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# Volunteered geographic information: future research directions motivated by critical, participatory, and feminist GIS

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**Abstract** New interactive web services are dramatically altering the way in which ordinary citizens can create digital spatial data and maps, individually and collectively, to produce new forms of digital spatial data that some term ‘volunteered geographic information’ (VGI). This article examines the early literature on this phenomenon, illustrating its shared propositions that these new technologies are part of shifts in the social and technological processes through which digital spatial data are produced, with accompanying implications for the content and characteristics of geospatial data, and the social and political practices promoted through their use. I illustrate how these debates about VGI conceive of spatial data as socially embedded, and suggest ways in which future research might productively draw upon conceptualizations from participatory, feminist, and critical GIS research that have emerged from similar foundations.

**Keywords** Critical GIS · Geo-enabled technologies · GIS and Society · Geoweb · Volunteered geographic information

## Introduction

A host of new technologies and online services are dramatically changing the way in which many of us produce, use, obtain and share geographic information. Interactive geovisualization interfaces such as GoogleMaps or Microsoft’s Virtual Earth make it possible for nearly anyone with an Internet connection to disseminate their own maps and geographic information (Miller 2006; Turner 2006). Some governments now gather geographic information online from residents, relying on their observations of local needs or problems (Ghose 2003). A growing number of cell phones, digital cameras, PDAs, and other handheld devices use GPS technology to provide users with information based on their location, or to add locational information to other media, such as digital photographs. ‘Geotagging’ allows nearly any online content to incorporate information about its geographic location, whether described in formalized terms such as latitude/longitude coordinates or in linguistic descriptors such as place names (Gartner et al. 2007). Together these developments contribute to a phenomenon that Goodchild (2007a) and others (Sui 2008) have termed ‘volunteered geographic information (VGI)’: digital spatial data that are produced not by individuals and institutions formally charged as data producers, but rather, are created by citizens who use the tools described above to gather and disseminate their observations and geographic knowledge.

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VGI and the technologies used to produce it are receiving increasing attention as geographers and other researchers begin to articulate a research agenda for examining their potential applications and societal significance. On the applications side, early research concerns include examining the hardware, software, and data structures that support VGI services, and developing techniques for analyzing and using the vast new data sources that are expected to materialize (Williams 2007; Mummidi and Krumm this issue; Bishr and Mantelas this issue). GIScience researchers are particularly concerned with understanding the implications of VGIs user interactivity and user-generated content for GIScience and GISystems (Goodchild 2007b; Gartner et al. 2007). On the social side of this emerging research agenda, scholars are considering how VGI might foster new forms of surveillance and further erosions of privacy (Obermeyer 2007); enable new forms of activism, participatory democracy, and civic life (Miller 2006; Turner 2006); or exacerbate existing inequalities and creating new forms of exclusion (Zook and Graham 2007a, b).

These discussions about the societal significance of VGI are strikingly similar to the so-called 'GIS and Society' debates of the mid 1990s, in which GIS was hailed by some as a tool for the empowerment of marginalized individuals and social groups and decried by others as a mechanism of exclusion and disempowerment (Schoorman 2000). VGI and the technologies behind it differ in many ways from GIS and the conventional forms of digital spatial data that are most common in GIS environments. But the strong echo of GIS and Society questions in early discussions of VGI suggests the utility of drawing upon these ideas in developing research on the social and political implications of this phenomenon. Thus, this article examines how propositions from several research trajectories inspired by the GIS and Society debates—critical GIS, public participation GIS (PPGIS), participatory GIS (PGIS),<sup>1</sup> and feminist GIS—might be brought to bear upon our efforts to explore the potential and impacts of VGI. In the

following section, I begin by showing how the existing discussions about VGI assume that their societal impacts, for better or for worse, will be fostered by the data themselves, from the social and technological processes that shape the way in which they are produced and shared, their content and characteristics, and the purposes for which they are used. I continue in the third section by suggesting three conceptualizations from these GIS and Society-inspired research areas that might productively inform these priorities in VGI research. My goal is not to offer a comprehensive account of all ways in which ideas from critical GIS, PPGIS/PGIS and feminist GIS might inform VGI research, nor to offer a comprehensive agenda for exploring societal impacts of VGI. Rather, I seek to show how *some* of the foundational conceptualizations from GIS and Society-inspired research can motivate important questions we need to ask in the VGI research agenda, as well as offer us productive frameworks from which to explore these questions.

