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To cite this article: Billy Tusker Haworth (2018) Implications of Volunteered Geographic Information for Disaster Management and GIScience: A More Complex World of Volunteered Geography, *Annals of the American Association of Geographers*, 108:1, 226-240, DOI: [10.1080/24694452.2017.1321979](https://doi.org/10.1080/24694452.2017.1321979)

To link to this article: <https://doi.org/10.1080/24694452.2017.1321979>



Published online: 09 Jun 2017.



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Implications of Volunteered Geographic Information for Disaster Management and GIScience: A More Complex World of Volunteered Geography

Billy Tusker Haworth

School of Agriculture and Environment, University of Western Australia

Volunteered geographic information (VGI) refers to changing practices in recent years associated with technological advancements that provide increasing opportunities for private citizens to produce geographic information. VGI activities range from public contributions to online crowdsourced mapping projects to location-related posts on social media sites. These changing practices have important implications for citizens, traditional authoritative systems of geographic knowledge production, and the disciplines of geography and GIScience. One field affected by VGI is disaster management, with numerous studies reporting on the opportunities associated with increased citizen data and involvement in crisis response. There are also significant limitations to the application of VGI, however, notably related to scale, the digital divide, trust, uneven power relations, and adaptability of existing authoritative systems, such as formal emergency management. In this article, these issues and more are critically discussed through examination of three discreet yet related studies of VGI in community bushfire (wildfire) risk reduction in Australia. Although each study has its own unique contributions already published, the collective insight gained by analyzing the studies together provides new and deeper perspectives on critical issues of relevance to both disaster management policies and geography and GIScience. Importantly, the article advocates for greater emphasis on the social aspect of VGI, with citizens mapping and sharing knowledge together, rather than on individual observations and large volumes of data. Further, it raises questions of some of the much-promoted promises of VGI, particularly those that suggest that VGI can allow “everyone” to contribute to geographic knowledge production. *Key Words: digital divide, disaster management, disaster risk reduction, GIScience, volunteered geographic information (VGI).*

自发地理信息 (VGI) 指的是与近年来为普通公民提供更多机会生产地理信息的科技进展相关的改变中的实践。VGI 的活动, 从追踪网路群体的製图计画之公共贡献, 到社交媒体网站上与地点有关的帖子。这些改变中的实践, 对于公民、地理知识生产的传统权威系统, 以及地理学领域和地理信息科学具有重要的意涵。灾害管理是受到 VGI 影响的领域之一, 其中诸多研究报导了增加的公民数据及参与之于灾害回应的契机。但 VGI 的应用同时有着重大的限制, 尤其是关于尺度、数码鸿沟、信赖、不均权力关系, 以及诸如官方应急管理之既有权威系统的可调适性。本文透过检视有关澳大利亚社区矮林地大火 (野火) 风险降低的 VGI 之三个互异但相关之研究, 批判性地探讨这些议题及其他。尽管这些研究出版各自有其独特的贡献, 但共同分析这些研究所获得的集体洞见, 则对于关乎灾害管理政策与地理学及地理信息系统科学的关键议题, 提供了崭新且更为深刻的观点。重要的是, 本文提倡应更为强调 VGI 的社会面向, 其中公民共同绘製并分享知识, 而非强调个人化的观察与大量的信息。此外, 本文对于 VGI 受到大力提倡的若干允诺提出质疑, 特别是 VGI 让“人人”皆可对地理知识生产作出贡献的主张。 *关键词: 数码鸿沟, 灾害管理, 灾害风险降低, 地理信息科学, 自发地理信息 (VGI)。*

