decision-making (Johnson & Mamula-Seadon, 2014). The third and fourth of the larger events, on 13th June (M_w 6.0) and 23rd December 2011 (M_w 5.9), respectively, were less disruptive, although they significantly compounded liquefaction and damage effects (Bradley et al., 2014; King et al., 2014). This article uses Canterbury Earthquake Sequence (CES) when referring to the larger, cumulative

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[4] Estimated as at June 2010. Source: Subnational Population Estimates: At 30 June 2010. Statistics New Zealand. http://www.stats.govt.nz/.

earthquake disaster. It is largely focused, however, on the state of national emergency period that followed the Christchurch Earthquake.

Damage to older buildings and facades in the CBD after the Darfield earthquake informed the decision to cordon off a significant proportion of the city center for safety reasons for a week, from 4-10 September (Chang et al., 2014). After the 2011 Christchurch earthquake, damage to the ~2,000 commercial buildings in the CBD was so extensive that the entire 349 hectare district was cordoned off as a ‘red zone’ (Chang et al. 2014). Although progressively reduced in size, a substantial cordon manned by the NZ Defence Force remained in place for more than two years, from 22/2/2011 to 30/6/2013 (Chang et al., 2014; McGregor, 2013.) More than half the commercial buildings in the CBD have been demolished, including a significant proportion of the city’s heritage buildings (Cooper, Carter & Fenwick, 2013; Chang et al., 2014). A large majority of residential buildings also sustained damage, as evidenced in more than 500,000 residential insurance claims for earthquake damage to buildings, land and contents from approximately 160,000 dwellings, as well as 30,0000 non-residential insurance claims (King et al., 2014).

The dominant cause of building damage was widespread liquefaction ground damage throughout central and eastern suburbs, particularly in the Christchurch earthquake (Cubrinovski et al., 2011; Bradley et al. 2014). Liquefaction also caused severe damage and disruption to road networks and aging, buried infrastructure networks, compromising water, electricity and sewage systems (Rogers et al., 2014; van Ballegooy et al., 2014). The extent and range of land damage caused by liquefaction and slope instability in some areas of the city was such that in 2011 the decision was made to categorize over 7,500 residential properties (~5% of total housing stock) as too difficult, uneconomic, dangerous and/or impractical to repair (Chang et al. 2014; Rogers et al., 2014). Those with properties zoned red on this basis were able to engage with a Government offer process, which provided eligible homeowners in these zones with the opportunity to relocate (Rogers et al. 2014).

The total cost of recovery and reconstruction has been estimated at as much as NZ$40 billion, which is equivalent to around 19% of New Zealand’s GDP (New Zealand Treasury 2013; Stevenson et al., 2014).

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APPENDIX B

Table B1: Broad categories of CES-related research activity coordinated through the NHRP

Geological sciences	Aerial photography and LIDAR; ground penetrating radar (GPR); landslide/rockfall data; seismic fault trace data; aftershock shaking data	Establishing uplift and subsidence; modelling seismic stress re-distribution, aftershock forecasting, mapping the fault trace; identification of other seismic features; quantifying contributions to seismic hazard, stochastic ground motion simulation of Chch Earthquakes, mapping seismic faulting in the region; dynamic updates of state of current knowledge to inform agencies and the industry	UC, GNS, VUW, (NZ) & international research partners	**End-users included**: CDEM, CERA, OPMSA, TEC, MoE, MSD, CCC, WDC, SDC, ECAN, EQC, DBH/EAG; Also: Te Rūnanga o Ngāi Tahu; Aecom; small & medium business organisations **Research informed**: response & recovery decision-making; land use and other planning decisions including land zoning legislation; changes to building codes and practices; (2012) Royal Commission of Inquiry into Building Failure Caused by the Canterbury Earthquakes.
Social Sciences	Immediate and medium term social, demographic and economic impacts; Disaster risk and resilience data.	Research advice and assessments: psycho-social support regimes and information provision for individuals, staff, organizations and communities impacted by the earthquakes; socio-economic impacts of the earthquake on urban and rural businesses and communities; disaster resilience, community resilience and recovery monitoring; predictions of population and capital 'flight', and other short/medium term demographic and economic changes following damage, red-zoning and response, recovery and rebuild operations; risk communication	MU, UC, GNS, LU, UO, Opus; private providers of psycho-social support and research	
Geotechnical Engineering	Liquefaction-related land and foundation damage; aerial photography liquefaction;, slope stability data	Risk assessments/safety issues; liquefaction mapping; establishing lateral displacement; mapping rockfall and landslide risk, including modelling rockfall trajectories; geotechnical life safety assessments	UC; GNS; UA; Tonkin & Taylor; international research partners; Opus; other private providers	
Structural Engineering	Seismic performance of structures – buildings and infrastructure.	Structural damage and safety assessments; dynamic updates of state of current knowledge to inform agencies and the industry; basic research on seismic performance of wide range of structures and buildings; seismic site response effects, acceptable seismic risk of older buildings, retrofit solutions for heritage unreinforced masonry buildings.	Leads: UC and UA – included GNS, BRANZ and private providers; international research partners	
Lifeline & Natural Resources Engineering	Seismic performance of lifelines & pipe networks/systems; disaster waste management; groundwater contamination of aquifers	Damage and performance assessments, including interdependence; waste disposal options; reinstatement of lifeline services; design new lifeline approaches and solutions	UC; UA; GNS; Opus; private providers, international research partners	

List Of Acronyms (In Alphabetical Order) Used In Table B1:

BRANZ – Funded by New Zealand Building Research Levy to invest in building research & provide testing, research advice & knowledge. (www.branz.co.nz)
CCC – Christchurch City Council (one of the three territorial authorities impacted by the Canterbury Earthquake Sequence) (www.ccc.govt.nz)
CERA – Canterbury Earthquake Recovery Authority; established by the Canterbury Earthquake Recovery Act (2011).
DBH – Department of Building and Housing, a branch of the Ministry of Business, Innovation and Employment (MBIE). (www.dbh.govt.nz)
DBH/EAG – Department of Building and Housing Engineering Advisory Group (www.dbh.govt.nz/canterbury-earthquake-eag)
ECAN – Environment Canterbury, the Canterbury Regional Council, New Zealand (the regional council impacted by the Canterbury Earthquake Sequence).
GNS – GNS Science, New Zealand Crown Research Institue (CRI) established by the CRI Act (1997).
LIDAR – remote sensing technology using lasers to measure distance
MU – Massey University, New Zealand
MoE – NZ Ministry of Education
MSD – NZ Ministry of Social Development
NZTA – New Zealand national transport authority
Opus – private NZ research provider
OPMSA – Office of the Prime Minister's Chief Science Advisor - www.pmcsa.org.nz
SDC – Selwyn District Council (one of the three territorial authorities impacted by the Canterbury Earthquake Sequence) (*www.selwyn.govt.nz)*
Stanford – Stanford University, California, US (*www.stanford.edu)*
Tonkin & Taylor – private NZ research provider
TEC – New Zealand Tertiary Education Commission
Te Rūnanga o Ngāi Tahu – tribal organisation with traditional authority in the Canterbury region (www.ngaitahu.iwi.nz/te-runanga-o-ngai-tahu*)*
UA – University of Auckland, New Zealand
UC – University of Canterbury, New Zealand
UC Berkeley – University of California, Berkeley campus, US
UO – University of Otago, New Zealand
VUW- University of Victoria, Wellington, New Zealand
WDC – Waimakariri District Council (one of the three territorial authorities impacted by the Canterbury Earthquake Sequence) (*www.waimakariri.govt.nz)*