### Emerging propositions about the impacts of VGI

There exists a small but growing literature on VGI, its applications, and its potential social and political implications. These discussions of VGI implications and research needs center strongly upon spatial data. Part of what has captured the attention of researchers is the potential of VGI tools to gather, visualize, produce, and share information on a scale never before achieved—from millions of potential contributors—and to create digital records of human observations and experiences never before recorded and saved as digital data. More specifically, I identify three ways in which this literature assumes VGI might alter digital spatial data: Its production and sharing, its content and characteristics, and the purposes for these new data resources might be used.

First, the hardware, software and web services associated with VGI are altering the ways that spatial data may be produced and shared. These new approaches to producing and sharing spatial information, whether through VGI services such as WikiMapia or Microsoft's Virtual Earth or through geotagging one's own web content, are significantly more open to general public contributions than existing structures such as geoportals or data

<sup>1</sup> Some authors use PPGIS and PGIS interchangeably, while others delineate a careful distinction between them. Two recent reviews of the field provide detailed discussion of these areas of GIS research and practice (Sieber 2006; Dunn 2007). Here, I use PPGIS/PGIS to refer to them together.

clearinghouses. As well, they may alter some of the hardware, software, and expertise barriers typically associated with GIS. Web browsers are used to visualize and share spatial information, and data may be communicated and stored in everyday terminologies, rather than in the codified language of many existing spatial databases.

These shifts are critical to understanding the societal impacts of VGI, because they have the potential to alter which individuals and institutions can and do act as data producers, with implications for access, participation, power relations, and data content. More specifically, researchers envision an expansion in the number and diversity of individuals and social groups that create data, with the possibility that the observations and experiential knowledge of new constituencies—such as children—may become part of existing digital data resources (Bell et al. 2007; Kishor 2007; Lewis 2007; Wilson 2007; Silva 2007; Sieber 2007; Budhathoki et al. this issue). Others propose that these changes in spatial data creation and dissemination will have implications for the access of individuals and social groups to information, as well as for the inclusion and exclusion of people and places from online spatial data (Zook and Graham 2007a, b; Harvey 2007; Goodchild 2007a). In a similar vein Tulloch (this issue) and Seeger (this issue) note the importance of theorizing why individuals and groups may contribute information, while Obermeyer (2007) and Wilson (2007) call for investigation of how these shifts in data production and access may affect privacy and surveillance. Perhaps most importantly, several contributors urge us to problematize the notion of such information as ‘volunteered’. They note that this characterization implies an intentionality or altruism that may not be present. Conceiving of these spatial data as ‘volunteered’ may also obscure critical differences, such as those among geotagged information that was shared online but only intended for certain recipients, spatial information that contributors genuinely intend to be freely available, or spatial data created by users of GPS-enabled devices that may be used by corporate or government actors for purposes not disclosed to the user (Obermeyer 2007; Sieber 2007; Williams 2007; Bishr and Mantelas this issue).

Second, the existing literature suggests that VGI services will alter the content and characteristics of

digital spatial data resources. By making it possible for more people to produce more data in digital form, VGI tools are likely dramatically increasing the volume of existing digital spatial data about an ever-expanding range of topics. But more important may be shifts in the content and characteristics of these data. Some suggest that volunteered information has fundamental differences from spatial data that are created in highly structured institution-initiated and expert-driven contexts. Hyon (2007) and Grossner and Glennon (2007) suggest that VGI may show a high and increasing degree of heterogeneity, both because of the diversity of forms of knowledge that may be contributed to these highly open data models and because their relatively simple user interfaces and web accessibility may lead to data contributions from a more diverse group of participants.

There has been relatively little empirical investigation of these predicted changes in the content and characteristics of digital spatial data, but if these predictions bear out, we face a number of questions about how volunteered information might be stored, managed, searched, and shared in a digital environment. Discussion of these issues draws strongly on spatial data infrastructure research. Several researchers point out that SDIs are not premised around the need to handle user-generated content, and argue that SDIs’ top-down model of supporting digital data access, storage, and sharing is quite different from the bottom-up approach on which VGI is premised (Craglia 2007; Gould 2007; Elwood 2008). Other researchers acknowledge these differences but note that SDIs have long-standing practices for dealing with issues such as interoperability that could be useful in efforts to work with VGI (Craglia 2007). Others suggest that new approaches may be needed, as in Hardy’s (2007) notion of a ‘geospatial digital commons’, Hecht’s (2007) use of web-based techniques for handling spatial attributes, or Grossner and Glennon’s (2007) outline for a ‘digital earth system’—a structure equipped to handle both VGI and more conventional spatial data archives. All three of these approaches draw upon existing procedures and infrastructures for distributed data handling, but modify them to include and interface with user-generated data content.