La información geográfica voluntaria (IGV) se refiere a prácticas variables que en años recientes han estado asociadas con los avances tecnológicos que brindan mayores oportunidades a las personas privadas para producir información geográfica. Las actividades de la IGV incluyen desde contribuciones públicas a proyectos de mapeo de colaboración abierta hasta puestos en sitios de los medios sociales relacionados con localización. Estas prácticas cambiantes tienen importantes implicaciones para la ciudadanía, los sistemas tradicionales autorizados en la producción de conocimiento geográfico y para las disciplinas de la geografía y la SIGciencia. Un campo afectado por la IGV es el manejo de desastres, sobre lo cual hay numerosos estudios que informan de las oportunidades asociadas con crecientes datos del ciudadano e involucramiento en respuesta a las crisis. Sin embargo, hay también limitaciones significativas para la aplicación de la IGV, notablemente relacionadas con escala, la divisoria digital, confianza, relaciones desiguales de poder y con la adaptabilidad de los sistemas autorizados existentes, tales como el manejo formal de las emergencias. En este artículo, estos y otros asuntos son discutidos críticamente por medio del examen de tres estudios individuales de la IGV, pero relacionados entre sí, sobre la

reducción de riesgo comunitario por incendios forestales en Australia. Aunque cada uno de esos estudios tiene sus propias contribuciones específicas ya publicadas, la perspicacia colectiva que se gana al analizarlos en conjunto provee nuevas y más profundas perspectivas sobre asuntos críticos de relevancia para las políticas de manejo de desastres y para la geografía y la SIGciencia. Muy importante es que el artículo propugna por un mayor énfasis en el aspecto social de la IGV, esto es, los ciudadanos mapeando y compartiendo conocimiento juntos, en vez de centrarse en observaciones individuales y grandes volúmenes de datos. Surgen, adicionalmente, interrogantes sobre algunas de las promesas más promocionadas de la IGV, en particular las que sugieren que la IGV puede permitir que “cada quien” contribuya a la producción de conocimiento geográfico. *Palabras clave: divisoria digital, manejo de desastres, reducción del riesgo de desastre, SIGciencia, información geográfica voluntaria (IGV).*

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, Goodchild, and Sui 2012). Web 2.0 (O’Reilly 2005) referred to the bidirectional online environment where users are able to add their own information to the Internet as well as read from it (Goodchild 2007b), 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 2007a). Ricker, Daniel, and Hedley (2014) argued that whereas 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, Goodchild, and Sui 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, Global Positioning Systems (GPS), graphics for visualization, broadband communication (Goodchild 2007a), and, more recently, cloud storage, mobile locational platforms, and smartphones (Raento, Oulasvirta, and Eagle 2009). VGI is 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 and Weber 2008) and activities that are “fun,” like locating holiday photos on social media (Goodchild 2007a). There is a need for critical research on the societal benefits and implications of these practices.

Differentiation between active and passive sensing has been described through a typology of VGI offered

by Craglia, Ostermann, and Spinsanti (2012). They posited that volunteering can be explicit or implicit and so, too, the geographic location can be either explicit or implied in VGI. True VGI in the strictest sense is information that is explicitly volunteered and explicitly geographic, such as OSM (Craglia, Ostermann, and Spinsanti 2012). Implicit VGI, such as a social media post containing a place name, is being increasingly used for geospatial research, however (Senaratne et al. 2017).

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, Goodchild, and Sui 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 Goodchild 2008; Haklay, Singleton, and Parker 2008; Sui 2008). Neogeography denotes the proliferation of Web-based geographic information technologies and the precipitated phenomenon of laypeople or nonexperts creating their own geographic content and maps (Leszczynski 2014). 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 that VGI is both 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 indistinct and the implied assumption that geography is about describing the world rather than understanding and explaining it (Elwood, Goodchild, and Sui 2012). The notion of software encompassing the skills of the geographer has prompted criticism concerning trivialization of the geographic discipline (Leszczynski 2014). Neogeography has been critiqued for its instrumentalist reductionism of geography, but Leszczynski (2014) highlighted the social

implications of the *neo* component of this concept. There is a need to explain why geography is more than mapmaking and why the methods of geographers are powerful and far from intuitive (Goodchild 2008). Whereas neogeography is about collection and compilation of geographic information and facts without 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; Leszczynski 2014). Critical geographers have experience and skills absent in nonexperts, 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, Goodchild, and Sui 2012). Although Connors, Lei, and Kelly (2012) argued that 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. VGI represents changes to the ways in which geospatial information is created, used, and consumed, with important implications for numerous fields and applications. One such field impacted by VGI is disaster management (Haworth and Bruce 2015), which is the focus of this article.

