The University of Sydney

Assessing the potential, application, and implications of volunteered geographic information in disaster risk reduction

by

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School of Geosciences

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DECLARATION OF AUTHORSHIP

I, Billy Tusker Haworth, declare that this thesis titled, '*Assessing the potential, application, and implications of volunteered geographic information in disaster risk reduction*' and the work presented in it are my own. I confirm that:

- This work was completed wholly while in candidature for a research degree at the University of Sydney.
- No part of this thesis has previously been submitted for a degree or any other qualification at this University or any other institution.
- Where I have consulted the published work of others, this has been clearly attributed.
- Where I have quoted from the work of others, the source has been given.
- I have acknowledged all main sources of help.
- Where the thesis is based on work completed by myself jointly with others, I have made clear what was contributed by others and what I have contributed myself.

Signed by Billy Haworth

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Date: 10/10/2016

AUTHORSHIP ATTRIBUTION STATEMENTS

Chapter 2 of this thesis is published as: **Haworth, B.** & Bruce, E. (2015). A review of volunteered geographic information for disaster management. *Geography Compass*, 9(5): 237-250.
I was responsible for sourcing and reviewing the literature, identification of key discussion themes and findings, and writing drafts of the manuscript. The co-author agreed on the research objectives, provided valuable advice and discussions, and reviewed and edited text in a supervision capacity.

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I was responsible for development of the specific methodology including survey design and pilot testing, survey administering and data collection, interpretation and analysis of the data, drafting the manuscript, and the conception and execution of figures. The co-authors jointly agreed upon the research objectives, provided guidance in theoretical, technical and practical elements of survey design and fieldwork methods, and reviewed and edited text in a supervision capacity.

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As supervisor for the candidature upon which this thesis is based, I can confirm that the authorship attribution statements above are correct.

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ABSTRACT

This thesis examines the potential role of volunteered geographic information (VGI) practices in fostering community engagement in disaster risk reduction (DRR). Through various technological innovations citizens can now collect, share and map geographic information for disaster management in unprecedented ways. VGI refers to the widespread voluntary engagement of private citizens in the creation of geographic information, predominantly through sources such as social media, smartphones and inexpensive online mapping tools. VGI represents shifts in the ways geographic information is created, shared, used and experienced. This has important implications for various applications of geospatial information, including disaster management, and geographers, with a broad cross-section of skills spanning modern critical human geography and the technical components of GIS, are ideally positioned to examine the impacts of VGI. VGI technologies enable cost-effective, rapid sharing of diverse geographic information from community members at all stages of the disaster management cycle, including prevention, preparation, response and recovery (PPRR). But VGI also presents new challenges, including issues of data quality, data management, liability and the digital divide. Research in this emerging area has focussed on disaster response while largely ignoring prevention and preparedness. Preparing for disasters dramatically reduces the likelihood of negative impacts on life and property and there is a global need for increased community engagement in DRR. This thesis provides valuable insight into how VGI can contribute to addressing this need, where, particularly in the preparedness phase of PPRR, VGI considered as a social practice and not simply a type of data has potential to aid in building community connectedness, risk awareness and increased disaster resilience.

The objective of this research is to assess the usefulness of VGI in fostering community bushfire preparation engagement and increased disaster resilience, and to ascertain the broader impacts of VGI practices on traditional top-down systems such as emergency management. The thesis has several main components. First, community surveys were completed with residents of bushfire-risk communities in Tasmania to examine bushfire preparedness and the current uptake, usage patterns and limitations of VGI technologies like social media. Results indicated high potential for the use of VGI in community engagement in DRR, but also important challenges related to demographics, usage patterns and trust of online information.

Second, semi-structured interviews were conducted with 13 emergency management professionals to assess their views on how community VGI practices are impacting authoritative emergency management. The study identified key opportunities and challenges of VGI for emergency management, as well as how community-driven bottom-up systems such as VGI can both disrupt and complement authoritative top-down systems.

Third, a novel participatory mapping approach to VGI was employed through community workshops in four Tasmanian communities to assess the user-experience of contributing local information for community bushfire preparation, and the value to individuals of sharing knowledge and mapping collaboratively with other community members for DRR. Workshop observations and questionnaire results provided evidence that participatory mapping of VGI in bushfire management aids the promotion of social inclusion, capacity building and enablement of democratic participation. While the local knowledge exchanged was of value to participants in their bushfire preparedness, the social

quality of VGI appeared to be the most valuable element of participatory mapping. Concerns regarding VGI that arose in the study included issues of data quality, privacy, trust and the underrepresentation of particular individuals or groups in: the study; community bushfire management; and mapping and geospatial datasets.

This thesis develops a multifaceted understanding of the opportunities and challenges of VGI in community DRR and resilience building, as well as the broader implications of VGI on traditional authoritative systems, social systems, and the disciplines of geography and geographic information science. Significantly, VGI disrupts the traditional top-down structure of emergency management and reflects a culture shift away from organisational power, control and regulation of information. The thesis argues changes to traditional systems catalysed by VGI involve decentralisation of power and increased empowerment of citizens, where value can be increasingly recognised in both 'expert' and citizen-produced information, initiatives and practices.

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Version one:
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To any marginalized individual or group who has ever been underrepresented on a map, or any citizen who has ever had their knowledge undervalued, at any time, in any context, as well as anybody who has never had anything dedicated to them, I dedicate this thesis to you.

Version two:
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LIST OF ACRONYMS AND ABBREVIATIONS

ABS – Australian Bureau of Statistics

BRN – Bushfire-Ready Neighbourhoods (Tasmania)

CFA – Country Fire Authority (Victoria)

COAG – Council of Australian Governments

DRR – Disaster risk reduction

FEMA – Federal Emergency Management Agency

EMA – Emergency Management Australia

GIS – Geographic information systems

GIScience – Geographic information science

NSDR – (Australian) National Strategy for Disaster Resilience

NSWRFS – New South Wales Rural Fire Service

OSM - OpenStreetMap

PGIS – Participatory geographic information systems

PPGIS – Public participation geographic information systems

PPRR – Prevention, preparedness, response, recovery

SER – Social-ecological resilience

TFS – Tasmania Fire Service

TFSBSP – Tasmania Fire Service Bushfire Survival Plan

TFWCH – Tassie Fires We Can Help (Facebook page)

UCG – User-generated content

UNISDR – United Nations International Strategy for Disaster Reduction

VGI – Volunteered geographic information

CHAPTER 1: INTRODUCTION

1.1 Volunteered geographic information (VGI)

The world has recently witnessed the rapidly growing phenomenon of user-generated content (UGC) resulting from the advent of the internet and the geoweb 2.0 environment (Elwood *et al.* 2012). Web 2.0 (O'Reilly 2005) refers to the bi-directional online environment where users are able to add their own information to the internet as well as read from it (Goodchild 2007a), and the geoweb is defined as the geographic extension of web 2.0, encompassing geographically related web services, locational technologies and data (Sieber *et al.* 2016). In 2007, Goodchild coined a special case of UGC volunteered geographic information (VGI). VGI refers to the widespread voluntary engagement of large numbers of private citizens in the creation of geographic information (Goodchild 2007b). Ricker, Daniel, and Hedley (2014) argue that while Goodchild's definition explicitly refers to data collection, much of the literature since refers to VGI as also encompassing data presentation and dissemination (e.g. Elwood *et al.* 2012; Bruce *et al.* 2014).

VGI has been facilitated by the development of particular enabling technologies, including Web 2.0 and social media, georeferencing, geotags, GPS, graphics for visualization, broadband communication (Goodchild 2007b), and more recently, cloud storage, and mobile locational platforms and smartphones (Raento *et al*. 2009). Characterized by an increasing variety of practices (Haklay 2013) ranging from contributions made in response to disaster events (Zook *et al.* 2010), to public use of geographic information systems (GIS) and global crowdsourced mapping efforts such as OpenStreetMap (OSM) (Haklay & Weber 2008), and activities motivated by bringing attention to oneself or 'fun', like locating holiday photos on social media (Goodchild 2007b), there is a need for critical research on societal benefits/implications.

VGI can be further defined by its differentiation from both traditional forms of geographic information collection and other forms of UGC. Unlike authoritatively-collected geographic data, VGI typically involves participation without necessarily having geographic expertise or training (Haklay *et al.* 2008), resource costs are comparatively low, data can be collected and disseminated at an increasingly rapid pace, and data quality and accuracy are paramount concerns (Goodchild & Li 2012). In the context of UGC, exemplified by social media sites such as Wikipedia and Facebook, VGI is that subset that concerns the explicit characterization of the geographic domain or any other information that has been associated with a geographic location (Elwood *et al.* 2012).

Differentiation between active and passive sensing has been described through a typology of VGI (Table 1) offered by Craglia, Ostermann and Spinsanti (2012). They posit that volunteering can be explicit or implicit, and so too the geographic location can be either explicit or implicit in VGI. In the latter, geographic location is not the main focus, such as a Tweet mentioning a place in the context of another

(non-geographic) topic. 'True' VGI in the strictest sense is information that is explicitly volunteered and explicitly geographic, such as OSM (Craglia *et al*. 2012). However, implicit VGI is being increasingly utilised for geospatial research (Senaratne *et al.* 2016).

Table 1: Typology of VGI (modified from Craglia *et al.* 2012, p.405).

	Geographic	
	Explicit	Implicit
Explicitly volunteered	'True' VGI in the strictest sense. E.g. OpenStreetMap	Volunteered (geo)spatial information. E.g. Wikipedia articles about non-geographic topics, which contain place names
Implicitly volunteered	Citizen-generated geographic content. E.g. any public Tweet referring to the properties of an identifiable place	Citizen-generated (geo)spatial content such as a Tweet simply mentioning a place in the context of another (non-geographic) topic

VGI represents unprecedented shifts in the content, characteristics, and modes of geographic information creation, sharing and use. Despite concerns over the digital divide, data quality and trustworthiness, VGI has potential application to research questions in all areas of the geography discipline (Elwood *et al*. 2012). This emerging field has important implications for what GIScience, geography and social practices will look like in the future, and has been linked to the concept of neogeography (see Sui 2008; Haklay *et al.* 2008; Goodchild 2008). Neogeography denotes the proliferation of web-based geographic information technologies and the precipitated phenomenon of 'lay-people' or non-experts creating their own geographic content and maps (Leszczynski 2014). But what is the role of the expert geographer when those in the general public can now easily create their own geographic data and maps? Some have argued VGI is both exciting and worrisome; exciting for the opportunities associated with a dense network of individual, intelligent observers, and worrisome as the identity of geography as a discipline is becoming increasingly blurred and the implied assumption that geography is about describing the world rather than understanding and explaining it (Elwood *et al.* 2012). The notion of software encompassing the skills of the geographer has prompted criticism concerning trivialisation of the geographic discipline (Leszczynski 2014). Neogeography has been critiqued for its instrumentalist reductionism of geography, but Leszczynski (2014) highlights the social implications of the *neo* component of this concept. There is a need to explain why geography is more than map-making, and why the methods of geographers are powerful and far from intuitive (Goodchild 2008). While neogeography is about collection and compilation of geographic information and facts with no further analyses, expert geography is an enterprise of knowledge production, involving

differentiation between spatial relationships of contingency and causality and the devising of explanatory spatial theories (Goodchild 2009; Leszcynski 2014). Critical geographers have experience and skills that non-experts lack, allowing for filtering of the most important trends from noisy data; geographers help put context and local meaning back into big data. Geographers, with a broad cross-section of expertise spanning technical components of GIScience as well as the critical and social dimensions of modern human geography, are ideally-positioned to examine the opportunities, limitations, and broader impacts of VGI (Elwood *et al.* 2012). While Connors *et al.* (2012) argue there are benefits of diverse participants including citizens contributing to new knowledge discovery and multimodal interaction, there remains a need for geographers to engage in research and critique of the social dimensions and implications of such diverse participation.

1.2 VGI in disaster management

GIS and geospatial data play a crucial role in disaster analysis and management with elements at risk, such as infrastructure and populations, existing as spatial entities conducive to spatial modelling, GIS analyses, and mapping (Klonner *et al.* 2016). Shifts associated with VGI towards greater public involvement in GIS and in how geospatial information is produced, disseminated, used, and experienced have important implications for various applications, including disaster management[1].

Research so far has emphasized the role of VGI in disaster response (Klonner *et al.* 2016). The presence of both researchers and volunteers is concentrated in response to crises, as opposed to during mitigation or preparedness activities, likely related to response being more visible and prominent, especially in the media (Klonner *et al.* 2016). Examples include: the global volunteer mapping effort which assisted the humanitarian response to the 2010 Haiti earthquake (Meier 2012); the use of crowdsourced-mapping and social media for capturing community information and communicating with impacted people in response to cyclones and floods in QLD in 2010/11 (McDougall 2011; Taylor *et al.* 2012; Bird *et al.* 2012); and the role of VGI as an alternative information source to authoritative disaster information during fires in Santa Barbara in 2007-2009 (Goodchild & Glennon 2010), and Tasmania in 2013 (Irons *et al.* 2015).

There are, of course, both great opportunities presented by VGI in disaster management, as well as challenges and implications. Studies have reported timely information exchange and promotion of community connectedness (Taylor *et al.* 2012), the collection of data in near-real time without limitations of other geospatial technologies, such as satellite imagery being obstructed by weather (Triglav-Čekada & Radovan 2013), collection of complimentary geospatial data in regions where other data are poor or absent (McDougall 2011), and the ability of individuals to volunteer and participate from outside the impacted disaster location (Whittaker *et al.* 2015) as some of the unique opportunities

[1] Varying terms have been adopted in the literature to denote the concept of *disaster management*, including *emergency management* and *crisis management*. In this thesis the terms are used interchangeably to refer to the general practice of managing people and resources to lessen the human impacts of hazardous events.

presented by VGI. Examples of reported challenges include issues of source credibility and data quality (Ostermann & Spinsanti 2011; Goodchild & Li 2012), information and personal security (Shanley *et al.* 2013), data management, perceived legal concerns associated with privacy and liability (Scassa 2013), and the underrepresentation of particular groups and individuals through the notion of the digital divide (see Van Dijk & Hacker 2013; Sui *et al.* 2013).

But there is more to be said of the impacts of VGI in disaster management beyond a simple binary classification of opportunities and challenges. Disaster management follows a 'command-and-control' model, and these "do not easily adapt to the expanding data-generating and –seeking activities by the public" (Palen & Liu 2007, p.727). McLennan and colleagues (2015) argue instances of VGI or 'digital volunteering' in emergency management have thus far largely occurred outside of formal emergency management systems. To adequately explore these and other issues related to VGI in disaster management in the subsequent chapters of this thesis, background understanding is required on the current structure, approaches, and goals of disaster management upon which VGI might be impacting.

1.3 Disaster management in Australia

Historically, disaster management has been conducted for, not with, the community[2] following a para-military, top-down, command-and-control model (Pearce 2003; Palen & Liu 2007). Prior to the end of the twentieth century, emergency management was an enterprise concerned largely with the hazard event itself (Buckle 1999). Disaster thinking has since progressed to placing increased emphasis on humans and their vulnerabilities as causative factors (Manyena *et al.* 2011; Wisner *et al.* 2003). Alongside this, the focus of disaster management also shifted from emergency response, to recognizing the importance of mitigation, and the possibility of increased public participation (Pearce 2003). Pearce (2003) reports disaster management policies came to recognize that public participation in combination with both disaster management planning and community planning results in sustainable hazard mitigation. This recognition was evident in the Hyogo Framework for Action 2005-2015, a major policy document adopted by 168 countries which emphasized community resilience-building for effective disaster management (UNISDR 2005), and its successor, the Sendai Framework for Disaster Risk Reduction 2015-2030, which focuses on community participation and disaster risk management as opposed to disaster management (UNISDR 2015). Disaster management has gradually moved beyond a purely top-down bureaucratic model to become a more collaborative activity and dynamic enterprise

[2] The meaning of the term *community* has been contested. In emergency management, community most often refers to a geographic area, e.g. a town or suburb. In this thesis I adopt this general classification in part but also recognise and emphasise that other types of communities exist, such as cultural, business, or virtual communities. Mulligan *et al*. (2016) refer to a blurring of the 'local community' through increased citizen mobility and the concept of 'translocalism' with community members drawing on a wide array of knowledge and economic, social and cultural capital to enhance community resilience, which may not come from within a geographic community boundary. I use the term community to denote any group of people sharing a common interest. For the purposes of disaster management, a common interest may be risk exposure, and thus a *community* often is represented by a geographic area.

that facilitates multi-organizational, intergovernmental, and intersectoral co-operation (Waugh & Streib 2006).

In Australia, these shifts have led to a philosophy of shared responsibility, primarily driven by the Victoria Bushfires Royal Commission (McLennan & Handmer 2012; Teague *et al.* 2010). As a principle it implies increased responsibility for all concerned (being the state, municipal councils, the private sector, individuals, household members and the broader community) and a focus on community safety. As such, disaster management now places greater emphasis on community engagement and disaster risk reduction (DRR).

The notion of disaster resilience has come into vogue in recent decades. This is partly in response to concerns that the language of 'vulnerability' is disempowering for communities, but also increasing governmental expectations that communities will take greater responsibility in emergencies and disasters (Cretney 2014). Resilience has been interpreted in many ways, but a geographic perspective regards resilience as "the capacity of hazard-affected bodies to resist loss during disaster and to regenerate and reorganize after disaster in a specific area in a given period" (Zhou *et al.* 2010, p.28). The Australian National Strategy for Disaster Resilience (NSDR; COAG 2011) avoids defining resilience, describing instead "common characteristics of disaster resilient communities, individuals and organizations," which include functioning well while under stress, successful adaptation, self-reliance, and social capacity (p.5). A disaster resilient nation is said to be one that can recognise current and future risk, reduce and manage those risks, and is better-able to recover from disasters (COAG 2011). Current disaster management in Australia aims to achieve community disaster resilience through the model of Prevention, Preparedness, Response, and Recovery (PPRR) (Posser & Peters 2011). PPRR, also termed *the comprehensive approach*, refers to aspects of disaster management rather than discreet sequential phases (Abrahams 2001). Prevention represents regulatory and physical measures aimed at preventing emergencies, which might include land use planning and building design; preparedness denotes arrangements to ensure that individuals and communities are prepared for potential disaster impacts, and that all resources and services which may be needed to cope can be mobilized and deployed in a timely manner; response refers to actions taken during and immediately after a disaster event to ensure impacts are minimized and that people affected are provided immediate relief and support; and recovery is the coordinated process of supporting disaster-affected communities in rebuilding physical infrastructure and restoring emotional, social, economic and physical well-being (Abrahams 2001).

1.4 Bushfire

This thesis examines bushfire disaster as a specific case study. Also referred to as *wildfire* or *forest fire* internationally, bushfire refers to uncontrolled fires that burn in grass, bush, or forested areas. Bushfires originate from both natural causes and human activities, with common sources being lightning strikes, fires lit accidentally, and arson (Beale & Jones 2011; GA 2016). While VGI has relevance to all disasters, unlike other hazards which are less predictable, such as volcanic eruptions, flooding or earthquakes,

bushfire has a known annual period of heightened risk that communities can prepare for, and like VGI, preparation is inherently centred on community participation, and thus fire provides a unique case study through which to examine the contributions of VGI.

1.4.1 Bushfire in Australia

Bushfires threaten communities each year and represent one of the greatest environmental threats in Australia (Beale & Jones 2011). Fire is an inevitable part of the landscape due to climate, vegetation, and ignition sources, with Australia considered one of the most fire-prone regions in the world (Frandsen 2012; DPAC 2013). Many natural ecosystems have evolved with fire, with numerous plant species dependent on fire to regenerate, while many native species are extremely fire prone and combustible (GA 2016). Fire is both feared and exploited in Australia, with fire used as a land management tool historically by indigenous populations, and in the present day for agricultural purposes and to protect properties from extreme fire events (GA 2016).

Though bushfires in Australia are not new, recent pressures have exacerbated risk conditions. Population growth, particularly into areas of urban-bushland interface where the greatest potential for loss of life and property exists (McAneney *et al.* 2009), and the effects of climate change increasing temperatures and susceptibility to droughts have resulted in many societies experiencing new and/or intensified bushfire risk exposure (Frandsen 2012). The combination of changing frequency and intensity of severe fire weather periods and potential for growth, accumulation and reduced moisture content of vegetation fuel load (Grose *et al.* 2011) with increased exposure of human populations to bushfire risk associated with expanding peri-urban settlements (Gill *et al.* 2015) presents further challenges for emergency management. Major bushfire disasters have devastated numerous communities in recent years, including fires in South Australia in 2015 (Every *et al.* 2015), the New South Wales Blue Mountains region in 2013 (Rich *et al.* 2016), the Tasman Peninsula in Tasmania in 2013 (Irons *et al.* 2015), and in Victoria in 2009 (see Whittaker *et al.* 2016). The latter, termed the Black Saturday fires, is regarded as the worst Australian natural disaster in recorded history, killing 173 people (Frandsen 2012). The number and extent of fires in Australia is also placing pressures on ill-adapted ecosystems and compromising ecosystem services such as the yield of clean water (Beale & Jones 2011).

Accompanying increases in risk have been changes to approaches in emergency management from agency service response to risk mitigation and building community resilience (see section 1.3), resulting in mitigation activities forming a key part of fire agencies' remit. Mitigation activities reduce the probability of a hazard becoming a disaster with negative consequences (Jakes *et al.* 2004), and includes physical activities such as controlled burning, structural activities such as enforcing building standards, and risk communication through preparedness information and delivering warnings (Frandsen 2012).

Increasingly in Australia, communities and individuals are encouraged to manage their own bushfire risk in line with the policy changes towards shared responsibility and community resilience. A key focus here is increasing community and household preparedness. Media campaigns, such as the New South Wales

Rural Fire Service's "*I Am Fire"* public awareness campaign launched in 2015 (NSWRFS 2015), attempt to promote preparedness for bushfire by highlighting and personalizing potential negative consequences and providing relevant information for individuals to make their own bushfire survival plans. However, research has shown that providing communities with relevant information alone is ineffective in fostering meaningful and active disaster preparation engagement (Paton 2003). Given there are other threats with higher probability of occurrence in an individual's life, such as the risk of structural fires or car accidents, managing bushfire risk may be considered lower priority and advice is often ignored (McAneney *et al.* 2009). As such, alternative models with greater emphasis on community participation are being developed and implemented, reflecting broader shifts in disaster management with community participation considered a fundamental principle of DRR and resilience building (UNISDR 2015; COAG 2011). One such model is the community development approach to bushfire preparation adopted by the Tasmania Fire Service (TFS), which is presented in the next section.

1.4.2 Bushfire management in Tasmania

Environmental conditions in Tasmania are conducive to elevated bushfire risk, particularly in recent years with low rainfall and higher-than-average temperatures (BNHCRC 2015). Tasmania has experienced a number of significant bushfire events since European settlement, with the most devastating occurring in 1967. Over a period of 24 hours, 264,270 ha of land burned, over 1,400 homes were destroyed, and 62 people died (DPAC 2013). While events of this magnitude are infrequent, their impacts on communities are devastating and long lasting; the 1967 fires are still recalled today, even by people who weren't present (Frandsen 2012). Bushfire is the most economically disastrous of all natural hazards in Tasmania, and large bushfires in 2013 south east of Tasmania's capital, Hobart, caused damage in the order of $100M (DPAC 2013). The 2013 bushfire disaster has been a major influence on how the TFS continues to manage bushfire, with increased effort and resources given to improving risk reduction and community engagement in bushfire preparation.

1.4.2.1 Community engagement and Bushfire-Ready Neighbourhoods

Following a successful research based pilot program (Frandsen 2012; Frandsen *et al.* 2011), the TFS established the Bushfire-Ready Neighbourhoods (BRN) program. BRN adopts a community development approach to engaging Tasmanian communities at bushfire risk in DRR, aiming to enable people to develop their own bushfire survival plan and be better prepared for the bushfire season through increased community disaster resilience (TFS 2014). Participating communities are selected based on bushfire risk, capacity to participate, and community interest, with bushfire education and activities tailored to meet the local needs of each community. BRN activities include information sessions and community forums, workshops, field days, bushfire rehearsals, women's programs, establishment of local BRN groups, and property assessments (TFS 2014).

Recognizing that VGI practices and technologies are becoming increasingly commonplace in communities for creating and sharing information, with particular relevance to disaster scenarios, BRN has recently become interested in how these technologies can complement their existing community

engagement activities. In particular, community use of social media during the 2013 bushfire disaster has been highly influential. One Facebook page, "*Tassie Fires We Can Help*", attracted mass community support and interaction. The page facilitated the coordination of community information, resources, and activities from outside the disaster-affected region, which allowed a wide range of tasks to be completed by the public to assist with the disaster response, while at the same time highlighting gaps in the authoritative emergency response (see Irons *et al*. 2014; ABC 2013).

BRN is ideal to engage with as a case study for this thesis, aiming to examine the application of VGI in community disaster preparation, due to the combination of the TFS community development approach to community disaster preparation with their interest and recent experience with VGI platforms like social media. Furthermore, the combination of an extensive bushfire history, current high risk conditions and potential for more intense and prolonged risk as a result of climate change, and continued migration of people into peri-urban areas (Frandsen 2012), provides rationale for Tasmania as a site for studies concerning community disaster safety more broadly.

1.5 Aims and objectives

VGI technologies and practices provide significant opportunities and challenges for various fields, including disaster management, and further exploration of these is warranted. To date, research into VGI and disasters has focused on crisis response in isolation of prevention and preparedness applications (Haworth & Bruce 2015; Klonner *et al.* 2016). Yet, there is a global need to determine new methods for increasing community engagement in disaster preparation and prevention, particularly for regions where risk is persistent and foreseeable, such as the bushfire prone areas of Tasmania. Further, changes associated with VGI have broader implications for the disciplines of geography and GIScience, and social systems more broadly, and these too demand further critical geographical examination.

Considering the above statements, the scientific objective of this research is to assess the usefulness of VGI in fostering community bushfire preparation engagement and increased disaster resilience, and to ascertain the broader impacts of VGI practices on traditional top-down systems such as emergency management. More specifically, the thesis aims to address the following research questions:

1. What is the potential for use of VGI in fostering community engagement in bushfire risk reduction, based on technology uptake, community interest, and present limitations?
2. From the perspectives of emergency management professionals, what are the key opportunities and challenges of VGI, and how can community VGI practices and traditional authoritative disaster management operate better together?
3. Does the process of mapping local knowledge for bushfire preparation with other community members as a shared practice contribute to increasing an individual's awareness and understanding of local bushfire risk, their social connectedness, and engagement in DRR?

Disaster management provides a useful lens through which to examine the impacts of VGI on traditional systems more broadly, as the benefits and limitations of VGI are intensified in a disaster management

context. Further, the top-down model of information control and service delivery adopted by authoritative emergency management is akin to other institutional systems impacted by VGI, such as governance structures or geographic science and map-making.

1.6 Thesis structure and general methodological workflow

The main body of the thesis is composed of seven chapters, including this introduction and a final chapter of conclusions. Chapters two through six are prepared as scientific journal articles, forming a compilation thesis by publication. The status of each article, whether published or submitted/in review, is provided under the authorship attribution statement. Figure 1 presents the general outline and workflow of the thesis, emphasizing new research contributions throughout, the content and methods adopted in each chapter, and how the various components of the thesis interrelate and inform others.

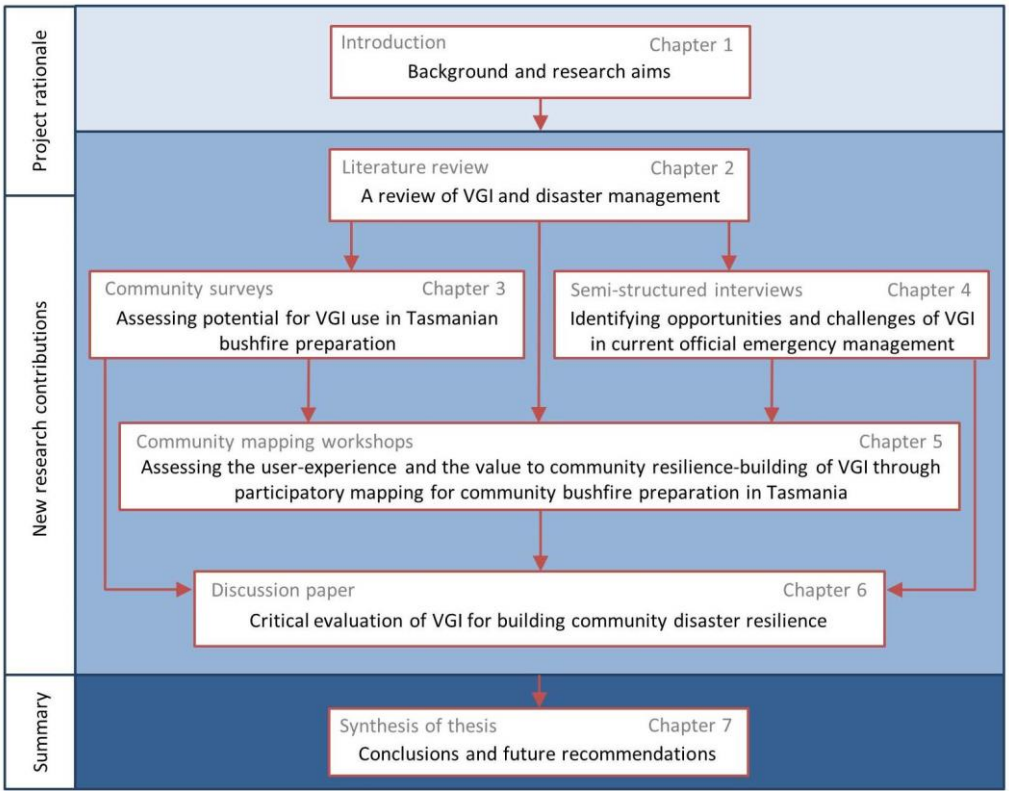

Figure 1: Structure of thesis, including main chapter content, methods, and general workflow.

Following this introduction is a detailed literature review of the current field of VGI and disaster management (Chapter 2). The review takes a thematic approach to examining the emergence of VGI in disaster management, key studies, key opportunities identified in the literature, as well as important limitations for VGI in disaster management. It is not the intent of this chapter to document all relevant literature systematically, but rather to provide a context for this research and present the current state of knowledge. Significantly, the chapter identifies key areas for further geographical enquiry, thus

constituting new research findings, including the need for further research in the pre-event phases of disaster management. This chapter has been published as a review article in *Geography Compass*. Additional literature is reviewed throughout the thesis to identify gaps in existing knowledge, with review and discussion of key concepts appearing in the chapters where most relevant, for example, community engagement (Chapters 3 and 5), citizen science (Chapter 4), community mapping and participatory GIS (Chapter 5), and the history and application of 'resilience' (Chapter 6).

Chapter 3 assesses the potential role of VGI in fostering community engagement in bushfire preparation in Tasmania through the use of community surveys and addresses research question 1. Gaining perspectives from residents in 12 communities at bushfire risk across various regions of Tasmania, the survey addresses key elements informing the usefulness of approaches using VGI in disaster preparation activities, including community uptake of the technologies, community interest in using VGI for bushfire management, and current limitations to use. The study presented in this chapter builds an evidence base for the potential utilization of VGI in strengthening bushfire resilience through community engagement and provides directions for further research. The content in this chapter has been published as a research article in *The Australian Journal of Emergency Management*.

Chapter 4 examines the perspectives of emergency management professionals on the perceived opportunities and identified challenges VGI presents to current authoritative disaster management. This study was not limited to Tasmania or to bushfire. While the thesis adopts a case study of bushfire in Tasmania to assess the potential use and implications for community members of VGI in disaster preparation, the impacts of VGI on authoritative emergency management are relevant to those operating beyond bushfire and Tasmania, and the experiences of professionals in other locations and emergency contexts translates to the case study of this thesis. Semi-structured interviews conducted with 13 emergency management professionals from eight organizations across five Australian states provided insights into the impacts of VGI on official emergency management. The chapter directly contributes to answering research question 2. The key contributions of the chapter involve drawing on the interview data analysis to discuss implications of VGI on top-down systems more broadly, and proposing ways forward for more effective utilization of VGI alongside and within authoritative emergency management. This chapter has been published as a research article in *Computers, Environment and Urban Systems*, in a special themed issue on *Advances in Geospatial Emergency Management*.

Chapter 5 draws upon the findings of chapters 2, 3, and 4 to test the application of VGI in community bushfire preparation in a practical setting, namely participatory mapping workshops in four Tasmanian communities. The chapter provides rationale for a participatory mapping approach in examining VGI, providing commentary on the positioning of VGI within the critical geospatial knowledge domain with particular reference to other established fields such as public participation GIS. The study examines VGI as a social practice and not simply a data source by considering the user experience of contributing VGI and the potential for these activities to increase community connectedness for building disaster

resilience. Each workshop included a paper-based mapping activity and an online digital mapping exercise, with a questionnaire used to evaluate outcomes. This chapter addresses research question 3 and has been published as a research article in *Applied Geography*.

Chapter 6 presents a critical evaluation of VGI for building community disaster resilience. This discussion chapter considers the findings of the studies undertaken in chapters 3, 4 and 5, as well as the literature surveyed in chapter 2, to provide analysis on how VGI contributes to increasing disaster resilience, but also how VGI practices can operate to undermine or erode resilience building processes. The paper examines how resilience thinking can better inform the development of public participation platforms and understandings of the motivations and requirements of such initiatives. The resilience perspective is adopted to provide a contextual framework for critical evaluation of the role of VGI and participatory mapping practices in disaster management. The paper emphasizes significant concerns remain over the social consequences of VGI practices that need critical analysis in ensuring VGI becomes a more effective resource in building community disaster resilience. The chapter is structured as a research article and the corresponding manuscript has been submitted to *ACME: An International Journal for Critical Geographies,* where it is currently under review for potential publication.

Chapter 7 summarizes the key findings of the thesis, including responses to the scientific objectives and aims outlined in section 1.5. It offers general conclusions on the broader implications of VGI for traditional systems such as emergency management and the discipline of geography, and proposes directions for future work.

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CHAPTER 2: A REVIEW OF VOLUNTEERED GEOGRAPHIC INFORMATION FOR DISASTER MANAGEMENT

This chapter corresponds with the following publication (see Appendix A):

Haworth, B. & Bruce, E. (2015). A review of volunteered geographic information for disaster management. *Geography Compass*, 9(5): 237-250.

2.1 Abstract

The immediacy of locational information requirements and importance of data currency for natural disaster events highlights the value of volunteered geographic information (VGI) in all stages of disaster management, including prevention, preparation, response, and recovery. The practice of private citizens generating online geospatial data presents new opportunities for the creation and dissemination of disaster-related geographic data from a dense network of intelligent observers. VGI technologies enable rapid sharing of diverse geographic information for disaster management at a fraction of the resource costs associated with traditional data collection and dissemination, but they also present new challenges. These include a lack of data quality assurance and issues surrounding data management, liability, security, and the digital divide. There is a growing need for researchers to explore and understand the implications of these data and data practices for disaster management. In this article we review the current state of knowledge in this emerging field and present recommendations for future research. Significantly, we note further research is warranted in the pre-event phases of disaster management, where VGI may present an opportunity to connect and engage individuals in disaster preparation and strengthen community resilience to potential disaster events. Our investigation of VGI for disaster management provides broader insight into key challenges and impacts of VGI on geospatial data practices and the wider field of geographical science.

2.2 Introduction

Natural disaster events, such as the recent Typhoon Haiyan in the Philippines, floods and bushfires (wildfires) in Australia, or Hurricane Sandy in the United States, remind us of the importance of geospatial data and the need for timely and reliable communication in all aspects of disaster management. New opportunities for the creation and dissemination of important disaster-related geographic data from a dense network of intelligent observers are now provided through online user-

generated geospatial data termed volunteered geographic information (VGI) (Goodchild 2007; Elwood *et al*. 2012). Like geographical information systems (GIS), VGI involves the sharing and mapping of spatial data, however through voluntary information gathered by the general public. Though, extant debates question the appropriateness of the adjective 'volunteered' noting differences between crowdsourced data that is actively contributed with the individual's awareness and user-generated data that is harvested otherwise (Harvey 2013; Stefanidis *et al*. 2013). Similarly, definitions of the 'general public' and who produces VGI are often blurred (Budhathoki *et al.* 2008), with contributions coming from disparate sources (Haklay 2013a; Coleman *et al*. 2009; Schlossber & Shuford 2005). VGI represents various opportunities and threats for traditional data production systems, as summarised by Genovese and Roche (2010), some of which are particularly relevant to disaster management, including the opportunity for citizens to actively contribute to public issues with personal local knowledge and the threat that VGI may reduce the importance of authoritative mapping.

Disasters create a time-critical need for geographic information that is unlike the normal pace with which geographic information was traditionally acquired, compiled, and disseminated, and VGI is ideally suited to fill the need for near real-time information (Goodchild & Glennon 2010). Management of disasters follows the four phases of the disaster lifecycle: prevention, preparedness, response, and recovery (PPRR) (Abrahams 2001; Zakour & Gillespie 2013; Crondstedt 2002). Reduction of negative impacts of disasters requires improving approaches in all four phases (Zakour & Gillespie 2013). Through rapid exchange of geographic information between authorities and citizens for disaster response, and promoting connectedness and community engagement in disaster preparation practices, VGI can contribute to all phases of disaster management. Further, digital humanitarianism can add to traditional systems with techniques such as crowdsourcing, remote volunteer collaboration, and 'crisis mapping' (Burns 2015). Authorities and individuals are already exploiting VGI technologies, both for communicating disaster-related information (see Taylor *et al.* 2012; Bird *et al*. 2012; St. Denis *et al.* 2012) and for collating and mapping relevant geospatial data (see Meier 2012; Ziemke 2012; McDougall 2011; Liu & Palen 2010). This has created a new landscape of geo-data production and knowledge sharing for disaster management, generating a need for researchers to explore and detail the implications of these data and data practices.

This article aims to review the current state of research in this field. The intent of this paper is not to exhaustively document all related literature, but to offer a context for future thinking. An outline of key themes in VGI and disaster research is presented here, with emphasis on present limitations and potential areas for further geographical enquiry. We acknowledge that this review emphasises the post-disaster application of VGI over prevention and preparedness. This is a product of the current state of academic literature in this field and is in itself an important finding which we discuss later in the paper.

The VGI phenomenon may be one of the most important to impact the discipline of geography in recent years, and the associated changes in the production and sharing of geographic information are not just

pertinent to the field of natural disasters, but also the broader discipline of GIScience, with geographers in a unique position to examine the impacts of VGI (Elwood *et al.* 2012).

2.3 A brief background to VGI and disasters

VGI is defined as the widespread engagement of large numbers of public citizens in the creation of geographic information (Goodchild 2007). User generated content (UGC) is exemplified by social media sites such as Twitter and Facebook, and VGI in this context is that subset of UGC that contains a geographic reference, either explicitly or implicitly (Craglia *et al.* 2012; Elwood *et al.* 2012). The voluntary nature of data production distinguishes VGI from other spatial UGC (Elwood et al. 2012). Efforts to theorise why individuals volunteer information (see Poser & Dransch 2010; Goodchild 2007; Haklay 2013a; Budhathoki & Haythornthwaite 2013; Starbird & Palen 2011) note that motivations for volunteering or withholding will shape the dynamics of inclusion and exclusion in VGI development and influence data content (Elwood 2008b; Leszczynski 2012; Thatcher 2013; Stephens 2013).

Recent spatially enabling technologies including Web 2.0, georeferencing, geotags, global positioning systems and broadband communication have enabled mass proliferation of UGC via the internet and allowed citizens to produce maps using free or inexpensive online resources, giving rise to VGI (Goodchild 2007). Further, smartphones equipped with location and data recording sensors have enabled near-instant geospatial data collection and dissemination using mobile platforms (Raento *et al.* 2009; Lane *et al.* 2010).

The ease of volunteers to create and publish geographic information combined with the need for rapid communication during crisis events has created a new disaster management context (Goodchild & Glennon 2010; Wald *et al.* 2011). Emerging social media platforms are changing the way people create and use information for crisis events (Ostermann & Spinsanti 2011; Liu & Palen 2010) with significant increases in the uptake of internet-based communication technologies reported during recent disaster events (e.g. Fraustino *et al.* 2012).

The growth of VGI has begun to transform not only practices of technology use for disaster communication, but also attitudes towards the value of user-generated online geospatial data and technologies. For example, in response to flooding in Queensland in 2011, the Australian Broadcasting Corporation utilised data volunteered online by citizens to produce maps of crisis incidents in what was referred to as “an experiment in gathering information from the community” (Middleton 2011). In contrast, responding to bushfires in January 2013, the New South Wales Rural Fire Service Commissioner urged “people to stay plugged into social media” (AAP 2013). This reference from authority to social media as a source to trust for crisis information came just two years after it was referred to as experimental, emphasizing the recent and rapid emergence of VGI technologies in the emergency response space. This shift reflects the growing number of citizens seeking to access online technologies for sending and receiving disaster information, and in turn the response, and often

expectation, of many official agencies to exploit these technologies for connecting with citizens (e.g. St. Denis *et al.* 2012).

The era of 'big data' defined by the exponentially increasing "volume, velocity and variety" of data (McNeely & Hahm 2014) has also resulted in the emergence of new tools for data curation, management and analysis (Fischer 2012; Kitchin, 2013) with significant potential for disaster management. Although VGI contributes to only one of the three categories of big data sources identified by Kitchin (2013), directed, automated and volunteered, the myriad of challenges and vulnerabilities presented by big data have implications for the application of VGI in disaster management. In supporting disaster management, methods for big data analytics need to optimize the collation of contextual information, contribute to understanding causal mechanisms, and recognize the underlying social processes that are not easily represented, characterised or interpreted using big data technologies.

As individuals and authorities continue to utilise VGI for disaster management, important challenges need to be overcome. In the following sections we present discussion on key issues for the uptake of VGI in disaster management, including questions of data collection and dissemination, data quality and security, data management, and the notion of empowerment.

2.4 Data collection and dissemination

The emergence of VGI has created a new platform for collection and dissemination of information for disaster management. Authorities can now rapidly communicate important time-critical geographic disaster-related information directly with the public at a fraction of the logistical and resource costs of traditional communication methods. VGI also presents unique ways for the general public to contribute and map important geospatial information for crisis management and engage directly with authorities and each other in alternative ways, even if they are located outside the potentially affected areas (see Meier 2012; Crowley & Chan 2011; St. Denis *et al.* 2012).