But in these discussions of the unique characteristics of VGI compared to other forms of spatial information, by far the most attention has been paid

to issues of data quality, accuracy, and validity (Jain 2007; Maue 2007; Sieber 2007; Friedhorsky 2007; Bishr and Mantelas this issue; Flanagan and Metzger this issue; Gouveia and Fonseca this issue). Some of these contributions are conceptual, outlining how we might re-theorize notions of information validity, credibility and authority in ways that are appropriate in the context of user-generated and user-modified spatial information (Jain 2007; Sieber 2007; Flanagan and Metzger this issue). Other contributions are oriented toward developing systems for assessing the credibility or validity of information and information contributors. Some researchers propose relying on existing structures such as metadata to incorporate details on the reputation or knowledge of information producers (Maue 2007; Sieber 2007; Gouveia and Fonseca this issue), while others propose incorporating user/client rating systems such as those used by Internet vendors or using visualization to track editing of user-generated content (Flanagan and Metzger this issue). These approaches are oriented toward helping users assess the validity of user-generated content for their own applications, whereas some other researchers seek automated techniques for filtering information based on its probably quality or credibility (Bishr and Mantelas this issue). The way in which these issues are resolved in future VGI development will surely have implications for how geographic knowledge is represented in VGI services, whose knowledge may be included and excluded, and how VGI can be obtained and used. Even the way in which concepts such as data quality, accuracy and validity are operationalized in our efforts to work with VGI will affect knowledge production, inclusion, exclusion, and access.

The third important element of these debates about the impacts of VGI involves efforts to characterize the knowledge production purposes for which VGI might be used. Here, I do not mean descriptions of the use of VGI in specific activities such as urban planning or community activism. Rather, I mean characterizations of broad differences in the roles that this volunteered information is expected to play amidst other information/knowledge production practices. Two such roles are prominent in the existing literature. First, researchers note the production and use of VGI resources to augment, update, or complete existing spatial databases. Goodchild (2007a) refers to this use VGI as part of a 'patchwork' approach to

developing public spatial data resources. From this perspective, contributed information is seen as a resource for adding to existing data, especially when public funds and staffing cannot generate a complete data set (Beardon 2007; Cowen 2007; Goodchild 2007a), or when the temporal and spatial scales of a phenomenon exceed the capacities of 'official' data-producing institutions and practices to develop current complete data sets (Cowen 2007; Gupta 2007; Tulloch this issue).

Others suggest that VGI services can and will continue to enable completely new forms of knowledge production, fostering new social and political practices. Examples of these new knowledge practices abound. Miller (2006) and others have described how citizens in New Orleans and outside of New Orleans used Google's mapping platform to publish information about local conditions and rescue needs after Hurricane Katrina. Williams (2007) illustrates how spatially enabled data content (such as calls to a local government's non-emergency complaint line) might provide new information about local needs, using the example of how a rapid rise in complaints about rats could indicate a trash collection problem. Activists around the world are using online geovisualization services to create new forms of political speech, communication, and networks, often disseminate information that authorities may strive to restrict (Miller 2006; Gharbia 2007; Zook and Graham 2007a). Others note especially that the new forms of knowledge production enabled by these technologies may well be problematic, fostering further erosions of privacy and new forms of surveillance (Jain 2007; Obermeyer 2007; Sieber 2007; Forest and Torkington 2008). Many examples already in existence, such as a website called "Rotten Neighbors" that allows individuals to post the location and offenses of their neighbors.

A number of scholars situate new data and applications amidst other shifts associated with digital spatial technologies. Bell et al. (2007), for example, argue that VGI developments are part of the latest of several 'popular revolutions' in the access and production of spatial information: desktop GIS, online mapping services such as Mapquest, and now the VGI-enabled capacity for users to obtain, create, combine, and modify spatial data as never before. Lewis (2007) and Kishor (2007) propose that VGI represents fundamental shifts in the social processes



through which data are created. They suggest that digital spatial knowledge production, formerly a process carried out by a finite number of known producers, is becoming a collaborative process among an infinite number of producers who may or may not be known to one another. While some researchers question just how open or collaborative these VGI tools are (Zook and Graham 2007a, b), it is nonetheless clear that these tools are fostering new social and political practices around the creation, sharing, and use of spatial knowledge.