VGI and Disaster Risk Reduction

This article examines 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.

Historically, disaster management has been conducted for, not with, the community, following a paramilitary, top-down model (Pearce 2003; Palen and 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 (Wisner et al. 2003; Manyena et al. 2011). 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) reported that 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 that emphasized community resilience building for effective disaster management (United Nations International Strategy for Disaster Reduction [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 that facilitates multiorganizational, intergovernmental, and intersectoral cooperation (Waugh and Streib 2006).

In Australia, these shifts have led to a philosophy of shared responsibility, primarily driven by the Victoria Bushfires Royal Commission (Teague, McLeod, and Pascoe 2010; McLennan and Handmer 2012). 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 DRR.

The notion of disaster resilience has gained currency 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, 28). The Australian National Strategy for Disaster Resilience (NSDR; Council of Australian Governments 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 (5). Current disaster management in Australia aims to achieve community disaster resilience through the model of prevention, preparedness, response, and recovery (PPRR; Prosser and Peters 2011). *Prevention* represents regulatory and physical measures aimed at preventing emergencies; *preparedness* denotes arrangements to ensure that individuals and communities are prepared for potential disaster impacts and that all resources and services that might 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 infrastructure and restoring well-being (Abrahams 2001).

Research so far has emphasized the role of VGI in disaster response (Haworth and Bruce 2015; 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 that assisted the humanitarian response to the 2010 Haiti earthquake (Meier 2012); the use of crowd-sourced mapping and social media for capturing community information and communicating with impacted people in response to cyclones and floods in Queensland in 2010 and 2011 (McDougall 2011; Taylor et al. 2012); and the role of VGI as an alternative information source to authoritative disaster information during fires in Santa Barbara in 2007 to 2009 (Goodchild and 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 and 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, McLennan, and Handmer 2015) as some of the unique opportunities presented by VGI. Examples of reported challenges include issues of source credibility and data quality (Ostermann and Spinsanti 2011; Goodchild and 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 Sui, Goodchild, and Elwood 2013; Van Dijk and Hacker 2013).

There is more to be said of the impacts of VGI in disaster management, however, 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 and Liu 2007, 727). VGI signals significant social changes related to power relations and traditional systems of top-down, authoritative production of geographic knowledge.

Drawing on the findings of three distinct yet related studies on the opportunities, challenges, and implications of VGI in the context of community preparedness for potential bushfire disaster (also referred to as *wildfire* or *forest fire* internationally), this article aims to elucidate through critical discussion some of the broader implications of VGI on (1) authoritative emergency management and (2) the disciplines of geography and GIScience. Separately, the studies are data rich as a result of three independent survey efforts, including community surveys, professional stakeholder interviews, and participatory mapping focus groups, and each presents individual findings of value. The collective insight gained through consideration of the studies together, however, provides a deeper understanding of the current and future considerations of VGI for the professional and academic fields of disaster management and GIScience. This article differs from previous work published in this field, including a review of VGI for disaster management (Haworth and Bruce 2015), whereby

conclusions here are drawn from experimental and empirical case study-based research rather than a review of themes emerging from wide-ranging existing literature, and the three studies that form the basis for analysis in this article (Haworth, Bruce, and Middleton 2015; Haworth 2016; Haworth, Whittaker, and Bruce 2016), in that the insights described here are not immediately apparent in the individual studies alone. It is only through research experience, critical reflection, and collective analysis of the various unique perspectives presented in each study that the wider implications of VGI are illuminated.

The structure of the article is as follows. The next section briefly describes each of the three studies, including a summary of their context, aims, methods, and findings. After that, I discuss recurring themes that emerge through collective consideration of the works, before turning attention to the broader policy and discipline implications of VGI. Finally, I detail important considerations associated with the studies and offer directions for future work.