The internet is well structured to facilitate collaboration among individuals, thus increasing utilization of knowledge assets by reducing limitations such as high costs associated with traditional geographic information production (Flanagin & Metzger 2008; Meier 2012). The collection of large amounts of near real-time information by individuals at the disaster location (Gao *et al.* 2011), and the dissemination of information from relief agencies *(*Abbasi *et al.* 2012) have been shown to be critical for effective response efforts. VGI postings were demonstrated to provide an alternative to official sources during the Santa Barbara wildfires of 2007-2009 with significant time efficiency in the collation and sharing of information (Goodchild & Glennon 2010). A shift away from traditional cartographic practices and protocols has important implications for information contributions during disasters and the role of geographic information producers. The production of disaster-related information is no longer simply an expert's game for those organizations that can resource the acquisition of authoritative data. The

emergence of VGI has enabled anybody with access to the technology to contribute in a new disaster management context that has seen knowledge-users become knowledge-producers, or "produsers" (Coleman *et al.* 2009; Budhathoki *et al.* 2008).

There is value in the depth of information and immediacy gained through people from a breadth of backgrounds contributing and disseminating disaster related information. This was emphasized during the 2007-2009 Santa Barbara wildfires (Goodchild & Glennon 2010) and the 2010/2011 Queensland floods (McDougall 2011). The Queensland flood events were characterised by an unprecedented use of social media to report incidents as they happened (McDougall 2011; Bird *et al.* 2012), and flood extent mapping for rudimentary post disaster assessment was enabled by VGI through geotagged images and social media content. VGI contributors with personal cameras and mobile phones often have the advantage of being in-situ at the disaster location capturing near real-time data without the constraints associated with other forms of technology, such as cloud-obscured satellite imagery (Triglav-Čekada & Radovan 2013).

Sharing content online facilitates fast and broad information mobility. VGI collection and dissemination through social media in particular has an inherent ability to promote or propagate messages (e.g. Gao *et al.* 2011). During the 2010/11 Queensland floods a high level of re-sharing of social media posts was reported, particularly of those publically expressing gratitude for emergency services, even well beyond the disaster, indicating a significant form of emotional engagement with the acute event (Shaw *et al.* 2013). Technologies and the capacity to spread individual information are allowing individuals to engage, and remain engaged, with crisis events in unprecedented ways. For disaster recovery, there is a need to consider how this new context of engagement may impact the efforts of individuals to recover or 'move on' following a disaster.

It is important to recognise that the same mechanisms enabling messages of support and emergency information to be shared widely and quickly can also work to propagate misinformation, malicious and/or false content. This issue needs to be understood in the broader context of traditional geospatial data dissemination and efforts should be made to comprehend how these new data sharing practices are impacting the veracity of geographic information as it proliferates through the online arena.

2.5 Data quality and security

Security and data quality are major concerns for VGI. Individual's physical and online security may be compromised by utilising low-quality VGI. Data from (often) untrained individuals with varying agendas and experience often suffers from an absence of quality assurance (Goodchild & Li 2012). *S*tudies have highlighted the importance of data verification by reporting on issues of quality control, misinformation, spurious or fraudulent postings, duplicate and doctored images, and the lack of 'right' information for disaster relief (see McDougall 2011; Bird *et al.* 2012; Fraustino *et al.* 2012; Ostermann & Spinsanti 2011; Gao *et al.* 2011; Triglav-Čekada & Radovan 2013*).* Despite these concerns, it has been noted that in some contexts, such as the 2010 Haiti earthquake which occurred with a void of quality authoritative

geospatial data, crowdsourced maps produced with volunteered data can be the most comprehensive and up-to-date information available (Meier 2012; Crowley & Chan 2011). In this section, issues of data quality and security are discussed with particular reference to credibility. We then outline and critique reasons why VGI has been recognised for its capacity to complement authoritative datasets.

The lack of adequate security features associated with VGI is a concern pertinent to natural disaster management (Gao *et al.* 2011; Shanley *et al.* 2013). The nature of VGI is that it is often made openly available to the general public. Data of this nature may be particularly compromising during a disaster event, especially when those affected are at their most vulnerable and privacy may be less of a priority than in 'normal' circumstances (Crawford & Finn 2015). For example, a geotagged image of a disaster impacted property provides useful information to emergency authorities if shared through social media, but that same locational information about a vulnerable and potentially vacant property may also be available to those with malicious intent. In the hostile environment of the 2011 humanitarian crisis in Libya, two crowdsourced maps were produced to mitigate security issues; one was password protected for humanitarian workers, and the other contained heavily edited information for the public on a 24-hour time delay (Meier 2012). Crawford and Finn (2015) assert that while it could be assumed people can manage their own privacy settings on public platforms, many are not well-informed about who can access the data they contribute.

Furthermore, authorities acting on information posted by members of the public, without credibility assurances, may potentially be exposed to risks beyond those already associated with the hazard event (Shanley *et al.* 2013). Goolsby (2013) argues disaster responders, relief workers, and digital volunteers who provide support for crisis events should be particularly cautious in regards to social media as a source of VGI. In a study of information posted on Twitter during various high impact events, Gupta and Kumaraguru (2012) showed just 17% of event-related tweets contained credible information, while 13.5% was spam (the rest was either not credible or event-related but not useful, i.e. personal opinions). Uncertainty surrounding credibility of online data and data sources is contiguous with uncertainty surrounding online security. Anxiety associated with data security and privacy of volunteered information may prevent individuals from contributing during a disaster and may limit the uptake and capabilities of the technologies for official emergency agencies (Shanley *et al.* 2013; Crowley & Chan 2011).

Credibility of data and data sources is thus a concern for VGI in disaster management. Flanagin and Metzger (2008) highlight the difficulty in locating and authenticating digital information sources and the lack of quality control standards as key issues for credibility. By making it possible for more people from a diverse range of groups to produce more data in digital form, the heterogeneity and sheer volume of information and information sources has increased (Flanagin & Metzger 2008; Elwood 2008b; Crowley & Chan 2011), and Callister (2000) argues standard conventions for determining credibility break down in cyberspace. How can such vast amounts of data from non-experts, following no institutional or legal

standards, be trusted as credible, particularly in the case of emergencies? Though limited by using Twitter data in isolation, Castillo et al. (2013) describe features that may be effective for automatically classifying microblog posts as credible or not with emphasis on information posted during natural disasters, showing that credible posts tend to be longer, contain a URL, and are questioned less by other users.

Data may contain false positives and negatives (Goodchild & Glennon 2010). For example, a hypothetical oil spill may cause a false positive with an untrue rumour of the chemical spill, or a false negative through absence of information about the spill's existence (Goodchild & Glennon 2010). Information about the spill is time-critical and delay in its availability amounts in effect to a false negative. A false positive may result in unnecessary evacuation. However, if the event was true and people were to wait for official information, the delay could have life threatening consequences and constitutes high risk. This is not to argue false positives are preferable to false negatives. There are substantial costs to false positives, including the resource costs and danger involved in evacuation, and the weakening of confidence in the system reducing the effectiveness of future true positives. We argue that regardless of use, quality of VGI for disaster management applications is a serious and potentially life-threatening issue, whether false positive or negative.

Some have argued that VGI may approach the quality standards of authoritative data, offering various justifications (see Goodchild & Li 2012; Goodchild & Glennon 2010). First, sites such as Wikipedia provide evidence that crowdsourcing is an effective mechanism for eliminating propagation of erroneous information via masses of individuals submitting and reading information (Giles 2005). But what threshold volume of contributors is required for the source to be deemed accurate? Linus' Law, which implies that by having more observers fewer errors go unnoticed and data is improved, has been shown to apply to OpenStreetMap (Haklay *et al.* 2010). But Haklay *et al.* (2010) could only speculate on VGI more broadly and focused on positional accuracy without considering other aspects of data quality, such as attribute accuracy or the currency of VGI sources. Application of Linus' Law to VGI is problematic for incidents that are obscure, such as those that persist for only a short period of time, which is the nature of many disaster-related incidents (Goodchild & Li 2012). If the 'wisdom of the crowds' can eventually filter out false information, this may happen too late in a time-critical situation like a disaster event (Spinsanti & Ostermann 2013). In addition, is there potential for mass contributions to encourage 'group think' and propagation of misinformation (Murdock 2011)? By its nature UGC broadly is incomplete and despite very large volumes of data bias is not removed (Hollenstein & Purves 2010; Purves 2011; Graham 2010; Stephens 2013; Burns 2014; Crawford & Finn 2015).

Second, geographic information is rich in context (Goodchild & Glennon 2010). In the context of Tobler's first law (Miller 2004), which states that any location is likely to be more similar to its surrounds than distant things, geographically inconsistent information stands out as erroneous. Tobler's law suggests that information about a location should be consistent with what is already known about the location's

surrounding area (Goodchild & Li 2012). Report of a bushfire, for example, is more likely to be true if fire has recently been described nearby.

Third, Goodchild and Glennon (2010) report currency is a feature of accuracy. Rapid generation of VGI has potential to capture changes in landscapes as they occur, which is unachievable with the lengthy delays associated with traditional map production. Thus data that has currency is potentially more reliable in the sense that it is more up-to-date. But does currency of data indicate accuracy in the form of 'correctness'?

Fourth, advances in positional technology and increase in the ubiquity of technologies that give the average person access to geographically-referenced data production may increase data quality. But this does not conclusively eliminate human error. There is no guarantee users consistently operate equipment correctly (for example, use of appropriate map datum settings) or that they are necessarily aware when the technology is not operating properly. As researchers continue to seek new applications for these data, innovative methods are needed for empirical validation of the quality and credibility of VGI.

2.6 Data management

Data from the general public presents a number of challenges for data management which are particularly relevant to disaster management. Key issues include data filtering and verification with increased volumes of data and data sources, the place for VGI in spatial data infrastructures (SDIs), and issues of liability surrounding the use of UGC.

The sheer volume of information provided through VGI is a current obstacle to its efficient use in emergency management, highlighting the need for effective methods to mine, filter, verify and summarise these data and data sources to ensure credible and relevant content (Bakillah *et al.* 2014; Spinsanti & Ostermann 2013; Crowley & Chan 2011; Graham 2010). Verifying data accuracy and the potential value of information for a range of purposes under the time-critical and rapidly changing circumstances of a disaster scenario presents significant challenges. Spinsanti and Ostermann (2013) incorporate the knowledge of experts for refining UGC. They present a prototype system to retrieve, process, analyse and evaluate social media content on forest fire using expert input to establish key words, contextual information and spatio-temporal clustering parameters (Spinsanti & Ostermann 2013). Gao *et al.* (2011) note the ability of social media tools to allow for rudimentary analysis and summaries to help observe trends and partition data into pre-determined most-urgent categories during disasters, such as medical assistance requests or trapped persons. Social media technologies have the ability to coordinate widespread communication and strengthen information flows, but also to adapt in real time to changing needs of those affected by the disaster (Yates & Paquette 2011).

Traditionally, SDIs are not premised around the need to handle UGC, and SDIs' top-down model of supporting digital data access, storage, and sharing is unlike the bottom-up approach on which VGI is

established (Craglia 2007; Gould 2007; Elwood 2008a, b; Díaz *et al.* 2011; Duce & Janowicz 2010). VGI represents a departure from the assumption with contemporary SDIs that formal organizations are the producers of geospatial information and users are the passive recipients (Budhathoki *et al.* 2008). Budhathoki *et al.* (2008) argue for reconceptualization that sees production expanded from expert organizations to user organizations and individuals, establishing two-way interaction and blurring the boundary between producers and users. The sharing and availability of VGI within mainstream SDIs may improve traditional geospatial analysis and decision support tasks (Díaz *et al.* 2011). Genovese and Roche (2010), however, argue VGI inclusion in official SDIs may pose a threat to data integrity. For disaster management, opportunity exists for VGI to augment existing SDIs, providing valuable localised and contextual information for planning decisions and encouraging information flow between communities and disaster management authorities. De Longueville *et al.* (2010) illustrated how VGI sensing and SDI components can act as complementary senses for supporting a crisis-related scenario.

Liability questions associated with the use of VGI in authoritative public and private geographic datasets are among the most paramount (Rak *et al.* 2012). Due to the higher level of inherent risk to life and property in disaster management decision making, liability concerns may deter organizations from integrating VGI into their datasets (Shanley *et al.* 2013). Who is responsible if harm results from reliance on volunteered information: the initial contributor; the host or organization responsible for the website or product relying on VGI; the user? Scassa (2013) argues VGI site operators, users and contributors must all have some awareness of the legal and ethical issues that may be triggered by their activities, including issues of intellectual property, liability for faulty information, and defamation. 'Digital volunteers' are at risk if they disseminate false information, develop sloppy software, or fail to use reasonable care, act in a manner comparable with similarly situated individuals, properly supervise volunteers, or act when they have a duty to do so (Robson 2012; Shanley *et al.* 2013). Furthermore, as websites have a global reach and laws vary widely between regions, liability risks in and across foreign jurisdictions need consideration (Scassa 2013; Shanley *et al.* 2013). Robson (2012) argues that evaluating the precise contours of potential liability for 'digital volunteers' can be difficult because of the novelty of issues and a lack of court guidance, but many potential liabilities can be mitigated through planning and organization.

2.7 Empowerment through VGI

A loss of empowerment for individuals has been described during disaster events (Bird *et al.* 2009), and research has suggested VGI technologies can act to empower citizens (Tulloch 2008; Goodchild & Glennon 2010). Empowerment is described as an individual's capacity to have control over their personal affairs and confront hazard issues while receiving the necessary emergency management support (Bird *et al.* 2009). The notion of citizen empowerment through VGI must be considered alongside marginalization.

Goodchild and Glennon (2010) argue the average citizen, already equipped with powers of observation, is now empowered through VGI technologies with the ability to georegister those observations, transmit

them through the internet, and synthesize them into readily understood maps and reports. But does this indicate VGI can enable individuals to achieve connectedness, more control, and empowerment in disaster management? Numerous papers have discussed the concept of empowerment through public participatory GIS (PPGIS) (Sieber 2006; Harris & Weiner 1998; Elwood 2002), including in natural disaster research (Kemp 2008; Kienberger 2007). In this context, empowerment is a complex social construct and political process, whereby its attainment through PPGIS is contingent upon multiple factors including community make-up, endorsement from local leaders, nature of power relations and administrative structures within the community (Kyem 2002). The relationship between VGI and citizen empowerment is similarly complex. Elwood (2008b) claims discussions about the societal significance of VGI are similar to 'GIS and Society' debates during the mid-1990s, in which GIS was welcomed by some as a tool for the empowerment of marginalized individuals and decried by others as a mechanism of exclusion and disempowerment (Schuurman 2000). Research has similarly considered how VGI may aggravate existing inequalities and create new forms of exclusion (see Zook & Graham 2007a, b).

While VGI may empower some citizens to contribute and engage in disaster management, it also acts to marginalize others. If we consider the digital divide (see Van Dijk & Hacker 2003; Chinn & Fairlie 2007; Gilbert 2010; Sui *et al.* 2013), what is the role of citizens with limiting socio-economic circumstances or those in parts of the world without access to these 'empowering' technologies? Sui, Goodchild, and Elwood (2013) report two-thirds of humanity does not have access to the rapidly expanding digital world. What contribution does VGI have to make to disaster management for these citizens? VGI cannot represent 'the everybody' and in fact favours 'the privileged', or those with money, access and time to utilise the technology (Haklay 2013b; Crawford & Finn 2015). Just 36% of the population had internet access in the Philippines when Typhoon Yolanda struck in 2013, presenting a partial and skewed picture of the disaster through social media data (Crawford & Finn 2015). We must recognise that UGC will provide only selective representations of any issue, and that there will always be people and communities that are missing from the map (Zook *et al.* 2010; Burns 2015).

For those that are 'included' the use of geospatial data from the crowd has been shown to enhance existing inequalities. Text messages sent to the Mission 4636 service (Crowley & Chan 2011; Meier 2012; Ziemke 2012) during the 2010 Haiti earthquake crisis were translated into English and subsequently mapped and reported in English, preventing the *Kreyòl* speakers who texted for help from accessing the project outputs and benefiting from their own data, thus reproducing unequal power relations between the poor Haitians and the rich who acted on the information (Crawford & Finn 2015). Information is often least available where it is most needed (Sui *et al.* 2013), and during disasters, those in society already marginalized are often the most vulnerable (Hewitt 1983b, 1997; Watts 1983). Thus, a shift in focus to data sources for emergency management that are potentially excluding of those vulnerable is not plausible. For emergency management, VGI may only be a useful tool alongside more traditional disaster management methods, and triangulation of various spatial data sources should remain a goal of any project leveraging UGC (Ziemke 2012; Hassanzadeh & Nedovic-Budic 2013).

VGI also provides novel capabilities and opportunities for authorities and those undertaking geographical research. By providing new insight into the complexities of disasters at various spatial scales, with increased access to important local and community knowledge, VGI can aid in strategizing and planning for all stages of the PPRR cycle. Studying a community's daily life activities and spatial patterns at a local level may be where VGI offers the most interesting and lasting value to geographers (Goodchild 2007). Material conditions of daily life prefigure disasters (Hewitt 1983a) and there is little long term value in confining attention to hazards in isolation from local vulnerabilities and their causes (Wisner *et al.* 2003). Failure to include important local data for management of diverse issues over varying spatial scales and choosing rather to focus on data at broader scales alone can result in ineffective policies (e.g. Haworth *et al.* 2013). VGI may also have implications for the perceived value of geographers. With skills formerly relied on now enshrined in software, the production of geographic data and knowledge is no longer exclusive to geographers (see NeoGeography, or "geography without geographers;" Sui 2008; Turner 2006; Liu & Palen 2010; Haklay *et al.* 2008; Goodchild 2008).

2.8 Future research recommendations

As citizens and authorities continue to embrace VGI for disaster management, researchers must continue to address important questions surrounding data quality, the social and institutional implications for adopting UGC, and the overall utility of VGI for all stages of disaster management. Further consideration needs to be given to best practices for emergency management agencies to support digital volunteers, and for digital volunteers to support traditional and authoritative disaster management practices. Burns (2015) notes that no formal relationship exists between digital humanitarians and traditional humanitarian institutions. In this final section we reflect on the existing literature to offer recommendations for further academic research in the field of VGI and disaster management.

There is limited systematic research on the role of different types of VGI platforms during disasters. Similarly, comparisons are limited between different types of disasters and whether or not the disaster type has any influence on VGI usage patterns. Particular research emphasis should be given to improving data validation and automatic report summation. Several studies have emphasized the need for further research into VGI verification and reporting systems for disaster management to assist in addressing data quality and management issues (see Poser & Dransch 2010; Gao *et al.* 2011; Abbasi *et al.* 2012).

Research is needed on more appropriate use of VGI enabling technologies. The inclusion of geotags in reports from some devices (such as smartphones), for example, can assist in discriminating between reports based on location and allow for more targeted relief action and improved spatial planning. However, it has been observed that less than 5% of users provide location information due to privacy concerns or lack of awareness about the feature (Abbasi *et al.* 2012). Murdock (2011) estimates just 1.5% of Twitter posts are geotagged, proving a major limitation to the geographic application of tweets and an under-representation of information. Those posts that are geotagged also pose issues, such as

whether a geotagged image provides the location of the image-subject or of the photographer (Hollenstein & Purves 2011). Another relevant example is the need for appropriate and effective use of hashtags for managing large volumes of data on social media (Ziemke 2012). New methods for encouraging the most effective use of VGI technologies may lead to increased adoption and improved data accuracy, ultimately increasing capacity for those seeking to engage VGI for disaster management.

Significantly, we propose research is needed on the role of VGI in the preparation and prevention phases of disaster management. This review clearly highlights that contemporary research on the role of VGI in disaster management predominantly focuses on the response phase of the PPRR cycle. Disaster preparation has been considered through spatial data technologies such as GIS (Asante *et al.* 2007; Chou 1992; Atkinson *et al.* 2010; Atkinson *et al.* 2007). But the use of VGI for pre-disaster planning and preparation has not received the same attention. Burns (2014) also describes the need for inclusion of preparedness and risk information in volunteered humanitarian databases. In the preparedness phase of the PPRR cycle, a range of possible events must be analysed for both hazards and vulnerabilities, providing a useful opportunity for effective risk analysis (Asante *et al.* 2007). Several researchers have argued there is potential for social media to assist in building pre-disaster resilience (Dufty 2012, 2011; White 2012). Boon (2014) reports the most effective emergency communication is two-way and locally derived, enabling those at risk to obtain more personalised information and advice about their preparations. Specific local knowledge shared via a VGI platform may assist individuals and communities better understand local vulnerabilities and risks, and develop effective planning and response procedures for a variety of hazards. Directing increased attention to the pre-disaster phases may present an opportunity for VGI to foster community engagement and empower individuals to be more directly involved in risk reduction practices.

2.9 Conclusion

Academic commentary on VGI in disaster management is recent; however, a body of work exists that demonstrates utility and significance. Through VGI vast amounts of diverse, local knowledge can now be collected and shared for disaster management at a fraction of the costs associated with traditional data collection and map-making, while at the same time potentially fostering community engagement in disaster prevention, preparation, response, and recovery. We have argued that alongside these opportunities there are important challenges for VGI, chiefly issues of data quality, bias in contributions, data management, and the security of individuals, authorities, and their information. Addressing limitations will build confidence in VGI as a reliable resource for disaster management, ultimately adding to its utility for citizens as well as emergency services, policy makers, and GIScientists. There is an urgent need for further research on the technical and critical dimensions of VGI and for human geographers to engage with GIScientists to comprehend the implications of these data and data practices for citizens, traditional methods of disaster management, and geography as a discipline more broadly.

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CHAPTER 3: ASSESSING THE POTENTIAL USE OF VGI FOR INCREASING COMMUNITY ENGAGEMENT IN BUSHFIRE PREPARATION

This chapter is an expanded version of the following publication[3] (see Appendix A):

Haworth, B., Bruce, E. & Middleton, P. (2015). Emerging technologies for risk reduction: assessing the potential use of social media and VGI for increasing community engagement. *The Australian Journal of Emergency Management*, 30(3): 36-41.

The expanded content provides additional detail on participant demographics, study methods, including survey design and participant recruitment, survey results and associated statistical analyses, and discussion related to the expanded content. The additional content was excluded from the published version to adhere to the journal's article length guidelines, and is primarily taken from a larger-scope report based on the same survey:

Haworth, B. (2014). *Volunteered Geographic Information, Community Engagement and Bushfire Preparation in Tasmania: Field study preliminary results*. Report compiled for the Tasmania Fire Service (not peer reviewed), June 2014.

3.1 Abstract

Each year Australia is prone to potential negative and devastating impacts of bushfires and other natural hazards, highlighting the importance of community engagement in disaster risk reduction and building resilience. Volunteered geographic information (VGI) is an emergent technology that is increasingly providing authorities an effective method for engaging with high risk, vulnerable and impacted communities. VGI involves members of the general public voluntarily contributing geographic information, predominantly through sources such as social media, photo and video sharing platforms, and online map-making software. The potential role of VGI in disaster response has been well documented in recent years, but VGI for disaster preparation has received comparatively less attention.

[3] Minor editorial amendments to the published article Haworth *et al*. (2015) have been incorporated in the text presented in this chapter.

The current research explores the potential role of VGI for fostering community engagement in bushfire preparation and building individual empowerment and disaster resilience in Tasmania. Through collaboration with the Tasmania Fire Service, a survey of 154 participants across 12 communities at bushfire risk has quantified trends in individual and community preparedness and VGI and social media use. This paper provides an evidence base for both the use of VGI technologies in bushfire preparation initiatives and directions for further research.

3.2 Introduction and project background

Each year Australia is prone to potential negative and devastating impacts of bushfires and other natural hazards. With climate change and increased global warming, extreme weather events such as bushfires, floods and heatwaves are predicted to increase in both frequency and intensity (IPCC 2012). Adequately preparing for disasters can dramatically reduce the risk to life and assets (Paton 2003). Yet, despite efforts to educate communities with relevant and up-to-date information, research has shown individuals in at-risk communities still may not actively engage in risk reduction activities (Paton 2003; Frandsen *et al.* 2011). Innovative approaches are needed to engage communities in disaster preparation to reduce risk and build disaster resilience. Social media and other online geographic information communication technologies are increasingly providing authorities an effective method for engaging with high risk, vulnerable and impacted communities. The role of these technologies in disaster response has been well established in recent years; however, research into their utility in the pre-disaster phases of the disaster cycle remains relatively limited (Haworth & Bruce 2015). This article presents findings of a collaborative study undertaken by researchers at the University of Sydney and the Tasmania Fire Service (TFS) examining the potential role of social media and other online geographic information technologies for fostering community engagement in bushfire preparation in Tasmania, Australia.

Social media refers to internet-based applications that enable people to communicate and share resources (Taylor *et al*. 2012). Other geographic information communication technologies referred to in this article include online map-making software open to public contributions (e.g. Wikimapia; Ushahidi Crowdmap; OpenStreetMap) and devices such as smartphones, enabling collection, creation and sharing of data in unprecedented ways. The widespread engagement of members of the general public in the voluntary creation of geographic information using these technologies is referred to as volunteered geographic information (VGI) (Goodchild 2007). Prior to the emergence of VGI, community geographical information was collected through focus groups, surveys, community discussion and public consensus, with local, traditional and indigenous knowledge shown to be useful in both environmental management and disaster mapping (Prober *et al.* 2011; Tran *et al.* 2009). Despite significant challenges, particularly those of data quality, accuracy and credibility (see Flanagin & Metzger 2008; Goodchild & Li 2012; Elwood *et al*. 2012), VGI in disaster management allows for cost-effective, rapid collection and dissemination of diverse local information, with large amounts of data collected in near real-time. It

enables increased connectedness of communities and authorities and facilitates increased understanding of local risk through the mapping and sharing of local knowledge.

The research reported in this paper aims to build an evidence base for the potential utilisation of VGI in building bushfire resilience through community engagement. More specifically, this study aims to determine for a study sample in Tasmania: 1) the proportion of community members that currently engage in bushfire preparation; 2) the proportion of people that use VGI, the social media tools they use and purpose of use; and 3) how many people use or would use VGI, and to what extent, in bushfire preparation. The intent of this paper is to present descriptive research on the potential of VGI use, and analysis of methods for VGI generation is not within the scope of this work but rather is the focus of on-going research.

3.2.1 Bushfire in Tasmania and community engagement

The south east of Australia is one of the most fire prone regions in the world (CSIRO 2007), and in Tasmania bushfires are the most economically disastrous of all natural hazards (Frandsen 2012). Bushfire events have long lasting impacts for communities and individuals. Tales of the 1967 Black Tuesday fires around Tasmania's capital, Hobart, which caused 62 deaths and destroyed over 3000 buildings (VBRC 2009), are recalled frequently, even by those who weren't present (Frandsen 2012). In January 2013, disastrous bushfires swept across the south east of Tasmania, destroying 203 residential buildings with an overall financial cost in the order of $100M (DPAC 2013). This event has been a major driving force behind continued TFS efforts to increase community engagement in risk reduction activities.

Research indicates developing community bushfire preparedness programs based on community engagement is effective, sustainable, and economical (Frandsen 2012). The TFS Bushfire Ready Neighbourhoods (BRN) program aims to build resilience and capacity in bushfire preparedness through sustainable community development. BRN is centred on changing behaviour by accessing existing community networks and resources and supporting communities to develop specific local strategies. BRN preparation activities include community forums, field days, bushfire rehearsals, women's programs and property assessments. From an agency perspective, it is important for community engagement to trial innovative approaches and critical to remain abreast of current and emergent technologies. Through this research collaboration, insight has been gained into the potential role of VGI in contributing to aims of the BRN program.

3.3 Survey methods

A research survey with predominantly closed questions (Appendix E) was developed and administered in 12 at-risk communities across Tasmania (Figure 1) selected to represent a relatively equal distribution across the main populated fire-risk regions of Tasmania, including the South, the East Coast, and the North. The proposed survey content was discussed with project supervisors and key emergency management personnel at the Tasmania Fire Service prior to pilot testing of the survey with 15

individuals from academic, professional and non-professional backgrounds, 7 of which were lay people residing in bushfire risk areas external to the case study sites. Pilot testing was done to assess survey duration and flow, question clarity and relevance, and the presence of errors. The survey was administered in January and February of 2014, a period of peak bushfire risk in Tasmania. This time of year was considered important for capturing community preparedness levels during the bushfire season, and for capitalising on potentially heightened community interest in bushfire to gain a more comprehensive survey data set. Receipt of completed surveys for inclusion in the data analysis ceased 6 weeks after survey distribution.

Multiple survey distribution methods were adopted to reduce potential bias in responses associated with survey format (e.g. paper-based vs online) and varying lifestyle/work patterns, and both probability and non-probability sampling techniques were employed. The lead researcher opportunistically[4] surveyed individuals in person on visits to each of the study communities. An open version of the survey was available online (hosted on Survey Monkey) and promoted to communities through sharing on the official TFS Facebook page, local radio appearances, and flyers placed on community noticeboards and distributed to local businesses and libraries. In addition, questionnaires were mailed to all residential addresses (n=1075) in 4 targeted communities spread across each region of the state. A total of 154 complete survey responses were received (Table 2). Survey responses were collated, office coded, and analysed by the lead author in Microsoft Excel and Esri software ArcGIS 10.2, and results were standardised using Australian Bureau of Statistics (ABS) 2011 Census data. Single factor ANOVA tests were performed in Microsoft Excel to examine the hypothesis of a positive relationship between time of residence and preparation of a Tasmania Fire Service Bushfire Survival Plan (TFSBSP).

3.4 Survey results

3.4.1 Demographics

The age distribution is uneven with approximately half of the respondents aged 51 or older (Table 1). Comparison with the ABS Census demographic profile confirms the survey dataset as broadly representative of the study communities. Table 1 presents the survey sample as a proportion of the total population based on age group in the surveyed communities. Each age group was evenly represented except for a slight under-representation of the 18-24 group.

An equal proportion of male (n=73) and female (n=77) respondents were recorded ('other'=2; did not state=2). 13% of respondents have completed year 10, 15% year 12, 25% a trade certificate or TAFE (Technical and Further Education) course, 17% a university undergraduate degree, and 24% a higher degree (graduate diploma, Masters or PhD) or other. Occupation fields varied with higher proportions evenly spread across industries of education, community services/healthcare, public sector, and retail

[4] This form of non-probability sampling technique has also been referred to as '*accidental',* whereby "all people that the researcher accidentally meets during a certain period are considered for investigation" (Bird 2009, p.1314).

and hospitality. The 'retired' population made up 29% of respondents. Just 1% stated they were unemployed. Most respondents owned their home (87%), 9% were renting and 4% were visitors or other. The majority of respondents had lived in their area and current house for more than 5 years. Table 2 shows the number of complete surveys returned for each participant recruitment method employed.

Table 1: Sample size of each age group as a proportion of the total population of the surveyed communities based on ABS 2011 Census data.

Age	**18-24**	**25-34**	**35-50**	**51-70**	**71+**	**Sum**
Sample Size	6	15	46	66	21	154
Total Population	1,003	1,300	3,318	4,539	1,485	11,771
Proportion	0.60%	1.15%	1.39%	1.45%	1.41%	

Table 2: Number of respondents per survey method.

Survey distribution method	**In person survey**	**Mail out (returned by post)**	**Mail out (completed online)**	**Online** (community flyers, letter-box flyers, social media, internet, radio promotion)	**Total**
Count	40	82	7	25	154

3.4.2 Bushfire preparedness

Awareness of bushfire risk was high with almost all respondents (96%) recognising they live in a bushfire risk area, 59% of respondents identifying themselves as vulnerable to bushfires, and when asked if they felt responsible for preparing for bushfires, 88% of respondents said yes. When proposed that it was the responsibility of local, state and/or federal agencies to prepare for bushfires, 78% either agreed or strongly agreed. Although 70% of respondents considered themselves to be well informed about bushfire and bushfire risk, and 74% of respondents were familiar with the TFSBSP, just 59% confirmed they have a TFSBSP. Respondents rated their own preparedness higher (35% said they were 'prepared' or 'highly prepared') than they rated the preparedness of their community (23% said their community was 'prepared' or 'highly prepared'). 24% rated their own preparedness as 1 or 2 on a scale to 5 of preparedness (1 being not prepared at all and 5 highly prepared), and 43% rated the preparedness of their community as 1 or 2.

Comparison of the numbers of people with a TFSBSP and the time of residency showed for those who responded as having a TFSBSP, the average number of years spent living in their current area was 11.47 years, and the average number of years spent living in their current house was 10.28 years. For those

without a TFSBSP, the average number of years spent living in their current area was 9.02 years, and the average number of years spent living in their current house was 8.22 years. Single factor ANOVA tests for time spent living in their current area reveal a calculated *F-value* of 3.06 with a *p-value* of 0.08, and for time spent living in their current house a calculated *F-value* of 2.738 with a p-value of 0.1. The critical *F-value* was 3.91, thus confirming the null hypothesis that time did not have a significant influence on the likelihood of respondents preparing a TFSBSP. The differences between values of time in the survey dataset fell within the normal expected random variance.

50% of respondents were aware of their TFS Community Protection Plan and Nearby Safer Place. Most respondents (69%) had never attended a bushfire awareness event and only 37% of total respondents said they intend to become more prepared in the next 1-2 years (48% said 'possibly').

3.4.3 Social media use

Social media uptake within the study communities was high with 76% of respondents using some form of social media. Social media usage levels varied spatially with higher rates in more populated areas (Figure 1). There was a decreasing trend in social media use with increasing age (Figure 2). The platform most widely accessed amongst respondents who stated they use social media sites was Facebook (82%), followed by YouTube (53%), LinkedIn (26%), Twitter and Instagram (15% each). Other platforms were reported but not in significant numbers. The main reasons respondents used social media (Figure 3) was to communicate with family and friends (63%) and for news and information (49%). Of those that use social media, 51% contribute their own content online and 60% access social media at least once daily. The level of trust given to different online information sources varied with greatest trust given to government agencies (Figure 4).

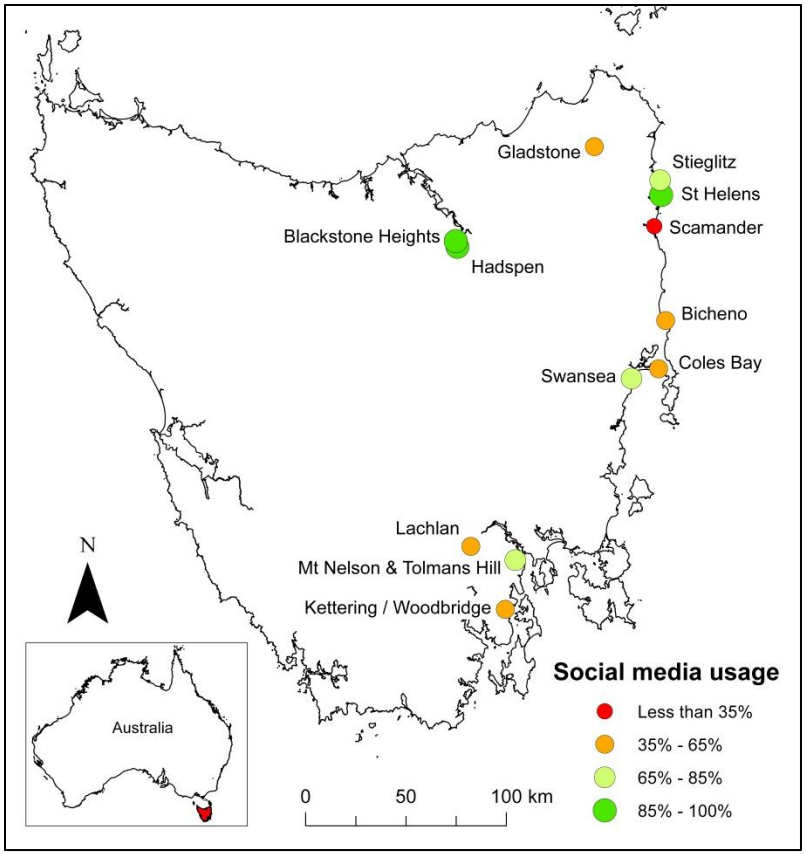

Figure 1: Map depicting the spatial distribution of social media usage levels in the study communities, normalised based on ABS 2011 Census data for survey populations. The inset map shows the location of Tasmania (shaded red) in the broader context of Australia.

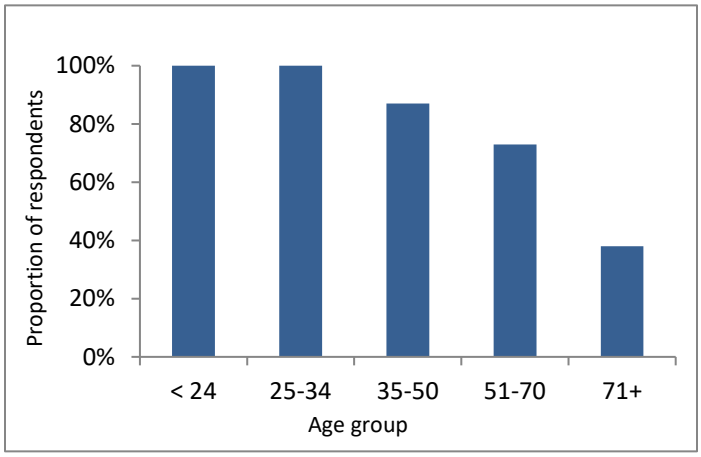

Figure 2: Graph depicting social media usage by age showing a decrease in usage with increase in age.

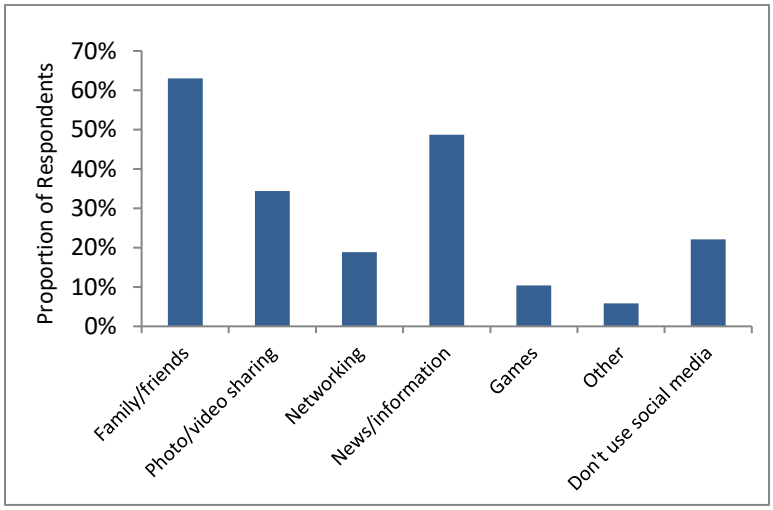

Figure 3: Graph depicting motivations for social media use and the proportion of respondents for each.

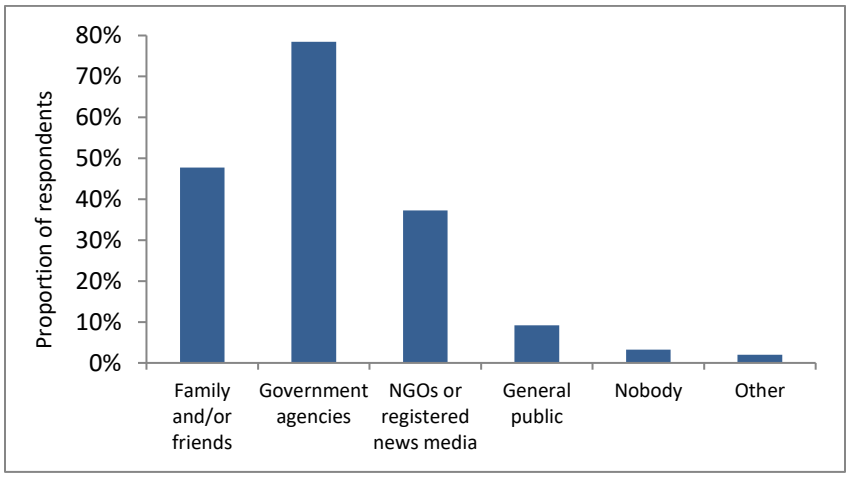

Figure 4: Graph depicting the proportion of respondents who trust various sources of information through social media (not specific to bushfire information).

3.4.4 The potential for VGI use in bushfire preparation and communication

The potential role of VGI and associated technologies, including social media, for bushfire preparation was well recognised. 75% of respondents either agreed or strongly agreed that these technologies can assist in improving preparation, and 74% believed they could provide an opportunity for authorities to use local information provided by community members. But in preparing for a potential bushfire in the next 1-2 years, just 48% of respondents said they would like to share and receive relevant information through social media.

The survey also addressed the potential of VGI platforms to assist with bushfire communication. Communication between community members and authorities was identified as important by 97% of

respondents. Participants were asked how they would prefer to receive information from authorities regarding bushfires for different stages of disaster management. The results presented in Figure 5 show distinct differences in preferences of communication methods before, during and after a bushfire.

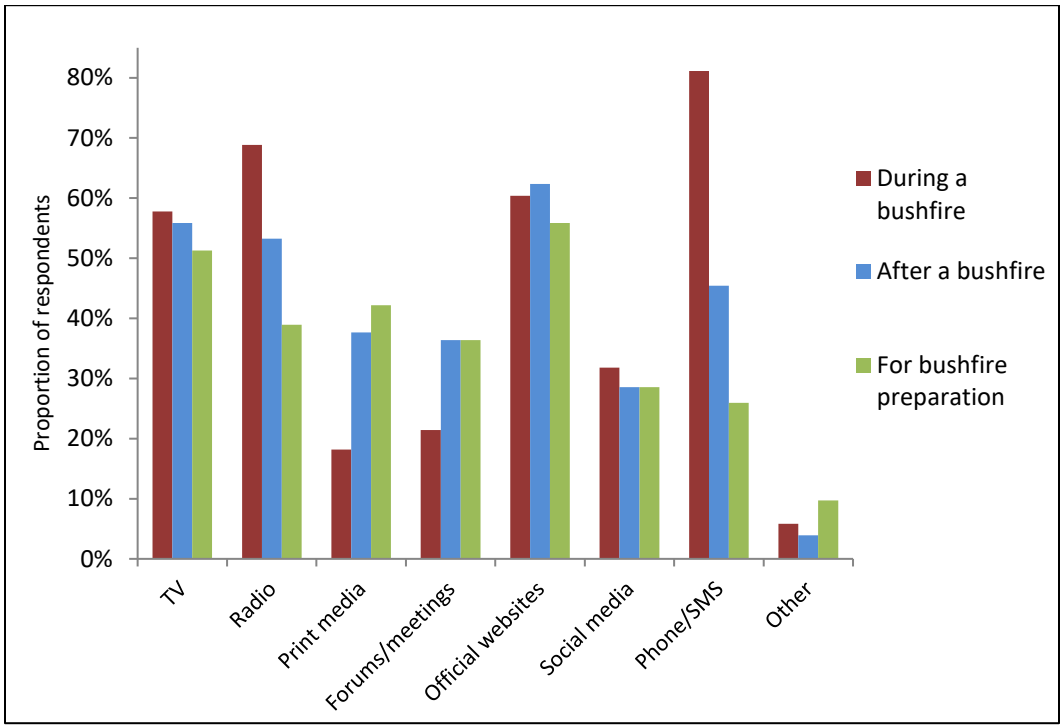

Figure 5: Graph depicting the proportions of respondents preferring various communication methods for relevant information from authorities at various stages of bushfire management.