These differentiations between ‘patchwork’ approaches and entirely new knowledge practices of course advance descriptive efforts to characterize VGI and its implications. But I would argue that such differentiations are also critical to structuring research on the societal impacts of VGI, because these different knowledge practices raise different social and political considerations. For instance, VGI for ‘patchwork’ knowledge practices raises questions about how to identify contributors to existing data resources, and how or whether their contributions should be vetted or verified. Most of the concerns about data accuracy and validation in VGI reference these ‘patchwork’ approaches. Existing data structures, whether organized by public, private, or nonprofit institutions, may have liability, copyright, or other legal concerns that arise with the integration of VGI into existing structures. New knowledge practices advanced through VGI may present slightly different kinds of considerations. Here for instance, it may be useful to consider how the technological interfaces and data structures of existing VGI services shape the forms of knowledge (and by extension, the social and political practices) that may be advanced, as Zook and Graham (2007a, b) have done in their work on Google’s mapping platforms. There are of course many other ways that these knowledge practices associated with VGI might raise differing social and political issues or concerns, and I would expect that VGI research will likely begin to detail these considerations. The ways in which these challenges are addressed will certainly affect social and political practices, participation, empowerment, access, and representation of different individuals and social groups.

In sum, early efforts to identify potential impacts of VGI and articulate a VGI research agenda show a predominant focus on data: How and with what

implications VGI is influencing the creation and sharing of digital spatial data, its content and characteristics, and the roles it may play in broader societal knowledge production efforts. What is notable in this literature is a shared tendency to conceptualize data as socially produced and embedded. For instance, most of the discussions of spatial data handling challenges associated with VGI treat shifts in volume or heterogeneity not as strictly ‘technical’ problems, but rather, understand them as also rooted in the diverse forms of social knowledge that are ‘activated’ into digital forms through VGI applications. Along similar lines, efforts to theorize why individuals volunteer information note that socially- and politically-grounded motivations for volunteering or withholding will shape the dynamics of inclusion and exclusion in VGI development and affect data content. These assumptions that the impacts of VGI will emerge from closely mingled social and technological structures and practices are quite similar to the guiding assumptions of a range of GIS research that responded to critiques of GIS in the mid-1990s. As such, these closely related efforts to understand spatial data and their impacts as socially and technologically produced have much to offer these dimensions of VGI research, as I will explore in the following section.

### **Guiding VGI research with propositions from critical, participatory, and feminist GIS**

The ‘GIS and Society’ critiques of the mid-1990s gave rise to a body of work investigating the impacts of GIS upon participation, power relations, and existing inequalities in access to spatial data and technologies, and theorized how these impacts occur (Aitken and Michel 1995; Weiner et al. 1995; Elwood 2002). PPGIS and PGIS research have further developed this investigation of how spatial data and technologies may include and exclude, focusing upon how these forces stem from social and political processes in which they are embedded *and* from the forms of spatial knowledge and reasoning that GIS software and data structures can handle (Obermeyer 1998; Craig et al. 2002; Sieber 2006; Dunn 2007). Critical GIS research focuses in part on the core challenges of representing and analyzing spatial objects, their characteristics, and their

relationships in a digital environment, and the consequences of these practices for social knowledge, representation, and power (Schuurman 1999; O'Sullivan 2006). Critical GIS also includes GIS research and practice with an explicitly emancipatory agenda of engaging spatial technologies to disrupt socially and technologically-mediated forms of exclusion and disempowerment (Harvey et al. 2006). Feminist GIS draws strongly upon many of the same ideas and practices that inform critical and participatory GIS, and there is a great deal of shared territory between them. In particular, feminist GIS has examined the implications of GIS for feminist research methodologies, exploring ways of working with knowledge as multiple and situated in a GIS, and challenging assumptions about inherent linkages between GIS and any specific epistemology (Kwan 2002; Schuurman and Pratt 2002; Gilbert and Masucci 2006; McLafferty 2006; Pavlovskaya and St. Martin 2007).<sup>2</sup>

These three areas of GIS research share in common a notion that the societal impacts of GIS are in part wrought by the ways that geographic information is created, represented, communicated and accessed in a digital environment. But they also hold that the ways in which these procedures are handled in a digital environment are themselves the product of social, political, and economic relationships, histories, and practices. This integrated conceptual framework is precisely the sort of foundation from which we might build a better understanding of the social and political impacts of VGI. But more specifically, these three research areas in GIS also offer a number of conceptualizations that can inform VGI research—specifically efforts to understand how and with what implications VGI may alter spatial data production, its content and characteristics, and the knowledge practices it advances.