A Tale of Three Studies

The three studies were undertaken in an Australian emergency management context, focusing on the role of VGI in community DRR in the state of Tasmania, where bushfire risk is high and established community engagement programs (see Bushfire Ready Neighbourhoods 2014) provided a useful setting in which to access community members and explore approaches using VGI. Although VGI has relevance to all disasters, unlike other hazards that 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 centered on community participation and thus fire provides a unique case study through which to examine the contributions of VGI.

Bushfires threaten communities each year and represent one of the greatest environmental threats in Australia (Beale and Jones 2011). Although bushfires in Australia are not new, recent pressures, including population growth into areas of urban-bushland interface, where the greatest potential for loss of life and property exists (McAneney, Chen, and Pitman 2009), and the effects of climate change increasing temperatures and susceptibility to droughts have exacerbated risk conditions (Frandsen 2012). Major bushfire disasters have devastated numerous communities in recent years (see,

e.g., Every et al. 2015; Irons et al. 2015; Rich et al. 2016; Whittaker, Eriksen, and Haynes 2016).

Increasingly, communities and individuals are encouraged to manage their own bushfire risk in line with the policy changes toward shared responsibility and community resilience. A key focus here is increasing community and household preparedness. Preparing for disasters dramatically reduces the risk of negative impacts on life and property. Research has shown, though, that the number of people who actively prepare for disasters is significantly lower than the number of people at risk, and providing communities with relevant information alone is ineffective in stimulating meaningful and active disaster preparation engagement (Paton 2003). Finding new ways to engage communities is an important global issue, and community participation is considered a fundamental principle of DRR and resilience building (UNISDR 2015). Questions related to the effectiveness of approaches incorporating VGI in promoting increased community engagement in DRR were central to each of the studies detailed next.

Study 1: Assessing the Potential Use of VGI in DRR through Community Surveys

The first study aimed to examine the potential for use of VGI in fostering community engagement in bushfire risk reduction in Tasmania based on technology uptake, community interest, and limitations to use. A survey was administered in twelve at-risk communities across Tasmania, issued by mail, in person, and online, with 154 complete surveys returned (for full methods, analysis, and findings, see Haworth, Bruce, and Middleton 2015). The article 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. 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 generation and the efficacy of these technological practices for promoting positive behavioral

change and empowering individuals to engage in risk reduction activities were beyond the scope of the survey.

Study 2: The Perspectives of Emergency Management Professionals

Having discussed the views of community members in Study 1, the second study considered the perspectives of emergency professionals on the key opportunities and challenges associated with VGI for disaster management through detailed semistructured interviews with thirteen participants from a range of professional roles and emergency management organizations (for full methods, analysis, and findings, see Haworth 2016). Important insights were gained into how VGI practices and traditional authoritative emergency management could operate more effectively together in the future. 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 article 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 adoption of VGI in disaster preparation and recovery.

Study 3: Testing VGI in Practice through Participatory Mapping

The aim of the third study 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, his or her social connectedness, and engagement in DRR. This was accomplished through participatory mapping workshops in three Tasmanian communities accompanied by participant questionnaires (for full methods, analysis, and findings, see Haworth, Whittaker, and Bruce 2016). Participants each attended a workshop lasting four hours, which involved collaborative paper-based and digital mapping activities related to bushfire

risk and preparation in their local community. A small sample size ($n = 31$) compared with larger survey methods limited statistical generalizations 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 to current debates in the field of VGI and GIScience. 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 was that although 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. Concerns around community mapping of VGI that arose in the study included issues of data quality, privacy, trust, and the underrepresentation of particular individuals or groups in (1) the study, (2) community bushfire management, and (3) mapping broadly, such as youth, people experiencing socioeconomic disadvantage, people with dependents, and travelers.

General Discussion

By considering the findings of these three studies together, we can observe threads emerging throughout the work. Before moving to outline the implications of the findings in the next section, I 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 neighborhoods 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 everyday lived experiences at local scales are valuable. Kitchin and Lauriault (2015) argued that 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 data sets. They made comparisons to mining practices, whereby big data are equivalent to open pit mining and small data involve 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 and Lauriault 2015). Kwan (2016) emphasized that no geographic knowledge or research results associated with big data are obtained sans mediation by algorithms. Algorithmic mediation produces uncertainties in how data are generated, processed, and analyzed and potentially limits the types of societal questions that can be addressed, further highlighting the quality and value of traditional or small geographic data (Kwan 2016).