3.5 Discussion

There is a need for new approaches to engage citizens in risk reduction as shown in this evidentiary analysis. Emerging technologies such as VGI platforms which allow dynamic and interactive exchange of information may contribute to alternative engagement methods. However, the survey results highlight limitations in the use of these technologies in bushfire management from recognised issues such as the digital divide to more nuanced concerns that should be considered in any initiatives to promote uptake of these technologies.

3.5.1 The need for new methods of risk reduction engagement

Respondents' awareness of bushfire risk did not necessarily translate to levels of preparedness or intentions to prepare (for similar findings see Whittaker *et al.* 2013; Eriksen & Gill 2010). Akin to the notion of shared responsibility (see McLennan & Handmer 2012), respondents identified themselves as responsible for their own bushfire preparation alongside authorities. But, although many respondents stated there was a bushfire risk where they lived and felt vulnerable, fewer respondents have a TFSBSP (though many were familiar with it) or intend to become more prepared in the future. Frandsen *et al.*

(2011) argue that the goal of facilitating household and community bushfire preparedness cannot be achieved simply by making information on risks and hazards available to people, a notion supported in the literature (e.g. McFarlane *et al.* 2011; Lindell & Perry 2000). Sustained hazard preparation is a function of how people interpret information in social and community contexts (Frandsen *et al.* 2011). Thus, novel approaches for communicating bushfire preparedness information are needed; but not only information communication from agency to citizens, but from citizens to agency and between citizens. Approaches that are able to augment traditional processes of information dissemination and reception while facilitating a more collective, two-way and integrated system of sharing local and authoritative knowledge may in turn create a bushfire preparedness landscape of wider understanding, increased connectedness, and greater participation in risk reduction activities, ultimately increasing disaster resilience.

That individuals typically rated their personal preparedness higher than that of their community is consistent with the notion of unrealistic optimism bias (see Sharot 2011). Unrealistic optimism results in the likelihood of positive events occurring being overestimated and the likelihood of negative events occurring underestimated. Individuals hold the belief that they are less likely to experience a negative event than the average person (Gold 2008). For bushfire risk, this results in individuals accepting the need for preparation for their community, but perceiving themselves as having comparatively less need to prepare. Gold (2008) suggests that individuals exhibit unrealistic optimism bias for reassurance. Fearing they may suffer the negative event, individuals distort their reasoning so as to arrive at the comforting thought that they are at less risk than the average person (Gold 2008). Practically addressing this issue is a challenging task for emergency management and bushfire preparedness initiatives. Collection and distribution of local community information through VGI technologies may facilitate increased understanding and a more realistic appreciation of comparative risk by individuals of their surrounding community.

3.5.2 Potential for social media and VGI

It is evident that a large portion of the surveyed community is currently using VGI technologies. This engagement is not limited to reading online content but involves people contributing their own data and information, on a daily basis. Many already have the skills, motivation and physical access to the technology required to utilise social media platforms for various tasks, including communicating with family and friends, information acquisition and sharing photos/videos (Figure 3). Respondents also recognised potential to extend to new tasks which utilise the same skillset, such as sharing local knowledge and concerns relating to bushfire preparedness with community members. This presents a potential new 'virtual landscape' for disaster preparedness engagement, facilitating both maintenance of existing community ties and enabling new ones. By making users feel connected to a community and increasing their knowledge of other members, social media sites can foster norms of reciprocity and trust and, therefore, produce opportunities for collective action (Valenzuela *et al.* 2009).

The potential for the use of VGI is evident in this study not only in terms of technology uptake and perceived possession of relevant skills, but also in terms of community interest. Most respondents felt social media could assist in improving bushfire preparation, for instance. Though, less than half would actually like to contribute and receive relevant preparation information with their community through social media. This disconnect between perceived relevance and intent to directly engage is unclear and suggests limitations to the use of VGI technologies in this space that require further research.

3.5.3 Limitations of social media and VGI

The survey data highlights important challenges to the utilisation of VGI methods in bushfire preparation. The trend of decreasing social media use with increasing age (Figure 2) observed in this study is consistent across the general Australian population (see Socialbakers 2014). The use of these technologies may therefore not be applicable to all members of the community and it is inappropriate to adopt a blanket approach for bushfire management across Tasmania using social media and other VGI technologies. Research in other fields has shown that adopting strategies that utilise a broad-scale approach to address diverse issues and that fail to account for local variation can result in ineffective management policies (e.g. Haworth *et al.* 2013).

Technological factors may also limit VGI approaches resulting in further inequalities associated with remoteness. Figure 1 reveals spatial variation in the current uptake of social media across the study sites. This result may reflect technology access in particular areas (poor internet and mobile phone coverage), or other factors, such as varying life situations. Communities with higher rates of social media usage (Figure 1) tend to be in areas of higher population density (such as Launceston, St Helens, and Hobart). It may be that these denser population centres have higher concentrations of younger people (the group using social media the most; Figure 2) living in cities for increased employment and education opportunities with consequently higher concentrations of retirees in smaller rural towns, for instance.

Concern relating to the trust and credibility of online information sources was an important study finding. Identifying the most trusted information sources is considered important for improving the efficacy of disaster risk communication (Haynes *et al.* 2008). While communication with family and friends was most frequently given as a main reason for social media use (Figure 3), less than half of the respondents reported family and friends as a trustworthy information source on social media (Figure 4). Government agencies (such as TFS or local council), however, were cited as trustworthy by most respondents. These results contrast with other studies of trust in disaster communication sources (not specific to online tools or social media), such as work by Haynes, Barclay and Pigeon (2008), which found friends and relatives to be the most trusted source for volcanic disaster information, and government officials among the least trusted. Thus, the findings presented in this study are encouraging for government agencies seeking to incorporate social media and online technologies into their emergency management strategies. Low levels of trust in information sourced from the general public may be preventing some community members utilising VGI.

Understanding preferences in communication methods and how they differ between stages of disaster management (Figure 5) could have important implications for the success of management strategies seeking to utilise a combination of communication tools. The results of this study concur with a recent study by Taylor et al. (2012) on community response during Cyclone Yasi in which respondents preferred to utilise a range of communication channels, including Facebook, TV news, online news and local radio for seeking disaster information. It is evident that although social media is popular with a significant percentage of the community there is still a strong desire for emergency communication via traditional forms of media. The current study showed that social media is not the most preferred communication medium in any stage of disaster management, but unlike other communication methods it shows the least variation in preferences before, during, and after a bushfire event, i.e. there is a substantial and consistent user base that communication through social media may be effective for across varying situations.

3.5.4 Study limitations and future considerations

Common survey method challenges need to be recognised. Possible biases may be introduced during in-person surveys if respondents alter their responses based on what they perceive to be more socially desirable (Krosnick 1999; Fisher 1993), and question interpretation may influence survey responses (Smith 1987). Despite pilot testing of the survey to minimise such issues, we posit that both these phenomena are relevant to questions relating to the TFSBSP, for example, resulting in higher reporting of respondents with a comprehensive TFSBSP than may actually be the case. Some respondents were unable to distinguish between phases of the disaster management cycle. To illustrate, when asked about social media use specifically for bushfire preparation some individuals commented on limitations such as technologies going down *during* a fire, i.e. the response phase. Future studies would benefit from placing greater emphasis on explaining key terms within the survey or employing methods of data collection whereby increased opportunity is available for queries and explanations. Substantial value in this study was gained from in-person surveys, in particular by facilitating question clarification (also reported by Bird 2009). Consistent with Bird (2009), we observed in-person survey distribution to be costly and time consuming, however. The self-administered survey methods (online and via mail) were more efficient in terms of costs, community coverage, and response rates (Table 2), and afforded respondents greater time to consider their responses, all of which are important advantages of this mode of distribution (Bird 2009).

Significantly, this study provides evidence for the potential utilisation of VGI based on perceived need, uptake of technologies and community interest, but it does not address *how* this potential could be realised. To offer a possible example, VGI contributed by local community members to a dynamic risk/hazard map could identify areas of importance or concern, such as community assets, vulnerable people or areas, 'safer' places for evacuation, or vegetated areas in need of attention, thus further empowering community members with knowledge of their surrounds and assisting in strategizing for bushfire response. Further, spatial awareness of others' activities may encourage individuals to mobilise together and cooperate on preparation tasks that meet mutual needs and offer mutual benefits. Future

research should aim to extend this work with more detailed, localised studies to examine how the potential of VGI initiatives highlighted in this paper can be most effectively realised.

3.6 Conclusion

Results of the community survey conducted in this study demonstrate potential of VGI and associated technologies to be useful in fostering engagement in bushfire preparation. Approaches utilising VGI should not aim to replace traditional methods of bushfire communication and engagement. However, with rapidly increasing access and familiarity of social media and VGI amongst the community, there is a timely need to understand how they can act as a complimentary mechanism for increasing awareness of disaster preparedness. The efficacy of these enabling technologies for promoting positive behavioural change and empowering individuals to engage in risk reduction activities by contributing important local information, in turn facilitating greater community awareness, connectedness and collaborative action, needs to be evaluated.

3.7 Acknowledgements

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CHAPTER 4: EMERGENCY MANAGEMENT PERSPECTIVES ON VOLUNTEERED GEOGRAPHIC INFORMATION

This chapter corresponds with the following publication (see Appendix A):

Haworth, B. (2016). Emergency management perspectives on volunteered geographic information: Opportunities, challenges and change. *Computers, Environment and Urban Systems*, 57: 189-198.

4.1 Abstract

Volunteered geographic information (VGI) refers to the widespread creation and sharing of geographic information by private citizens, often through platforms such as online mapping tools, social media, and smartphone applications. VGI has shifted the ways information is created, shared, used and experienced, with important implications for applications of geospatial data, including emergency management. Detailed interviews with 13 emergency management professionals from eight organisations across five Australian states provided insights into the impacts of VGI on official emergency management. Perceived opportunities presented by VGI included improved communication, acquisition of diverse local information, and increased community engagement in disaster management. Identified challenges included the digital divide, data management, misinformation, and liability concerns. Significantly, VGI disrupts the traditional top-down structure of emergency management and reflects a culture shift away from authoritative control of information. To capitalise on the opportunities of VGI, agencies need to share responsibility and be willing to remain flexible in supporting positive community practices, including VGI. Given the high accountability and inherently responsive nature of decision making in disaster management, it provides a useful lens through which to examine the impacts of VGI on official authoritative systems more broadly. This analysis of the perceptions of emergency management professionals suggests changes to traditional systems involve decentralisation of power and increased empowerment of citizens, where value is increasingly recognised in both expert and citizen-produced information, initiatives and practices.

4.2 Introduction

In January 2013 Australia was in the midst of a bushfire (wildfire) disaster. Fire swept across the state of Tasmania, stretching capacities of emergency services and devastating communities (DPAC 2013). No fatalities occurred during the blazes, but the event left many in need of emergency assistance with

significant access issues due to road closures, power and communications disruptions, and the destruction of 203 residential buildings (DPAC 2013).

As the disaster unfolded people flooded social media to connect to each other and share relevant geographic information and resources. One Tasmanian resident observed the growing online activity and set up a social media page to help coordinate the flow of information. Interest in the Facebook page Melanie Irons established, "Tassie Fires We Can Help" (www.facebook.com/tassiefireswecanhelp), rapidly spread with people sharing their locations, their requirements for help, offers of assistance and other disaster related information (ABC 2013). Within 24 hours the page had gained over 17,000 followers and had reached over 2 million individuals (DPAC 2013; ABC 2013).

> "We understood quite early on that people were trusting this page, that people were sharing information and it was getting results. People were putting out requests for fuel, for generators, for food and people were responding. So it almost bypassed the official channels. Well, it did. It essentially became a way for volunteers to communicate directly with people that needed help, without having to go through the official channels."- Damien McIver, journalist (ABC 2013).

With emergency services consumed by other tasks, such as fighting the spread of fire, Ms Irons' page filled critical gaps in the response to the disaster. Social media and geographic information volunteered by the public proved highly valuable in responding to the disaster through increasing connectedness, sharing information quickly and widely, and provision of crucial local perspectives and data that met specific local needs. This citizen-driven initiative engaged the public and mobilised the population to undertake a whole suite of important tasks not able to be completed by the official emergency response.

The activities described above fall under the definition of volunteered geographic information (VGI), and in a disaster management context have also been labelled "digital volunteering" (McLennan *et al.* 2015), or "digital humanitarianism" (Burns 2014), among other terms. VGI refers to the widespread voluntary engagement of private citizens in the creation of geographic information, predominantly through sources such as social media, smartphones and inexpensive online mapping tools (Goodchild 2007; Elwood *et al.* 2012). VGI is quickly becoming a new type of asserted geographic information complementary to authoritative geographic information collected by governmental agencies or private organizations (Jiang & Thill 2015). Neither the practice of citizens contributing geographic information nor high public involvement in disasters are new. However, the rise of information communication technologies, broadband internet and Web 2.0, along with the proliferation of location-acquisition technologies such as global positioning systems and smartphones, has dramatically enhanced these practices and increased their visibility (Goodchild 2007; Palen & Liu 2007). VGI has shifted the ways geographic information is created, shared, used and experienced. This has important implications for various applications of geospatial data, including disaster management. VGI technologies enable cost-

effective, rapid sharing of diverse geographic information from large numbers of community members. But VGI also presents new challenges for disaster management, including a lack of data quality assurance and issues surrounding data management, liability, and the digital divide (see Haworth & Bruce 2015).

The implications of these changing social practices need to be considered in the context of traditional disaster management. Historically, disaster management has been an authoritative system with a top-down 'command-and-control' structure (Palen & Liu 2007). As with traditional map-making and geography more broadly, the system was centred on experts, in this case emergency organisations, disseminating controlled messaging and services to the public. In this hierarchical system, authorities effectively hold power over information while citizens often remain passive end-users. Assistance and services to communities are delivered through the four phases of disaster management: Prevention, Preparedness, Response and Recovery (PPRR) (Prosser & Peters 2010; Zakour & Gillespie 2013). In recent years, there have been international moves towards disaster management approaches that focus on resilience and building community capacity with emphasis on shared responsibility (Prosser & Peters 2010; McLennan & Handmer 2012). Current emergency management policy in Australia aims to use the PPRR model to achieve a more resilient nation (Prosser & Peters 2010). Increasingly, community engagement is becoming a key feature of strategies seeking to achieve this goal (e.g. Frandsen *et al.* 2011).

The "Tassie Fires We Can Help" example, like other cases of online public volunteering or crowdsourcing information for disaster management (see Meier 2012; Bird *et al.* 2012), represents a disruption to traditional authoritative systems of disaster management. If traditional disaster management is centred on the notion of experts having control, the bottom-up, unpredictable and spontaneous nature of VGI challenges conventional authoritative practices within disaster management. Traditional command-and-control models "do not easily adapt to the expanding data-generating and –seeking activities by the public" (Palen & Liu 2007, p.727), and instances of digital volunteering in emergency management have thus far largely occurred outside of formal emergency management systems (McLennan *et al.* 2015).

The purpose of this study is to explore the implications of VGI for authoritative emergency management. Challenges associated with the impacts of digital humanitarianism identified by volunteers themselves have recently been reported (see Burns 2014). This paper examines the perspectives of individuals working in formal disaster management. Interviews with emergency management professionals provided insights into the benefits and challenges of VGI, opportunities for ensuring complementarity between VGI and authoritative practices, and perceived changes in disaster management catalysed by VGI. I discuss the implications of VGI on traditional expert systems more broadly with particular reference to the discipline of geography.

The terms *disaster management* and *emergency management* are used interchangeably, but the paper's focus is on emergencies associated with *natural hazard events*, such as fires, earthquakes, floods and storms.

4.3 Background to VGI and emergency management

Academic research into VGI and emergency management has largely focussed on the application of citizen-contributed data in disaster response (Haworth & Bruce 2015). To provide some examples, after the devastating 2010 Haiti earthquake, volunteers from all over the world worked together to map the event online using information provided by the public. In the days following the earthquake over 600 volunteers contributed over 1 million edits for Haiti to OpenStreetMap (Meier 2012). Similar volunteered mapping, data sharing and knowledge creation has also been critical for responding to the recent Nepal earthquake crisis (Bailey 2015). The Ushahidi Crowdmap platform (www.crowdmap.com) was utilised during the Haiti earthquake to collect and map information contributed by those impacted by the disaster, notably through a text message service (Meier 2012; Crawford & Finn 2015). VGI and Crowdmap also proved useful in responding to cyclone and floods in Queensland, Australia in 2010/11 (McDougall 2011). Social media was used by impacted community members and authorities to effectively collate and share information during the flood events and combat the spread of misinformation (Bird *et al.* 2012; Taylor *et al.* 2012). Further, VGI was demonstrated to provide an alternative to official information sources during wildfires in Santa Barbara in 2007-2009 (Goodchild & Glennon 2010).

Studies emphasise benefits and important considerations of VGI in disaster management (see Haworth & Bruce 2015). Benefits include timely information exchange and promotion of connectedness (e.g. Taylor *et al.* 2012), provision of complimentary information for disaster mapping in regions where other spatial data are poor or absent (e.g. McDougall 2011), and the ability to capture data in near-real time without limitations of other technologies, such as satellite imagery being affected by weather (e.g. Triglav-Čekada & Radovan 2013). Challenges reported that need careful consideration for effective VGI use include issues associated with demographics, internet use and technology access (Haworth *et al.* 2015), data quality (Goodchild & Li 2012; Ostermann & Spinsanti 2011), trust and credibility of VGI sources (Flanagin & Metzger 2008), security (Shanley *et al.* 2013), data management for large volumes of data (Spinsanti & Ostermann 2013), and legal concerns around privacy and liability (Scassa 2013).

While some claim VGI can empower citizens with the ability to georegister and transmit observations through the internet (Goodchild & Glennon 2010), others have argued VGI can also act to marginalize people, furthering the 'digital divide' (see Van Dijk & Hacker 2003; Sui *et al.* 2013; Crawford & Finn 2015). Haworth and Bruce (2015) question the link between VGI and citizen empowerment, arguing the relationship is a complex one dependent on a number of factors including community make-up, administrative structures, and existing power relations. Power has been defined as the ability to get things done (Pfeffer & Salancik 1978). As described in the introduction to this article, power in emergency management traditionally lies with authorities. Power, or 'the ability to get things done',

may be highly limited for particular communities or individuals. Morrow (1999) asserts the impacts of disasters are determined by everyday patterns of social interaction and organisation, and disaster vulnerability is constructed by the social and economic circumstances of everyday living. Risk is concentrated in certain categories of people, such as the poor, ethnic minorities, single-parent households, or women, for example (Morrow 1999). Moreover, vulnerability factors frequently occur in combinations, so an individual who aligns with multiple risk categories will experience higher vulnerability and reduced power in emergency management. It has been shown that people with strong networks fare better in disasters, and social capital ties may work to improve community resilience (Murphy 2007). The greatest contribution of VGI in disaster management may be in strengthening community ties through the sharing of local knowledge in communities, increasing the power and resilience of those vulnerable. Goodchild (2007) posits communities' daily life activities and spatial patterns at a local level may be where VGI offers the most interesting and lasting value.

Given this context, it is important to understand how technological and social practices such as VGI, that are already occurring, are impacting the field of emergency management. Technological research in this field continues to address challenges and develop innovative ways to utilise VGI. Thus, it is increasingly important to understand the existing emergency management settings in which these innovations may be adopted. Significantly, this study goes beyond exploring applications and examines the implications of VGI from the perspective of current emergency management professionals. This novel perspective is important for understanding how VGI can be used for effective disaster management in the future.

4.4 Methods

Study participants were selected based on professional engagement in emergency management in a formal paid capacity (e.g. state emergency agency, local council or emergency volunteering management organisation). Representation across different organisations, regions in Australia, and professional expertise was sought to ensure a breadth of participant backgrounds from local community engagement roles through to senior government policy-makers. More specifically, key informants were chosen for having experience relevant to one or more of the key focus areas of the study, including disaster communication, citizen participation, changes in emergency management structures, and/or advances in geospatial information technologies and their application in emergency management, including those that enable VGI and increased community contributions, such as the internet and social media. By accessing the industry and research networks of the author and project supervisors, participants were recruited purposively initially, and secondly through a snowball technique. All identified potential interviewees were invited to participate in the study via email letter.

All participants were representing their views as emergency management professionals and not necessarily the official views of their respective agencies. Thus the participants, including details of their specific roles and organisations, will remain anonymous. In total 18 professionals were invited to be interviewed. Two could not be interviewed due to their unavailability and three did not respond. 13 semi-structured interviews were conducted, six with females and seven with males, with participants

from eight organisations across five Australian states. All participants had at least 12 months experience working in professional emergency management and their collective expertise spanned the hazards fire, flood, storms, cyclones and earthquakes.

Each interview lasted approximately 60 minutes. Interviews were chosen over other qualitative research methods, such as focus groups, to ensure participants were providing individual responses and were not influenced by others. To establish consistency, each participant was presented with the same topics for discussion, broadly including the following: current challenges in emergency management and community engagement; experiences of VGI in emergency management; perceived strengths and weaknesses of VGI technologies and practices; VGI in the context of authoritative emergency management; and, how community VGI practices can best compliment official emergency management and vice versa (Appendix F). The outcomes of other interviews were not discussed with any participant. It is acknowledged that the presence of the researcher may have influenced participants' responses. For example, a common consideration of interviews is that participants may provide responses they feel more socially acceptable or more desirable by the researcher (Krosnick 1999; Fisher 1993). Potential for this introduced bias was not assessed within the scope of the study. Interviews were audio recorded, transcribed, and coded manually by the author following an inductive approach. The adopted methods, analysis process and findings were discussed regularly, verified as appropriate, and conferred with the project supervisors and multiple researchers independent of the study to strengthen dependability (see Saumure & Given 2008). Thematic content analysis (Anderson 2007) identified key categories that summarise the interview data. The findings are presented and discussed in the next section.

4.5 Findings and discussion

4.5.1 Opportunities presented by VGI

Present in all interviews was the notion of VGI presenting opportunities, many of which were centred on advantages for citizens. This included opportunities for authorities to communicate with communities, and for communities and individuals to share data. The opportunities identified through interviews are presented in Table 1 with examples of evidence from participants. They are then discussed further in the subsections that follow. Figure 1 shows the proportion of participants who identified and discussed topics relevant to each of the opportunity categories listed in Table 1.

Table 1: Opportunities associated with VGI identified by emergency management professionals. Examples are a representative sample of responses. "PX" refers to a number assigned to individual participants.

Opportunities	**Evidence examples**
Increased reach of communications	P5. They have incredible power in terms of being able to reach large numbers of people in broad and targeted ways. P6. Strengths are that there is another medium for delivery. So, more people or the same people in different ways are getting access to information. P1. The idea of getting information to that demographic [those disengaged from their broader community – typically from low socio-economic backgrounds untrusting of authorities] is very important. They rely very much on their friend's social media. P6. With younger people becoming more comfortable with those sorts of things and being able to mark-up maps themselves, it'll all become a bit easier, theoretically, for people to understand things around them.
Increased exchange of local knowledge: two-way dialogue	P2. I think it is incredibly valuable for people to communicate with each other…it's [community resilience] about connectedness. It's about a sense of belonging and a sense of place and people being aware of each other and supporting each other and being able to assist each other, planning together rather than at a household level.
Individual empowerment	P7. All these platforms, they're making it easier for them [community members] to collaborate and share, make their own maps and make their own plans and fundamentally help each other. P12. The way technology is being used now is a huge liberator for a lot of people, so then it does go to the heart of control and oppression, and control where information has always been a source of power and now

	information is readily available to a lot of people and they can use it in a whole range of different ways, which can strengthen their cause.
Increased individual self-worth	P10. I think sites like that are good because people in the community want to feel as though they're doing something or they can contribute.
Increased spatial awareness	P13. The value of digital mapping to bring it together so they get a holistic view of the whole catchment. So therefore, that's a way of getting localized information, bringing it together so they can look at it as a bigger patchwork and then to see how they all slightly thought of things in a different way. P12. I think there's scope to use geospatial tools and mapping... they're extremely important when you're having conversations with communities around prevention and preparedness… extremely effective for demonstrating to people what their risk is, and then helping them identify strategies for how they might reduce or mitigate their risk. P3. Once you've got that map form and you draw some arrows and things on it people really, they can comprehend that. You can easily put up photos of houses burning, but when you put down a map with some lines on it that show where the fire was at 15 minute intervals coming across the landscape that they recognize, that is really, really powerful. P6: With younger people becoming more comfortable with those sorts of things and being able to mark-up maps themselves, it'll all become a bit easier, theoretically, for people to understand things around them.

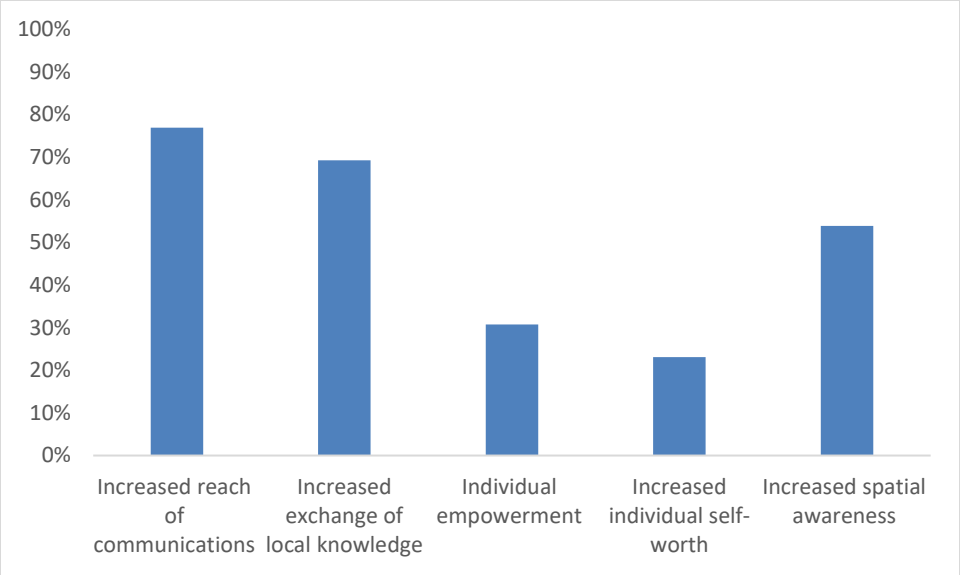

Figure 1: Graph presenting the proportion of participants who identified and discussed particular opportunities of VGI in emergency management.

4.5.1.1 Increased reach of communications

Technologies such as Web 2.0, social media and mobile and smart devices were seen as useful for increasing the reach of communications (Taylor *et al*. 2012 report a similar finding). Figure 1 shows this was the most widely identified and discussed benefit of VGI. Participants positively described the fast pace of information sharing and the speed of online communication, as well as the large volume of people engaged with social media sites like Facebook and Twitter, enabling further communication and providing alternative means for information dissemination. These benefits have been reported elsewhere (e.g. Gao *et al.* 2011; McDougall 2011), and emergency management perspectives here provide validation from an operational standpoint.

Further, increasing use of VGI technologies may be expedient for engaging people in communities who are typically difficult to engage through more traditional disaster communication methods (e.g. community events or media advertising), such as those from more disadvantaged socio-economic backgrounds. For those distrustful of authorities or government agencies, information from outside traditional channels is valuable. Relevant information from their friends, community members or peers shared on social media may be useful for raising disaster awareness and communicating important information that may otherwise be disregarded. Disaster messaging needs to appear relevant to recipients and informal personal networks can reinforce, undermine or deflect official communications (Handmer 2002).

4.5.1.2 Increased exchange of local knowledge and two-way dialogue

The increased ease for people to share information was considered a major strength of VGI (Figure 1). Community sharing of information was said to increase risk awareness, facilitate the exchange of local

knowledge, and assist with building community disaster resilience through increasing connectedness of individuals. The potential for two-way dialogue through social media was described, allowing not only authorities to communicate more effectively with the public, but individuals to communicate with authorities, and for authorities to utilise community-supplied information in their planning and response strategies.

In a study of access to communications during two disaster case studies, Boon (2014) found the most effective disaster communication to be two-way and locally derived, allowing more personally-relevant information to be obtained and acted upon. Contributions from individuals made through social media and other VGI platforms have proved highly useful in the management of numerous recent disaster events (see Haworth & Bruce 2015). For disaster preparation, community input has been acquired in the past through community consultation and forums. VGI and two-way dialogue may provide opportunity to reduce limitations associated with these traditional methods, such as the time and resources required.

4.5.1.3 Individual empowerment

Interview results suggest VGI can empower people through information access, enhanced community autonomy, and increased capacity to complete tasks without the assistance of authorities, both freeing up time and resources for authorities to undertake other tasks and increasing community connectedness. Taylor and colleagues (2012) report social media can empower individuals to help themselves through provision of accurate, timely and relevant information, and provides a mechanism to connect with other community members.

4.5.1.4 Increased individual self-worth

The ability of VGI to assist people in helping others during a disaster was positively described, giving community members a sense of purpose. In particular, social media platforms like the "Tassie Fires We Can Help" Facebook page provide opportunity for individuals to gain a sense of worth or usefulness.

While motivations for VGI and crowdsourcing contributions vary widely (Haklay 2013), sense of purpose and the feeling of contributing to something important is a key motivation (Good & Su 2011). In managing emergencies citizens often have a strong desire to help, especially during disaster response and recovery. VGI presents mechanisms to enable this. Indeed, Ms Iron's motivation for establishing "Tassie Fires We Can Help" during the Tasmanian bushfires was a feeling of, "Well what can I do to help?" (ABC 2013).

4.5.1.5 Increased spatial awareness

The spatial component of VGI is important for representing disaster risk and preparedness information. Mapping was described as providing alternative ways for individuals to engage with relevant information, as well as for individuals to see their personal or local information in a broader context of community risk.

The increasing ubiquity of technologies and the increasingly commonplace use of maps in the public domain through platforms like Google Maps and in-car navigation systems provide further opportunities for mapping, both expert-driven and VGI, to be useful for communicating risk and building community awareness in disaster management. The pervasiveness of spatially-enabled technologies and consequent increased familiarity with mapping further highlights the potential of VGI in natural disaster management.

4.5.2 Challenges presented by VGI

Currently emergency management organisations do not appear to encourage or foster practices that would best-enable the opportunities of VGI to be realised. While perceptions of VGI-use varied within and between organisations, predominantly social media were being used as one-way communication tools for authorities to broadcast information, typically in the response phase, suggesting limited understanding of the potential of VGI in promoting information sharing and inclusion of community stakeholders at different phases of disaster management. While interviews suggested agencies were feeling increased expectation from the public to be using social media for two-way dialogue, participants expressed sentiment that organisations were still trying to determine how to use information provided through those communications. Developing mechanisms for utilising VGI in that manner was not perceived as a priority with several challenges and limitations associated with VGI for emergency management emerging from interview discussions. These are presented in Table 2 and discussed further below. Figure 2 shows the proportion of participants who identified and discussed topics relevant to each of the challenge categories listed in Table 2.

It should be noted that, in contrast to the opportunities of VGI which placed emphasis on benefits to citizens, the challenges identified by emergency management professionals appear largely institutional (e.g. lack of data management resources or fear of liability) or structural (e.g. the digital divide). This suggests changes to current emergency management systems may be required for more effective use of VGI, and this is discussed further in later sections of the paper. In environmental and regional planning, Brown (2012) argues significant limitations to positive impacts of public participatory methods have been institutional constraints such as regulatory barriers, fear of unpredictability, and lack of specific incentives for agencies to engage.

Table 2: Challenges associated with VGI identified by emergency management professionals. Examples are a representative sample of responses. "PX" refers to a number assigned to individual participants.

Challenges	**Evidence examples**
Demographics, digital divide and internet access	P1. The more senior people glaze over even when I just talk about the website, and how to access alerts and information. But from my experience, the majority people coming to my [community preparedness] events are middle class middle age, so the majority of them will be using social media and smartphones and things like that to access information. P5. Particular ages, particular demographics are more likely to engage with it than others, and not everybody is tech savvy or IT savvy and wants to engage with VGI. P8. I think if people were more familiar and accustomed to it, then we would see the benefits of it and how they could use it for themselves. P13: If geography plays a part in 'has' and 'has-nots', then it's probably the same people in those geographies that are most at [disaster] risk. They are in the inaccessible locations or they are in the more remote locations, and therefore will need greater support when something happens. And yet, they're probably the most prone to not being able to access things through those ways. Its people in the cities who have it all and they're probably the least likely to need it.
Infrastructure disruption during disasters	P8. Sometimes with disasters power gets cut. So how is that information still going to get out there if you've not got power in an area for 12 days or more?
Resources required to manage VGI	P6. We will be challenged in a major event to be able to monitor everything that's going on. P7. Any information that comes from the public or an agency, it's not useful until it's processed to become something. A photo without

	metadata is just junk. So we're trying to build that process of capturing the metadata. P13. But if we're struggling to use the vasts of information we have, that we've collected over the last hundred years even, then we're going to even more so struggle with the vast volumes of information, big data and such like that, in an instantaneous sort of environment. P7. Things are a bit too temporary sometimes. They pop up and people contribute and I'm sure there's benefit that comes out but then they fizzle off.
Data quality, trust in online sources and misinformation	P6. At times organizationally we had a few problems with information that was being transferred because it wasn't accurate information, it wasn't validated…there became self-correction, in that other users were able to correct things. It got such a momentum of scale that the breadth of people was able to correct the group. P2: Often the community will moderate it themselves. If somebody says something really silly they'll often be howled down by their peers, which is really lovely. Somebody says something inappropriate and everybody deals with it, without the organization having to be in control. P9: The unauthorized stuff can actually be better quality in terms of accuracy and timeliness than the official. We naturally default to the official version, but by the time it has actually been through its verification and authorization it may actually be of less value or less quality than the stuff that's getting generated by the community on the ground in real time. P12. I actually think that's not as serious an issue as people make it out to be, and I think that agencies use it as a barrier to actually engage and to be a part of it... I think it's a little bit overblown this notion that people will

	misuse it and it'll be full of misinformation, because I think that's only a very small percentage of people that get on there and do those things.
Perceived legal concerns: a) agency reputation; b) liability	P2. I think it's [data quality] the thing that emergency services fear most and I suspect that their fear is disproportionate. I think in the current climate with royal commissions and coroner's inquests, emergency services are actually quite anxious. If we were signed up to that page and people were having this conversation and we didn't correct them, are we liable and can we be on every page where everybody is having a conversation? What is our responsibility; what's our liability?

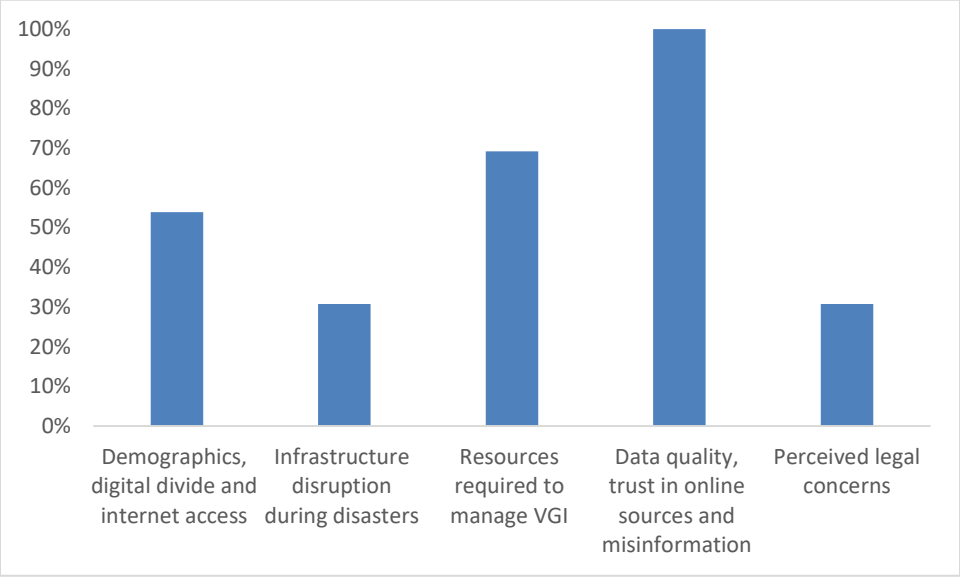

Figure 2: Graph presenting the proportion of participants who identified and discussed particular challenges of VGI in emergency management.

4.5.2.1 Demographics, digital divide and internet access

Demographics, the digital divide and access to the internet were reported as major limitations for the organisational uptake of VGI and within communities. Social media and smartphones were seen to be used less by older people, those with particular limiting circumstances and low socio-economic status, and people living in remote areas, limiting the application of VGI for whole-of-community strategies. This is in part related to infrastructure and physical access to internet and mobile coverage, as well as affordability of technology, time and priorities, and necessary skills.

But it was also suggested that age itself is not the limiting factor, but age is a determinate of lower familiarity with the technology. Unfamiliarity with technology shouldn't be seen as a limitation in itself,

but highlights the need for alternative approaches that cater for varied skills and interest, especially if individuals perceive benefits to be gained.

The geography of access to VGI-enabling technologies was described alongside geographies of risk and location. Those people in society already marginalised are often the most vulnerable to negative disaster impacts (Hewitt 1997), and a growing gap between those with technology access and those without will further marginalise some while unequally benefiting others. Information is often least available where it is most needed (Sui *et al.* 2013) and the use of crowdsourced data has been shown to augment existing unequal power relations and enhance inequalities (Crawford & Finn 2015). This has important implications for disaster management. How can VGI benefit those who cannot use VGI technologies? Haworth, Bruce and Middleton (2015) showed social media use to be concentrated in urban areas. Will people in rural areas not receive the same timely information spread through social media? In some cases it is an individual's choice to live in such an area, and the connection between rurality and lack of technology use may not always correlate with socio-economic disadvantage. However, often the opportunity for individuals to relocate is limited due to economic or other factors. Emergency management needs to plan and strategize for the majority and regardless of basis, the digital divide needs priority consideration. Sui, Goodchild and Elwood (2013) argue that while the world is shrinking, the divide between those with access to production and use of geographic data and those without is increasing significantly and will continue to be a major challenge for geographic information science.

4.5.2.2 Infrastructure disruption during disasters

Participants frequently cited potential technological failures during disaster events as a limitation to the utility of VGI. For those that are engaged online, reliance on communication through web platforms may be problematic in the event of disaster if infrastructure is disrupted. VGI shouldn't be considered the primary communication solution and platforms like social media should be employed as part of a suite of engagement and communication methods. Studies have shown the public prefer to utilise a range of communication mediums for disaster-related information, including Facebook and other social media, television, radio, online sources and print media (Haworth *et al.* 2015; Taylor *et al.* 2012).

Participants at a social media workshop at the 2014 Australia and New Zealand Disaster and Emergency Management conference reported similar concerns (Anikeeva *et al.* 2015). The possibility of network failure, particularly in remote areas with poor network coverage, was identified as a barrier to organisational adoption of social media. It was also acknowledged, however, that social media platforms are often more robust than standard websites and less prone to failure during periods of high traffic, such as emergencies (Anikeeva *et al.* 2015).

4.5.2.3 Resources required to manage VGI

Organisations require substantial resources to utilise VGI effectively and data management was identified as a key challenge by a large proportion of study participants (Figure 2). Systems need to be established to mine data supplied by the public, which may involve methods for filtering large amounts

of data from social media, monitoring feeds to combat rumours in near real-time, processing information to meet agency needs and standards, or platforms for structured input of geospatial data, as well as necessary personnel. Many organisations lack dedicated staff and the responsibility of managing social media or other VGI is often given to those with a special interest in the technology, who then must find additional time for these tasks around their primary job (Anikeeva *et al.* 2015).

Agencies already have many and varied forms of data and knowledge to handle without the challenges of increasingly large amounts of diverse information supplied through VGI, and a balance between the increased workload and required resources and the benefits to be gained from utilising VGI needs to be considered. Data management needs to address how individual pieces of important local knowledge can be extracted and retained from large aggregated datasets.

The resourcing required for maintaining VGI platforms was also described by participants. Whether it is an official platform or entirely community-driven, the sustainability of VGI platforms was identified as a limitation. Often social media pages or local mapping initiatives emerge and are useful for a time before usage declines. Episodic trends could be related to contributors' motivations, or data/system management.

4.5.2.4 Data quality, trust in online sources and misinformation

Data quality is another key concern, and was identified and discussed by emergency management professionals more than any other challenge associated with VGI (Figure 2). Participants described issues of trust in online sources and management of misinformation, particularly on social media. A 2014 survey of community members revealed trust is also a limitation to VGI for the general public (Haworth *et al.* 2015). Though, Tierney and others (2006) have described how traditional mass media and even official discourse also promote false information and ideas with negative consequences in disaster scenarios. A commonly identified strength of VGI is the speed and volume of information dissemination, but these mechanisms can also work to spread misinformation. Further, the information that is 'credible' may not be of content or form that is useful for emergency services' needs. Numerous studies have reported similar findings, with some documenting quality issues in social media data (McDougall 2011; Gupta & Kumaraguru 2012), the risks to emergency responders and relief agencies in using these data (Shanley *et al.* 2013; Goolsby 2013), and mechanisms for attempting to determine quality in VGI (Ostermann & Spinsanti 2011; Castillo *et al.* 2013). Others have argued the 'crowd' can manage many of these issues themselves, much like the Wikipedia model (see Giles 2005), with large volumes of people online observing, moderating, correcting and therefore reducing errors (Haklay *et al.* 2010), and perspectives from emergency management professionals in this study provide support for this notion.

Information volunteered by the public is sometimes the most current and the best quality available. 10 days after the Haiti earthquake in 2010, the head of the U.S. Federal Emergency Management Association said that humanitarian crowdsourced mapping provided the most comprehensive and up-

to-date information (Meier 2012). This was also recognised in the current study, with participants describing the challenge for agency information verification systems to keep pace with the speed at which the public can generate, verify and share data. Some participants perceived the benefits of VGI to outweigh data quality issues and suggested these concerns were overstated when compared to the actual occurrence of harm caused by unverified posts.

4.5.2.5 Perceived legal concerns

The possibility of legal ramifications associated with VGI was a commonly cited concern. There were two main components to this. First, the reputation of the agency could be impacted through association with negative online events or activities. A negative impact on agency reputation may erode community trust and decrease the effectiveness of official emergency management strategies, potentially resulting in job insecurity, legal ramifications, or further damage and loss during a disaster. Second, people acting on information shared online with or without some connection to the agency may result in liability and legal complications if agencies are deemed responsible in some way. For example, should agencies be responsible for correcting all the rumours or misinformation circulating on social media? These issues are particularly important given the traceability and permanency of some online data.