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 and Lauriault 2015), and management of volunteered data was identified as a key challenge experienced by emergency management professionals (Study 2). Here, the broader scale might negatively affect the usefulness of VGI in disaster management if it cannot be effectively managed. Broader scale VGI projects might also be difficult to monitor and sustain into the future. Large numbers of people engaged in VGI, however, have been shown to be useful for reducing errors, misinformation, and the spread of rumors associated with online information contributed from nonprofessionals, which were identified as important issues for VGI in each of the studies.

VGI facilitates new scales of participation in disaster management, and I argue that 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 (1) conceptualizations of community in disaster management with the growing significance of virtual and other nongeographic communities for community resilience (Mulligan et al.

2016) and (2) 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 could have valuable knowledge to assist in emergency management, could maintain connections to people and place, and might be affected emotionally or otherwise by a disaster in that community. How does that individual’s local status differ from that of those who reside in the geographically local community, and how does this affect community participation, disaster resilience, and broader social practices? The three studies have presented arguments for increased utilization 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 of the studies, 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 (Study 1). Emergency professionals reported trust of citizen-produced information as a concern for integration of VGI into official systems (Study 2). Workshop participants were not confident that they could trust people not to alter their contributed content or use it in unintended ways (Study 3).

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 these studies. VGI relies on reciprocated trust (McCall, Martinez, and Verplanke 2015), and learning might 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, Martinez, and Verplanke (2015) raised 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 might

have merit in increasing trust of VGI and its sources and therefore usefulness for some purposes. I argue, though, that some of the value of VGI shown in these studies, 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 that VGI provides and appears to contribute to some of its weaknesses through the exclusion of particular groups and individuals. This leads me to the third recurring topic.

Finally, demographics and who can and does contribute VGI are key considerations. Throughout the three studies it was 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 showed that 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 technologies 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 might 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, could exacerbate existing socioeconomic divisions and raise increasing concerns about the role of geotechnological advancements globally. This research 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 might 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 toward reducing it, providing more people greater access to the benefits of geospatial technologies and achieving increasingly accurate and comprehensive pictures of populations on maps.

Implications

Implications for Authoritative Disaster Management

VGI has had a remarkable impact on emergency management in just a few years, and together the outcomes of these studies 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, strengths of VGI in the preparedness stage of disaster management were demonstrated to include increasing community connectedness, local knowledge exchange, risk awareness, and engagement in disaster preparation. 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 that 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, VGI through participatory mapping and social media sites like Facebook should be increasingly used with greater confidence. The evidence base provided by this work demonstrates that 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 recognize 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 that 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 described in Study 3. In policy, this might 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, and ethical and potential legal concerns, are especially pertinent in determining how these sometimes-competing modes of practice can operate cooperatively and complementarily. 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 might be difficult to overcome and the opportunities of VGI might not be effectively realized. There might also be tensions lurking around private ownership of VGI platforms, such as social media sites, whereby official and government agencies are increasingly expected to utilize commercially driven resources to connect with citizens. Related are considerations around corporate gains and vulnerability of affected 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 organizational change to best capitalize on the innovations of recent years. An important finding from interviews with emergency management professionals (Study 2) 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 toward 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 these studies I argue that there is a level of adaption required of emergency management organizations. 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 might result in ineffective emergency management strategies. Greater acceptance, encouragement, and exploitation of VGI technologies and practices by disaster management authorities are key changes required. These studies outline important challenges to the increased utilization of VGI in authoritative emergency management, but they also demonstrate 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 using VGI in the preparedness phase of disaster management.

I acknowledge, however, that VGI is not a stand-alone 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 organizations. Emergency management has many and varied functions, with procedures and policies often produced and refined through generations of knowledge exchange and learning; it is unreasonable to expect that processes and behaviors 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 might initially be isolated to subsections of organizations and on small scales, such as community engagement programs, as demonstrated in these studies to be beneficial for Tasmanian communities in the context of bushfire preparation. This approach could serve as a model for research utilization and implementation of initiatives making use of VGI going forward.

Implications for Geography and GIScience

Contributions of the research to critical geospatial knowledge theory are twofold. First, the conceptualization of VGI adopted in these studies advances understandings and applications of the concept of VGI originally proposed by Goodchild (2007a) by emphasizing VGI as more than a type of data but as a more complex social practice. In the 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 in which individuals participate (Goodchild 2007a; Haklay 2013), motivations of individuals (e.g., Coleman, Georgiadou, and Labonte 2009), the credibility and trustworthiness of individuals as VGI sources (e.g., Flanagan and Metzger 2008), and the data accumulated from masses of individuals' VGI practices. Although the individual is germane to VGI and these topics were considered in the papers, the studies also investigated the user experience of contributing VGI with other community members, specifically for the cause of assisting in community DRR. It was shown that the social aspect of contributing VGI (i.e., 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 behavioral change for a wide range of geographical questions.

Second, the studies challenge 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, Martinez, and Verplanke 2015; Brown 2017). Authors such as McCall, Martinez, and Verplanke (2015) and Brown (2017) have claimed that VGI is not participatory, that it lacks cultural information, that it is not empowering on an individual scale, and that it focuses more on volume of information rather than depth. This work (in particular, Study 3) presents methods and findings in opposition to these claims.

In response to calls for VGI and citizen science to become more participatory (Haklay 2013; McCall, Martinez, and Verplanke 2015), the work of these studies harnessed PPGIS theory and collaborative practices in using 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 Study 3, offers promise for empowering and engaging individuals. This approach 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 it 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.

Table 1 presents a summary of the general implications associated with VGI and those more specific to authoritative disaster management and the disciplines of geography and GIScience, as revealed through analysis of the three studies in DRR and illuminated in the preceding discussions.

Considerations and Future Work

Although the research presented in the three studies makes substantial and timely contributions to DRR

and extant critical debates in the fields of geography and GIScience, they remain in-depth studies 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 important considerations for future work.

The studies, in particular the community surveys (Study 1) and the participatory mapping workshops (Study 3), were limited by who volunteered to participate. Study samples tended to overrepresent older, highly educated, wealthier, retired people without dependents, underrepresenting youth, people with children, and those from marginalized or lower socioeconomic backgrounds. It has been reported elsewhere that participatory mapping studies rarely result in representative samples and usually exhibit biases toward older, more formally educated male participants with higher incomes and underrepresent ethnic groups and minorities (Brown and Kytta 2014; Brown 2017). Further work is required to determine how to better include the underrepresented in VGI and participatory mapping projects.

Longitudinal studies would enhance this work. For instance, repeat participatory mapping workshops in each of the study communities would require further time and resources to extend the participating communities and address the 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 the studies was made via questionnaires assessing participants' perceived outcomes. Follow-up studies with participants would strengthen the work by permitting evaluation of outcomes based on actual behavior change or specific actions taken following the VGI mapping exercises that 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 (Study 2) and community members during participatory mapping workshops (Study 3), but these were both 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

Table 1. A summary of the key implications of volunteered geographic information

General implications	Implications for disaster management	Implications for GIScience
<ul style="list-style-type: none"> • Scale of participation influences the use and value of VGI 	<ul style="list-style-type: none"> • Increased citizen participation and community connectedness 	<ul style="list-style-type: none"> • VGI should be considered not just as data but as a complex social practice (with social cohesion, democratization, community participation, and action as potential outcomes)
<ul style="list-style-type: none"> • Trust limits the usefulness of VGI 	<ul style="list-style-type: none"> • VGI (including social media) should be increasingly utilised in community engagement for disaster risk reduction 	<ul style="list-style-type: none"> • VGI, especially through a participatory mapping approach, can be more local and cultural
<ul style="list-style-type: none"> • Digital divide, exclusion, and elitism are key challenges shaping VGI 	<ul style="list-style-type: none"> • Changes to the “local” landscape of disaster management through online participation 	<ul style="list-style-type: none"> • VGI as small data can be more important than big data
<ul style="list-style-type: none"> • Decentralization of power: reduced authoritative control of information 	<ul style="list-style-type: none"> • Top-down disaster management needs to adapt to change and work with citizens using VGI • VGI methods and value of geoweb should be formally included in disaster management policies • Increased expectation to utilize commercially driven, privately owned resources 	