Questions of who is liable and when are among the most important questions which impact VGI (Rak *et al.* 2012), and Shanley *et al.* (2013) report liability concerns may deter emergency management organisations from utilising VGI. Scassa (2013) argues VGI site operators, users, and contributors require awareness of the legal and ethical issues that may be triggered by their activities. Important to consider are issues of intellectual property, defamation, and liability for faulty information, particularly as websites have a global reach and laws differ across jurisdictions (Scassa 2013; Shanley *et al.* 2013).

4.5.3 Balancing VGI and top-down emergency management

The spontaneous, often-unstructured, bottom-up nature of VGI disrupts the top-down, procedure-driven, ordered structure of official emergency management. Palen and Liu (2007) describe a "tension between the mismatch of the public's role in disaster and command-and-control models of crisis response" (p.734). Participants described the differing nature of both systems and the challenge of rectifying their contradictions so that the practice of citizens contributing VGI as well as the data produced can be useful in emergency management. Table 3 presents evidence of these tensions from the interviews.

Table 3: Tensions associated with using VGI in current emergency management settings. Examples are a representative sample of responses. "PX" refers to a number assigned to individual participants.

Tensions	**Evidence examples**
Unstructured VGI in top-down emergency management	P6: As agencies we have really strict structures around risk management and incident planning, with different reps. It's quite structured top-down or agency-down out to the community, and what the community gets is what the community is given. So at the moment I wouldn't see a strong incentive for community-based activity. P12: I always think about incident management always has boxes and lines and lines joining boxes and things like that. It is very structured, it is very ordered, and this information sort of isn't that. It's ad-hoc.
Information control	P3: The risk is if these groups think they're being listened to, they think that they can instruct. P10: I would say the best thing they [citizens wanting to engage online] can do is just share the information that we've got…So as long as they come to us, we don't care if they share and do whatever, as long as they don't change it. P9: I think agencies and governments will often have concerns about its [VGI] quality, but I think if we were really blunt and maybe a little bit sceptical, those concerns may actually emanate more from the fact that it's not information that we can control. P12: The technology is not the issue. The technology is just the mechanism or the means. The issue is about control. Can we, and are we as agencies courageous and bold enough to give up some of that control and empower communities and actively work with them to empower them so that they can prepare for, respond and recover, and develop a degree of resilience?

The impacts of VGI on official emergency management are synonymous with the impacts of VGI on the creation of geographic information and geography more broadly. Geographic information is traditionally created in hierarchical systems of formal, expert organisations, but through information technology, private citizens, often with little or no expertise, are now disrupting this system by creating and disseminating geographic information spontaneously outside of official structures (Goodchild 2007). Similar to emergency management, challenges arise in integrating systems premised on differing processes and standards (e.g. expert vs. non-expert, authorised vs. unauthorised, hierarchical vs. unstructured). Elwood, Goodchild and Sui (2012) argue there is a need to consider and re-establish the value and identity of the expert geographer in the new world of VGI, and in some respects the same might be required for the expert emergency manager. At the very least VGI alters the dynamics of the relationship between official emergency management and the general public. In the same way that VGI might empower citizens through map-making outside of formal and expert geography, VGI gives more power to communities and individuals in disaster management, which requires a fundamental reduction in agency power, regulation, and control.

4.5.3.1 Information control

Control influences the impacts of VGI on official emergency management and agencies' utilisation of VGI. VGI reduces the control of agencies in the production, handling, and dissemination of information. Effectively, control, regulation and power in emergency management become increasingly decentralised through VGI. It is in this way that the traditional top-down power structure of emergency management is disrupted by VGI. The legacy of information control is a present barrier to agency utilisation of VGI. Others have argued that attempts to command and control citizen action, including informal volunteering and VGI practices, are misguided and may be counterproductive (Whittaker *et al.* 2015).

These claims are supported by two lines of evidence in the interview data. First, concern over losing control was indirectly implied by participants with discussions relating to agencies being the only authority – a sense of 'us and them'. Some implied that communities should be passive recipients of information and not involved in information input. Second, participants directly stated control as significant, and in particular the decrease in agency control of information was a principal challenge for organisations (see Table 3).

The redistribution of power and control in emergency management associated with VGI is aligned with broader shifts within emergency management that accompany policy changes towards community engagement and building resilience.

In order to share responsibility for disaster resilience, control over risk management decisions, actions and processes also needs to be shared (McLennan & Handmer 2013). The principle of shared responsibility implies "increased responsibility for all concerned" (Teague *et al.* 2010: vol. 2, p. 352), including "the state, municipal councils, individuals, household members and the broader community" (p. 352). Digital volunteering inherently comprises disaster management arrangements that involve

more community-based, decentralised and adaptive processes, which arguably encapsulates notions of community resilience and shared responsibility that are central to Australian disaster policy (McLennan *et al.* 2015). There are various opportunities for the social practice of VGI to contribute to increased disaster resilience, including through the sharing of local contextual risk information, improved disaster awareness, and increased community connectedness. But until a policy shift or greater cultural change in emergency management transpires enabling agencies to further share control and to appreciate the power and value of citizens' contributions, the opportunities for disaster management presented by VGI may not be effectively realised.

4.6 Ways forward

The rise of digital volunteerism has been described as part of broader transformations in emergency management volunteering, and McLennan and colleagues (2015) challenge organisations to harness the opportunities of a new volunteering landscape by: a) developing more flexible approaches to engage with an increasingly diverse volunteer base, and b) pursuing new modes of collaboration between public, voluntary and private sectors. Drawing on participant responses, I offer observations relevant to both authorities and citizens engaged in VGI on what may be required to foster synergies in their goals and practices. Specifically, I propose the following recommendations presented in Figure 3 for effective use of VGI in emergency management. Recommendations are listed and subsequently discussed in order of perceived importance in terms of necessary change required.

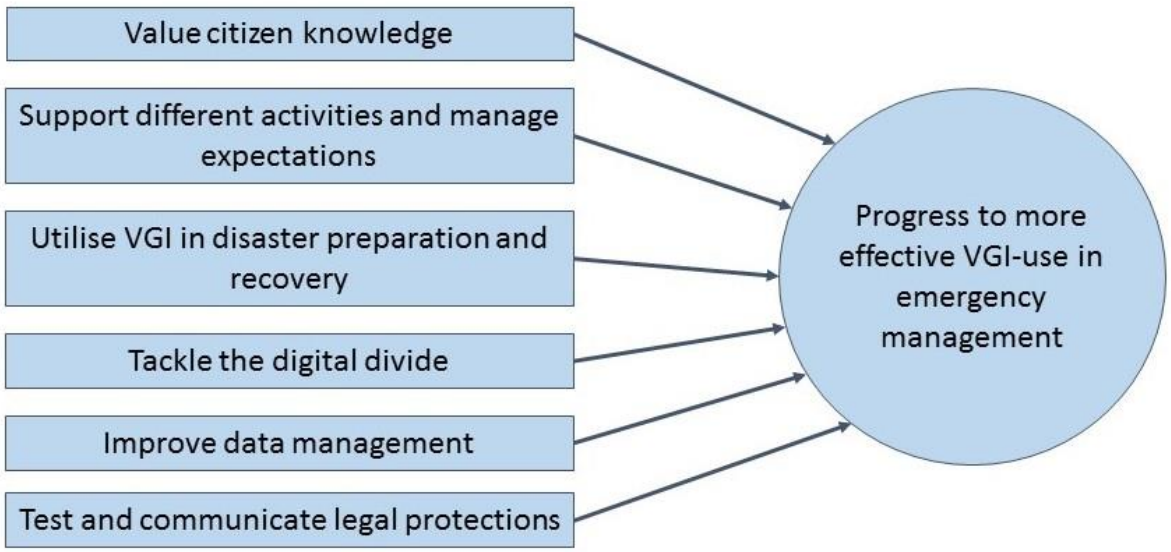

Figure 3: Recommendations for progress towards more effective utilisation of VGI in emergency management.

4.6.1 Value citizen knowledge

Progress will require organisational level adaption to less control and regulation over community activities and information. Accompanying this, public input into disaster management needs to be valued and citizen knowledge should be valued alongside expert knowledge. Citizen knowledge or traditional ecological knowledge (see Berkes 1999) "often provides place-specific, contextual and finer-scale spatiotemporal information that offers insight on localized system response to management practices or altered environmental conditions" (Biggs *et al.* 2014, p.57). Morrow (1999) argues full utilisation of citizen expertise and energy will effectively improve community safety. Yet, in most developed countries, citizens volunteering without an official agency affiliation have been viewed as a nuisance or liability, and their efforts are often undervalued (Whittaker *et al.* 2015).

> "*We have to get to the point where local knowledge is valued on the same basis as expert knowledge. That's a really big challenge, but what we have to be able to understand is, because you have a uniform, doesn't mean that your knowledge is of a different calibre or credibility than the stuff that people know about their own community in the day-to-day... we've got to be able to say, well, he knows what he's talking about because he's from the fire service and she knows what she's talking about because she's there on the ground, and we'll actually understand the value of both of those people as sources." - P9 (interviews 2015).*

The citizen science literature offers important lessons learnt of relevance to official emergency management. Citizen science refers to the practice of engaging public citizens in scientific research projects (see Bonney *et al.* 2009). Thanks to citizens observing, collecting, sharing and analysing data, a vast range of high-quality scientific research has been completed, much of which would not have been possible otherwise. For example, *e-bird*, a project harnessing over five million observations of birds each month from birders around the globe, has resulted in at least 90 peer-reviewed scientific articles and book chapters covering topics in ornithology, ecology, climate change, and statistical modelling (Bonney *et al.* 2014; Sullivan *et al.* 2014). Like VGI, the practice of citizen involvement itself is not new but has been enhanced through various technological advancements including the advent of the Internet (Bonney *et al.* 2014). Similarly like VGI, the quality of citizen science data has been questioned (Rise of the citizen scientist 2015), but it has also been shown that with appropriate methods, training, and oversight, citizen-collected data can meet the same quality standards as data collected by experts (Danielsen *et al.* 2014; Bruce *et al.* 2014). Contrast is made between the value of information supplied by the amateur birder reporting local bird observations in their neighbourhood to *e-bird* and a farmer observing and sharing neighbourhood fire risk information to a social media platform. I argue the key difference between the birder and the farmer is the birder has a structured platform to submit data with pre-defined standards and knowledge that their input will be valued and utilised. Why should information supplied by a farmer recording rainfall on their property to assess dryness and potential fire risk to inform agricultural practice be valued less than information collected by a paid-professional performing the same task for a bureau? If official emergency management valued community

knowledge in the same way citizen science does, protocols and systems could be set up in advance to promote and encourage the most useful VGI practices and allow for improved harnessing of community-supplied data.

4.6.2 Support different activities and manage expectations

In sharing responsibility for building disaster resilience, agencies should recognize community diversity and individual strengths by supporting their activities and initiatives to promote innovation and increased disaster preparedness. Rather than being prescriptive they should be flexible and willing to trial the technologies community members are already using, such as social media, at community scales. VGI won't be useful in all places, and its use may vary between different communities, but there are positive outcomes to be gained in working to support communities and individuals that are engaging in VGI. Integrating public participation into disaster management and community planning has positive outcomes for sustainable hazard mitigation (Pearce 2003) and VGI is one mechanism for the public to participate. While community initiatives will benefit from agency input, resources and expertise, initiatives should be allowed to remain community-led. The open and collaborative nature of VGI is particularly suited to fostering grass-roots engagement.

> "*We need to recognize and show communities that we're prepared to engage with technologies and the way that many groups are communicating." – P5 (interviews 2015).*

Conversely, community members engaged in VGI initiatives should attempt to support official emergency management activities. Citizens should recognize that while their input is valuable, some tasks remain better-suited to handling by formal emergency management. By involving agencies and keeping them informed of community-led activities, support and expertise can be garnered to ensure initiatives remain valuable. Building relationships in advance between communities and other stakeholders will aid this.

While supporting communities' use of VGI, emergency organisations should simultaneously be managing expectations of their internal use of the technologies. Given there are substantial resourcing, time and capacity challenges during disaster events it is reasonable for agencies to have limitations on what they can achieve and provide for the public using social media or other platforms. However, at present the limits of what they will or will not provide are not clearly articulated to communities. The public needs to understand these technologies and practices are new and somewhat foreign to emergency management organisations as well, and managing expectations is important.

4.6.3 Utilise VGI in disaster preparation and recovery

VGI may be best-suited to the preparedness and recovery phases of disaster management. Challenges associated with VGI in the response phase, such as power disruptions and incapacity to resource and manage large amounts of instantaneous data efficiently, are considerably less significant in other stages of PPRR. Further, some of the identified strengths of VGI are directly beneficial to goals of the preparedness phase. In particular, the potential capacity for community members contributing and

sharing local data to increase local risk awareness, encourage engagement in disaster risk reduction, enhance community connectedness, and provide local contextual knowledge for agency-use in planning and strategizing. In the long-term process of disaster recovery where sharing resources and rebuilding the community and social connections are important, social media and local geographic information exchange may become increasingly valuable as mechanisms for supporting these needs.

4.6.4 Tackle the digital divide

The digital divide is a key challenge for disaster management (as reported in section 4.2). The present nature of user generated content is that there are large portions of the population unable to contribute and consequently maps can only provide selective representations of any issue (Haworth & Bruce 2015). Crowdsourcing through social media in particular sees large groups of people underrepresented, such as elderly people for example (Haworth *et al.* 2015). For VGI to be most valuable, emergency management and geographic research need to continue to investigate and develop strategies to bridge the digital divide, include the underrepresented on maps, and engage a wider variety of people, particularly those most vulnerable, to contribute in disaster management. Mobile social media may offer promise as a step toward closure of the gap between developed and emerging nations, with mobile phones vastly outnumbering computers in many underrepresented countries (Kaplan & Haenlein 2010).

4.6.5 Improve data management

Adoption of more sophisticated systems for collecting metadata and filtering and verifying VGI will assist in overcoming agency challenges associated with usability of large volumes of data and quality and credibility of online information, particularly social media data. Recent advancements in methods for spatial data mining and data quality allow filtering for both extrinsic quality (source characteristic and reputation) and intrinsic quality (accuracy and precision) but also pragmatic quality relating to user needs and intended purpose (Bordogna *et al.* 2014). Implementation of systems that allow for more efficient use of VGI by agencies will also require investment in necessary resources and dedicated personnel. Improving data management will build greater confidence in VGI as a reliable and usable resource.

4.6.6 Test and communicate legal protections

Emergency management professionals have identified the need for clearer and more defined legal parameters relating to VGI. The legal responsibilities and liabilities agencies are subject to regarding their conduct in relation to VGI and public activities online during disasters was a principal barrier to agencies embracing VGI. Emergency management professionals may face political and legal liability for their actions due to the substantial risks to life and property associated with disasters (Waugh & Streib 2006). In the absence of legal precedence participants felt current legislative and policy frameworks may not adequately address issues of indemnity associated with decisions based on VGI. Improved legal protections in this space may be required to allow emergency management organisations to adopt VGI within decision processes. Though, it has been shown that under current Australian law the liability risks

perceived by agencies relating to VGI are unfounded (Eburn 2014), and better communication of existing laws may be the required action to overcome this challenge.

4.7 Conclusion

The outcomes of this study support the notion that adopting an inductive approach in interviewing key stakeholders is a useful method for understanding current opportunities and challenges associated with the application of burgeoning geospatial information innovations in traditional settings, and is effective for informing future research directions. While this study focuses on the *Australian* emergency management perspective and further work is required for translation to other international contexts, the analysis has provided valuable insights into the implications of VGI for official disaster management systems. VGI disrupts the top-down structure of information creation and dissemination associated with authoritative emergency management. In order for VGI to be most effective, agencies need to be flexible and willing to adapt and support community initiatives, recognising the strengths of VGI. In essence, as the "Tassie Fires We Can Help" example demonstrates, VGI involves community members taking an interest in disaster management, sharing information together, contributing local knowledge, and increasing connectedness with their communities, authorities and beyond – all of which are positive steps towards shared responsibility and disaster resilience. By valuing local knowledge alongside expert knowledge, and with clearly-defined legal protections for agencies, VGI will become an increasingly reliable, timely, and significant resource in disaster management and community development.

Disaster management provides a useful lens through which to examine the impacts of VGI on official authoritative systems more broadly, as the benefits and limitations of VGI are intensified. This study of emergency management professionals suggests changes to traditional systems involve decentralisation of power and increased empowerment of citizens, where value is increasingly recognised in both expert and citizen-produced information, initiatives and practices.

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CHAPTER 5: ASSESSING THE APPLICATION AND VALUE OF PARTICIPATORY MAPPING FOR COMMUNITY BUSHFIRE PREPARATION

This chapter corresponds with the following publication (see Appendix A):

Haworth, B., Whittaker, J. & Bruce, E. (2016). Assessing the application and value of VGI and participatory mapping for community bushfire preparation. *Applied Geography*, 76: 115-127.

5.1 Abstract

The increased ease for individuals to create, share and map geographic information combined with the need for timely, relevant and diverse information has resulted in a new disaster management context. Volunteered geographic information (VGI), or geographic information voluntarily created by private citizens enabled through technologies like social media and web-based mapping, has changed the ways people create and use information for crisis events. Research has focussed on disaster response while largely ignoring prevention and preparedness. Preparing for disasters can reduce negative impacts on life and property, but despite strategies to educate communities, preparation remains low. This study assesses the application and value of VGI in bushfire risk reduction through a participatory mapping approach. It examines VGI as a social practice and not simply a data source by considering the user experience of contributing VGI and the potential for these activities to increase community connectedness for building disaster resilience. Participatory mapping workshops were held in bushfire-risk communities in Tasmania. Workshop activities included a paper-mapping exercise and web-based digital mapping. Survey results from 31 participants at three workshops indicated the process of mapping and contributing local information for bushfire preparation with other community members can contribute to increased social connectedness, understanding of local bushfire risk, and engagement in risk reduction. Local knowledge exchange was seen as valuable, but the social dimension appeared even more engaging than the specific information shared. Participants reported collaborative maps as effective for collating and sharing community bushfire information with a preference for digital mapping. Some limitations of online sharing of information were also reported by participants, however, including potential issues of privacy, data quality and source trustworthiness. Further work is needed to extrapolate findings from the study sample to the broader population.

5.2 Introduction and background

5.2.1 Bushfire preparation and community engagement

Community preparation is a fundamental component of bushfire safety. Preparation can assist residents to protect houses and property, and to evacuate safely. Recent studies have investigated factors influencing preparation decision-making (Prior 2010), the importance of 'mental preparedness' (Eriksen & Prior 2013), measures of adequate preparedness (Penman *et al*. 2013; Dunlop *et al*. 2014), preparation costs (Penman *et al*. 2016), gender (Whittaker *et al*. 2016), and levels of preparedness in specific bushfires (McLennan *et al*. 2013; Whittaker *et al*. 2013). Despite community education strategies and the impact of past events, active disaster preparation remains low (Paton 2003; Hausman *et al.* 2007; Gargano *et al.* 2015). There is increasing recognition in emergency management that information provision alone is insufficient to increase community preparation and that more engaging, participatory approaches are needed. This reflects a shift in disaster management more broadly, where community participation is increasingly considered a fundamental principle of disaster risk reduction (DRR) and resilience building (e.g. UNISDR 2015). In Australia, the principles of shared responsibility and community participation are embodied in the National Strategy for Disaster Resilience (COAG 2011).

In Australia, community participation in fire and emergency management is a well-established practice. The Victorian Country Fire Authority's 'Community Fireguard' program, for instance, was established in 1993 to engage and educate groups of interested neighbours about bushfire preparation (CFA 2016). The community development approach adopted by the Tasmania Fire Service (TFS) involves a 'Bushfire-Ready Neighbourhoods' (BRN) program, in which communities are selected based on bushfire risk, capacity and community interest, and bushfire education events and activities are tailored to their local needs. The program aims to provide information to enable people to develop their own bushfire survival plan and be better prepared for the bushfire season (TFS 2014). Similar programs exist in Canada ('FireSmart-ForestWise') and the USA ('Firewise Communities'), with assessments suggesting that neighbourhood programs help to reduce bushfire (or wildfire) risk but also enhance social connectedness and resilience (McGee 2011; MacDougall *et al*. 2014).

Community engagement and participation in disaster management is typically initiated and managed by official agencies. Increasingly, however, community capacities for initiating and managing activities throughout the prevention, preparedness, response, and recovery (PPRR) phases are recognised (e.g. Scanlon *et al*. 2014; Whittaker *et al*. 2015). Recent examples include the 'Student Volunteer Army' that formed in the aftermath of the 2010-11 earthquakes in Christchurch, New Zealand, to help residents clean up liquefaction (Villemure *et al*. 2012), and the group of local volunteers that travelled to Dalchowki village, three hours from Kathmandu, following the 2015 Nepal Earthquake to distribute donated tarpaulins, food and anti-diarrheal tablets (Rousselot 2015). Key advantages of such activities are that local volunteers often arrive on the scene before official agencies, have considerable local knowledge, and are highly responsive and adaptive to changing local needs. The greater accessibility and sophistication of information and communication technologies has seen considerable growth in digital

volunteerism in disaster management, with the emergence of volunteered geographic information (VGI), in particular, changing the ways impacted citizens, the broader public, and emergency management agencies participate in disaster management (see Haworth & Bruce 2015).

5.2.2 The emergence and promise of VGI

VGI refers to user-generated content with a spatial component, which involves the voluntary collection, organisation and dissemination of geographic information (Elwood *et al.* 2012; Goodchild 2007; Tulloch 2008). Technologies such as the Internet, GeoWeb 2.0, global positioning systems, cloud storage, broadband communication, social media and personal locational devices, including smartphones, have enhanced the visibility of practices involving the creation and sharing of geographic information by private citizens (Goodchild 2007; Palen & Liu 2007). The wide usage of smartphones with multimedia capabilities and increased collaborative potential through the proliferation of social media provides innovative opportunities for individuals to contribute towards and consume a collective knowledge base, allowing users to engage with geographic information systems (GIS) in an unprecedented social way (Jayathilake *et al.* 2011).

Researchers have reported on the promise of VGI to address issues and provide opportunities for a range of fields and applications. For example, as a resource for spatial data infrastructures, Genovese and Roche (2010) report on the opportunities for VGI to empower citizens in developing countries by making them part of collaborative local governance and enhancing the information used by decision makers. Community participation in local decision making has been recognized as fundamentally important for regional democracy, and thus the potential contribution of VGI is significant (Genovese & Roche 2010). Elwood *et al.* (2012) describe opportunities for GIS and geography scholars provided by the dense network of individual, intelligent observers associated with VGI. Biggs and colleagues (2014) point to the opportunity of VGI to harness traditional ecological knowledge (TEK) under increasing climate and environmental pressures. TEK constitutes the cumulative and dynamic knowledge, practices and beliefs of local cultures about living things and the environment, and the importance of its inclusion in analyses of community livelihood security is gaining increased global recognition (Biggs *et al.* 2014).

Alongside the promise of VGI, there are important broader implications. Changes to traditional authoritative systems catalysed by VGI involve decentralisation of power and increased empowerment of citizens, where value is increasingly recognised in both expert- and citizen-produced information, initiatives and practices (Haworth 2016).

5.2.3 VGI in disaster management

The increased ease of individuals to create, share and map geographic information combined with the need for timely, relevant and diverse information during disaster events has resulted in a new disaster management context (Goodchild & Glennon 2010; Haworth & Bruce 2015). Social media and web-based mapping platforms have changed the way people create and use information for crisis events (Ostermann & Spinsanti 2011; Liu & Palen 2010). This includes basic use of sites like Facebook to share

text, images and videos (Taylor *et al.* 2012; Bird *et al.* 2012) as well as more complex activities such as data mining or crowdmapping (Meier 2012). Bittner *et al.* (2016) describe a continuum of participation in volunteer mapping for crises, ranging from passive viewing to map establishment, and argue crisis maps promise bottom-up participation and a departure from hierarchical crisis communication and response. Through rapid exchange of geographic information between authorities and citizens for disaster response, and promoting community connectedness and engagement in disaster preparation practices, VGI contributes to all PPRR phases of disaster management (Haworth & Bruce 2015).

VGI presents both opportunities and challenges for disaster management (Haworth & Bruce 2015; Haworth 2016). VGI cost-effectively increases the speed and reach of communications between authorities, affected-communities and the broader public, and facilitates collection of large volumes of diverse information from people in and outside disaster-affected areas. While local knowledge is critical for understanding risk, vulnerability and specific emergency strategies, VGI enables people outside the disaster location to assist in managing disasters, as demonstrated by volunteer involvement around the world in mapping impacted areas following the 2010 Haiti earthquake (Meier 2012). By giving citizens more control over information mobility, technologies such as social media, smartphones and the web empower people to be more involved in disaster management, more connected to each other, and potentially better-prepared to respond to an event. These technologies are becoming increasingly familiar to large portions of the global population. People in emerging and developing countries are more likely to engage in social media than developed countries, even though internet use is lower (Poushter 2016). For smartphones, however, research indicates users are more likely to consume locational information and services rather than contributing their own VGI (Ricker *et al.* 2015).

A priority challenge of VGI is data quality (see Senaratne *et al.* 2016). As VGI is data from the crowd and lacks the same standards and checks as authoritatively-produced data, some have questioned its quality and therefore usability in high risk scenarios such as emergencies. Reported issues include erroneous or spurious postings, lack of contributor credibility, and misleading information (e.g. Bird *et al.* 2012; Hung *et al.* 2016; Gupta & Kumaraguru 2012). Issues of privacy, malicious data use, and personal and information security have also been described (e.g. Shanley *et al.* 2013). Related are concerns over liability, particularly as VGI spans the globe via the internet and legal parameters vary across jurisdictions (Scassa 2013; Shanley *et al.* 2013). Uncertainty also exists regarding who will contribute VGI, and when, what, or how they will volunteer. This is not to say VGI is unreliable, but that it should be treated as a supplementary data source alongside others rather than in isolation (Whittaker *et al.* 2015).

Increased volumes of data produced through platforms like social media means data management is another key challenge, with many disaster agencies lacking dedicated resources to manage VGI, limiting uptake and innovation (Latonero & Shklovski 2011; Anikeeva *et al.* 2015). Further, the unstructured nature of VGI conflicts with emergency management's top-down approach to information dissemination (Haworth 2016; Palen & Liu 2007). Finally, some argue VGI contributes to the digital divide (Norris 2001),

with those without access, time, money or capability to utilise these 'empowering' technologies becoming further marginalized (Sui *et al.* 2013; Crawford & Finn 2015).

Literature in this field has tended to focus on disaster response while largely ignoring prevention and preparedness (Haworth & Bruce 2015). This study differs in that it focusses on assessing the application and value of VGI in preparation for a potential bushfire. VGI studies have also tended to be data- or technology-driven, with a paucity of work on VGI theory or applications (Granell & Ostermann 2016). Through examination of VGI as a social practice, or as a human activity involving collaborative behaviour, and not simply a data type, this research provides an alternative/novel methodology for evaluating its role in disaster management. It considers not only VGI data, but also the user experience of contributing VGI and the potential for participatory mapping to increase community connectedness. VGI conceived as a social practice also involves considering how processes, relationships, and products of VGI represent knowledge, and the social and political relations that shape, and are shaped by, VGI, including who is included or excluded from VGI practices and why (Elwood *et al.* 2012).

5.2.4 Participatory mapping

Involving local communities is a prerequisite to sustainable DRR (Gaillard & Maceda 2009). Gaillard and Maceda (2009) note that community-based DRR fosters participation by involving communities in the identification of risk (including hazards, vulnerabilities, and capacities) and ways to reduce it. Although official information is critical, such participation can provide more up-to-date and locally relevant risk information (Jing *et al.* 2013).

One approach to involving communities in DRR is through participatory GIS (PGIS), or public participation GIS (PPGIS). PGIS and PPGIS are both established fields, but with continuing ambiguity over their application in practice (Brown & Fagerholm 2015). Assigning greater privilege and legitimacy to local or indigenous spatial knowledge, PGIS emerged in response to critiques of the theoretical assumptions and social implications of GIS (Dunn 2007). It involves providing skills and expertise for community members to create maps themselves to represent their individual spatial knowledge (Corbett 2003), with the intent to facilitate participatory decision-making processes, community advocacy, and increased empowerment for communities involved (Tulloch 2007; McCall *et al*. 2015). The assumptions underpinning PPGIS are that local people know their landscape, the interacting socio-economic and environmental processes, the nuances of social behaviour, local culture and institutional structures, and can identify mechanisms for resilience and coping (McCall *et al*. 2015). It is not our intention in this paper to unpack the differences between the two approaches (for analysis on this topic see Brown & Kyttä 2014), but rather we adopt Brown and Fagerholm's (2015) clarification of 'participatory mapping' to describe any process where citizens are involved in creating maps, which includes VGI.

Although there is overlap and connectivity between PPGIS and VGI (Tulloch 2008), the placement of VGI within the critical GIS studies is contested (McCall *et al*. 2015; Sieber & Haklay 2015). VGI is considered

less participatory and critical with an emphasis on the volume of data collection rather than depth of information, and provides opportunity for social empowerment at a macro scale but is limited at an individual level (McCall *et al*. 2015). Based on Borgmann's 'device paradigm', Sieber and Haklay (2015) consider PPGIS as focused on *cultural information* while the mechanisms of VGI further promote the provision of *technological information*. A conceptual summarisation of key differences between VGI, PPGIS and PGIS is presented in Figure 1. There is a need for continued exploration of the relationship between PPGIS and VGI, areas of overlap and points of divergence (Cinnamon & Schuurman 2013; Tulloch 2008). The current study draws on PPGIS theory and collaborative practices in harnessing local spatial knowledge and encouraging information sharing through the use of VGI based techniques that extend beyond the 'device paradigm' as termed by Sieber and Haklay (2015) associated with the proliferation of location-aware technologies.

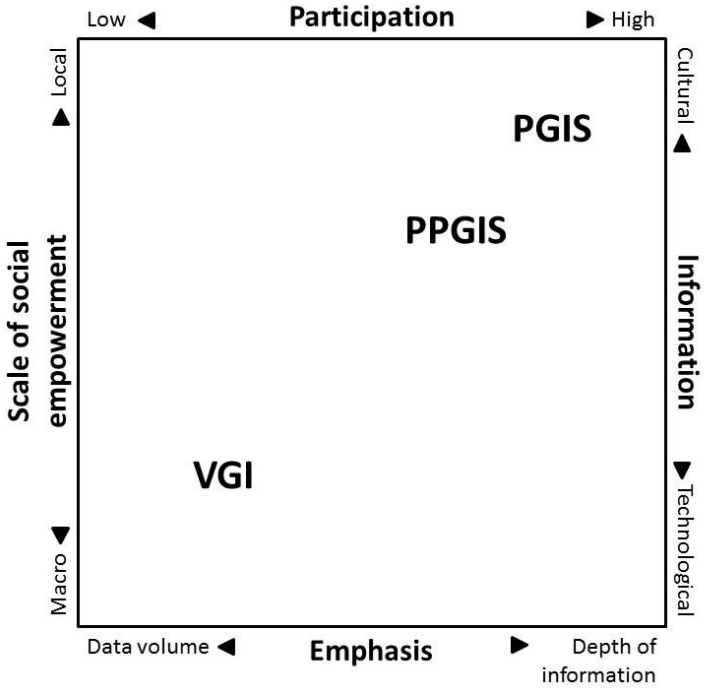

Figure 1: Conceptual representation of the relationships and differences between VGI, PGIS, and PPGIS.

Participatory approaches can be considered to offer communities an efficient, cost-effective method for making robust observations (Acker *et al.* 2010), with technologies, such as the GeoWeb, multimedia, and mobile GIS addressing issues related to the traditionally uneven access to digital spatial data, GIS, and the societal processes that incorporate them (Elwood 2006). However, Cavallo *et al.* (2014) argue for critical evaluation of the beneficial impacts of such technologies on citizens' interaction with government institutions and potential for narrowing the digital divide as their findings suggest that differential participation in VGI initiatives will reflect demographic profile.

GIS and mapping have long been important for DRR and fire management, with applications such as remote sensing for forest fire hazard assessment (Chuvieco & Congalton 1989), and computer modelling methods for understanding fire behaviour and risk (Keane *et al.* 2010). Participatory mapping, however, enables communities to delineate areas they perceive as vulnerable and prone to hazards, and to plot desired and useful risk reduction measures (Gaillard & Maceda 2009). Jing *et al.* (2013) describe a community-based system which allows local residents to report risk information for disaster mitigation, which is both accessible to the community and useful for decision-makers. In the specific case of fire, public participation science research may lead to more effective wildfire management by increasing knowledge and prominence of wildfire issues in communities and providing opportunities for professionals to work with community members (Ferster & Coops 2014). Ferster and Coops (2014) evaluated the quality of data collected via participatory mapping by tasking a group of volunteers to record forest fuel loading using smartphones. They demonstrate the value of these techniques but also recognise the need for further investigation on the importance of understanding the range of participant experience and motivations. Importantly, Corbett (2003) argues the participatory mapping process can contribute to building community cohesion, help stimulate community members to engage in land-related decision-making, raise awareness about pressing issues, and contribute to empowering local communities.

Critique of PPGIS has traditionally focused on claims that participatory GIS disempowers or marginalizes communities through the complexity of the technology, the high associated costs, the inaccessibility of data, and a lack of genuine community participation (Corbett & Keller 2005). VGI may address some of these concerns but still presents limitations including participant representational bias associated with disparity of access.

In this study we adopt a participatory mapping approach to considering VGI for bushfire risk reduction through community workshops. It has been shown that participatory mapping through other methods, such as household surveys, produces more accurate and complete spatial data, with workshop methods recognised as being appropriate for planning processes rather than as producing quality data for decision support (Brown *et al.* 2014). Workshops tend to allow for more qualitative data (Mayoux 2006; Brown *et al.* 2014), including through participant discussions and researcher observations. Workshops facilitate interaction and collaboration between participants, with greater emphasis on the participation with others and the mapping process over data production, and therefore are the most suitable method for this study. These participatory approaches not only contribute to knowledge gained by the researchers, but also from the development of participants' knowledge and understandings gained (DeLyser & Sui 2014). The qualitative sampling approach adopted in this study was conceptually driven to support the research questions and allow analytical generalisations rather than robust statistical generalisations applied across broader populations (Curtis *et al.* 2000). However, it is important to consider the effects of sampling when adopting workshop-based methods. Those who participate in workshops as volunteers may be more likely to introduce biases into the mapping process than

participants recruited through random sampling (Brown *et al.* 2014), which is a significant consideration for evaluating VGI practice broadly.

5.2.5 Study aims

The aim of this study is to assess whether the process of mapping, contributing, and sharing local information for bushfire preparation with other community members can increase an individual's social connectedness, awareness and understanding of local bushfire risk, and their engagement in risk reduction. More specifically, we asked the following questions:

1) Does the social practice of contributing and reviewing VGI increase engagement in bushfire preparation?
2) Does the activity of collaborative mapping increase community connectedness?
3) Is the local knowledge and understanding gained from the mapping process of value to communities?
4) Is the map itself perceived as an effective medium for collating and sharing community bushfire information?

5.3. Methods

5.3.1 Study sites and rationale

Participatory mapping workshops were held in four bushfire risk communities in Tasmania, Australia (Figure 1). Much of Tasmania is covered by bushland and potential fire hazard. Bushfires are the most economically disastrous of all natural hazards in the state and the impacts on communities are long-lasting (Frandsen 2012). The Black Tuesday bushfires in 1967 around Tasmania's capital, Hobart, caused 62 deaths and destroyed over 3,000 buildings (EMA 2011). Disastrous bushfires impacted the south east of Tasmania in January 2013, destroying 203 residential buildings with an overall financial cost in the order of $100m (and this estimate does not include the additional costs of emergency response and recovery operations or consequential costs to public and private sectors) (DPAC 2013). The 2015-16 Tasmania bushfire season exhibited above-normal risk conditions as a result of recent warm years and low rainfall (BNHCRC 2015). Authorities recognise that a projected 250% increase in the area of Tasmania categorised as 'Very High Fire Danger' during spring by 2081-2100 under a high emissions scenario will shorten preparation and recovery cycles (Fox-Hughes *et al*. 2015). Thus Tasmania is ideal for studies concerning bushfire safety.

Workshop locations (Figure 2) were selected for their characteristics listed in Table 1. While aspects of sites were common, such as bushfire risk, diversity between sites was preferred to ensure identification of a breadth of VGI application issues across communities with differing geographies, existing levels of community engagement, community profile, and known fire history.

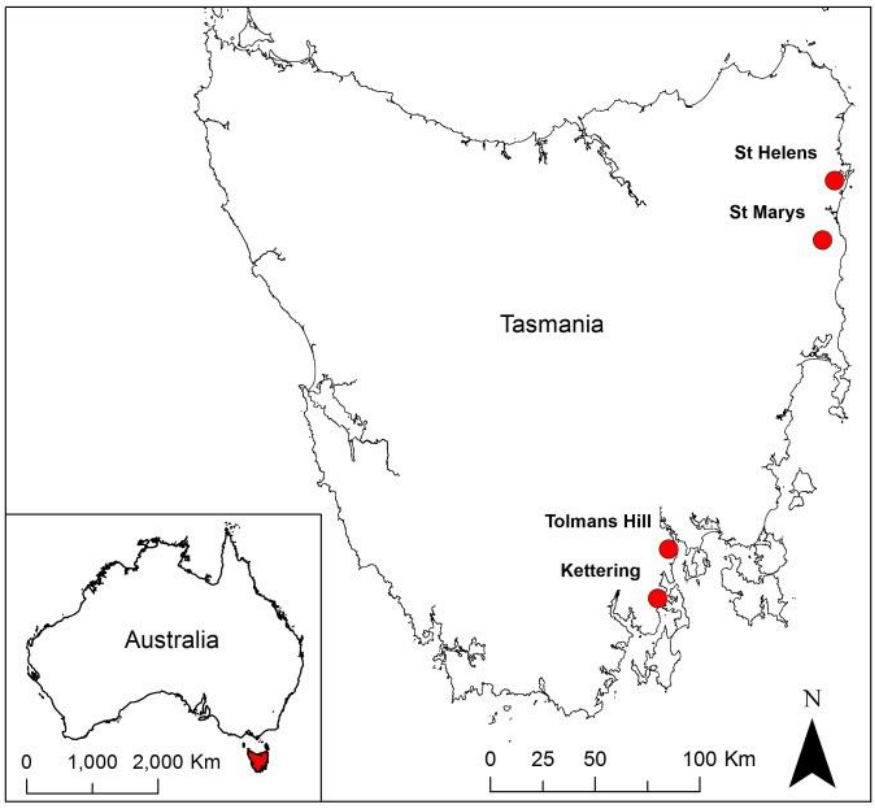

Figure 2. Workshop locations within the state of Tasmania.

Table 1. Characteristics of workshop sites

	Region	Bushfire risk[1]	Significant fire event[2]	Population[3]	Geography	Engaged bushfire groups[4]	Part of BRN program[5]
Kettering	South	Extreme	1967	984	Rural	Yes	Some works
St Marys	North East	Extreme	2006	800	Rural	Yes	Yes
St Helens	North East	Extreme	2014	1,498	Peri-urban	No	Some works
Tolmans Hill	Hobart	Extreme	2014	490	Urban	No	No

[1] Tasmania Risk map, produced by Parks and Wildlife (PWS), 2010. Accessed 9/2/2016 at <https://wikis.utas.edu.au/display/ext03/Risk+Assessment+Mapping>. [2] Significant: an event that at a minimum involved fire service attention. Emergency warnings may have been issued and/or community daily life was interrupted in some other way (e.g. road closure, closed businesses, injury or death). Various information/news sources. [3] 2011 Census, Australian Bureau of Statistics (ABS). [4] Did the community have pre-existing and visible operating community-led fire management-related groups? E.g. neighbourhood groups, annual meetings, established telephone trees. [5] Bushfire-Ready Neighbourhoods: No, not part of BRN; some engagement works undertaken; Yes, current core community. <http://www.bushfirereadyneighbourhoods.tas.gov.au/>.

5.3.2 Participant recruitment

Participants were recruited through: (1) approaching participants involved in a previous related study (see Haworth *et al.* 2015), (2) known local contacts, and (3) tailored invitations to residents, community fire groups, local businesses, community organisations and other local services including schools. As Tolmans Hill is an entirely residential area, workshop information was mailed to all households (n=240) six weeks prior to the event, and flyers placed in a random sample (n=50) of letter boxes one week prior to the event. Information was also mailed to a random sample of households in St Marys (n=150) and St Helens (n=150) as local contacts were limited. Workshops were advertised more broadly in local council newsletters and online through social media and other relevant websites (e.g. Tasmania Fire Service, community organisations), and through targeted promotion on Facebook (based on geography and age > 18).

5.3.3 Workshop process

Workshops were held in local venues over three weekends in November and December 2015 over a 4-5 hour period. Workshops allowed participants to test multiple mapping methods with hands-on activities tailored to their community, and enabled the experience of undertaking these tasks together with other community members to be evaluated. Each workshop included a short introductory presentation, a paper mapping activity (approximately 90 minutes), a lunch break (30 minutes), and a digital mapping activity (approximately 75 minutes) before participants completed a questionnaire (15 minutes). Present at each workshop was the lead author, an assisting researcher, and a TFS representative from the BRN program. While the fire service were represented at each workshop, it was made clear to participants in

advance that the purpose of the workshop was to contribute to the research and that information they contributed would not be utilised by the Tasmania Fire Service or directly inform official emergency management practices in their area.

The lead author introduced the facilitators, provided background on the research and study aims, and explained the workshop activities. The first activity involved paper mapping whereby participants in groups of 2-5 were given a hardcopy satellite image (size A1), topographic map (size A1), community protection plan (an official TFS document outlining 'nearby safer places' and other relevant information) (size A2), blank paper, plastic overlays, and a suite of coloured markers, stickers and other stationary. Participants were asked to add information to the maps they considered relevant to bushfire preparation in their community, using any combination of the provided-resources. With the focus of the exercise on the experience of collaborative mapping, the content participants should map was not prescribed. However, facilitators provided guidance through discussions during the activity on what might be appropriate to include, such as local knowledge on areas perceived as vulnerable to bushfire, community assets, resources available to people for preparing their homes, community groups, home-to-work travel routes, and potentially important sites in the event of disaster including alternatives to the TFS 'safer places'. At completion of the exercise participants presented their maps to the other groups for discussion. Figure 3 presents an example of a paper map completed during the exercise. Further examples can be found in Appendix G.

The second activity (digital mapping) involved collating the information from each group into a combined web map. Though its GIS functionality is limited, the Zeemaps platform (www.zeemaps.com) was used for its simplicity and accessibility. Base maps were established for each community prior to the workshops to ensure consistency in geographic coverage with the paper maps (though participants could then zoom and pan), and a URL to the map enabled participants to contribute through a web browser on laptop computers, smartphones and tablets live in the workshop. Participants could view a street map and/or satellite image base layer. The platform allowed data to be added as points with different colours and icons and as regions in a choice of colours. A short description and photo could be added to an entry, and a description/attribute given to each entry automatically populated a legend. Participants were able to add and edit their own points, but administrative access was required to delete entries. Figure 4 presents an example of a completed digital map. Additional examples are presented in Appendix G.

A questionnaire was completed by participants to capture both quantitative and qualitative data regarding their views on key topics, including the user experience of mapping community information, mapping methods, local knowledge in community bushfire preparation, community connectedness, potential concerns such as privacy and data security, and future use of VGI (Appendix H). Questionnaire responses were collated and analysed in Microsoft Excel alongside Australian Bureau of Statistics (ABS) 2011 Census data. Key insights were gained through observation and informal discussions with participants during and following each activity that were later documented by the researchers.

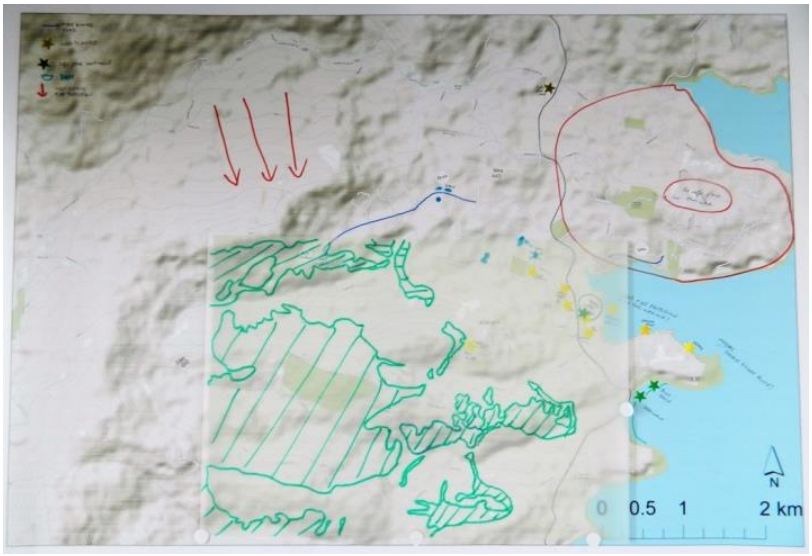

Figure 3. An example paper map produced during the Kettering workshop

Figure 4. An example digital map on the Zeemaps platform produced during the Kettering workshop

5.4. Results

5.4.1 Participant demographics

Survey results from 31 participants are included in the following analyses (Kettering, n = 16; St Marys, n = 9; St Helens, n = 0; Tolmans Hill, n = 6). While more individuals attended workshops, not all returned a completed questionnaire. An even distribution of male (53%) and female (47%) participants attended.

The age distribution of participants was skewed towards those over 35 (age 35-50 = 20%; 51-70 = 53%; >70 = 27%). Figure 5 presents a comparison between age representation in the study samples for each workshop community and census population data. 90% lived in a household without children or dependents, either alone (10%), as a couple (67%) or with other adults (13%). Most participants had lived in their community for over 5 years (76%), with 24% living in the area for more than 20 years. 57% of participants had a tertiary qualification and the majority were either employed (47%) or retired (50%).

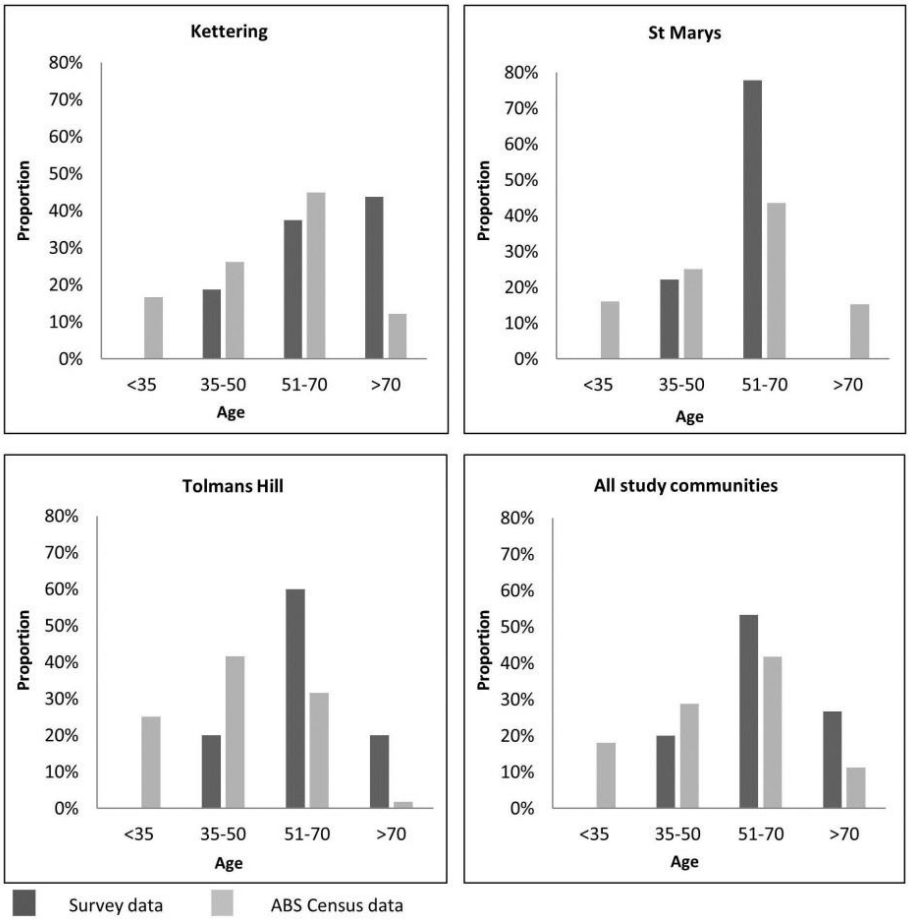

Figure 5. Graphs for study communities presenting the proportion of workshop participants for each age group compared to ABS 2011 Census population data.

5.4.2 Workshop observations

5.4.2.1 Participant interactions

Participants appeared interested and motivated to learn and contribute to bushfire preparation in their community. They worked quickly and easily with others and discussions were lively. In particular, the paper mapping activity yielded a high level of participant interaction. Some participants described

working with others, discussions between community members, and the increased community connections generated through the mapping activities as the most valuable aspects of the workshop (as opposed to the information gained or the maps produced).

Interaction appeared lower during the digital mapping activity. This may reflect the sequencing of activities and subsequent participant fatigue associated with the second activity. In some instances a particular group member controlled the input device (tablet, laptop computer, smartphone) leaving others in the group with minimal opportunity for interaction with some participants observed to be slightly intimidated by the technology. After initial hesitation, most, however, did engage with the activity and commented on the greater potential for mapping in their community enabled through internet and computer devices.

5.4.2.2 Group Discussions

Dominant discussion points included what content to map, the differences between mapping methods, and how a VGI-derived map may be useful and applied in the broader community outside the workshop setting. Despite concerns about power outages during bushfire events and limited computer access, map ownership and administration, privacy, and the risk of malicious intent, overall discussions on the use of web mapping were positive.

Participants generally described a preference for digital mapping, in contrast to the observations described in section 3.2.1. They discussed how online mapping would be useful for people who are less-engaged in more traditional bushfire preparation activities and forums, including younger people, and vulnerable groups such as travellers, new residents, and those whose first language is not English. The web map was seen as preferable for examining finer detail information (e.g. ownership of particular tools in a neighbourhood), wider distribution, maintaining information relevance, the convenience of contributing when/where people desire, inclusion of more detailed comments and photos, and the potential for greater data use (e.g. GIS analyses).

5.4.2.3 The information contributed

The content participants chose to map focused on response to a potential fire event, and included services and community assets such as communications or food suppliers, potential hazards such as fuel stores or one-way roads, areas of increased risk such as dense bushland, ‘safer’ places to assemble and possible evacuation routes.

Significantly, the activities also revealed to participants how little they knew about other residents in their community, and how disconnected and unprepared their community possibly is. In Tolmans Hill, some described feeling uncomfortable knocking on their neighbour’s door, which was in contrast to other communities visited, such as Kettering where participants appeared well-connected and were including neighbourhood-level bushfire management groups on their maps. Participants discussed how important sense of community might be for improving bushfire preparedness in Tolmans Hill. Referring back to the community map, they identified locations for a playground and a coffee shop that may be

useful in building community connections. Participants regarded the content they mapped as more useful, and most needed, for strengthening engagement in bushfire preparation within their community than for use by emergency response services.

5.4.3 Questionnaire responses

5.4.3.1 The user experience of mapping community information

Broadly, participants described the experience of mapping their own information for their local community positively. 97% of respondents stated the activities were useful for their bushfire preparation, 97% thought maps in general were an effective way to present and share their information, and 77% learnt something new about bushfire preparation in their community through the mapping exercise. Participants stated discussions informed them of the preparation approaches taken by others, and having access to a broader range of community knowledge helped highlight how the community may struggle to manage a large bushfire.

Undertaking the activities with other community members was seen as important, with all participants reporting working with others as a positive experience, and 94% confirming that it helped them understand the broader bushfire risk and preparation activities in their wider community. Some participants commented on the local knowledge of individuals, and how bushfire preparation should be a collective effort. For example:

> "*If two brains are better than one, then 17 brains have to be even better! Each person has personal knowledge of their own environment and neighbours not necessarily known by others in the overall community" (questionnaire response, workshops 2015)*.

Others commented they were not aware of each other's resources, capabilities and fire safety concerns prior to the mapping activities.

Figure 6 presents participants' perceptions of various aspects of the participatory mapping activities, depicting strong modal scores of 4 (agree) for all items and overall positive feelings for the experience of community mapping for bushfire preparation.

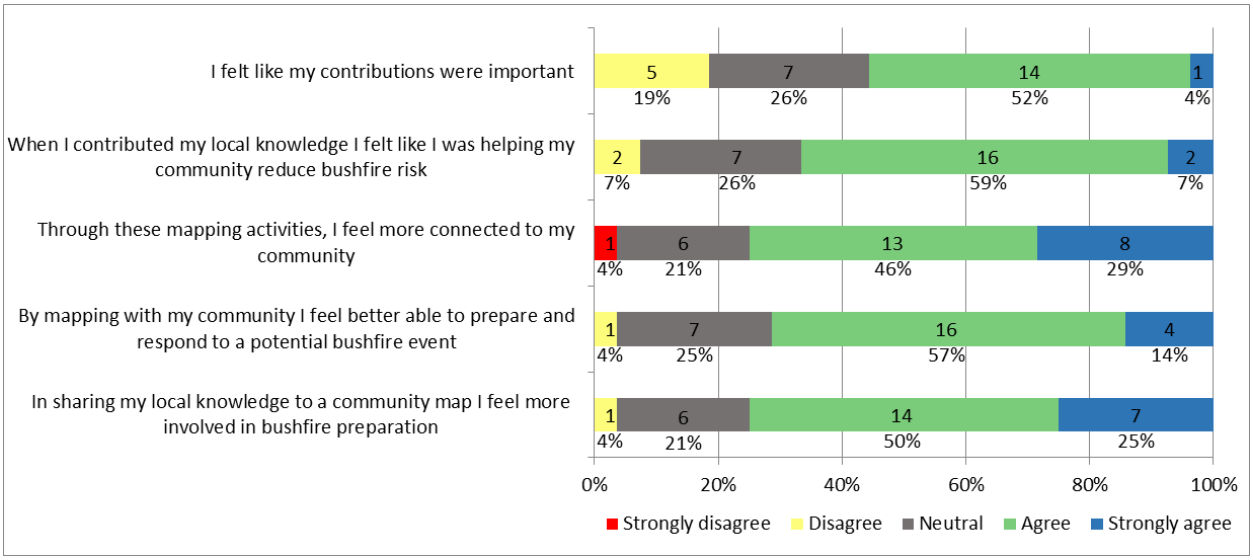

Figure 6. Likert Scale item responses to participatory mapping exercises, showing a modal score of 4 (agree) for all items. The values on each of the bars represent the number of responses for each of either 'Strongly disagree', 'Disagree', 'Neutral', 'Agree', or 'Strongly agree' to the Likert Scale items, with the proportion of responses as a percentage underneath.

While a low percentage had concerns (26%), some points raised by participants to consider in sharing information to a public community map included the accuracy of information and how it can be verified, privacy and awareness of who can access and use the information, and security concerns. Despite this, 86% of participants stated they would contribute to community maps similar to those used in the workshop in the future.

5.4.3.2 Paper mapping versus digital mapping

In response to questions on the differences between paper mapping for sharing community VGI and digital mapping, participants described strengths and weaknesses of each method (Table 2). Figure 7 shows participant preferences for either paper mapping or digital mapping, and which method they perceived as more useful for their broader community.

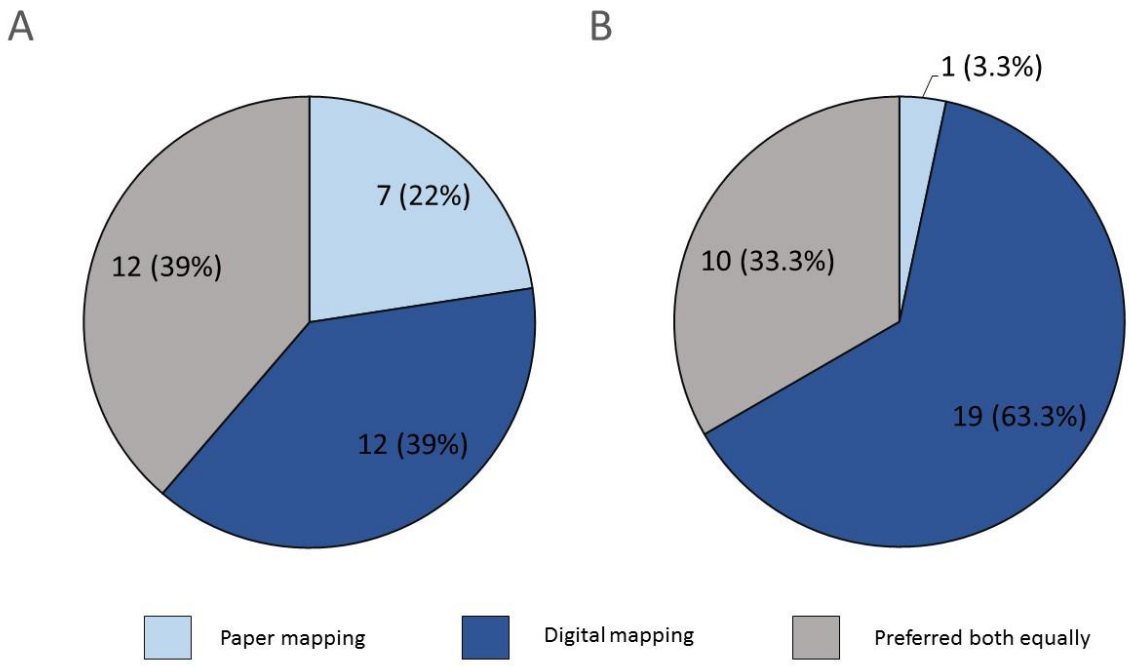

Figure 7. The number and percentage of participants preferring each mapping method for A: themselves, and B: their broader community.

Table 2. Strengths and weaknesses of VGI mapping methods identified by workshop participants.

	Strengths	Weaknesses
Paper Mapping	Good for discussion / brainstorming	Difficult to maintain currency
	Inclusive activity	Unlikely to carry around final maps
	Good when technology is disrupted	Resulting maps easily lost or damaged
	More fluid input – e.g. sketching	Poor legibility
	Not reliant on power or internet access	Limited scale / boundary of the page
	Useful to issue to new residents or tourists	Limited audience / not easily communicated or shared
		Resource costs
		Information needs to be translated to digital to be used in other ways, e.g. in a GIS
Digital Mapping	Higher resolution	Technology difficult for some to use
	Accessible to many	Digital divide – not everyone has access
	Collating various information	Technology failure
	Increased accuracy and greater detail	Inaccurate/false information
	Can zoom/pan to locations – changeable scale	Information verification – managing malicious intent
	Easier to edit and update	Cluttering of data on the map
	Storage	Ephemeral nature of GIS platforms
	Mobile accessibility	Dependent on power/internet access
	Multiple layers of information, e.g. satellite imagery	Time needed to learn the technology/software
	Data can be combined and manipulated with other databases	Who has access to the information mapped? E.g. the public, arsonists
	Other stakeholders can contribute information, e.g. fire service, police	
	Ability to share easily	

5.4.3.3 The information mapped

Participants described favourably the mapped information itself. 84% felt the information was personally relevant and 74% felt it increased their understanding of community bushfire preparation. 93% felt VGI would be useful to emergency management authorities. 94% believed participatory VGI increased their awareness of other community members and their preparedness, and all participants reported the information would be useful to other members of their community. One participant commented:

"People living in our area don't know what others have available. I.e. water, safer place. Not everyone is aware of particular hazards" (questionnaire response, workshops 2015).

5.5. Discussion

This study provides evidence for the application and value of participatory based VGI in community bushfire preparation. Results indicate that the process of mapping and sharing local spatial information for bushfire preparation with other community members can contribute to increased social connectedness, understanding of local bushfire risk, and individual engagement in risk reduction. However, the findings need to be considered in the context of the study sample.

5.5.1 Study sample

The limited and potentially skewed sample of 31 participants restricts extrapolation of the findings to the broader population, with particular underrepresentation of people < 35 years of age and an overrepresentation of people > 50 (Figure 3). Vulnerable groups such as those experiencing greater levels of social disadvantage, supporting dependents, or visitors to the area are also underrepresented. In considering the broader application of VGI, if not 'everybody' in a community is contributing; can a map ever be fully representative? The lack of participants in St Helens, as well as the small sample size overall, reiterates the challenge of community engagement in DRR, despite innovative and sustained efforts through initiatives like BRN, which has also experienced variable participation rates (DSA 2016). While the link cannot be assumed, if the lack of workshop engagement is related to a broader community disinterest in disaster preparedness this has relevance for community safety efforts. Though, others have reported that participatory mapping studies rarely result in representative samples and can exhibit biases towards older, more formally educated participants with higher incomes (Brown 2016), and thus our sample does not appear atypical.

Despite extensive recruitment efforts as part of the research design in the current study, recruitment was problematic, demonstrated by the lack of attendance at the St Helens workshop. An exhaustive approach, including broad-scale, community-wide promotion through digital and offline methods, as well as targeted invitations to key community individuals and organisations with tailored messaging, following the guidance of researchers at ExCiteS – University College London (personal communication 2015), still failed to result in a study sample representative of the broader community.

The limited study sample, however, does not devalorize results reported on the experiences of those that did participate. Participants spent a minimum of 4 hours participating in the study, developing a deep engagement with the mapping activities, collaborating with other participants, and discussing their responses with the researchers, providing a rich dataset that includes a depth of understanding and appraisal of the participatory VGI methods proposed for bushfire preparation engagement. While the study collected quantitative data through the questionnaire, importantly it also facilitated generation of rich qualitative data through observations, focussed discussions, as well as sections of the questionnaire, thus further emphasising the importance of 'small' contextual data and methodological pluralism

(DeLyser & Sui 2014). The study is more aligned with focus group methods, in which a typical useful sample size is 6-12 (Griffith 2013), than broad scale survey methods which involve less participation and require much larger sample sizes. The benefits of such qualitative research is information drawn through experiences rather than the participant sample size (Sandelowski 1995). If we accept the flaws in studies of this nature, such as limited sample population and response biases associated with surveys or workshops where participants self-select, we should consider the results of this study as indicative rather than definitive. We must recognize that the experience of those not represented in the study sample may differ from the results we report here.

5.5.2 Insights gained

In response to the first study aim, the experience of workshop participants suggests the social practice of contributing VGI was engaging for bushfire preparation. There was an understanding that everyone had different knowledge to contribute and that bushfires can affect all members of the community, thus managing risk should be a shared experience. The social aspect of VGI, with people connecting to each other through the mapping process, appeared even more engaging than the specific content being mapped. This should be a consideration for future DRR-engagement efforts. Others have reported that empowerment in PPGIS initiatives is linked to the participatory process, and the emphasis for a successful project should be on participation rather than technical components (e.g. Jordan 2002).

Participants were observed to be most engaged in the workshops when they were able to map their neighbourhood fire groups and details about individual streets, with information at the local neighbourhood scale proving more personally relevant to participants. Mapping at broader geographic scales, such as the wider community level, produced relevant information, but was limited to content already available on existing maps, such as communication towers and dead-end roads, and failed to harness local expertise and lived experience in the same way achieved by finer-scale mapping. Gaillard and Maceda (2009) state while working at larger scales allows household-level detail to be mapped, it also requires more participants from a smaller area to gain enough data for use. McCall *et al*. (2015) argue that the focus in participatory mapping on smaller groups is its strength over most VGI projects that tend to be broad in coverage. Goodchild (2007) also pointed to the significance of scale, positing that the most value of VGI to geographers may be what it can inform about life's activities and the lived experience at local scales.

Regarding our second aim, the study suggests the act of group mapping can contribute to increased community connectedness. Greater analysis employing more complex psychological scaling measures is required to further this understanding. Taylor and colleagues (2012) show how social media helped people share information, connect and assist each other in response to a cyclone event in Australia in 2011, arguing that VGI activities promote connectedness and directly help reinforce social capital and community competence for disaster resilience. Social capital has been described as "the interconnectedness of individuals and organisations, in which strengths come through social support, sense of community and attachment to place" (Taylor *et al*. 2012; Norris *et al*. 2011). Connectedness of

individuals and sense of community were shown in this study to influence a community member's bushfire preparation, particularly in Tolmans Hill. Participatory mapping initially revealed how disconnected participants were, but then became a useful tool to aid in discussing strategies to improve sense of community. VGI and participatory mapping not only allowed communities to record their concerns, but also had transformative capacities in contributing to change and increased community connectedness. Through strong social networks, high levels of trust, and high civic participation, elevated social capital unites community members and is important for information dissemination and building shared attitudes and behaviours (Hausman *et al*. 2007), leading to improved disaster resilience (Murphy 2007).

In the context of the third aim, local knowledge shared was of value to study participants with 94% reporting VGI increased their awareness of other community members and their preparedness contributing to the ongoing process of building community resilience. If disaster resilience and bushfire risk reduction is to be a shared experience and a shared responsibility, those involved must have a common understanding of each other's risks, responsibilities and actions.

In addressing the fourth study aim, mapping was perceived as an effective mechanism for collating and sharing community bushfire information, especially in digital form (Figure 7). Given the study sample age bias towards older people, the preference for the technological solution over offline methods was unexpected. Research shows that Web 2.0 technologies are used more commonly by youth (Haworth et al. 2015; Perrin 2015). However, given 57% of participants were tertiary-educated, the observed openness to digital mapping may in part reflect sample bias alluded to by Sieber and Haklay (2015) who warn of the potential for VGI to become the diversion of those who have the time, knowledge and education. Similarly, Bittner and colleagues (2016) question the promise of VGI to represent and empower 'ordinary people' and argue that those who can and do participate in crisis mapping often form a privileged minority. Our participatory mapping approach did reveal potential for such biases and participant characteristics, but, unlike involvement in other phases of disaster management, in the preparedness phase, well designed VGI initiatives at a focused community level could foster broader uptake. Corbett and Keller (2005) note as information technologies have proliferated and become easier to use, the role of the tools themselves in the empowerment process has gained greater importance. For community bushfire preparation, a combination of paper and digital mapping may be appropriate in some instances to reduce the limitations outlined in Table 2 and facilitate participation of those who do not use VGI technologies.

Participants' concerns about potential inaccuracy of information and trust of non-authorized data sources have been reported elsewhere (Gupta & Kumaraguru 2012; Haworth et al. 2015). Solutions offered include systems for determining a measure of credibility or data quality (Ostermann & Spinsanti 2011; Hung *et al*. 2016), or reasoning for why data quality should not be a major concern, such as the evidence provided by Linus' Law and the Wikipedia model that demonstrates error reduction through collective agreement (e.g. Haklay *et al*. 2010). However, we question whether numbers would reach a

sufficient critical mass in community-scale mapping projects for effective self-correction. Other Web 2.0 platforms, such as eBay and Couchsurfing, have employed systems of contributor reputation ratings to increase information credibility and source trustworthiness (McCall *et al*. 2015). McCall *et al*. (2015) argue that trust is built over time in smaller participatory mapping groups, whereas validation is sought for broader scale VGI.

Privacy and consent issues were consistently raised, with participants concerned in particular about who would have access to information on a web-based platform. Information mapped about vulnerable people, for instance, may be sensitive, particularly if those formally classified as vulnerable do not view themselves in that way. Access of shared information to people with malicious intent (e.g. arsonists or thieves) also links the issue of information privacy to compromised personal security. Sieber and Haklay (2015) argue for the integration of societal value in system design and the need to anticipate potential geolocational privacy violations through embedded techniques for location masking. VGI also has potential to create or exacerbate conflict in communities. For example, the identification of unmanaged properties or unprepared households could generate tension or division, particularly if information is contributed without consent. The potential for VGI to create conflict within communities, possibly undermining community connectedness and social capital, warrants further research. Potential solutions for privacy and trust issues associated with VGI more broadly also require further research, particularly as addressing many of these matters will be dependent on policy and legislative arrangements which may vary across jurisdictions.

5.5.3 Future considerations

It is important to recognize that this study has measured increased community engagement based on survey responses and workshop observations related to people's perceived preparedness, rather than assessing change in actual bushfire preparation actions, such as existence of a survival plan, or long term behavioural change. This was beyond the scope of this paper and future analyses would strengthen this work by investigating longer-term impacts of participatory mapping as a bushfire preparation engagement mechanism.

This study does not comprehensively address questions concerning motivation, self-directedness and custodianship over VGI initiatives. Reliance on coordination, whether by community or authorities, may be required to ensure success of VGI applications (Sieber & Haklay 2015). This becomes increasingly important if participatory maps are associated with funding or political agendas (Gaillard & Maceda 2009). Further, without the impetus of research or an individual 'champion', would a VGI system be implemented and would it be maintained? The short lifespan of many web-based platforms, how seriously VGI maps are perceived by the viewing public and the relationship between volunteers and emergency management authorities (Bittner et al. 2016) further challenges the sustainability of VGI practices. Governments are often restricted by top-down 'command and control' style frameworks which give little flexibility for supporting alternative initiatives (Gaillard & Maceda 2009). Brown (2012) argues that government organisations' engagement with more inclusive participatory initiatives in

regional and environmental planning has been limited due to a lack of specific incentives, the unpredictability that accompanies engaging the general public, lack of experience, the 'expert-lay-divide', and regulatory barriers. Longitudinal studies are required to determine opportunities for and barriers to sustaining participatory mapping initiatives maintained by communities and the appropriate level of organisational involvement and support.

5.6. Concluding remarks

Key contributions of participatory mapping in bushfire management include the promotion of social inclusion, capacity building, and enabling democratic participation. This study has demonstrated the role of participatory mapping, facilitated through VGI, in providing opportunities for community connectedness, local knowledge exchange, and individuals' engagement and responsibility in DRR. Further work is needed, however, to extrapolate findings from the study sample to the broader population. The low workshop attendance was a key finding in itself, reiterating the question of how a community can achieve social connectedness and disaster resilience if there are potential barriers to congregating for a common cause, emphasizing the importance of engagement with the broader population as an ongoing goal, particularly diverse and/or under-represented groups. Evidence of the benefits of involving community members in disaster management is mounting and emergency organisations should work to determine how they can support participatory bottom-up approaches and ensure present organisational systems are not a barrier to their success. Additional resources and funding may be required to manage issues such as large volumes of data and misinformation, but VGI-sharing in communities should be encouraged to increase risk awareness, the use of local knowledge and community engagement. In existing community engagement strategies, mapping can be utilised to raise local spatial awareness and for capturing, collating and distributing community bushfire information. However, VGI is not a standalone approach and successful community engagement will be achieved by employing a range of strategies.

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CHAPTER 6: A CRITICAL EVALUATION OF VGI PRACTICES AND COMMUNITY DISASTER RESILIENCE

This chapter corresponds with the following publication (see Appendix A):

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6.1 Abstract

Adoption of location-based information sharing technologies, and the emergence of volunteered geographic information (VGI), has seen changes to community involvement in disaster management. The concept of resilience and recognition of the capacity for renewal, re-organisation and societal development has gained currency in disaster management. However, the opportunities presented by spatially-referenced data for sourcing contextual information at geographical and temporal scales relevant in understanding processes of social-ecological resilience and fostering local inclusion has not been examined. We examine how geoweb 2.0 platforms, including VGI and social media, can support resilience building, and critically evaluate how these technologies potentially undermine resilience. We concentrate our analysis on factors deemed important for community disaster resilience through review of recent literature, policy documents and author experience. Establishing which elements of VGI in disaster management should be emphasized, such as increased flexibility or individual empowerment, and which require careful management, such as compromised privacy or data quality, will enable VGI to become less opportunistic, data-centric, disruptive and exclusionary, and allow for more reliable, community-centric, complementary and socially-inclusive practices. Incorporating awareness and training on collaborative geoweb technologies into preparedness programs will equip individuals to make informed judgements on VGI content and reduce unintended consequences of social media initiatives.

6.2 Introduction

Adoption of social media and location based information-sharing technologies, and the emergence of volunteered geographic information (VGI), has seen a shift in the spatio-temporal scales of community involvement in disaster management. However, social-media and VGI efforts tend to focus on reactive response initiatives, such as the use of Facebook to connect community members during bushfires

(wildfires) in Tasmania, Australia (Irons *et al.* 2015) or volunteer mapping with OpenStreetMap (OSM) to assist humanitarian responses to the Haiti earthquake disaster (Meier 2012), rather than preparedness and participatory practices for promoting community resilience. The concept of resilience and recognition of the capacity for renewal, re-organisation and societal development following system disturbance has gained currency in disaster management research. This paper examines how resilience thinking can better inform the development of public participation geoweb platforms and understandings of the motivations and requirements of such initiatives. The resilience perspective is adopted here to provide a contextual framework for critical evaluation of the role of VGI practices in disaster management.

Derived from the Latin word *resilio* for "bounce" (Manyena *et al.* 2011) the resilience concept has been embraced by various disciplines, including anthropology, engineering, urban planning and geography (Weichselgartner & Kelman 2015), with origins in physics (Van der Leeuw & Aschan-Leygonie 2005), development psychology and ecology (Manyena 2006). The resilience perspective emerged from the ecology literature in the 1960-1970s with the discovery of multi-stable states in natural systems and non-linear forms of functional response (Folke 2006). In challenging the dominant assumption of static equilibrium, Holling (1973) introduced the concept of multiple basins of attraction in which the size of stability domains (basin) or amount of disturbance a system can tolerate before shifting into another regime provides a measure of resilience (Folke 2006). Recognised importance of process dynamics across multiple and interacting spatio-temporal scales later placed the resilience perspective in the context of complex adaptive systems (Folke 2006). Integration of the social dimension in resilience thinking led to the concept of social-ecological resilience (SER). SER considers the amount of disturbance the system can absorb, the system's ability for self-organisation and the degree to which the system can build and increase capacity for learning and adaptation (transformability) (Carpenter & Gunderson 2001; Folke 2006). Rather than focusing on ecosystems or societies as separated entities, recognition of the dynamic interplay between the social and ecological components is critical in understanding system resilience (Gallopín 2006).

In ecology, resilience emphasizes efficiency, control, constancy and predictability as attributes of reliable systems (Holling & Gunderson 2002). Another perspective considers the persistence, adaptability, variability and unpredictability of ecological systems (Holling 1973). The first definition is a measure of the speed at which a system 'bounces back' after disturbance (Pimm 1984); while the second measures the degree of disturbance that can be absorbed by a system before undergoing structural change (Holling & Gunderson 2002). More recently, geographical interpretations of resilience have encompassed elements such as capacity and capability, moving from the early ecology-based 'bounce back' perspective to something that suggests doing better than before, or 'bouncing forward' (Weichselgartner & Kelman 2015; Manyena *et al.* 2011).

The term resilience has come into vogue in disaster management in recent decades with concern the language of 'vulnerability' in disaster management was disempowering. Often resilience is treated as an

antonym of vulnerability, being a more positive way to talk about the same problem, but Whittaker (2008) argues there are important differences. Vulnerability is constructed in the social and economic circumstances of everyday living and describes the ways people are differentially exposed to hazards and have varying capacities to reduce risks and withstand potential impacts (Morrow 1999; Whittaker 2008). Recognizing the terms are related, Zhou and colleagues (2010) attempt to contrast vulnerability and resilience, placing the emphasis of resilience on the process of enhancing capacity to respond and recover from disaster impacts in the shortest possible time with minimal outside assistance. Disaster resilience considered from a geographic perspective is "the capacity of hazard-affected bodies to resist loss during disaster and to regenerate and reorganize after disaster in a specific area in a given period" (Zhou *et al.* 2010, p.28). In Australia, the National Strategy for Disaster Resilience (NSDR) (COAG 2011) opts to avoid defining resilience, preferring to concentrate on "common characteristics of disaster resilient communities, individuals and organizations," which include functioning well while under stress, successful adaptation, self-reliance and social capacity (p.5).

Understanding and management of disasters since the 1970s has shifted focus from hazard identification and response to the drivers of vulnerability that turn hazards into disasters (Collier *et al.* 2009). Promotion of the Disaster Risk Reduction (DRR) framework by the practitioner community, both internationally (Hyogo Framework for Action, and Sendai Framework) and at national levels, has highlighted the importance of SER thinking, the need for indicators of effective disaster preparedness, and participatory approaches that ensure local inclusion (Collier *et al.* 2009).

The aim of current emergency management policy is to use the Prevention, Preparedness, Response and Recovery (PPRR) model to work towards a more disaster-resilient nation, that is, one that aims to recognise current and future risk, reduce and manage those risks, and is better-able to recover from disasters (COAG 2009; Prosser & Peters 2011). Increased emphasis on resilience in disaster management requires emergency practitioners to shift focus from a top-down 'command-and-control' model to one more strategic, participatory, and dialogic with communities and stakeholders, where value is increasingly recognized in both authoritative and citizen information and practices (Burnside-Lawry *et al.* 2013). This has led to implementing initiatives centred on community engagement (e.g. Frandsen *et al.* 2011) and innovations in information and communication technologies, such as social media, that can empower citizens in disaster response (e.g. Taylor *et al.* 2012).

Allowing ordinary citizens to voluntarily create and share geographic information, technologies such as the internet and Web 2.0, global positioning systems, personal locational devices such as smartphones, inexpensive map-making platforms open to public contributions (e.g. OSM, Ushahidi Crowdmap), cloud storage, and broadband communication have transformed the traditional model of authoritative production of geospatial information, with particular pertinence to disaster management (Haworth & Bruce 2015). The production of geographic knowledge is no longer exclusive to experts such as geographers (Elwood *et al.* 2012). The central discourse of Web 2.0 technology and practices like VGI is

public participation and interactivity, a key element in crisis literature aimed at building resilience and increasing the involvement of the general public in disaster management (Bittner *et al.* 2016).

Although recent work has argued for the role of Web 2.0 information sharing platforms in building community disaster resilience (Dufty 2012; Taylor *et al.* 2012), this is often focused on disaster response or a single platform in isolation, such as social-media, at the exclusion of other practices such as VGI. The opportunities presented by spatially referenced (geotagged) data for sourcing contextual information at geographical and temporal scales relevant in understanding processes of SER and fostering local inclusion has not been examined. We consider Web 2.0 information sharing platforms more broadly in community disaster resilience to include social media-based exchange of information and resources as well as more participatory enterprises such as crowdsourced disaster risk mapping. We also include here the concept of participatory mapping, as conceptualized by Brown & Fagerholm (2015) to collectively denote any process whereby citizens contribute to the creation of maps, which includes VGI.

The intent of this paper is to examine how Web 2.0 information sharing platforms, including VGI and social media, can support resilience-building in emergency management and critically evaluate how these technologies potentially undermine resilience building. The emergence of resilience as a core concept in disaster management, relevance of SER and the resilience goals of disaster management will first be discussed.

6.3 Resilience and disaster management

6.3.1 The emergence of resilience in disaster policy

Towards the end of the twentieth century there was a shift in emergency management from a model concerned largely with the hazard event itself, to one which increasingly considered the interactions between human and natural systems (Blaike *et al.* 1994). Disaster thinking moved away from reducing disasters to *Acts of God* or *Nature* to placing increased emphasis on humans and their vulnerabilities as causative factors (Manyena *et al.* 2011; Furedi 2007). The UN General Assembly adopted the *International Strategy for Disaster Reduction* in 1999, reflecting a shift in focus from disaster response to prevention and DRR (Burnside-Lawry *et al*. 2013). At the 2005 World Conference on Disaster Reduction, 168 countries adopted the Hyogo Framework for Action 2005-2015: “Building the Resilience of Nations and Communities to Disasters” (UNISDR 2005). This signalled a shift from a command-and-control approach to a community-based resilience approach in disaster management policy (Jenkins 2015; Manyena *et al.* 2011). Emergency management has begun to diversify into a more collaborative activity and dynamic enterprise that facilitates multi-organizational, intergovernmental, and intersectoral co-operation (Waugh & Streib 2006). In Australia, this shift has led to a philosophy of shared responsibility (McLennan & Handmer 2012). Shared responsibility itself has evolved from the notion of community responsibility and self-reliance (Elsworth *et al.* 2009) to a principle that implies increased responsibility for all concerned (being the state, municipal councils, individuals, household members and the broader community) and a focus on community safety.

Despite its prevalence, the concept of resilience has undergone considerable critique. A basic criticism of the social-ecological systems approach is the assumption that the ecological and social domains of such systems can be addressed in a common conceptual, theoretical and modelling framework (Welsh 2014). A key problem here relates to the issue of defining the parameters of 'the system' and locating human action within it. MacKinnon and Derrickson (2012) note that resilience privileges spatial sites and scales such as cities, regions and local communities, which are implicitly equated with ecosystems, and are viewed as autonomous and subject to the same principles of self-organisation. They argue that a focus on the local scale neglects consideration of more powerful, global scale processes that enable and constrain action in specific places. Another criticism of resilience in disaster management concerns the transferral of responsibility for risk from the state to communities, households and individuals. Welsh (2014) notes that resilience approaches assume that communities can and should self-organise to manage risk, and that the role of government is limited to facilitating and supporting, rather than funding, these processes. Much resilience research has ignored questions of politics, governance and the unequal distribution of power and resources in disaster preparedness and response (Cretney 2014). Insufficient attention has also been paid to the value judgements that underpin resilience: what elements of the system should be protected, and for whom? (Davoudi 2012; Handmer & Dovers 1992). Weichselgartner and Kelman (2014) have questioned why people would want to 'bounce back' (even 'better') to a situation that is anywhere near the original circumstances that produced their vulnerability.

6.3.2 The resilience goals of disaster management

Resilience approaches aim to reduce the likelihood of disruption, damage and death caused by disasters and enable communities to absorb change and recover quickly while exhausting the least amount of resources (IPCC 2012; UNISDR 2009). But little consensus or formal clarity has been provided on the specific elements required for resilience or how to achieve them (Neely 2014; Arbon 2014; Goode *et al.* 2015). Australia's NSDR identifies four characteristics of disaster resilient communities but does not adequately expand on these or propose how they could be achieved (Jenkins 2015; Goode *et al.* 2015; COAG 2011). Neely (2014) discusses elements such as personal relationships, connectedness, co-operation, and formal and informal emergency management partnerships as important for a community resilience strategy. Goode and colleagues (2015) sought consensus among key stakeholders on the characteristics they consider relevant for developing disaster resilience, with partnerships between sectors, community connectedness and co-operation, and critical infrastructure reported as the most relevant characteristics. Participants in the study perceived a systemic approach encompassing both formal structures and grassroots efforts is required for resilience development (Goode *et al.* 2015).

It is not our intention to review and translate all interpretations of resilience goals, nor to provide an alternative unifying consensus. Instead, we have identified common elements and goals of resilience found throughout previous interpretations, focusing on social resilience, institutional resilience and community capital (Cutter *et al.* 2010), and elements most relevant to communities and individuals (as opposed to the natural environment, economics or infrastructure). Factors deemed important for

community disaster resilience were determined through examination and review of relevant resilience policy documents (e.g. Barnes *et al.* 2014; COAG 2011; UNISDR 2005) and recent academic literature relating to community disaster resilience (e.g. Goode *et al.* 2015; Arbon 2014; Neely 2014; McLennan & Handmer 2013, 2012; Dufty 2012; Taylor *et al.* 2012; Cutter *et al.* 2010; Renschler *et al.* 2010; Paton 2006) (all references found in the reference list), as well as through research experience of the authors gained via collaboration with DRR and community development units within formal emergency management organisations. For the purpose of this paper, the elements depicted in Figure 1 are used to describe how VGI may contribute to, or detract from, community disaster resilience.

Figure 1. Factors important for community disaster resilience as identified by the authors' review of relevant policy documents, scholarly literature, and research experience. Graphics have been modified from artwork by *Minduka, SimpleIcons, grin, GDJ, Iaobc, yves_guillou, russel, Fred the Oyster,* and *Netalloy* in the Open Clip Art Library and are licenced under a Creative Commons Attribution 4.0 International licence.

6.4 Potential for VGI to contribute to community resilience

Resilience thinking recognizes that multiple environmental and social stressors influence a community's adaptive capacity and different context-dependent factors will determine whether a community is adversely impacted by a hazard event (Murphy 2015). The factors with potential to be strengthened through VGI and social media based initiatives will be first discussed.

6.4.1 Effective communication

Resilience is intimately associated with good communication, whereby two-way dialogue delivers both resources to communities and intelligence regarding community needs to relevant agencies (Nicholls 2012). The most effective disaster communication is locally relevant, so those at risk can access and act upon specific information about their household and risk reduction (Boon 2014). Information transfer and knowledge networks, both formal and informal, required for resilience building are dependent on effective communication. Making existing local networks more robust can allow a community to sustain resilience building initiatives or programs more effectively than those created by outside knowledge and expertise (Collier *et al*. 2009).

Emergency management professionals identified increased levels of communication as the most significant opportunity presented by VGI (Haworth 2016). Social media platforms (e.g. Facebook, Twitter), in particular, increase the speed and reach of communication between community members and emergency organizations. Social media was utilised successfully in this way during the 2011 Cyclone Yasi and Queensland (QLD) flood disaster, where Facebook enabled a team of distributed volunteers to collate information on the disaster from a variety of official sources, to listen, share and respond to community needs, and to combat the spread of rumours (Taylor *et al.* 2012). Social media and other mechanisms for timely communication help spread important information, such as emergency warnings (Dufty 2012), and are vital components of resilient communities (Nicholls 2012).