Note: VGI = volunteered geographic information.

ways need to also be considered. Learning could be taken from citizen science (see Cooper 2016) in terms of system design and maintenance for ongoing projects that effectively use 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. The technological elements of VGI also require further attention, however. Future work might seek to consider data characterization and quality assessment measures, system development to better collate and use 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 in these studies were based on the premise that VGI practices can contribute to increasing community disaster resilience. It was beyond the scope of the work, however, to develop detailed measures of resilience. Others have recommended measures of resilience, often using indexes, and future work might 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 honor” affect future actions and support provided? These questions are both conceptual and practical in nature, and further work is needed to understand them.

Finally, the studies examined the specific case of VGI for bushfire preparation engagement in Tasmania. Although findings are 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 to explore the issues raised in this article in other geographic contexts, such as other parts of Australia, where community composition and disaster preparedness might differ; other countries with differing emergency management, governance, and political structures; or regions with different socioeconomic 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 revealed a saturation of studies examining VGI in disaster response, and the research described in this article considered disaster preparation, but the application of VGI practices for disaster prevention and recovery should also be examined. On the surface, it seems that the valuable qualities of VGI in DRR, such as increased community connectedness and exchange of local knowledge, might 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 could 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.

Third, similar questions to those in these studies of bushfire could be asked for other hazards, including floods, drought, cyclones and other storms, and volcanic eruptions, among others. This might also include nonenvironmental events, such as preparing for and responding to acts of terror, human conflict, disease outbreaks, or other crises. Research investigating 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.

Conclusion

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 mapmaking and the disciplines of geography and GIScience. Much has been published on the opportunities presented by VGI, including in disaster management, but this article demonstrates a more complex “world of volunteered geography” (Goodchild 2007a, 211) with multidimensional implications for citizens, GIScience, and authoritative

systems of geographic knowledge production and dissemination. What and who VGI represents is dependent on factors such as the scale of participation; demographics; and existing social, cultural, and political systems that determine what is valued and where power lies, with often the already marginalized being the least visible in VGI. To what extent VGI can be useful in a given scenario is dependent on whether systems are established to best capitalize on the growing collections of citizen-supplied data. If organizations are not willing or able to adapt to the changes in information creation practices and increased citizen involvement enabled by VGI technologies, then the opportunities described could, in fact, become missed opportunities. A key area of opportunity for the future of VGI highlighted in this article is that of VGI as a social practice, where emphasis is placed on the potential for increased social cohesion and the participatory nature of people collectively contributing geographic knowledge, rather than on individual observations or large volumes of data. That VGI technologies and practices might contribute to a world of greater citizen participation in arenas such as disaster management or geographic and scientific knowledge production is a stirring suggestion, but the question remains, can this be a world for everyone?

Acknowledgments

I thank Eleanor Bruce, Kurt Iveson, Jon Corbett, Nadine Schuurman, and Deanne Bird for reading earlier versions of this article. I thank the editor and reviewer Mei-Po Kwan and one anonymous reviewer for their constructive comments. I thank all of the study participants for their valuable contributions.

Funding

Parts of this research were supported by the Commonwealth of Australia through the Bushfire and Natural Hazards Cooperative Research Centre, the Tasmania Fire Service, the International Association of Wildland Fire, and the University of Sydney.

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BILLY TUSKER HAWORTH is a Postdoctoral Research Fellow in the School of Agriculture and Environment at the University of Western Australia, WA, Perth 6009, Australia. E-mail: billy.haworth@uwa.edu.au. His research interests include critical participatory GIS, volunteered geographic information, and the opportunities and challenges of increased citizen participation in GIS for applications such as disaster management and livelihood security.