Communicating local information through VGI platforms may facilitate more open discussion of community risks and ways to reduce them. VGI platforms are often accessible via online forums, which people can engage with at their own convenience. Thus, VGI reduces potential barriers to resilience building, including the inaccessibility of traditional communication forums such as community meetings due to other commitments. The increased online communication of local and spatial information directly contributes to one of the key actions of the NSDR: c*ommunicating with and educating people about risks* (COAG 2011).

6.4.2 Understanding risks and associated uncertainty

Information and education about risk management, key factors in disaster resilience, need to consider the audience and harness existing means and technologies communities are already using (COAG 2011). Previous studies have demonstrated the current and potential reach of geoweb technologies within bushfire risk communities with 76% of residents using VGI and/or social media as both an information source and platform for the production and sharing of information (Haworth *et al.* 2015). 2016 global estimates of internet and social media usage report approximately half the world population are now internet and mobile phone users, while 2.3 billion people are active social media users, with many of these being mobile social users (Kemp 2016). These figures demonstrate the potential uptake of VGI and social media platforms for increasing disaster risk awareness.

Increased awareness of local risk, hazard and vulnerability shared through VGI enables individuals to make informed assessments about their individual and community preparation, planning and likelihood of danger and/or damage. VGI through participatory mapping was shown to be useful for increasing risk awareness among youth in the Philippines (Gaillard & Pangilian 2010). Rather than simply trying to educate on risk through one-way communication, participatory mapping increases risk awareness and engagement in DRR by involving marginalized groups, valorising their inputs, and materializing the hazard and risk as something personally relevant to the participants (Gaillard & Pangilian 2010).

Flanagin & Metzger (2008) report on the manyfold increase in the number of information sources provided through social media and VGI. Research has indicated that community perceptions and actions are influenced by exposure to risk and preparedness information, with Basolo and colleagues (2009) arguing individuals exposed to multiple sources of hazard information may feel more knowledgeable about disaster preparedness. They found that receiving preparedness information from multiple sources was correlated with an individual taking protective actions.

6.4.3 Local knowledge and resource sharing

The building and transmission of local knowledge has been associated with increased adaptive capacity in social-ecological systems (Folke *et al.* 1998). Inclusion of local knowledge is crucial for increasing community disaster resilience (Giordano *et al.* 2013; COAG 2011), and resilience-building strategies with an emphasis on local knowledge have positive impacts (Manyena 2006). Yet, the integration of local and scientific knowledge to support disaster monitoring is not standard practice (Giordano *et al.* 2013). Cadag and Gaillard (2012) argue that integrating local knowledge with professional data in DRR through approaches that encourage knowledge exchange and two-way dialogue is an important but challenging task.

VGI has potential to facilitate increased collection, exchange, and use of local knowledge and resources in disaster management and resilience building. The ability of VGI to capture local observations and interpretations provides contextual data at fine spatio-temporal scales of relevance to communities that is otherwise unavailable in aggregate data. VGI can complement information and maps on risks shared by authoritative or professional organizations, providing more complete appreciation of risk by authorities and community members. Further, the merging of local knowledge and authoritative information sources can demonstrate differences in opinions and perspectives on risk or vulnerability, providing new insight for improving disaster planning.

The “situated” nature of knowledge generation, through methods such as VGI, crowdsourcing and public participation geographic information systems (PPGIS), incorporates social position and experiential background of participants (McCormick 2012). These influence decisions participants make in identifying local risks and exposures resulting in multiple mapped representations.

Participatory mapping can facilitate co-learning and encourage communication between stakeholders (Lynam *et al.* 2007). Giordano *et al.* (2013) demonstrated a participatory methodology for improving the

usability of local knowledge from different stakeholders in analysing drought impacts at Lake Trasimeno in Italy. Synthesis of knowledge from different sources allowed for identification of the impacts most relevant to local communities. Gray *et al.* (2015) demonstrated the value of participatory mapping in promoting shared participation in management decision-making when examining changes to wildlife populations and community well-being in response to increasing immigration and bushmeat hunting in the Serengheti National Park. A study by Haworth *et al.* (2016) involving community-based participatory mapping in a collective setting demonstrated both individual and community level benefits for bushfire disaster resilience, with participants reporting the personal relevance of shared knowledge, improved understanding of broader community bushfire risk and preparation levels, and value to both community members and emergency authorities.

6.4.4 Social connectedness

Involvement in activities that engender a sense of community (feelings of belonging and attachment for people and places), efficacy and problem solving, strengthen peoples' disaster-resilience (Paton & Johnson 2001). Sense of community fosters involvement in community disaster response and increases access to social networks (Paton & Johnston 2001). Well-connected communities are able to draw on internal resources and competencies that will allow them to manage the challenges of future hazards (Frandsen 2012) and the role of VGI in fostering social connectedness is well documented (e.g. Taylor *et al.* 2012).

The social aspect of VGI, with people collectively sharing geographic information, has been shown to be valuable for community DRR and resilience building (Haworth *et al.* 2016). Removing constraints of time or geography, social media have made it simpler to interact with community members (Dufty 2012). Analysis of usage trends during response to cyclones and floods in 2010/11 found social media directly contributed to increased disaster resilience through promoting connectedness, with individuals feeling supported and encouraged by others, and was identified as a source of psychological first aid for those directly and indirectly affected by the disaster (Taylor *et al.* 2012). Social media can increase and improve social networks, leadership and support systems, and provide support to people during and after a disaster (Dufty 2012). Social capital in the form of trust and social networks is a recognised source of resilience, enabling a social-ecological system's capacity to adapt and shape change (Folke 2006). Social media can both preserve and strengthen existing ties but also facilitate the creation of new social relations (Dufty 2012).

6.4.5 Empowerment

Empowerment in disaster management refers to an individual's capacity to have control over their personal affairs and confront hazard issues with necessary support from emergency services (Bird *et al.* 2009). Empowering individuals and communities to exercise choice and responsibility is one of the NSDR's priority actions for achieving resilience (COAG 2011). VGI facilitates decentralization of top-down power held by disaster authorities and disruption of control in the production, handling, and dissemination of information (Haworth 2016). McLennan and Handmer (2013) argue that for shared

responsibility to be effective in developing community disaster resilience, control over decisions must also be shared. Through these shifts in control and power, citizens may become more empowered in their own disaster management decision-making, choices and capacities.

Elwood's (2002) framework for assessing three forms of empowerment associated with community-based participatory GIS can help to understand how VGI and social media can contribute to community and individual empowerment. The first element, *distributive empowerment*, relates to material changes and outcomes allied with greater access to goods and services and increased participation opportunities (Elwood 2002). VGI has been shown to increase opportunities for citizen-involvement in disaster management through tasks such as volunteer-mapping to assist with humanitarian aid efforts, including for individuals located outside the disaster location (e.g. Meier 2012). Social media resources like Twitter have also empowered individuals with the desire to help in response to crisis events by enabling remote assistance provision (Starbird & Palen 2011). Facebook was used by community members in response to Australian bushfires to dramatically enhance information access and the reciprocal exchange of resources for emergency relief and recovery (Paton & Irons 2016).

Procedural change involves shifts in processes resulting in communities' contributions and knowledge being granted greater legitimacy in decision-making (Elwood 2002). Responding to the 2010 Haiti earthquake crisis, VGI and the global citizen-volunteer mapping effort harnessing OSM, the Ushahidi Crowdmap platform, social media data, and information collected via SMS from impacted-individuals (see Meier 2012; Crawford & Finn 2015) influenced decision-making in an unprecedented way. The legitimacy of citizens' contributions was evidenced by comments made during the events by head of the U.S. Federal Emergency Management Agency (FEMA), Craig Fugate, who noted that "the live map provided the most comprehensive and up-to-date information available to the humanitarian community" (Meier 2012, p.93). In this event, and numerous inspired cases since, VGI technologies and practices facilitated collection, use, and legitimatization of citizen contributions in ways previously unseen, demonstrating capacity for VGI to support procedural dimensions of empowerment.

And finally, *capacity building* improves the ability of communities to take action on their own behalf through skill acquisition, community-based knowledge production, or new understandings of community conditions (Elwood 2002). VGI empowers citizens to georegister and transmit their own observations through the internet (Goodchild & Glennon 2010), and provides mechanisms for empowering people to help themselves and each other, thus enhancing community autonomy and capacity for independence from emergency authorities for various tasks (e.g. Taylor *et al.* 2012; Paton & Irons 2016). Community-based knowledge production and new understandings of community conditions have been associated with VGI through participatory mapping in community bushfire preparation (Haworth *et al.* 2016). Similarly, Taylor *et al.* (2012) described the empowerment of individuals and communities to help themselves during cyclones and floods where social media delivered a new mechanism for connecting with others, which for many constituted skill acquisition.

6.4.6 Preparation engagement

Frandsen (2012) demonstrated that community engagement is an effective, sustainable and economical approach to increasing bushfire preparedness and disaster resilience. However, merely providing relevant information and community education doesn't translate to meaningful engagement in disaster preparation (Frandsen *et al.* 2011; McFarlane *et al.* 2011; Lindell & Perry 2000; McGee 2005). Engaged preparation is dependent on inclusive and participatory approaches to DRR (Frandsen *et al*. 2011).

VGI provides diverse mechanisms for individuals to engage in DRR at multiple spatial scales. For example, global mapping efforts like the Humanitarian OpenStreetMap Team (HOT) utilise volunteers to co-create, curate and disseminate free and up-to-date spatial information for disaster management (https://hotosm.org). These projects involving map creation for disaster preparedness (e.g. Malawi Flood Preparedness) harness the potential of the crowd, allowing large numbers of people to engage, improving broader disaster awareness and increasing feelings of self-worth for contributors. The activities also provide geospatial products to assist local people and authorities to effectively engage in DRR. Although collaborative online mapping provides greater flexibility for individual involvement by removing geographical and temporal constraints (Haworth *et al.* 2016), participatory mapping through less technologically sophisticated platforms, such as sketch maps, paper maps, and three-dimensional maps using pushpins, have also been demonstrated to contribute to engagement in DRR (Gaillard & Pangilinan 2010).

The potential for social media to engage communities in DRR was demonstrated by the emergence of the *Tassie Fires We Can Help (TFWCH)* Facebook page during the 2013 Tasmania bushfire disaster in south-eastern Australia. Initially established to help residents respond to the bushfires and their immediate aftermath, TFWCH transitioned to a more permanent resource and information-sharing portal with a community engagement approach to disaster recovery, post-disaster learning, and disaster preparedness for Tasmanian communities (see www.tassiefireswecanhelp.com).

6.4.7 Collaboration between stakeholders

Collaborative disaster management is recognised as an important contributor to resilience but requires coordination and pre-existing trust between multiple government agencies, NGOs, private sector and the community (Kapucu 2008). Through VGI technologies and practices, opportunities are created for collaborative disaster management between individuals, communities and authorities, where increased value placed on citizen-information and bottom-up activities can lead to co-operation.

The 2010 Haiti earthquake disaster, which occurred with a dearth of official high quality spatial information, saw the emergence of crowdsourced and volunteered mapping to meet needs of the humanitarian response (see Meier 2012). Volunteers used OpenStreetMap and the Ushahidi platform, Crowdmap, to trace satellite imagery, collate information from other online sources, and capture reports from people directly in the disaster area via SMS from mobile phones (Meier 2012). Here, VGI created a new disaster response paradigm in which citizens take the lead (Levental 2012), or at least

complement the activities of authorities (Heinzelman & Waters 2010), in emergency operations with consequences for disaster management globally.

The Ushahidi Crowdmap platform was used again during response to the 2010/11 cyclones and flooding in QLD. The Australian Broadcasting Corporation launched the QLD Flood Crisis Map, a crowdmap capturing flood-related information from individuals via email, SMS, Twitter, or via a web form, which was then available for anyone with internet access to view and interrogate (McDougall 2011). The QLD Police Service also utilised social media with Facebook and Twitter hashtags proving advantageous in disseminating warnings, coordinating community posts, and combatting the spread of rumours (Bird *et al.* 2012). The connections established through this platform between authorities, responders and those directly impacted by the disaster demonstrated how community practices like VGI can facilitate effective collaboration.

6.4.8 Developing flexibility

A resilient system needs to have flexibility to avoid undesirable transformation (Allison *et al*. 2004), with inflexibility eroding adaptive capacity and leading to what have been termed 'rigidity traps' (Carpenter & Brock 2008). In a 'rigidity trap', strong self-reinforcing controls prevent the flexibility required for systems to adapt to change, thereby increasing the risk of system breakdown (Carpenter & Brock 2008) and preventing movement to a more desirable regime if the current state becomes untenable.

A potential rigidity trap lies in the top-down, 'command and control' style of authoritative emergency management. The hierarchical, bureaucratic approach of emergency management, centred on agency control of information, risks limiting resilience through inflexibility and an inability to adapt to change. Web 2.0 and VGI assist in deconstructing this rigid system by redistributing power over information creation and sharing among other individuals and stakeholders, including citizens (Haworth 2016). Through VGI, citizens are able to contribute alternative representations of and responses to risk, increasing flexibility in the system with diversity of information.

Increase in the variety and volume of information sources provided through geoweb 2.0 platforms such as social media has increased the flexibility of when, how, and in what form people receive and interact with disaster information. For instance, social media provided flexibility in crisis communication for earthquakes in Japan and Haiti, bombings in India, and severe storms in North America and Australia, particularly when power and telecommunications were disrupted. Sites like Facebook and Twitter became more reliable with robust capacity to handle much larger activity volumes than other services (Bird *et al.* 2012; Yates & Paquette 2011). Through exposing people to new ways of doing things, VGI and social media can add to future flexibility and resilience by improving citizens' ability to be agile in other contexts.

Inclusion of alternate viewpoints enabled by VGI through participatory mapping can lead to greater flexibility incorporated into decision-making over disaster planning and response strategies. For example, local knowledge shared on a community bushfire preparation map showing potential

evacuation sites may reveal alternative and improved site options to those designated by authorities. Participatory mapping provides an enabling environment for assessing risks, identifying solutions, and the integration of various strategy options into action plans (Cadag & Gaillard 2012), and thus aids in building flexibility into community and authoritative disaster management.

6.4.9 Capacity for self-organisation

An important component of resilience is the degree to which a social-ecological system is capable of self-organisation (versus lack of organisation or organisation by external factors) (Carpenter *et al.* 2001). Increasingly, 'digital volunteers' are emerging and self-organising online following disaster events in a similar way to on-site volunteer efforts, with the participatory nature of geoweb 2.0 providing numerous opportunities for self-organisation through mechanisms like crowdsourcing (McLennan *et al.* in press). A capacity for self-organisation is particularly important in disaster management, where citizen-led initiatives are often more timely, responsive to local needs, and effective over the longer term than external responses (Scanlon *et al.* 2014; Whittaker *et al.* 2015).

The internet and mobile devices are empowering individuals to organize themselves in ways previously unimaginable, as evidenced by activities such as Wikileaks, Twitter and citizen journalism, and the formation of spontaneous volunteering groups such as the Student Volunteer Army in response to the 2011 Christchurch earthquake disaster (Neely 2014). Social media platforms like Twitter and Facebook provided a space for volunteers to self-organise with others in sharing information and resources in response to the 2010 Haiti earthquake (Starbird & Palen 2011) and the 2013 bushfires (wildfires) in Tasmania, Australia (see Irons *et al.* 2015). The *TFWCH* site allowed rapid exchange of diverse local information leading to provision of resources and assistance for specific local needs by people both in and outside the bushfire-affected areas. Here, VGI enabled a form of self-sufficiency and self-responsibility previously not possible through more traditional disaster response approaches or communication media.

6.5 Potential for VGI to undermine community resilience

Next we shift the focus to the challenges presented by VGI for resilience-building in disaster management and whether these can lead to undesirable action which may erode a community's capacity to adapt to the inherent uncertainty associated with living in high risk areas.

6.5.1 Compounding risk

VGI initiatives with recognised benefits during disaster management can also provide a mechanism for precipitating other events with potentially negative consequences. It is important to consider the compounding processes in which VGI practices may exacerbate disaster risk and the consequences for disaster response planning and resourcing. For example, in January 2013 a request for help posted on the *TFWCH* page identified several people who had become isolated and needed supplies delivered (ABC 2013). The only access route was via boat across coastal water. In response to the Facebook post, hundreds of people gathered together geographically with donations, and 35 boats were involved in

delivering supplies (ABC 2013). But when water conditions became dangerous, several boats required rescuing thus diverting emergency response efforts and resources. In this instance VGI practices triggered unsafe actions and increased the risk of harm to VGI users and others.

During the Parliament Hill shooting crisis in Ottawa in 2014 social media posts unintentionally endangered others (Zoltick 2014). It was reported that individuals geotagged at the scene were tweeting live about the events as they unfolded to indicate they were safe and to keep the public informed. This practiced publicized their locations as well as the location of police response activities for potential exploitation by the then still-active gunman. These practices also have liability implications for emergency response agencies potentially acting on misinformation (see section 4.6).

6.5.2 Data quality and trust

For disaster resilience, uncertainties in data quality and source trustworthiness have important implications. The NSDR describes transparent, accurate, and trusted information sources as essential for empowering individuals and communities to be more disaster resilient (COAG 2011). Trust is a key component of social capital, a social source of resilience (Folke 2006), and is necessary for individuals to engage with collective activities, such as community or neighbourhood groups, either online or offline (Valenzuela *et al*. 2009).

Data quality is a well-recognized challenge associated with VGI, including elements such as positional accuracy and content inaccuracies (see Senaratne *et al.* 2016; Haworth 2016; Bird *et al*. 2012; Goodchild & Li 2012; Ostermann & Spinsanti 2011). During the Haiti earthquake response, locational uncertainty constrained the publishing of reports on crowdmap to just 3,854 of the 15,000-60,000 reports collected (Morrow *et al.* 2011) and only 202 of those published reports were marked as "verified" (Heinzelman & Waters 2010). In the QLD floods crowdmap, 75% of reports were verified by the map conveners, but many of these had been submitted by identifiable organisations, and, significantly, anonymous individuals were responsible for almost all of the unverified messages (Bittner *et al.* 2016). Pond (2016) argues that treating verification of crowdsourced data as a binary variable (verified or unverified) on platforms such as *Ushahidi* may limit the quantity of information that can be used for situational awareness. There is a need to consider the cognitive dimension of uncertainty and how perceptions of reported accuracy translate in decision-making processes (Bruce 2004). Alternative approaches for communicating data uncertainty extending beyond standard authentication criteria for determining "truthfulness" and categories of data verification would allow the context-specific value of the information to be judged by end users. Methods for qualifying VGI-derived data, which are informed by the communities relying on those data, would not restrict the publishing of crowdsourced reports to those considered by "experts" as verified and would engage people in critical assessment of data sources as part of the disaster preparation process.

Much of the uncertainty around VGI is due to a lack of known credibility of information sources, and, therefore, trust (Hung *et al*. 2016; Flanagin & Metzger 2008). Low levels of trust in information provided

by the general public was a rationale for Tasmanian community members' limited willingness to engage on social media for bushfire communication (Haworth *et al*. 2015). Public perceptions of community-supplied information on Facebook during Australian flooding events revealed VGI was more useful and up-to-date than government information, but was considered less accurate and less trustworthy (Bird *et al.* 2012). The hyper-local nature of data provided through social-media and mapping platforms can provide context-specific information not portrayed through mass broadcast media and emergency authority communications (Pond 2016).

If trust in VGI is nurtured, for example through past positive experiences, future complications may arise if the initiative is not sustainable, platforms are not maintained, if past key individuals are absent, or if a community becomes reliant on a single system. For example, the success of *TFWCH* in Tasmania raises questions about future events. People trusted the page and the VGI shared on it, so what might happen in a future disaster if the page does not function in the same way, or does not function at all? If people now expect a particular source of VGI to be present this may cause tensions in communities, disappointment, or anxiety, all of which negatively impact elements of community resilience, such as social capital, empowerment, and individual and community confidence. Further, *TFWCH* gained trust because it was seen as effective. However, while the initiative was fortunate to escape significant negative outcomes in 2013, the page is still subject to rumour propagation, misinformation and inaccurate or unhelpful posts. Precedence does not necessarily equate to perceived reliability or future proof VGI initiatives. Exposure to VGI and social-media could be embedded in disaster preparedness programs, involving techniques for using, interpreting, evaluating and contributing content to these platforms. Encouraging learning and flexibility to engage effectively in these new technologies when confronted with a disaster event would strengthen community and individual resilience.

6.5.3 Under-representing the 'crowd'

The NSDR describes the need for a resilient nation to understand risks and communicate with all levels of the community (COAG 2011), but due to the phenomenon of participant inequality (Haklay 2016) we argue VGI does not provide adequate opportunity for inclusive community participation. VGI inherently discriminates based on technology access and usage patterns associated with demographics, socioeconomic circumstances, and technical skills, knowledge and interest (see the 'digital divide'; Sui *et al.* 2013; Chinn & Fairlie 2007). Information gained through social media or other VGI sources will therefore only present partial and skewed representations (Klonner *et al.* 2016; Crawford & Finn 2015). Exclusion of some groups and individuals (Burns 2015; Zook *et al.* 2010) means VGI practices may operate at the detriment of resilience building for some community members.

It is worth considering who can and does contribute VGI. Bittner *et al.* (2016) critique the idea that crisis maps are the product of 'ordinary citizens' pooling their expertise. During the 2010/11 QLD floods, many more people viewed the crowdmap than actually contributed, and online contributors largely chose to submit their information anonymously (Bittner *et al.* 2016). VGI often represents the elite over the ordinary, as only those people with time, access to necessary social and technological systems, and

required skills are able to contribute (Haworth 2016; Bittner *et al.* 2016). Less privileged individuals may be unable to participate, thus being excluded from the resilience-building benefits of VGI. Marginalized groups and individuals are often not represented on maps, and, particularly troubling for resilience, those people already marginalized are often the most vulnerable to disasters (Hewitt 1997) especially since preparedness information is often not directed at vulnerable groups (Verrucci *et al.* 2016).

VGI may in fact enhance existing inequalities and vulnerabilities by further isolating those already economically, socially or technologically disadvantaged. Crawford and Finn (2015) showed how the crowdmapping efforts of the Haiti earthquake response exacerbated power differentials between the rich and the Haitian poor as VGI submitted in the local Kreyòl language was mapped in English only, excluding non-English speakers from benefiting from their own contributions. Thus, VGI curation practices and who is responsible may impact what is included in 'ordinary voices' (Bittner *et al*. 2016). Furthermore, the geography of technology access has been linked with the geography of risk, whereby those in urban areas with greater internet access also experience lower disaster risk in contrast to those in rural or isolated areas with poor internet and mobile coverage but potentially greater disaster risk (Haworth 2016). Even those with stable internet access may have their contributions limited through forms of online censorship, language barriers, or page ranking algorithms, and hence in disaster scenarios VGI may represent only a privileged minority (Bittner *et al.* 2016).

Critiques of PPGIS, where complexity of the technologies can contribute to marginalization of individuals contrary to the promise of citizen-empowerment (Corbett & Keller 2005), also apply to VGI. Use of technologies required for participation in VGI practices, such as computers, the internet, smartphones, social media platforms, location enabled mobile devices, satellite imagery and online map-making software may result in a technological learning curve effect that precludes "non-experts". Participant inequality potentially creates divide in communities negatively impacting community disaster resilience with some people disproportionally benefiting while others are left off the maps.

6.5.4 Compromised privacy and security

The focus on community empowerment and democratic participation in much of the geoweb and VGI narrative has tended to equate power with public visibility and neglected to consider potential for exploitation of VGI derived data by external groups (Young & Gimlore 2014). VGI is often publically available once contributed, potentially increasing vulnerability and risk exposure. Contributors' information may be exposed to unintended uses, either by governments, other individuals, or those with malicious intent. Greater openness exposes users to increased online security threats, such as malware, inappropriate content and breaches of confidential information (Shanley *et al.* 2013).

Many people are not confident in their understanding of how and by whom their data can be accessed (Crawford & Finn 2015). Moreover, in high-stress situations like disasters privacy may be less of a priority for individuals than in 'normal' settings, and thus individuals may be increasingly vulnerable (Crawford & Finn 2015). Lack of awareness of VGI features, such as image geotags captured from GPS-

enabled smartphones, has had demonstrable implications for privacy, personal safety and the protection of assets (Kruszelnicki 2012). As data remain on the internet after their initial use and can be repurposed in other ways, privacy and ethical issues persist into the future (Shanley *et al.* 2013). Further critical research on these ethical and technical dimensions is needed to establish methods for harnessing the power of geoweb-enabled platforms for disaster-prone communities while maintaining their privacy and security (Young & Gilmore 2013).

6.5.5 Increased community tensions

Tension within communities generated or exacerbated by mapping activities or outcomes can undermine the resilience of disaster-prone communities. The *TFWCH* example in which well-intended vessel owners responded to a VGI-enabled request for assistance highlights the potential for serious negative outcomes and resultant tensions between those involved. Although facilitating capacity for self-organisation, the outcomes of poorly orchestrated logistical response actions such as this may lead to feelings of blame and resentment; community ties could be broken, thus reducing community disaster resilience. Carroll *et al.* (2006) examined sources of social conflict following wildfires in the American West, finding that conflict can occur when social relations are disturbed by non-local entities, leading to a perceived loss of local agency. VGI can facilitate greater participation of 'outsiders' in community responses to disaster, and therefore creates potential for increased community tension or conflict.

Using VGI and participatory mapping for disaster preparation can involve the identification of particular residents, properties, or areas as unprepared or problematic in the wider community context. This process may motivate residents to improve their level of preparedness, but may also engender feelings of shame, guilt, or resentment towards those involved in the mapping. A sense of inadequacy in meeting the standards of others more actively-engaged in DRR may weaken community connectedness and reduce an individual's confidence in their ability to respond to disaster. Furthermore, VGI contributions may disclose personal or sensitive information unrelated to disaster potentially leading to tensions between community members.

Capacity to participate varies depending on status and position within the networks producing maps (Bittner *et al.* 2016). Therefore, VGI in disaster management is linked to the wealth, class status, community connections, reputation, politics, and power of particular community members. Disparities between individuals may be highlighted or aggravated by who can and cannot contribute. Berkes and Ross (2013) argue that a community resilience approach that integrates socio-ecological systems research and developmental psychology would give greater recognition to the importance of the ability to cope with divisions within community (Kulig 2000 as cited in Berkes & Ross 2013) and key resilience dimensions of community resources and collective action.

6.5.6 Responsibility for community-led initiatives and issues of data ownership

Community led VGI initiatives promote resilience benefits including a sense of ownership and power and foster innovation and projects that work for specific communities. But with ownership also comes responsibility and expectations including project establishment, site/platform maintenance, and data management. Community led social media pages, community maps or other VGI initiatives require some knowledge and expertise in use of these technologies, and individuals with some level of autonomy and community trust who can champion these efforts. Not all communities will have access to this social capital, a further barrier/limitation to the broader social inclusiveness potential of community led VGI. In addition to knowledge and technological skills, responsibility for VGI project and data maintenance also requires considerable time and resources, which may become burdensome leading to volunteer fatigue (Deutsch & Ruiz-Cordóva 2015), thus reducing community connectedness and disaster resilience.

Failure or abandonment of VGI initiatives when contributions cease, or if the responsible personnel change or leave can have consequences. It is important to anticipate potential turnovers which may lead to the abandoning of map updates or shifts in objectives or data use (Gaillard & Maceda 2009). The sustainability of a small scale bushfire risk mapping project across Australia, *Bushfire Connect*, was dependent on not only the sustainability of the volunteers, but the relationship of these volunteers with supportive emergency management professionals and how the participating/viewing public regarded the project and outputs, which ultimately affected its long-term viability (Bittner *et al.* 2016).

In line with shared responsibility, organizations and communities could work together on VGI initiatives in fostering community disaster resilience. However, consideration needs to be given to well-documented obstacles associated with agency involvement in participatory style mapping projects. These include undervaluing of community input, regularity barriers, unpredictability associated with public activities, lack of effective administrative structures, and lack of genuine community participation (Brown 2012; Corbett & Keller 2005). Further research is needed on the social learning value of community led VGI initiatives, and community preparedness efforts will benefit from dissemination of positive outcome stories, a strategy known to aid in reducing barriers to participatory approaches such as volunteer dropout (Deutsch & Ruiz-Cordóva 2015).

6.5.7 Disruptions to authoritative emergency management

The potential for VGI practices to disrupt official disaster management activities can reduce resilience in impacted or at-risk communities. Public trust gained for social media pages or VGI contributions on a disaster event presents the risk that the public will give precedence to these information sources over official disaster information. Disaster messaging is designed to be clear, concise, and consistent to provide the public with accurate and understandable information for given scenarios. Deviations from this messaging can be detrimental to community safety. Further, the accelerated rate of information exchanged enabled by social media and VGI during an event may become incompatible with the physical logistics involved in coordinating response activities (Pond 2016). Public preference for multiple disaster information sources emphasises that VGI should not aim to replace more traditional forms of disaster

communication (Taylor *et al.* 2012; Haworth *et al.* 2015). A balance between bottom-up and top-down practices needs to be maintained where appropriate value is procured from both for effective resilience development.

6.6 Conclusions

The application and relevance of emergent VGI practices to building community resilience requires continuing critical debate involving disaster-prone communities, researchers, practitioners and policy makers. Drawing on current literature and policy documents, we considered key elements of resilience to examine the community disaster resilience-building potential of VGI practices, and obstacles that may undermine resilience-building processes.

Although beyond the scope of this paper, indicators and frameworks have been offered for measuring community resilience (Cutter *et al.* 2010; Renschler *et al.* 2010). Future work to examine the impacts of VGI practices on resilience through alignment with these indices may clarify, for example, whether the increased risk to personal safety and issues associated with the digital divide outweigh the benefits of VGI, such as community connectedness and risk awareness.

The evolving and relatively embryonic nature of VGI in disaster management means practical adoption of VGI into current emergency management approaches has been limited to date and harnessing of VGI has often been ad-hoc or opportunistic at best. Despite a growing body of literature (Haworth *et al.* 2016; Paton & Irons 2016; Pond 2016; Haworth *et al.* 2015; Shanley *et al.* 2013; Bird *et al.* 2012; Dufty 2012; Meier 2012; Taylor *et al.* 2012; Ostermann & Spinsanti 2011; Goodchild & Glennon 2010) and identified opportunities associated with VGI (see Haworth & Bruce 2015), on-going cultural change involving adaption by authoritative emergency management to less information control and increased citizen participation may be required before VGI in disaster management becomes a more established field with measurable outcomes for community disaster resilience.

With much research on the data and technological components (Granell & Ostermann 2016), the social and behavioural elements of VGI are lacking critical analyses; directing greater attention to issues such as underrepresentation of the 'crowd' and the nuances of power relations in online and offline social networks will build confidence in VGI as a resource in developing community resilience. Further research on the ethical and technical dimensions of VGI practices is required to inform the development of novel methods for maintaining the privacy and security of disaster-prone communities. Incorporating awareness and training on collaborative geoweb technologies, including data ethics, effective VGI practice and potential digital footprint, into community preparedness programs will equip individuals to make informed judgements on VGI content during a disaster event and reduce unintended consequences of social media initiatives.

The positioning of VGI within critical GIS has been contested (McCall *et al.* 2015), but drawing on established approaches to community mapping from within the discipline of geography, such as PPGIS or participatory mapping (Brown & Fagerholm 2015), may offer promise for understanding the social

and behavioural elements of VGI and confining the use of VGI technologies to spatial scales most conducive to achieving the aim of increased community disaster resilience. By establishing which elements of VGI should be emphasized and which require careful management, a form of 'controlled' or 'facilitated' VGI at community scales with pre-established data systems, protocols, intended outcomes, and appropriate links to authoritative emergency management can be implemented. This may enable VGI in disaster management to be less opportunistic, data-centric, disruptive to authoritative activities and exclusionary, and allow for more reliable, community-centric, complementary and socially-inclusive practices. Recognition of the consequences of these divergent outcomes is critical for ensuring effective resilience strategies that encourage flexibility to cope with disaster, self-organising responses and inclusive participation.

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CHAPTER 7: SUMMARY AND CONCLUSIONS

7.1 General conclusions

This thesis began by introducing the concept of volunteered geographic information (VGI) as the growing practice of citizens voluntarily creating and sharing geographic information, predominantly facilitated through the advent of the internet and other spatially-enabled technologies. VGI is recognized as representing changes to the ways geospatial information is created, used, and consumed with important implications for numerous fields and applications. Significantly, this thesis considered VGI as a social practice, or something people do collaboratively, rather than simply as a data source or a type of information as previous conceptualizations have tended to do.

The thesis examined VGI in the context of disaster and emergency management, in particular disaster risk reduction (DRR). Disaster management is a particularly useful case study through which to consider the impacts of VGI on traditional systems more broadly. This is not only because disasters are important social, political, and environmental events with significant local and global impacts, but because key debates associated with VGI and its benefits and limitations are intensified and dramatized in a disaster management context. Matters related to VGI such as public engagement and data reliability are particularly pertinent to disaster management, for instance. Moreover, the top-down arrangements of information control and service delivery adopted by authoritative emergency management parallel other institutional systems impacted by VGI, such as governance structures or traditional map-production.

Chapter 1 presented a case for the need for increased community engagement in bushfire preparation and DRR. Preparing for disasters dramatically reduces the risk of negative impacts on life and property, and research has shown the number of people who actively prepare for disasters is significantly lower than the number of people at risk. Finding new ways to engage communities is an important global issue. This thesis is significant for its contributions to this goal.

The overall objective of the thesis was to assess the usefulness of VGI in fostering community bushfire preparation engagement and increased disaster resilience, and to ascertain the broader impacts of VGI practices on top-down authoritative systems such as emergency management. This work contributes to a deeper understanding of the opportunities and challenges presented by VGI in disaster management, the potential for use of VGI in DRR, the value in harnessing VGI through a participatory mapping approach to individual and community bushfire preparation, and the broader implications of the VGI phenomenon for disaster management and the discipline of geography. The next paragraphs briefly discuss the accomplishment of the thesis objectives with particular reference to investigation of the three main research questions. Following this, a synthesis of the policy and research discipline implications of the work is presented before focus shifts to future research recommendations.

The literature review (Chapter 2) synthesized key themes identified in the VGI and disaster management literature, including changes to modes of data collection and dissemination, challenges associated with data quality and security, data management considerations, and the notion of empowerment through VGI. The paper made a novel contribution in identifying gaps in the existing body of research. Of particular relevance to this thesis was the identification of a scarcity of research concerning VGI in disaster management beyond crisis response, such as in the mitigation and preparedness phases of the prevention, preparedness, response, recovery (PPRR) model of disaster management.

The first research question referred to the potential for use of VGI in fostering community engagement in bushfire risk reduction based on technology uptake, community interest and limitations to use. Chapter 3 argued based on empirical analysis that there is high potential for VGI to assist with individual and community disaster preparation, particularly through social media platforms like Facebook. Survey methods were appropriate for achieving this research aim by providing a wide-ranging overview of community members' views on relevant topics. Quantifying the need for increased community engagement and trends in VGI-technology uptake, usage patterns, and community preferences for information sharing methods in bushfire preparation contributed to an evidence base for the use of VGI in disaster preparedness approaches. Critically, the survey identified important limitations to VGI use related to spatial and demographic factors, trust of online information sources, and preferences for more traditional communication methods. Methods of VGI utilization and the efficacy of these technological practices for promoting positive behavioural change and empowering individuals to engage in risk reduction activities was beyond the scope of the survey and thus further work was required, as reported in succeeding chapters.

To address the second research question, having discussed the views of community members, Chapter 4 considered the perspectives of emergency professionals on the key opportunities and challenges associated with VGI for disaster management through detailed semi-structured interviews. The paper presents, to my knowledge, the first study to explicitly consider disaster managers' perceptions of VGI. Important insights were gained into how VGI practices and traditional authoritative emergency management may operate more effectively together in the future. The study demonstrated that adopting an inductive approach to interviewing key stakeholders can be a useful method for understanding opportunities and challenges associated with the application of burgeoning geospatial information innovations in traditional settings. Professionals identified the increased reach of communications, local knowledge exchange, citizen empowerment, feelings of self-worth, and spatial awareness as significant opportunities for VGI. Demographics and the digital divide, infrastructure reliability, required resources, data quality and source trustworthiness, and perceived legal and liability concerns were revealed as key challenges. The paper proposed ways forward to more effective VGI utilization in disaster management, including recommendations for greater valuing of citizen knowledge in authoritative systems such as emergency management, tackling the digital divide and inequalities in knowledge production, improvement in data management mechanisms, and further utilization of VGI in disaster preparation and recovery.

The aim of the third research question was to evaluate whether the process of mapping local knowledge for bushfire preparation as a shared practice with other community members contributes to increasing an individual's awareness and understanding of local bushfire risk, their social connectedness, and engagement in DRR. This was accomplished through the use of community workshops and participant questionnaires (Chapter 5). A small sample size compared with larger survey methods limited statistical generalisations to broader populations, but the qualitative intensive workshop approach facilitated interaction and collaboration between participants and provided information richness, with greater emphasis on the participation with others and the mapping process over data production. A novel participatory mapping approach to creating, sharing, and considering VGI was adopted in the workshops, which represents an important contribution of this work to current debates in the field of VGI and GIScience (for more on this see section 7.2.2). Together, workshop observations and questionnaire results provided evidence that participatory mapping of VGI in bushfire management contributes to the promotion of social inclusion, capacity building, and enablement of democratic participation. A major finding of the research was that while the local knowledge exchanged was of value to participants in their bushfire preparedness, the social aspect of VGI appeared to be the most engaging element of participatory mapping, and this needs to be a consideration in future efforts to engage the public in DRR. Concerns around community participatory mapping that arose in the study included issues of data quality, privacy, trust, and the underrepresentation of particular individuals or groups in a) the study, b) community bushfire management, and, c) mapping broadly, such as youth, people experiencing socio-economic disadvantage, people with dependents, travellers, and any other marginalized individuals.

Accepting that the goal of bushfire preparation and current disaster management in Australia is to achieve greater community disaster resilience, in meeting the objectives of this thesis it was necessary to provide critical analysis on the capacity of VGI practices to contribute to the building of resilience. Chapter 6 drew on work in the preceding papers to offer a detailed discussion of the ways VGI can add to community resilience, and how it can undermine it. The paper highlights inherent complexity in community resilience and demonstrated that despite increasingly-recognized benefits, there are still numerous challenges that need addressing before VGI practices can be most effectively and reliably harnessed. Whereas some of those challenges may be addressed with technological solutions, others will require deeper cultural and behavioural change in emergency management and social systems.

As a thesis by publication, this work is comprised of discreet, yet related, studies, with threads emerging throughout the work. Before moving to outline the implications of the findings in the next section, I will here describe recurring outcomes that arise through consideration of the papers collectively.

First, scale is important in VGI. Scale plays a role in determining the volumes and types of data contributed, and the user-experience of contributors. Previous studies have emphasized the large volumes of data contributed from a dense global network of observers as an exciting opportunity presented by VGI. In contrast, this research shows VGI collected and shared on local scales to be

effective for the aim of increasing community engagement in disaster preparation. In the participatory mapping workshops, information contributed about local neighbourhoods was the most personally-relevant to participants, and the local scale approach produced additional outcomes beneficial to community disaster resilience, such as increased community connectedness. For DRR and the discipline of geography, 'small data' (as opposed to big data) collected as VGI about every day lived experiences at local scales is valuable. Kitchin and Lauriault (2015) argue despite the rapid growth of big data and associated new analytics, small data and accompanying studies will continue to be an essential component of the geography research landscape, with increasing importance as it combines with new and other datasets. They make comparisons to mining practices, whereby big data is equivalent to open pit mining, and small data involves mining narrow seams of high quality data with greater control over research design and the ability to answer specific, targeted questions through the telling of individual, nuanced and contextual stories (Kitchin & Lauriault 2015).

VGI at broader scales with increasingly large volumes of diverse information becomes increasingly problematic to manage. Difficulty arises for big data in coping with abundance and exhaustivity (Kitchin & Lauriault 2015), and management of volunteered data was identified as a key challenge experienced by emergency management professionals (Chapter 4). Here, the broader scale may negatively impact the usefulness of VGI in disaster management if it cannot be effectively managed. Broader scale VGI projects may also be difficult to monitor and sustain into the future. Large numbers of people engaged in VGI, however, has been shown to be useful for reducing errors, misinformation, and the spread of rumours associated with online information contributed from non-professionals, which were identified as important issues for VGI in each component of this research.

VGI facilitates new scales of participation in disaster management, and I argue the notion of what is local, or 'localness', is increasingly distorted with the advent of VGI practices and associated platforms. That geoweb technologies allow individuals to contribute to disaster management from outside disaster locations and geographically-bound communities raises questions about a) conceptualizations of 'community' in disaster management with the growing significance of virtual and other non-geographic communities for community resilience (Mulligan *et al.* 2016); and, b) the legitimacy of individuals and their knowledge as 'local'. A person who no longer physically resides in a community but remains connected and engaged via platforms like social media may have valuable knowledge to assist in emergency management, connections to people and place, and may be impacted emotionally or otherwise by a disaster in that community. How does that individual's 'local status' differ to those who reside in the geographically local community, and how does this impact community participation, disaster resilience, and broader social practices? This thesis has presented arguments for increased utilisation and valuing of citizen local knowledge in disaster management, which can be potentially enabled through VGI, but further work is needed to determine what exactly is 'local' in VGI and the implications of associated blurred understandings of 'localness'.

Potentially influenced by scale, the second significant recurring topic is the notion of trust. In each component of this thesis, uncertainty in trust of unknown online data sources was identified as a limitation to the application and usefulness of VGI. Community members expressed concern about the level of trust attributed to data from anybody other than official information sources like government agencies for disaster communication (Chapter 3). Emergency professionals reported trust of citizen-produced information a concern for integration of VGI into official systems (Chapter 4). Workshop participants were not confident they could trust people not to alter their contributed content or use it in unintended ways (Chapter 5).

Trust in VGI is related to data quality, source credibility, and contributor reputation. These elements can be difficult to discern in VGI, and thus who participates in VGI practices is important. Trust of those involved and the data they share is crucial for limiting or enabling the successful adoption of VGI, as evidenced by this thesis. VGI relies on reciprocated trust (McCall *et al.* 2015), and learning may need to be acquired from other examples of online trust-building, such as Wikipedia, eBay, or Couchsurfing, which each have mechanisms for assessing and assigning levels of trust to contributors with verification often coming from other users. McCall *et al.* (2015) raise the notion of appointed versus self-selected volunteers. For disaster management, preferencing 'trusted' local people with known expertise for VGI contributions and community mapping participation over a system that allows 'anyone' to volunteer contributions may have merit in increasing trust of VGI and its sources, and therefore usefulness for some purposes. However, I argue that some of the value of VGI shown in this thesis, such as increased community connectedness and increased spread of information, would be sacrificed through such an approach. Assigning greater privilege and status to some community members as more suitable for VGI contribution is at odds with the opportunities VGI provides and appears to me to contribute to some of its weaknesses through the exclusion of particular groups and individuals. This leads me to the third recurring topic I wish to discuss.

Finally, demographics and who can and does contribute VGI are key considerations. Time and again throughout this research it has been evident that the inability for some to participate in VGI practices is a limitation to the usefulness of VGI in bushfire preparation and disaster management. The studies in this thesis showed VGI represents only a skewed picture of communities with varying degrees of participation of particular groups and individuals on social media and in participatory mapping activities. This inability of VGI to represent and reach 'everybody' was a barrier to further agency adoption of VGI into authoritative emergency management practices.

The converse of some people being left off VGI maps and excluded from any empowerment they may provide is those who are able to participate disproportionately benefiting and the notion of elitism. The power dynamics that accompany VGI participation are of significance to local disaster management in communities, through the potential amplification of community tensions and social divides, for instance, and to social systems more broadly. The contrasting abilities of VGI to empower and exclude, often simultaneously, may exacerbate existing socio-economic divisions and raise increasing concerns about

the role of geo-technological advancements globally. This thesis examined the case of Tasmania, a relatively homogenous community, relative to other regions of the world where the differences between the rich and the poor, and those with high social capital and those without, may be even more pronounced. Thus, these issues are potentially even more significant in other contexts. Geographers, particularly those working with VGI and public participation, need to remain acutely aware of the digital divide and work towards reducing it, providing more people greater access to the benefits of geospatial technologies and achieving increasingly accurate and comprehensive pictures of populations on maps.

7.2 Implications

7.2.1 Implications for authoritative disaster management

VGI has had a remarkable impact on emergency management in just a few years, and together the outcomes of this thesis tell a story of opportunity, disruption, and change. On one hand the implications of VGI for emergency management relate to positive change and opportunities with technological advancements leading to increased citizen-participation in disaster management. In particular, demonstration in this thesis of the strengths of VGI in the preparedness stage of disaster management through increasing community connectedness, local knowledge exchange, risk awareness, and engagement in disaster preparation has not been presented before. This represents a significant shift in how VGI is considered in disaster management. Previously, value in VGI was seen in crisis response for providing large volumes of information from new data sources and on-the-ground intelligence, amplification of authoritative messaging through social media, and mapping for humanitarian relief from locations away from the disaster location, with very little understanding or appreciation of the role VGI might play in other phases of disaster management.

That VGI offers promise for achieving the goals of disaster management outside of immediate event response, namely increased community disaster resilience, has practical and policy implications. In current and future community engagement initiatives, such as Bushfire-Ready Neighbourhoods (BRN) in Tasmania, VGI through participatory mapping and social media sites like Facebook should be increasingly used with greater confidence. The evidence-base provided by the work of this thesis demonstrates: these technologies are already being used by large portions of communities in diverse and sophisticated ways; communities are interested in their use for disaster communication; agencies recognise the opportunities they provide for improving disaster management; and there are substantial benefits of community-scale mapping of VGI to community bushfire preparedness and disaster resilience. Going forward, in practice this might mean social media and participatory mapping are used increasingly as engagement tools in current community development works, in a similar fashion to the participatory mapping workshops that formed part of this thesis (Chapter 5). In policy, this may mean formal recognition of the value of geoweb technologies and of citizen knowledge in disaster management through the proposal and implementation of new strategies and policies that better-promote and harness the potential of VGI.

On the other hand, tensions arise through the growth of VGI in disaster management. VGI and traditional disaster management are premised on contrasting models of information creation and dissemination. The first is relatively spontaneous, unstructured, and created by 'lay people', whereas the second is consistent, hierarchical, and produced by known 'experts'. VGI practices disrupt the model of authoritative emergency management and signify reduced control and regulation over information. Fundamentally, VGI is decentralizing, giving more power to citizens and reducing the power of authoritative agencies. In this context, the challenges of VGI highlighted through this research, in particular issues of quality assurance in heterogeneous data, source trustworthiness, data management, privacy, ethical and potential legal concerns, are especially pertinent in determining how these sometimes-competing modes of practice can operate cooperatively and complimentarily. Until a policy shift or greater cultural change in emergency management transpires enabling agencies to further share control and to value citizens' contributions, these challenges may be difficult to overcome and the opportunities of VGI may not be effectively realised. There may also be tensions lurking around private ownership of VGI platforms, such as social media sites, whereby official and government agencies are increasingly expected to utilise commercially-driven resources to connect with citizens. Related are considerations around corporate gains and vulnerability of impacted citizens in disaster management where those with commercial interests and vested profit stakes operate alongside government bodies.

I do not argue, however, that the disruptive changes or challenges of VGI negate the opportunities and benefits for bushfire preparedness or disaster management. Rather, I seek to demonstrate that the implications of VGI are complex and multidimensional, requiring further research and policy and organisational change to best-capitalise on the innovations of recent years. An important finding of this thesis through interviews of emergency management professionals (Chapter 4) was the notion of fear of the unknown and the fear of change and reduced control as a barrier to official agencies' participation in VGI practices. VGI is a phenomenon that *is* happening, not something that is proposed, and a choice not to engage with it would seem at odds with the goals of disaster management and shared responsibility. An implication of this research is that agencies will need to participate more in this space to extract benefit from the technologies for themselves in improving disaster management strategies, to work towards a more holistic approach to disasters that values and works *with* communities, and to best-deliver their service of ensuring community safety by engaging with people where they are, which is often online through VGI platforms.

A central message in authoritative disaster management is that communities need to be disaster resilient. A key element of resilience is the ability to adapt to change. In terms of VGI for increasing disaster resilience, based on the findings of this thesis I argue there is a level of adaption required of emergency management organisations. Agencies need to adapt to new technologies for disaster communication, more sophisticated and detailed data from varying sources at varying spatial scales, a lack of control over citizen information-sharing practices, actions and involvement in disaster management, and shifts in power from the dominance of centralized, top-down institutional power to increased distribution of power among various parties, including citizens. Failure of agencies to adapt in

culture and in policy may result in ineffective emergency management strategies. Greater acceptance, encouragement, and exploitation of VGI technologies and practices by disaster management authorities are key changes required. This thesis has outlined important challenges to the increased utilization of VGI in authoritative emergency management, but it also demonstrates the strengths and opportunities of VGI, rationale for further investigation and understanding, and ways forward for more effective use of VGI in disaster management. This includes a community-scale participatory mapping approach to utilising VGI in the preparedness phase of disaster management.

I acknowledge, however, that VGI is not a standalone approach, and agencies already need to manage and triangulate information from various sources, often with insufficient resources. Further, community engagement is just one of a suite of tasks undertaken by emergency organisations. Emergency management has many and varied functions, with procedures and policies often produced and refined through generations of knowledge exchange and learning, and it is unreasonable to expect processes and behaviours should or even could have adapted to change at the rapid rate at which VGI technologies and practices have advanced. Acknowledging this partially explains some of the tension that exists between the differing systems of VGI, disaster management and authoritative systems generally. VGI is both shaping and is shaped by authoritative systems like formal emergency management. Adaption and effective uptake of VGI within disaster agencies may initially be isolated to sub-sections of organisations and on small scales, for example in community engagement programs as was demonstrated in this thesis to be beneficial for Tasmanian communities in the context of bushfire preparation. This approach may serve as a model for research utilization and implementation of initiatives making use of VGI going forward.

7.2.2 Implications for geography and GIScience

Contributions of the research to critical geospatial knowledge theory are twofold. First, the conceptualization of VGI adopted in this thesis advances understandings and applications of the concept of VGI originally proposed by Goodchild (2007) by emphasizing VGI as more than a type of data, but as a more complex social practice. In VGI literature emphasis has been on VGI as data, and on the individual as a contributor of VGI. Scholars have written about individuals' data creation activities and different ways individuals participate (Goodchild 2007; Haklay 2013), motivations of individuals (e.g. Coleman *et al.* 2009), the credibility and trustworthiness of individuals as VGI sources (e.g. Flanagin & Metzger 2008), and the data accumulated from masses of individuals' VGI practices. While the individual is germane to VGI and these topics were considered in this research, the thesis also investigated the user-experience of contributing VGI with other community members, specifically for the cause of assisting in community bushfire risk reduction. It was shown that the social aspect of contributing VGI, that is sharing local knowledge collaboratively with others, was more valuable for individual and community bushfire preparation and disaster resilience than the specific information mapped or shared. VGI should be considered further as a powerful social process with implications for society and for geography far beyond the opportunities presented by a network of individual observers or distributed data contributors. Conceptualizing VGI as a social practice can lead to important outcomes related to

community connectedness and social cohesion, democratization, community participation, action and positive behavioural change for a wide range of geographical questions.

Second, the thesis challenges recent contestations in the critical GIS literature made in relation to the classification of VGI relative to other established fields, including participatory geographic information systems (PGIS) and public participation GIS (PPGIS) (see McCall *et al.* 2015; Brown 2016). Authors such as McCall and colleagues (2015) and Brown (2016) have claimed that VGI is not participatory, that it lacks cultural information, that it is not empowering on an individual scale, and that it focusses more on volume of information rather than depth. This thesis presents methods and findings in opposition to these claims.

In response to calls for VGI and citizen science to become more participatory (McCall *et al.* 2015; Haklay 2013), the work of this thesis harnessed PPGIS theory and collaborative practices in utilising local spatial knowledge and encouraging information sharing through the use of VGI methods. VGI, particularly on local scales capturing more cultural information and everyday lived experiences through a participatory mapping approach, as demonstrated in this thesis, offers promise for empowering and engaging individuals. The approach taken in this thesis allowed for benefits of both VGI and PPGIS to be gained, such as rapid dissemination of information through online platforms and convenient information contribution through tablets and smartphones, as well as incorporation of participatory values, depth of local and cultural information, individual empowerment, and increased social connectedness. Whereas VGI has been presented as a form of 'big data' (Burns 2015), this research highlights the value of VGI to geography as 'small data', with local and cultural knowledge shared being more critical to community disaster management. The approach taken here is not presented as gospel, and there will be others, but is a demonstrated case of how components of VGI and participatory mapping can be combined to deliver useful outcomes for both the public and the disciplines of geography and GIScience.

7.3 Considerations and future work

While the research presented in this thesis makes substantial and timely contributions to DRR and extant critical debates in the arenas of geography and GIScience, it remains an in-depth study of only a fraction of those fields. There are limitations to the work in relation to scope, methodological restrictions and practical realities, and the next paragraphs detail some important considerations for future work.

The studies in this thesis, in particular the community surveys (Chapter 3) and the participatory mapping workshops (Chapter 5), were limited by who volunteered to participate. Study samples tended to over-represent older, highly educated, wealthier, retired people without dependents, while under-representing youth, people with children, and those from marginalized or lower socio-economic backgrounds. It has been reported elsewhere that participatory mapping studies rarely result in representative samples and usually exhibit biases towards older, more formally educated male participants with higher incomes, and under-represent ethnic groups and minorities (Brown 2016;

Brown & Kyttä 2014). Further work is required to determine how to better-include the under-represented in VGI and participatory mapping projects.

Longitudinal studies would enhance this work. The practicalities of time and resource limitations for doctoral research impacted what could be achieved. For instance, ongoing participatory mapping workshops in each of the study communities would require further time and resources to extend the participating communities and address potential for participant fatigue, and thus assessment of long term community engagement outcomes based on this research was not possible. Related, evaluation of bushfire preparation engagement outcomes provided through VGI practices in this study was made via questionnaires assessing participants' *perceived* outcomes. Follow-up studies with participants would strengthen this work by permitting evaluation of outcomes based on actual behaviour change or specific actions taken following the VGI mapping exercises which would indicate increased bushfire preparation, for example the formulation of a written bushfire survival plan.

Further, studies of longer duration would also allow for more detailed appraisal of methods for maintaining and managing VGI initiatives and platforms. The notion of VGI management and maintenance was discussed with emergency management professionals (Chapter 4), and community members during participatory mapping workshops (Chapter 5), and was discussed in relation to resilience in Chapter 6. But each of these was limited and predominantly speculative. Hence, the topic deserves further research. Future work should consider the longevity of VGI platforms and practices, particularly as technology advances rapidly. The roles and responsibilities of the public, technology providers, and governmental departments, and related ethical concerns such as data storage, privacy, and the potential for repurposing of data in unintended ways need also be considered. As proposed in Chapter 4, learning could be taken from citizen science in terms of system design and maintenance for ongoing projects that effectively utilise and value citizen knowledge and large volumes of data.

The emphasis of this work has been on VGI as a social practice, with much of the focus on how people contribute and share knowledge, and what benefits and challenges these practices present for individuals and communities. But the technological elements of VGI require further attention too. Future work might seek to consider data characterization and quality assessment measures, system development to better-collate and utilise various forms of big data provided by VGI, and the integration of citizen-produced data on the geoweb in its varying forms into existing emergency management databases.

The research questions of this thesis were based on the premise that VGI practices can contribute to increasing community disaster resilience. However, it was beyond the scope of the work to develop detailed measures of resilience. Others have recommended measures of resilience, often using indices, and future work may benefit from exploiting these in assessing the contributions or impacts of VGI. The concept of measuring resilience raises a number of questions, such as whether some aspects of VGI are better than others; whether some components of resilience hold greater weight; whether 'resilience' is

indeed a desirable outcome, and if so, how much 'resilience' is 'enough'; and, what happens when an individual or community is deemed 'resilient'; how would a resilience 'badge of honour' impact future actions and support provided? These questions are both conceptual and practical in nature, and further work is needed to understand them and provide responses.

Lastly, this thesis examined the specific case of VGI for bushfire preparation engagement in Tasmania. While findings are certainly applicable to broader questions, it would be advantageous to examine VGI in other contexts. I see three key areas for further scientific investigation here.

First, it would be beneficial exploring the issues raised in this thesis in other geographic contexts, such as other parts of Australia where community composition and disaster preparedness may differ, other countries with differing emergency management, governance and political structures, or regions with different socio-economic circumstances, such as developing nations.

Second, research into the opportunities, challenges, and overall usefulness of VGI could be undertaken for other phases of the PPRR disaster management cycle. Review of the literature for this study revealed a saturation of studies examining VGI in disaster response. This thesis has considered disaster preparation, but the application of VGI practices for disaster prevention and/or recovery should also be addressed. On the surface, it seems the valuable qualities of VGI in DRR, such as increased community connectedness and exchange of local knowledge, may also be of value in disaster recovery, where communities are aiming to rebuild their lives together, often over the course of many years. VGI and participatory mapping may facilitate community connections and resource sharing, and could act as an indicator of progress by noting how community maps change throughout the recovery process. This potential warrants further investigation.

And, third, similar questions to those in this thesis could be asked for other hazards, including floods, drought, cyclones and other storms, and volcanic eruptions, among others. This might also include non-environmental events, such as preparing for and responding to acts of terror, human conflict, disease outbreaks or other crises. Research examining VGI in any combination of these differing scenarios would further elucidate its strengths, weaknesses, and modes of best practice, and broaden our understanding of this rapidly growing but juvenile field.

7.4 Conclusion

The findings delivered in this thesis demonstrate that VGI practices in disaster management, in particular DRR, are capable of moving from a largely opportunistic and ad-hoc phenomenon with great potential to become something more reliable, applied, and structured with clearer purpose and outcomes for citizens and authorities. This research has offered a participatory mapping approach to VGI sharing in bushfire-risk communities, but there may be other and/or better approaches, and further research in the areas described above will build on this work and increase our understanding of the advantages, challenges, and modes of best practice of VGI even further. In conclusion, individuals, communities and authorities are already sharing geographic data online at all stages of disaster

management, and that's unlikely to change any time soon. The work of this thesis is important for its contributions to determining how VGI technologies and practices can be most effectively used, both by community members and authorities, to better-realise some of the exciting opportunities they offer for disaster management. The insights gained through this analysis of VGI in DRR into the wider implications of changing, growing, and largely bottom-up practices of geospatial information creation and dissemination for traditional, authoritative, top-down systems have significance beyond the field of disaster management. In particular, VGI can be seen as disruptive, but also democratizing, where GIS is facilitating enhanced civic engagement and value is increasingly recognized in both 'expert' and citizen information and practices for a range of applications, including map-making and the disciplines of geography and GIScience.

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APPENDIX A: PUBLICATIONS

Haworth, B., Bruce, E. & Whittaker, J. (*in review*). A critical evaluation of volunteered geographic information practices and community disaster resilience. *ACME: An International Journal for Critical Geographies.*

Haworth, B., Whittaker, J. & Bruce, E. (2016). Assessing the application and value of VGI and participatory mapping for community bushfire preparation. *Applied Geography,* 76: 115-127.

Haworth, B. (2016). Emergency management perspectives on volunteered geographic information: Opportunities, challenges and change. *Computers, Environment and Urban Systems,* 57: 189-198.

Haworth, B., Bruce, E. & Middleton, P. (2015). Emerging technologies for risk reduction: assessing the potential use of social media and VGI for increasing community engagement in bushfire preparation. *Australian Journal of Emergency Management,* 30(3): 36-41.

Haworth, B. & Bruce, E. (2015). A review of volunteered geographic information for disaster management. *Geography Compass,* 9(5): 237-250.

Haworth, B. (2014). *Volunteered Geographic Information, Community Engagement and Bushfire Preparation in Tasmania: Field study preliminary results*. Report compiled for the Tasmania Fire Service (not peer reviewed), June 2014.

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Assessing the application and value of participatory mapping for community bushfire preparation

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ABSTRACT

The increased ease for individuals to create, share and map geographic information combined with the need for timely, relevant and diverse information has resulted in a new disaster management context. Volunteered geographic information (VGI), or geographic information voluntarily created by private citizens enabled through technologies like social media and web-based mapping, has changed the ways people create and use information for crisis events. Research has focussed on disaster response while largely ignoring prevention and preparedness. Preparing for disasters can reduce negative impacts on life and property, but despite strategies to educate communities, preparation remains low. This study assesses the application and value of VGI in bushfire risk reduction through a participatory mapping approach. It examines VGI as a social practice and not simply a data source by considering the user experience of contributing VGI and the potential for these activities to increase community connectedness for building disaster resilience. Participatory mapping workshops were held in bushfire-risk communities in Tasmania. Workshop activities included a paper-mapping exercise and web-based digital mapping. Survey results from 31 participants at three workshops indicated the process of mapping and contributing local information for bushfire preparation with other community members can contribute to increased social connectedness, understanding of local bushfire risk, and engagement in risk reduction. Local knowledge exchange was seen as valuable, but the social dimension appeared even more engaging than the specific information shared. Participants reported collaborative maps as effective for collating and sharing community bushfire information with a preference for digital mapping. Some limitations of online sharing of information were also reported by participants, however, including potential issues of privacy, data quality and source trustworthiness. Further work is needed to extrapolate findings from the study sample to the broader population.

1. Introduction and background

1.1. Bushfire preparation and community engagement

Community preparation is a fundamental component of bushfire safety. Preparation can assist residents to protect houses and property, and to evacuate safely. Recent studies have investigated factors influencing preparation decision-making (Prior, 2010), the importance of 'mental preparedness' (Eriksen & Prior, 2013), measures of adequate preparedness (Dunlop, McNeill, Boylan, Morrison, & Skinner, 2014; Penman et al. 2013), preparation costs (Penman, Eriksen, Horsey, & Bradstock, 2016), gender (Whittaker, Eriksen, & Haynes, 2016), and levels of preparedness in specific bushfires (McLennan, Elliott, Omodei, & Whittaker, 2013; Whittaker, Haynes, Handmer, & McLennan, 2013). Despite community education strategies and the impact of past events, active disaster preparation remains low (Gargano, Caramanica, Sisco, Brackbill, & Stellman, 2015; Hausman, Hanlon, & Seals, 2007; Paton, 2003). There is increasing recognition in emergency management that information provision alone is insufficient to increase community preparation and that more engaging, participatory approaches are needed. This reflects a shift in disaster management more broadly, where community participation is increasingly considered a fundamental principle of disaster risk reduction (DRR)

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Emergency management perspectives on volunteered geographic information: Opportunities, challenges and change

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ABSTRACT

Volunteered geographic information (VGI) refers to the widespread creation and sharing of geographic information by private citizens, often through platforms such as online mapping tools, social media, and smartphone applications. VGI has shifted the ways information is created, shared, used and experienced, with important implications for applications of geospatial data, including emergency management. Detailed interviews with 13 emergency management professionals from eight organisations across five Australian states provided insights into the impacts of VGI on official emergency management. Perceived opportunities presented by VGI included improved communication, acquisition of diverse local information, and increased community engagement in disaster management. Identified challenges included the digital divide, data management, misinformation, and liability concerns. Significantly, VGI disrupts the traditional top-down structure of emergency management and reflects a culture shift away from authoritative control of information. To capitalise on the opportunities of VGI, agencies need to share responsibility and be willing to remain flexible in supporting positive community practises, including VGI. Given the high accountability and inherently responsive nature of decision making in disaster management, it provides a useful lens through which to examine the impacts of VGI on official authoritative systems more broadly. This analysis of the perceptions of emergency management professionals suggests changes to traditional systems that involve decentralisation of power and increased empowerment of citizens, where value is increasingly recognised in both expert and citizen-produced information, initiatives and practises.

1. Introduction

In January 2013 Australia was in the midst of a bushfire (wildfire) disaster. Fire swept across the state of Tasmania, stretching capacities of emergency services and devastating communities (DPAC, 2013). No fatalities occurred during the blazes, but the event left many in need of emergency assistance with significant access issues due to road closures, power and communications disruptions, and the destruction of 203 residential buildings (DPAC, 2013).

As the disaster unfolded people flooded social media to connect to each other and share relevant geographic information and resources. One Tasmanian resident observed the growing online activity and set up a social media page to help coordinate the flow of information. Interest in the Facebook page Melanie Irons established, "Tassie Fires We Can Help" (www.facebook.com/tassiefireswecanhelp), rapidly spread with people sharing their locations, their requirements for help, offers of assistance and other disaster related information (ABC, 2013). Within 24 h the page had gained over 17,000 followers and had reached over 2 million individuals (ABC, 2013; DPAC, 2013).

> "We understood quite early on that people were trusting this page, that people were sharing information and it was getting results. People were putting out requests for fuel, for generators, for food and people were responding. So it almost bypassed the official channels. Well, it did. It essentially became a way for volunteers to communicate directly with people that needed help, without having to go through the official channels." — Damien McIver, journalist (ABC, 2013).

With emergency services consumed by other tasks, such as fighting the spread of fire, Ms. Irons' page filled critical gaps in the response to the disaster. Social media and geographic information volunteered by the public proved highly valuable in responding to the disaster through increasing connectedness, sharing information quickly and widely, and provision of crucial local perspectives and data that met specific local needs. This citizen-driven initiative engaged the public and mobilised the population to undertake a whole suite of important tasks not able to be completed by the official emergency response.

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0198-9715/

Emerging technologies for risk reduction: assessing the potential use of social media and VGI for increasing community engagement

Billy Haworth, Bushfire and Natural Hazards Cooperative Research Centre and University of Sydney, Eleanor Bruce, University of Sydney, and Peter Middleton, Tasmania Fire Service, look into the use of volunteered geographic information technologies.

ABSTRACT

Each year Australia is prone to potential negative and devastating impacts of bushfires and other natural hazards, highlighting the importance of community engagement in disaster risk reduction. Volunteered geographic information (VGI) is an emerging technology that allows members of the public to voluntarily contribute geographic information, predominantly through sources such as social media, photo and video sharing platforms, and online map-making software. The potential role of VGI in disaster response has been documented in recent years, but VGI for community preparation has received less attention. This research explores the potential role for VGI to foster community engagement in bushfire preparation and to empower and build disaster resilience for Tasmanians. Through collaboration with the Tasmania Fire Service, a survey of 154 participants across 12 communities at bushfire risk in Tasmania has quantified trends in individual and community preparedness and VGI and social media use. This paper provides an evidence base for both the use of VGI technologies in bushfire preparation initiatives and directions for further research.

Introduction

Australia is prone to the devastating impacts of bushfires and other natural hazards. Climate change and increased global warming means extreme weather events such as bushfires, floods and heatwaves are predicted to increase in both frequency and intensity (IPCC 2012). Adequately preparing for disasters can dramatically reduce the risk to life and assets (Paton 2003). Yet, despite efforts to educate communities with relevant and up-to-date information, research has shown individuals in at-risk communities still may not actively engage in risk reduction activities (Frandsen 2011). Innovative approaches are needed to involve communities in disaster preparation to reduce risk and build resilience. Social media and other online geographic information communication technologies are increasingly providing opportunities to connect communities. The role of these technologies in disaster response has been well-established in recent years, however, research into their utility in the pre-disaster phases of the emergency cycle remains relatively limited (Haworth & Bruce 2015). This article presents findings of a study examining the potential role of social media and other online geographic information technologies in fostering community engagement in bushfire preparation in Tasmania.

Social media are internet-based applications that enable people to communicate and share resources (Taylor *et al.* 2012). Other geographic information communication technologies referred to in this article include online map-making software open to public contributions (e.g. Ushahidi Crowdmap, OpenStreetMap) and devices such as smartphones, which enable collection, creation, and sharing of data in unprecedented ways. The widespread engagement of the public to voluntarily produce geographic information using these technologies is referred to as volunteered geographic information (VGI) (Goodchild 2007). Prior to the emergence of VGI, community geographical information was collected through focus groups, surveys, and community discussion, with local, traditional, and indigenous knowledge shown to be useful in both environmental management and disaster mapping (Prober *et al.* 2011, Tran *et al.* 2009). Despite significant challenges, particularly those of data quality, accuracy and credibility (see Flanagin & Metzger 2008, Elwood, Goodchild & Sui 2012), VGI in disaster management allows for cost-effective rapid collection and dissemination of diverse local information, with large amounts of data collected in near real-time. It enables increased connectedness with communities and authorities and facilitates the understanding of local risk through the mapping and sharing of local knowledge.

This paper builds an evidence base for the use of VGI in building resilience through community engagement.

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A Review of Volunteered Geographic Information for Disaster Management

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Abstract

The immediacy of locational information requirements and importance of data currency for natural disaster events highlights the value of volunteered geographic information (VGI) in all stages of disaster management, including prevention, preparation, response, and recovery. The practice of private citizens generating online geospatial data presents new opportunities for the creation and dissemination of disaster-related geographic data from a dense network of intelligent observers. VGI technologies enable rapid sharing of diverse geographic information for disaster management at a fraction of the resource costs associated with traditional data collection and dissemination, but they also present new challenges. These include a lack of data quality assurance and issues surrounding data management, liability, security, and the digital divide. There is a growing need for researchers to explore and understand the implications of these data and data practices for disaster management. In this article, we review the current state of knowledge in this emerging field and present recommendations for future research. Significantly, we note further research is warranted in the pre-event phases of disaster management, where VGI may present an opportunity to connect and engage individuals in disaster preparation and strengthen community resilience to potential disaster events. Our investigation of VGI for disaster management provides broader insight into key challenges and impacts of VGI on geospatial data practices and the wider field of geographical science.

Introduction

Natural disaster events, such as the recent Typhoon Haiyan in the Philippines, floods and bushfires (wildfires) in Australia, or Hurricane Sandy in the United States, remind us of the importance of geospatial data and the need for timely and reliable communication in all aspects of disaster management. New opportunities for the creation and dissemination of important disaster-related geographic data from a dense network of intelligent observers are now provided through online user-generated geospatial data termed volunteered geographic information (VGI) (Goodchild 2007; Elwood et al. 2012). Like geographical information systems (GIS), VGI involves the sharing and mapping of spatial data, however, through voluntary information gathered by the general public, though extant debates question the appropriateness of the adjective 'volunteered' noting differences between crowdsourced data that is actively contributed with the individual's awareness and user-generated data that is harvested otherwise (Harvey 2013; Stefanidis et al. 2013). Similarly, definitions of the 'general public' and who produces VGI are often blurred (Budhathoki et al. 2008), with contributions coming from disparate sources (Haklay 2013a; Coleman et al. 2009; Schlossberg and Shuford 2005). VGI represents various opportunities and threats for traditional data production systems, as summarised by Genovese and Roche (2010), some of which are particularly relevant to disaster management, including the opportunity for citizens to actively contribute to public issues with personal local knowledge and the threat that VGI may reduce the importance of authoritative mapping.

APPENDIX B: PRESENTATIONS

Invited Talks

Haworth, B. (2016). Assessing the potential, application, and implications of volunteered geographic information in disaster risk reduction. Seminar presentation for SSSI event at the University of Western Australia, Perth, WA. June 2016.

Haworth, B. (2015). Volunteered Geographic Information (VGI) for community engagement in bushfire preparedness. *BNHCRC Sustainable Volunteering annual workshop*, RMIT, Melbourne, November 2015.

Haworth, B. (2015). Three minute thesis. *AFAC/BNHCRC annual conference, 'New Directions in Emergency Management,'* Adelaide, September 2015.

Haworth, B. (2015). "Flooding Facebook" and "Tweeting up a storm": a review of volunteered geographic information for disaster management. Seminar given at the Museum of Natural Sciences, Raleigh, NC. April 2015.

Haworth, B. (2015). Three minute thesis. *BNHCRC Research Advisory Forum*, NSW Rural Fire Service headquarters, Sydney, April 2015.

Haworth, B. (2014). Volunteered geographic information, community engagement and bushfire preparation in Tasmania. *RMIT Non-traditional volunteering Annual Project Workshop*, Melbourne, October 2014.

Haworth, B. (2014). Invited panellist for discussion session on 'Social Media Issues'. *Emergency Management and Public Affairs (EMPA) annual conference, 'Collaboration in Communication'*, Canberra, June 2014.

Presented Papers

Haworth, B., Whittaker, J. & Bruce, E. (2016). Using participatory mapping to harness local knowledge and increase community connectedness in bushfire preparation. *AFAC/BNHCRC annual conference, 'Mitigation, Response, Recovery: Getting the Balance Right,'* Brisbane, August 2016.

Haworth, B., Whittaker, J. & Bruce, E. (2016). Volunteered geographic information (VGI) and disaster risk reduction: The application of participatory mapping in community bushfire preparation. *Geospatial information for monitoring socio-environmental risk, Institute of Australian Geographers Conference*, Adelaide, June 2016.

Haworth, B. (2015). Engaging Communities in Disaster Risk Reduction through Volunteered Geographic Information (VGI): a case study of bushfires (wildfires) in Tasmania, Australia. *Association of American Geographers annual meeting*, Chicago, IL. April 2015.

Haworth, B. & Bruce, E. (2014). Volunteered Geographic Information, community engagement and bushfire preparation in Tasmania: a preliminary study. *Geographies of natural hazards and disasters in the Australia – Pacific region, Institute of Australian Geographers Conference*, Melbourne, July 2014.

Haworth, B. (2014). Social media and information communication during natural disaster events. *GeoNext Location Matters Conference*, Sydney, February 2014.

Departmental Presentations

Haworth, B. (2016). Assessing the potential, application, and implications of volunteered geographic information in disaster risk reduction. 'Thinking Space' seminar series, School of Geosciences, University of Sydney, June 2016.

Haworth, B. (2014). Crowdsourcing geographic information: VGI, citizen science, and community engagement in bushfire preparation. 'Thinking Space' seminar series, School of Geosciences, University of Sydney, October 2014.

Haworth, B. (2013). Three minute thesis. 'Thinking Space' seminar series, School of Geosciences, University of Sydney, November 2013.

APPENDIX C: CONFERENCE POSTERS

Haworth, B., Whittaker, J. & Bruce, E. (2016). Using participatory mapping to increase community engagement in bushfire preparation. *AFAC/BNHCRC annual conference*, 'Mitigation, Response, Recovery: Getting the Balance Right,' Brisbane, August 2016.

Haworth, B. (2015). Power to the people: The implications of volunteered geographic information for official emergency management (conference poster). *AFAC/BNHCRC annual conference*, 'New Directions in Emergency Management,' Adelaide, September 2015.

Haworth, B., Bruce, E. & Whittaker, J. (2014). Non-traditional Volunteering: Volunteered Geographic Information (VGI) and bushfire preparation (conference poster), *AFAC/BNHCRC annual conference, 'After Disaster Strikes: Learning from Adversity,'* Wellington, New Zealand, September 2014.

Using participatory mapping to increase community engagement in bushfire preparation

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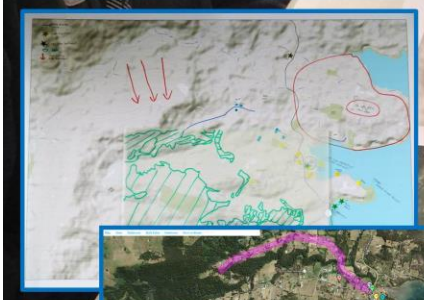
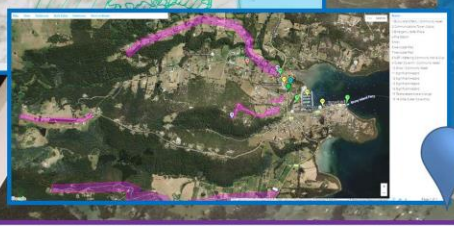
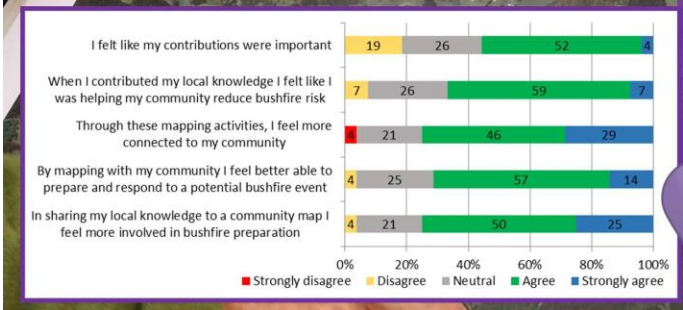
Involving communities is a prerequisite to sustainable disaster risk reduction. Participatory mapping is the creation of maps by local communities, often in collaboration with end users, organisations or universities. With the growth of locational and web-based technologies, community members can increasingly create maps to represent their local spatial knowledge, which can facilitate participatory decision making, community advocacy, and community empowerment.

With support of the Tasmania Fire Service, we held workshops in 4 bushfire-risk communities in Tasmania – Kettering, St Marys, St Helens, Tolmans Hill - to explore the potential application and value of participatory mapping in bushfire preparation engagement.





Participants mapped information they felt relevant to bushfire preparation in their community, first in groups on paper maps, then on a combined online map. Participants preferred digital mapping over paper, and the social aspect of the activities was more valuable for participants and their bushfire preparation than the specific information mapped.



Survey results from 31 participants confirm the process of mapping and contributing local information for bushfire preparation with other community members can contribute to increased social connectedness, understanding of local bushfire risk, and engagement in disaster risk reduction.

Further work is needed to address issues of online privacy and data quality, applications in other contexts, and biases in the study sample (e.g. involve people absent from our study sample, such as youth and more socio-economically disadvantaged groups).

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POWER TO THE PEOPLE:

IMPLICATIONS OF VOLUNTEERED GEOGRAPHIC INFORMATION (VGI) FOR OFFICIAL EMERGENCY MANAGEMENT (OEM)

bushfire&natural HAZARDSCRC

Billy Haworth[1]

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VGI refers to the creation and sharing of geographic information by community members, mainly through social media, smartphones and online mapping tools. VGI represents a shift in the ways information is created, shared, used and experienced. Detailed interviews with 13 emergency management professionals from 8 organisations across 5 Australian states provided insights into the impacts of VGI on OEM.

1. What are the opportunities of VGI?

- Fast, broad, 2-way communication
- Collection of diverse local knowledge

- Different ways to present information
- Increased community connectedness
- Increased risk awareness
- Community engagement in all stages of PPRR

2. Is OEM effectively realising these opportunities?

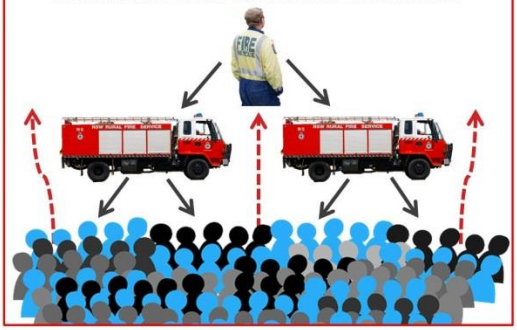
- Broadly, no
- VGI mostly used as 1-way broadcast medium
- Practices of citizens contributing and sharing information are not widely encouraged or fostered

3. What challenges limit the use of VGI in OEM?

- Digital divide
- Data quality and misinformation
- Legal concerns (liability)
- Data management
- Aligning spontaneous, unstructured data with structured OEM systems

4. How does VGI impact OEM?

- VGI disrupts top-down power structure
- A culture shift away from centralized control
- Citizens have more control over information



5. Ways forward

- To capitalise on the opportunities of VGI, agencies need to share responsibility and control
- Agencies should be flexible in supporting VGI practices, allowing people to collectively manage disasters
- Community information should be valued as expert alongside official information
- More defined responsibilities and improved legal protections will help agencies more effectively embrace VGI

End User statement: "The Bushfire Ready Neighbourhoods program is collaborating with the University of Sydney to support the development of an evidence base to inform our future work. The partnership allows Tasmania Fire Service to test the waters and be able to put the necessary steps in place to make an informed decision about our future involvement in this space."
***Peter Middleton**, Tasmania Fire Service Community Development Coordinator*

Business Cooperative Research Centres Programme
THE UNIVERSITY OF SYDNEY
Tasmania Fire Service
BUSHFIRE READY NEIGHBOURHOODS
E: billy.haworth@sydney.edu.au
W: www.billyhaworth.com
Twitter: @BillyTusker

Image credits: Anzac Day Adelaide 2015 – adapted from Jenny Scott (Flickr); NZ Defence Force (Wiki); NSWRFS – Forest Hill Pumper – adapted from Bidgee (Wiki)

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NON-TRADITIONAL VOLUNTEERING: VOLUNTEERED GEOGRAPHIC INFORMATION (VGI) AND BUSHFIRE PREPARATION

bushfire&natural HAZARDSCRC

Billy Haworth[1], Eleanor Bruce[1], Joshua Whittaker[2]

[1] School of Geosciences, University of Sydney, NSW [2] Math & Geospatial Sciences, RMIT, VIC

VGI involves the widespread engagement of the general public in generating and disseminating geographic information, predominantly through sources such as social media, photo and video sharing platforms, and online map-making software. This research explores the potential role of VGI for fostering community engagement in bushfire preparation and building individual empowerment and disaster resilience in Tasmania.

PROJECT BACKGROUND

The recent emergence of VGI is increasingly providing authorities an effective method for engaging with high risk, vulnerable and impacted communities. Authorities and individuals have begun to embrace VGI technologies, creating a new landscape of geo-data production and knowledge sharing for crisis events. VGI enables rapid sharing of diverse geographic information for disaster management at a fraction of the resource costs associated with traditional data collection and dissemination, and facilitates increased connectedness between individuals and authorities. However, VGI also raises important concerns relating to privacy, security, liability, data accuracy and credibility.

Much work on the role of VGI in disasters to date has focussed on response, creating a need for research in the pre-disaster phases of the disaster management cycle. Research has shown communities often feel disempowered and may not engage in disaster preparedness activities. This study provides an evidence base for the utilisation of VGI technologies in bushfire preparation initiatives, where VGI may offer a platform to build resilience through increased community engagement and connectedness.

A WORKING PARTNERSHIP

This work is being undertaken in collaboration with the Tasmania Fire Service and the Bushfire Ready Neighbourhoods facilitator, Mr Peter Middleton. An initial Tasmania-wide survey of 154 respondents across 12 high risk communities has provided insight into patterns of individual and community preparedness, social media and VGI use, and communication amongst community members and between communities and bushfire authorities.

KEY PRELIMINARY FINDINGS

- The proportion of people actively involved in risk reduction is significantly lower than those who identify themselves as at-risk
- There is high potential and interest in VGI technologies and social media for assisting with bushfire preparation amongst community members
- But limitations exist, such as age, reliable access to technology, and trust
- Spatially, higher levels of social media use occur around larger urban centres
- Strong preferences are still present among respondents generally for other forms of disaster communication, such as TV, radio, phone/SMS or official websites
- VGI should not aim to replace traditional methods, but can act as an additional tool for increasing awareness of bushfire preparedness, and to empower individuals to engage in preparation activities by contributing important local information.

WIDER SIGNIFICANCE

This research is important as authorities seek new ways to engage communities in increasing bushfire preparedness. VGI technologies are already being used by individuals and emergency management agencies, and the impacts of these data and data sharing practices need to be understood.

The issues raised in this study, particularly those of data credibility, trust, reliability, and the increasing role of the general public as information observers and sharers, are not just relevant to bushfire preparedness in Tasmania, but are pertinent to disaster management, geo data and social practices, and the discipline of geography more broadly.

bnhcrc.com.au

APPENDIX D: RELEVANT BLOG POSTS

Haworth, B. (2016, September 8). Using participatory mapping to increase community engagement in bushfire preparation (AFAC/BNHCRC 2016 conference poster + presentation + award). *billyhaworth.com.* Available at: <https://billyhaworth.com/2016/09/08/using-participatory-mapping-to-increase-community-engagement-in-bushfire-preparation-afacbnhcrc-2016-conference-poster-presentation/>.

Haworth, B. (2016, July 12). Reflections: Institute of Australian Geographers (IAG) annual conference, 2016. *billyhaworth.com.* Available at: <https://billyhaworth.com/2016/07/12/reflections-institute-of-australian-geographers-iag-annual-conference-2016/>.

Haworth, B. (2016, April 7). Reflections on a student placement with the Bushfire-Ready Neighbourhoods team at Tasmania Fire Service. *billyhaworth.com*. Available at: <https://billyhaworth.com/2016/04/07/reflections-on-a-student-placement-with-the-bushfire-ready-neighbourhoods-team-at-tasmania-fire-service/>.

Haworth, B. (2015, December 6). Field notes: Community mapping for bushfire preparation in Tolmans Hill, TAS. *billyhaworth.com.* Available at: <https://billyhaworth.com/2015/12/06/field-notes-community-mapping-for-bushfire-preparation-in-tolmans-hill-tas/>.

Haworth, B. (2015, November 30). Field notes: Community mapping for bushfire preparation in St Marys and St Helens, TAS. *billyhaworth.com.* Available at: <https://billyhaworth.com/2015/11/30/field-notes-community-mapping-for-bushfire-preparation-in-st-marys-tas/>.

Haworth, B. (2015, November 22.) Field notes: Community mapping for bushfire preparation in Kettering, TAS. *billyhaworth.com.* Available at: <https://billyhaworth.com/2015/11/22/field-notes-community-mapping-for-bushfire-preparation-in-kettering-tas/>.

Haworth, B. (2015, November 13). Connecting, informing, and building relationships: notes from the 2015 BNHCRC sustainable volunteering workshop. *billyhaworth.com*. Available at: <https://billyhaworth.com/2015/11/13/connecting-informing-and-building-relationships-notes-from-the-2015-bnhcrc-sustainable-volunteering-workshop/>.

Haworth, B. (2015, June 3). A review of volunteered geographic information for disaster management (Geography Compass). *billyhaworth.com*. Available at: <https://billyhaworth.com/2015/06/03/a-review-of-volunteered-geographic-information-for-disaster-management-geography-compass/>.

Haworth, B. (2015, April 27). AAG Annual Meeting, Chicago 2015: Reflections. *billyhaworth.com*. Available at: <https://billyhaworth.com/2015/04/27/aag-annual-meeting-chicago-2015-reflections/>.

Haworth, B. (2014, December 11). 'Community' and emergency management: A problematic construct. *billyhaworth.com*. Available at: <https://billyhaworth.com/2014/12/11/community-and-emergency-management-a-problematic-construct/>.

Haworth, B. (2014, March 23). VGI and bushfire preparation in Tasmania – Part 3. *billyhaworth.com*. Available at: <https://billyhaworth.com/2014/03/23/vgi-and-bushfire-preparation-in-tasmania-part-3/>.

Haworth, B. (2014, February 17). VGI and bushfire preparation in Tasmania – Part 2. *billyhaworth.com*. Available at: <https://billyhaworth.com/2014/02/17/vgi-and-bushfire-preparation-in-tasmania-part-2/>.

Haworth, B. (2014, February 7). VGI and bushfire preparation in Tasmania – Part 1. *billyhaworth.com*. Available at: <https://billyhaworth.com/2014/02/07/vgi-and-bushfire-preparation-in-tasmania-part-1/>.

Haworth, B. (2013, October 8). Social media and crisis management: A Sydney conference. *billyhaworth.com*. Available at: <https://billyhaworth.com/2013/10/08/social-media-and-crisis-management-a-sydney-conference/>.

APPENDIX E: COMMUNITY SURVEY QUESTIONS (2014)

School of Geosciences | Faculty of Science

ABN 15 211 513 464

Bushfire Preparation in Tasmania, Community Engagement, and Volunteered Geographic Information

SURVEY QUESTIONS

A. Personal Information

1) Age:
- ☐ 24 or under
- ☐ 25-34
- ☐ 35-50
- ☐ 51-70
- ☐ 71 +

---

2) Gender: ☐ Male ☐ Female ☐ Other

---

3) What community do you live in?

- ☐ Bicheno area
- ☐ Blackstone Heights
- ☐ Coles Bay Area - including Point Meredith, Swanwick and The Fisheries

□ Gladstone Area
□ Hadspen
□ Kettering / Woodbridge area
□ Lachlan area
□ Mt Nelson and Tolmans Hill
□ Scamander area - including Beaumaris and Upper Scamander
□ St Helens area
□ Stieglitz area
□ Swansea

---

4) Relationship status: □ Single □ De facto/Married □ Divorced/Separated □ Widowed □ Other/prefer not to say

---

5) Do you have any dependents that live with you? □ Yes □ No

If YES, please indicate the number of dependents in each age group:

□ 0-4

□ 5-12

□ 13-18

□ 18-64

□ 65 +

---

6) Highest level of education completed:

□ Year 10 □ Year 12 □ Trade Certificate □ TAFE Course □ Undergraduate Degree □ Graduate Diploma □ Masters Degree □ PHD □ Other (please specify):

---

7) Occupation:

□ Agriculture
□ Construction
□ Manufacturing
□ Community Services/Healthcare
□ Public Sector
□ Retail/Hospitality
□ Communications
□ Education
□ Retired
□ Unemployed
□ Other (please specify):_____

---

8) Do you own/rent your house? □ Own □ Rent □ Visitor □ Other

---

9) Residency status: □ Full time □ Part time □ Visitor

---

10) How long have you lived in this area? _____years _____months

---

11) How long have you lived in your current house? _____years _____months

---

B. Bushfire Preparedness

1) Do you believe there is a bushfire risk where you live? □ Yes □ No

---

2) Are you familiar with the Tasmania Fire Service Bushfire Survival Plan? □ Yes □ No

3) Do you have a Bushfire Survival Plan? □ Yes □ No

4) Are you aware of your Tasmania Fire Service Community Protection Plan and where your Nearby Safer Place is located? □ Yes □ No

5) How often have you attended a bushfire awareness event such as a bushfire forum, information session, or brigade open day in the past five (5) years?

□ Never

□ More than once a year

□ Once a year

□ Once every two years

□ Once in the past five years

Please provide details of the event(s):

6) Would you like to learn more about the connection between bushfire risk and steps you can take to prepare your household?

□ Yes. Please comment: _____

□ No

□ Don't know

7) Will you become more bushfire prepared in the next 12-24 months?

□ Yes

□ Possibly

□ No

If YES, briefly explain how you will become more prepared:

_____

_____

8) Would maps showing bushfire hazard and vegetation help you to understand bushfire risk?

□ Yes. Please comment:
_____

□ No

□ Unsure

_____

C. Previous Bushfire Experience

1) Have you experienced a bushfire? □ Yes □ No

If YES give details (when, where, was there any damage?):

_____

_____

2) Have other members of your local community experienced a bushfire? □ Yes □ No □ Don't know

_____

D. Social Media Usage and Volunteered Geographic Information (data provided by the general public)

1) Please indicate which of the following social media technologies or websites you use: (Tick all that apply)

- ☐ I have never used social media
- ☐ Facebook
- ☐ Twitter
- ☐ YouTube
- ☐ Instagram
- ☐ Myspace
- ☐ Pinterest
- ☐ Bebo
- ☐ Flickr
- ☐ Tumblr
- ☐ Blogger
- ☐ Wordpress
- ☐ LinkedIn
- ☐ Google +
- ☐ Other (please specify): _____

---

2) What are the main reasons you use social media sites? (Tick all that apply)

- ☐ Communication with family/friends
- ☐ Photo and/or video sharing
- ☐ Networking and meeting new people
- ☐ News/information
- ☐ Games
- ☐ Other (please specify): _____
- ☐ Don't use social media

---

3) Which sources do you trust to obtain reliable information through social media: (Tick all that apply)

- ☐ Family and/or friends
- ☐ Government agencies (such as Tasmania Fire Service or local council)
- ☐ Non-government organisations or registered news media outlets
- ☐ General public
- ☐ Nobody
- ☐ Other (please specify): _____

---

4) How do you use social media and the internet?

☐ I contribute my own content to social media and the internet (e.g. posting status updates and photos on social media, posting on blogs, commenting on YouTube or news articles etc.)

☐ I only receive content (e.g. reading updates, viewing shared photos, watching videos etc.)

☐ I both contribute my own content and receive content

☐ I don't contribute or receive content

☐ Unsure

---

5) How often do you access social media (either on a computer or a mobile phone/device, including tablets)?

- ☐ Multiple times per day
- ☐ Once per day
- ☐ A few times a week
- ☐ Once per week
- ☐ Less than once a week
- ☐ Never

---

6) Are you aware that you can provide your geographic location to posts on social media sites such as Facebook, Twitter and Instagram?

□ Yes

□ No

---

7) Do you use this location feature on your social media posts?

□ Yes

□ No

□ Don't know

If YES please comment on why and how often? If NO please comment why not:

E. Community Involvement

1) Which of the following activities are you currently involved with or have been involved with in the previous five (5) years? (Tick all that apply)

□ Local sports club

□ School group

□ Local community committee

□ Local craft group (e.g., sewing group)

□ Local children's group (e.g., mothers' group, crèche, kindergarten etc.)

□ Church group

□ Local arts/music/cultural group

□ Youth group

□ Local indigenous group

□ Local environmental group (e.g., Landcare)

□ Local bushfire awareness group

□ Local volunteer fire brigade

□ State Emergency Service

□ St John's Ambulance

□ Other. Please comment: _____

2) Do you feel connected to other members of your local community?

□ Yes

□ No

□ Don't know

3) Do you connect to others in your local community through social media?

□ Yes

□ No

4) Have you ever been involved in community activities which have involved providing information in map form (such as identifying sites of community importance or bushfire risk)?

□ Yes. Please comment:
_____

□ No

□ Unsure

F. Information Communication for Bushfires

1) How would you prefer to receive information from authorities regarding bushfires during a bushfire event? (Tick all that apply)

- ☐ TV
- ☐ Radio
- ☐ Print media (e.g. newspapers)
- ☐ Community forums/meetings
- ☐ Official websites (e.g. http://www.fire.tas.gov.au/, http://www.alert.tas.gov.au)
- ☐ Social media (e.g. Twitter or Facebook)
- ☐ Phone/SMS
- ☐ Other (please specify) _____

_____

2) How would you prefer to receive information from authorities regarding bushfires after a bushfire event? (Tick all that apply)

- ☐ TV
- ☐ Radio
- ☐ Print media (e.g. newspapers)
- ☐ Community forums/meetings
- ☐ Official websites (e.g. http://www.fire.tas.gov.au/, http://www.alert.tas.gov.au)
- ☐ Social media (e.g. Twitter or Facebook)
- ☐ Phone/SMS

☐ Other (please specify) _____

_____

3) How would you prefer to receive information regarding bushfires from authorities at times of no bushfire event (e.g. regarding preparation for the fire season)? (Tick all that apply)

- ☐ TV
- ☐ Radio
- ☐ Print media (e.g. newspapers)
- ☐ Community forums/meetings
- ☐ Official websites (e.g. http://www.fire.tas.gov.au/, http://www.alert.tas.gov.au)

□ Social media (e.g. Twitter or Facebook)
□ Phone/SMS
□ Other (please specify) _____

---

4) Do you consider yourself to be well informed about bushfire and bushfire risk?

□ Yes

□ No

---

5) If you were to experience a bushfire event in the next 12 months would you refer to social media for information?

□ Yes

□ No

□ Don't know

---

6) In preparing for a potential bushfire in the next 12 months would you like to share and receive relevant information through social media?

□ Yes

□ No

□ Don't know

---

7) Do you think social media could provide an opportunity for authorities to use information relating to bushfire preparation provided by the community?

□ Yes

□ No

□ Don't know

G. Please rate your response to each of the questions below by circling the most appropriate number:

1) How prepared do you feel you are for a potential bushfire event?

Not prepared at all				Highly prepared
1	2	3	4	5

---

2) How prepared do you feel your local community is for a potential bushfire event?

Not prepared at all				Highly prepared
1	2	3	4	5

---

3) How vulnerable do you feel about the possibility of a bushfire affecting you, your family, or property?

Not at all vulnerable				Highly vulnerable
1	2	3	4	5

---

4) How important is communication between community members and authorities for bushfire preparation?

No important at all				Highly important
1	2	3	4	5

5) How easy is it for you to communicate information and concerns about your bushfire preparation to authorities, such as the Tasmania Fire Service?

Very difficult				Very easy
1	2	3	4	5

---

6) How useful do you think social media technologies are for bushfire preparation (e.g. community organisation, decision making and planning, preparing properties to reduce fire risk, sharing information on nearby safer places and potential evacuation procedures)?

Not at all useful				Highly useful
1	2	3	4	5

---

7) How useful do you think social media technologies are for bushfire response (response relates to the period of time during or immediately after a bushfire event has begun)?

Not at all useful				Highly useful
1	2	3	4	5

H). Please indicate the extent to which you agree or disagree with each of the following statements:

1) I feel responsible for preparing for bushfires

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

2) I feel in control of my own bushfire preparation and able to prepare

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

3) It is the responsibility of Local, State and/or Federal agencies to prepare for bushfires

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

4) A highly connected community is important for bushfire preparation and recovery

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

5) Social media technologies allow me to feel more connected to my community

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

6) I feel empowered by technologies such as social media, photo and information sharing websites, and online mapping

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

---

7) Social media and online mapping technologies can assist in improving bushfire preparation

Strongly Disagree	Disagree	Neither Agree nor Disagree	Agree	Strongly Agree
1	2	3	4	5

I. Additional optional question:

Please note this question is entirely optional. Please do not complete this question if you have any privacy concerns. Collecting address details will allow us to analyse spatial relationships between social media use and location of bushfire defined on the Tasmania Fire Service hazard maps. No other personal details will be attached to your address details and your address itself will never be released in publications and reports. Address data will be aggregated and only used in producing generalized maps and statistics.

a) What is your address?

_____

APPENDIX F: SEMI-STRUCTURED INTERVIEW QUESTIONS (2015)

Semi-structured interview questions / interview plan

From a professional perspective, what are the key benefits and challenges of VGI, and how can VGI approaches fit with existing emergency management systems?

Introduction of interviewer

Explanation of PhD research project (within BNHCRC). What my research key questions and methods are. What the interviews will be used for and what is expected for the session, including timelines of interview and PhD

Why respondent was chosen, and check again okay to participate

Ethics - obtain written consent of respondent's participation

Explain respondent can stop/break at any time, and can refuse to answer any question/topic if they don't feel comfortable answering, and offer them the chance to ask questions

Introduction of key informant

Name, organisation, position?

Can you explain your role? What are your general tasks and responsibilities? How long have you been in this role/emergency management?

Background/context – disaster management, preparation and resilience

What are some of the limitations or barriers to communities actively and effectively preparing?

Are you aware of any typical traits of communities that are well-engaged?

VGI in disaster management

Have you been involved in the use of VGI for disaster management in either a professional or volunteer capacity (Provide examples to respondent where necessary)?

What do you see as the strengths of VGI and associated technologies in emergency management?

And any weaknesses?

VGI technologies and local information for preparation

How do you think VGI could be useful in disaster preparation?

How valuable to communities and individuals do you think local information shared by other community members is/can be for disaster preparedness? In what ways?

How valuable is local VGI for authoritative organisations and their preparation strategies? Can you provide some examples?

What are the main challenges in using VGI and social media technologies to foster community engagement in disaster preparedness activities?

What factors may influence the uptake of these technologies for disaster management within the community?

VGI and traditional/authoritative emergency management

Do you think approaches utilising VGI could be useful alongside traditional disaster preparation approaches? In what ways?

Could VGI replace official or authoritative methods and sources of information and mapping? (Assuming 'no') what elements of these official systems can VGI not replace; where can VGI *not* contribute?

How can official and 'non-official' practices best work together to achieve the goal of disaster preparedness and increased resilience? What specific actions or changes to current systems are required, if any?

How can emergency management agencies support community/local/digital volunteering and practices like sharing VGI?

How can community members sharing VGI best support official emergency agencies?

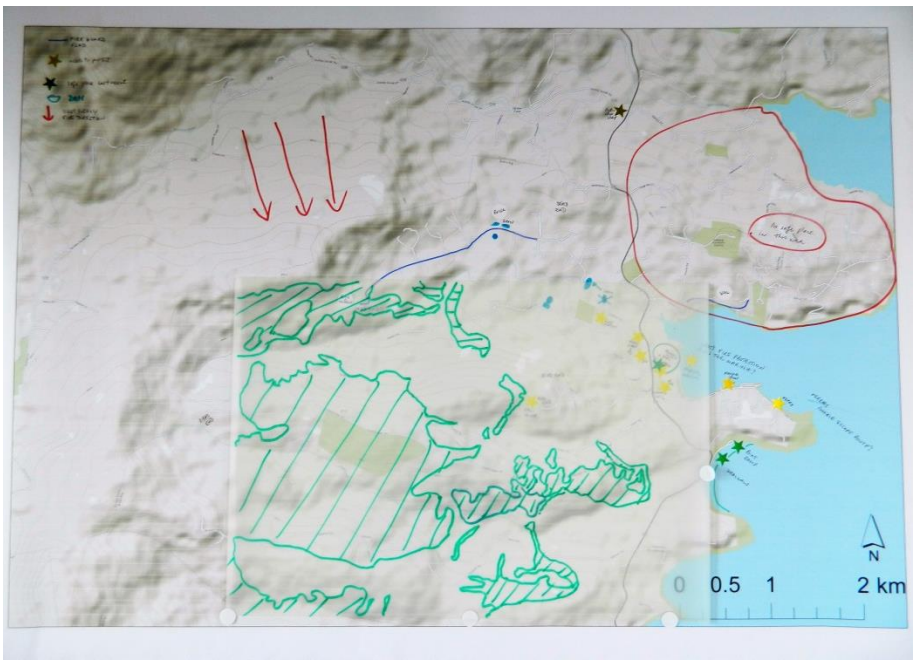
Concluding the interview

How do you see disaster preparation methods evolving into the future? How do you think VGI might play a role?

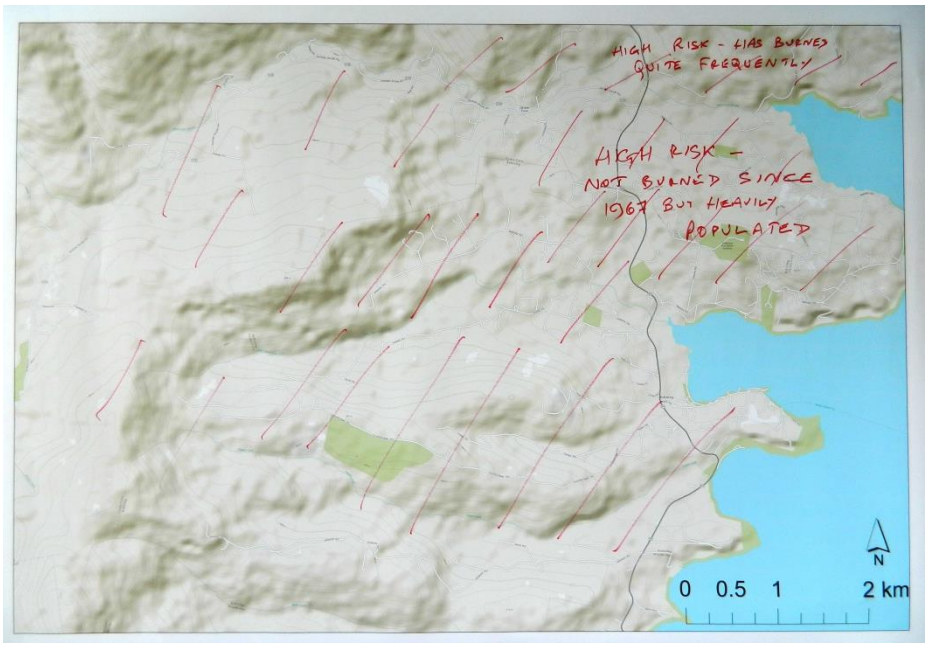
Is there anything else you'd like to add?

Thank you

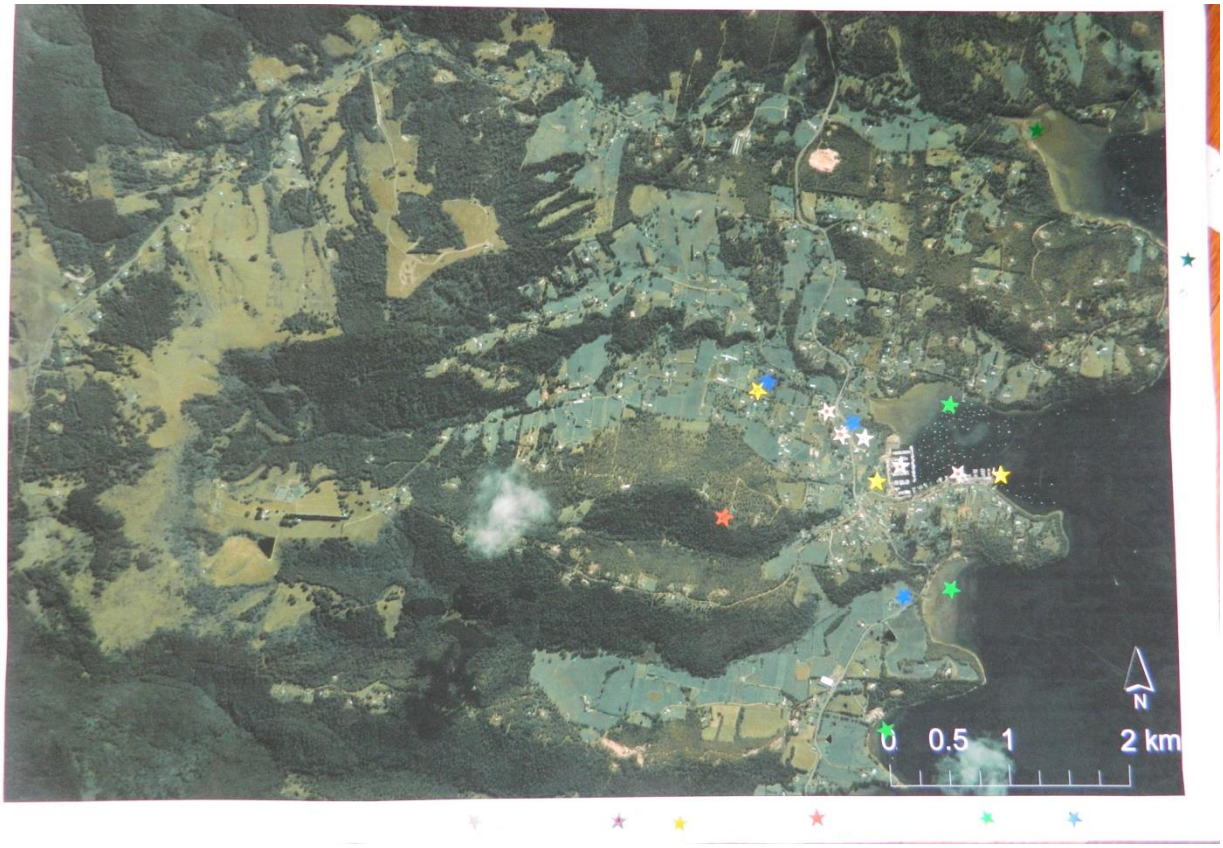
APPENDIX G: SAMPLE PARTICIPATORY MAPS (2015)



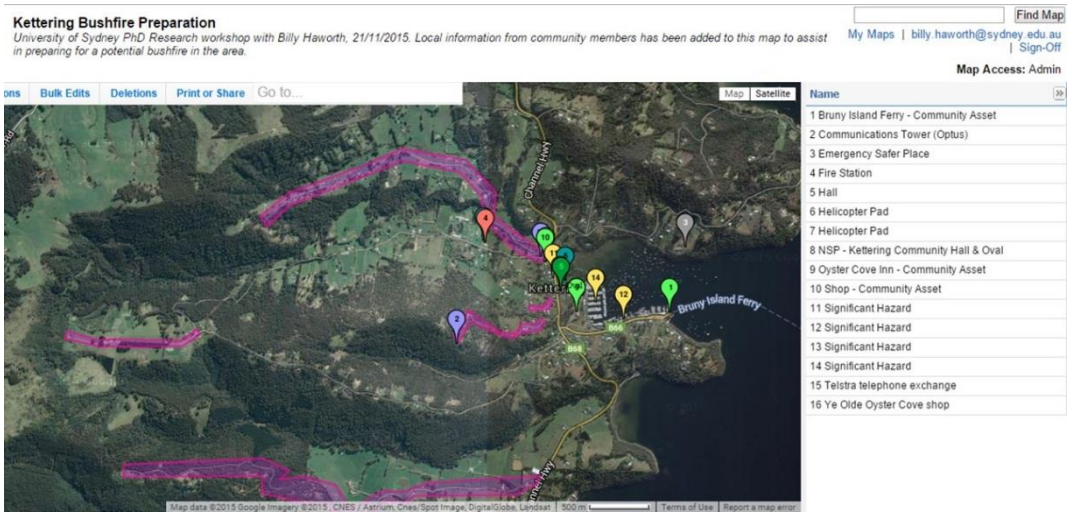
Bushfire preparation participatory map using topographic map – Kettering, 21/11/2015



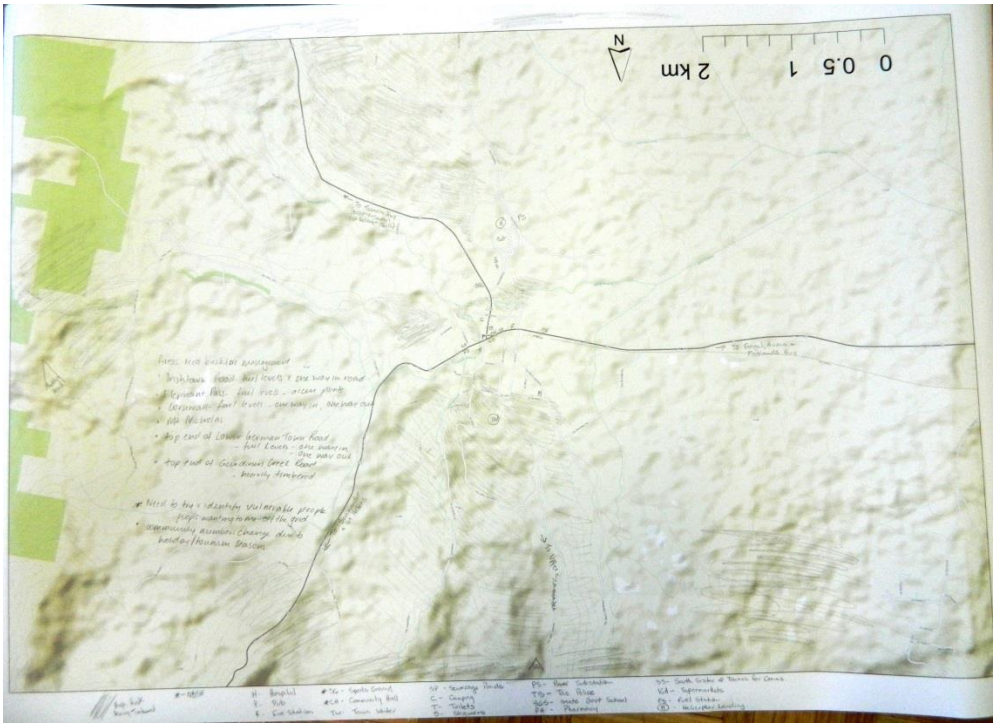
Bushfire preparation participatory map using topographic map – Kettering, 21/11/2015



Bushfire preparation participatory map using satellite imagery – Kettering, 21/11/2015

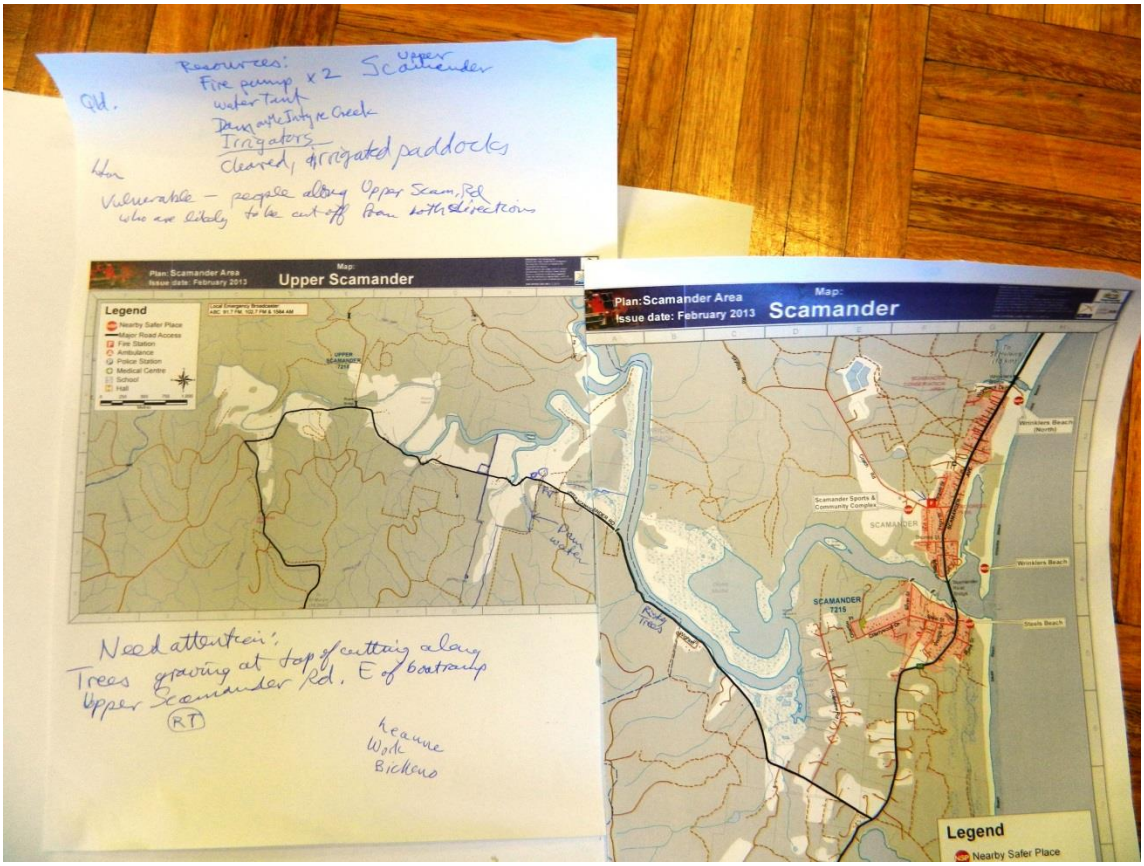


Bushfire preparation participatory map using web mapping platform (Zeemaps) – Kettering, 21/11/2015

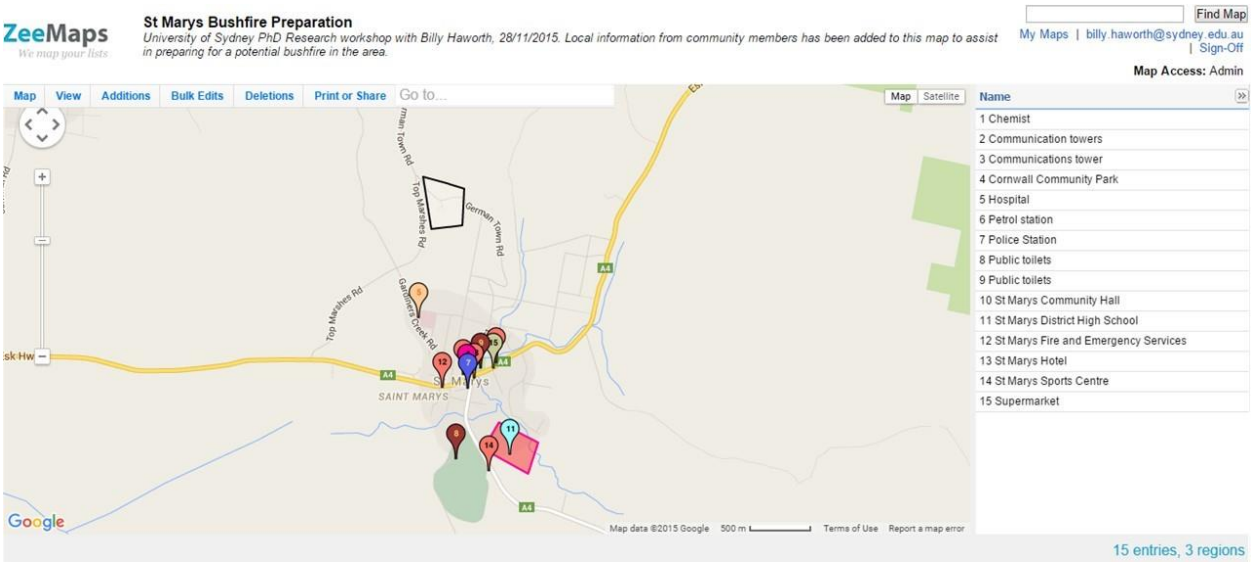


1. TOLMANS HILL
   - PULCHELLA
     - RETIRED / WORK IN HOBT.
   - WOODSTOCK RD
     - RETIRED
2. FRIENDS / FAMILY
   - ABERCROMBY RDS
   - COUNTRY TAS
3. WATER SUPPLY RESERVOIRS, SCHOOLS x 2, COMMS TOWERS
4. 1 x CHAINSAW (RESOURCE ?)
5. WATERWORKS RESERVE
   GULLIES OFF SOUTHERN OUTLET (x3)
6. SAFER PLACES - OLINDA RD ROUNDABOUT
   - TAS UNI. FOOTBALL OVAL
7. SOUTHERN END OF WOODSTOCK RD / HAM COMMON

Bushfire preparation participatory map using topographic map – St Marys, 28/11/2015

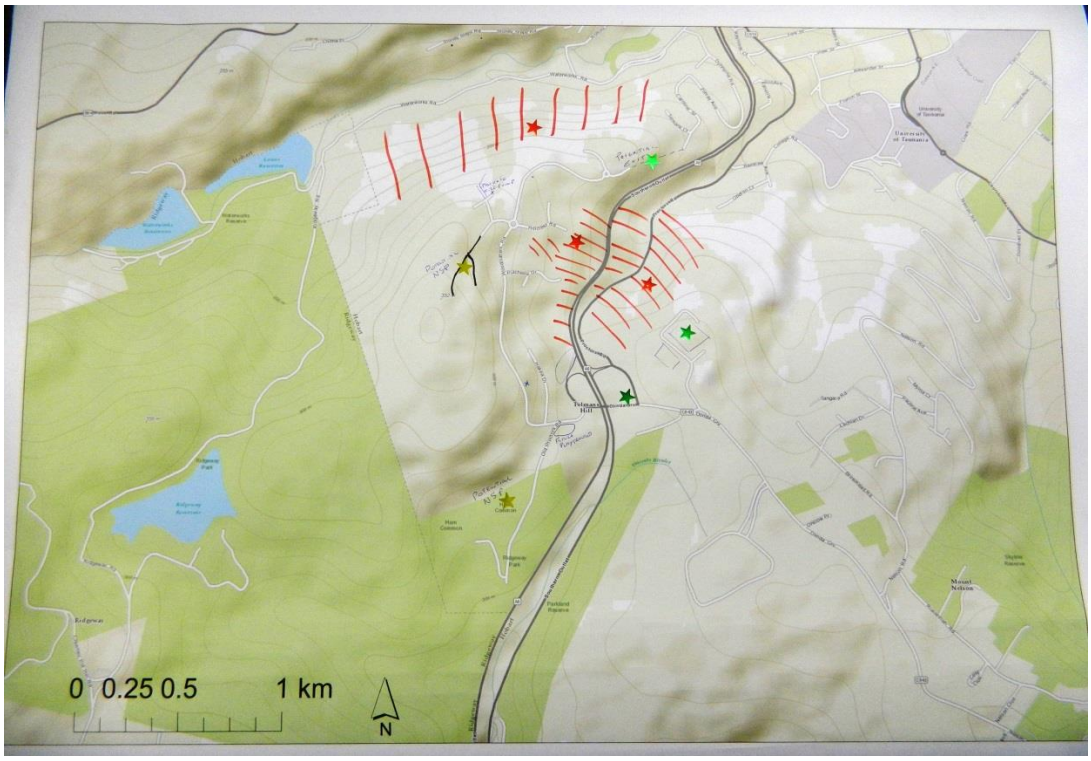


Bushfire preparation participatory map using Community Protection Plans (from Tasmania Fire Service) – St Marys, 28/11/2015

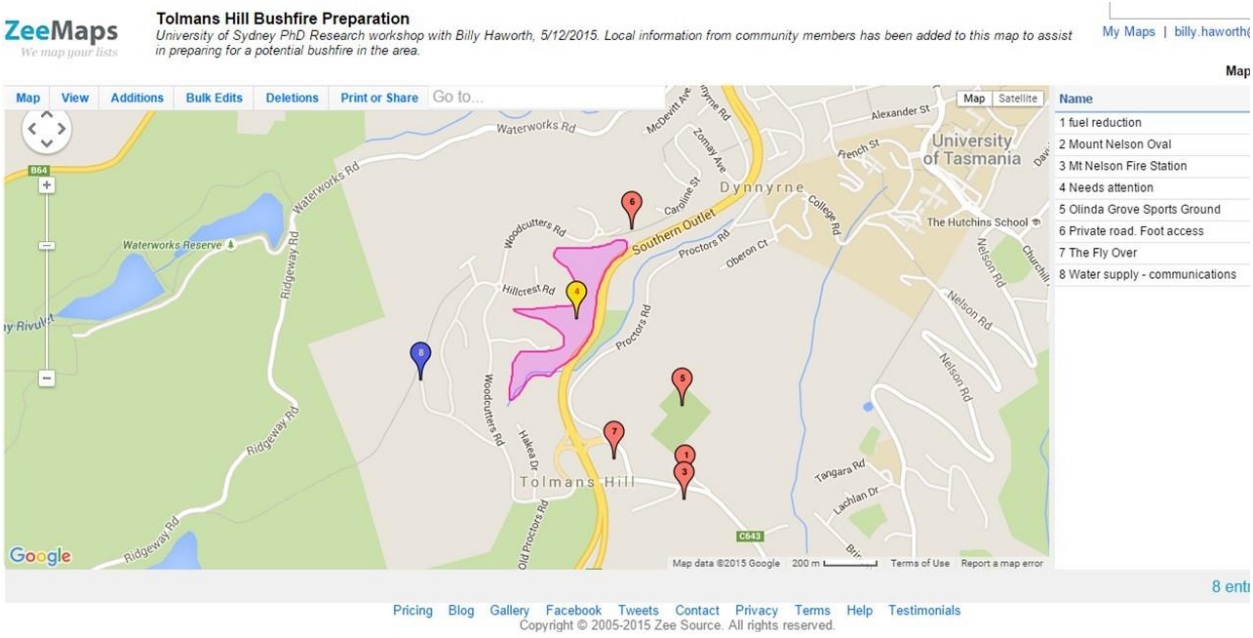


Bushfire preparation participatory map using web mapping platform (Zeemaps) – St Marys, 28/11/2015

Bushfire preparation participatory map using topographic map – Tolmans Hill, 5/12/2015



Bushfire preparation participatory map using topographic map – Tolmans Hill, 5/12/2015



Bushfire preparation participatory maps using web mapping platform (Zeemaps) – Tolmans Hill, 5/12/2015

APPENDIX H: COMMUNITY MAPPING QUESTIONNAIRE QUESTIONS (2015)

School of Geosciences, Faculty of Science

Volunteered Geographic Information, Community Engagement and Bushfire Preparation in Tasmania

COMMUNITY MAPPING QUESTIONNAIRE

The user experience of mapping community information

1) Overall, were the community mapping activities useful for your bushfire preparation?

☐ Yes

☐ No

2) Are maps an effective way of presenting and sharing community bushfire information?

☐ Yes

☐ No

☐ Don't know

3) Did you learn anything new about bushfire preparation in your community through the mapping activities?

☐ Yes. Please elaborate:

_____

_____

☐ No

4) Did you find any part(s) of the mapping activities challenging?

☐ Yes. Please specify:

_____

_____

☐ No

5) Do you have any concerns about sharing information on a public community map?

☐ Yes. Please elaborate:

_____

_____

☐ No

6) Was working with other members of your community a positive experience?

☐ Yes
☐ No

Why / why not?

_____

_____

7) Did working with others help you understand the broader bushfire risk and preparation activities in the community?

☐ Yes

☐ No

Paper mapping versus computer mapping

8) Which mapping method did you prefer?

☐ Paper mapping.

☐ Computer Mapping

☐ I did not prefer either method more than the other

Please elaborate:

_____

_____

9) Which method do you think would be more useful for your broader community?

☐ Paper mapping

☐ Computer Mapping

☐ I don't think either would be more useful than other

Please elaborate:

_____
_____
_____

10) a. In your opinion, what are the strengths of the paper-mapping?

_____
_____
_____

b. Any weaknesses?

_____
_____
_____

11) a. In your opinion, what are the strengths of the computer-mapping?

_____
_____
_____

b. Any weaknesses?

_____
_____
_____

Community bushfire preparedness and local knowledge

12) Was the information shared on the community map relevant to you?

☐ Yes

☐ No

13) Did the local information shared on the maps improve your understanding of bushfire preparation in your community?

☐ Yes

☐ No

14) Did the mapping activities increase your awareness of other community members and their bushfire preparedness?

☐ Yes

☐ No

15) Do you think the local information shared on the maps would be useful to others in your community?

☐ Yes

☐ No

Please elaborate:

_____

_____

_____

16) Do you think the local information shared on the maps would be useful to emergency management authorities?

☐ Yes

☐ No

Please elaborate:

_____

_____

_____

Please indicate the extent to which you agree or disagree with the following statements by circling a number on the scale from 1 (strongly disagree) to 5 (strongly agree):

17) In sharing my local knowledge to a community map I feel more involved in bushfire preparation

Strongly disagree				Strongly agree
1	2	3	4	5

18) By mapping local information with my community I feel better able to prepare and respond to a potential bushfire event

Strongly disagree				Strongly agree
1	2	3	4	5

19) Through these mapping activities, I feel more connected to my community

Strongly disagree				Strongly agree
1	2	3	4	5

20) When I contributed my local knowledge to the map I felt like I was helping my community reduce bushfire risk

Strongly disagree				Strongly agree
1	2	3	4	5

21) I felt like my contributions to the community maps were important

Strongly disagree				Strongly agree
1	2	3	4	5

Future use of community mapping

22) Would you contribute to community maps like those in the workshop in the future?

☐ Yes

☐ No

Why / why not?

_____
_____
_____

23) If you were to make a community map in your community, would you do anything differently?

☐ Yes. Please elaborate:

_____

_____
_____

☐ No

24) Do you have suggestions about how the use of community information and mapping can be improved to assist bushfire preparation?

_____
_____
_____

Basic information about you

25) Which of the following age groups do you belong to?

☐ 24 or under

☐ 25-34

☐ 35-50

☐ 51-70

☐ 71+

26) What is your gender?

☐ Male

☐ Female

☐ Other

☐ Prefer not to say

27) What is the composition of your household?

☐ Couple with children or other dependents

☐ One adult with children or other dependents

☐ Couple without children or other dependents

☐ One person household

☐ Shared house with other adults

☐ Other/prefer not to say

28) How long have you been living in this town or suburb?

☐ 0 – 2 years

☐ 3 – 5 years

☐ 6 – 10 years

☐ 11 – 20 years

☐ 21+ years

29) What is the highest level of education you have completed?

☐ Secondary school

☐ Trade Certificate / TAFE

☐ Undergraduate Degree

☐ Postgraduate degree (e.g. Masters, PhD)

☐ Other (please specify): _____

30) What is your occupation?

☐ Employed. Please specify:

_____

☐ Unemployed

☐ Retired

☐ Other/prefer not to say

31) Are you a Tasmania Fire Service volunteer/employee?

☐ Yes

☐ No, but I have been in the past

☐ No, and I never have been

32) Are you a member of a community bushfire group?

☐ Yes. Which group(s)? _____

☐ No, but I have been in the past

☐ No, and I never have been

33) Have you attended any other Bushfire Ready Neighbourhoods events?

☐ Yes. Please elaborate: _____

☐ No