Emerging debates about the societal impacts of VGI include a concern about the potential of this phenomenon to disempower and to worsen existing inequalities and exclusions. Critical, participatory,

and feminist GIS offer a number of conceptualizations that might inform our efforts to understand precisely what forms of disempowerment are occurring and how they are produced. Especially important is the notion that in their representation of people and places, spatial data are a central loci or mechanism of inclusion and exclusion, empowerment and disempowerment. Specifically, the exclusion and under-representation of information from and about marginalized people and places in existing data records and is linked to the ensuing exclusion of their needs and priorities from policy and decision making processes (Elwood and Leitner 2003; Weiner and Harris 2003; Elwood 2008). For example, national census data records reflect undercounts in places that have a large number of homeless people, a high level of household mobility, or many informal settlements. Local government data on property conditions and housing abandonment are frequently incomplete in those areas in greatest need—those places where residents are less likely to contribute information and where field-based staff members may be reticent to go. Individuals' isolation, language barriers, frequent moves, fear, or other barriers may inhibit their involvement even in explicitly participatory efforts to create data. But these gaps are simultaneously constructed through mismatches between existing data structures and lived experiences. Consider for example the difficulty posed by single racial categorizations in the US Census prior to 2000, for those individuals who identify as multi-racial.

In short, when the epistemologies, vocabularies, and categories of data structures do not or cannot encompass the experiences, knowledge claims, and identities of some social groups or places, this produces their under-representation in digital data. These under-representations have all sorts of social and political implications and so must be part of our investigation of the empowerment and disempowerment potential of VGI. But further, this notion that spatial data are representative *and* constitutive of unequal access and power needs to inform efforts to use VGI for the 'patchwork' practices discussed in the previous section. While the vision that VGI might be used to flesh out incomplete public data sets is important and promising, these ideas from critical, participatory and feminist GIS suggest that the very mechanisms that produced these gaps in the first place may well perpetuate them. The social and technological barriers that inhibited representation of

<sup>2</sup> Such efforts to de-couple supposed fixed links between research methods and epistemologies are a longstanding contribution from feminist geographers' writing on methodologies, such as the edited collection "Should Women Count" from *The Professional Geographer*, 1995, volume 47, issue 4.

some people and places from existing data records will likely challenge their participation in efforts to generate VGI to fill the gaps. This is not to suggest that such efforts are futile or should not be undertaken. Rather, it is imperative to shape 'patchwork' VGI initiatives in ways that respond to what we already know from critical, participatory and feminist GIS research about how exclusion and representation are constituted in digital spatial data.

A second important proposition from critical, feminist, and participatory GIS research (drawing from feminist theory and critiques of science) is that identity, power, and spatial knowledge are inseparably linked (Hanson 2002; Kwan 2002; Pavlovskaya 2002). Put more succinctly, who we are shapes what we know, and vice versa. For example, in research with community-based organizations in a Chicago neighborhood, I have found that Latino residents and community activists tend to characterize an enclave of Puerto Rican businesses and community agencies in their community as a vibrant center of economic activity, community services and capacity building, and neighborhood revitalization (Elwood 2006). In contrast, Wilson and Grammenos' (2005) research in the same neighborhood documents how real estate agents, mostly white and from outside the neighborhood, typically frame the neighborhood as gang-ridden, dangerous, and dilapidated. These cases show how identity shapes knowledge, as seen in different articulations of neighborhood characteristics. But the authors of each also emphasize how characterizations of place (whether in maps, spatial data, and public media) also influence the identities and power of individuals and social groups in those places.

These theorizations of the situated nature of spatial knowledge and the co-productive relationship between knowledge and identity may be woven into VGI research in many ways. Even early studies of VGI services show that contributors will seek to use these services to generate and share diverse forms of knowledge (Miller 2006; Turner 2006). This suggests that VGI research must consider the extent to which the data structures and visualization services that foster VGI can support the inclusion of multiple knowledges. As well, we may wish to consider whether the data structures and visualization services commonly used with VGI are able to store or communicate anything about the situated context in which volunteered information was generated.

Schuurman and Leszczynski (2006) and others have illustrated that such details about the context of spatial knowledge production (and its representation as digital data) are centrally important to understanding the data themselves and their societal applications and impacts. The situated nature of spatial knowledge is also important to questions of accuracy and reliability in volunteered information. Given the diverse range of contributors who may contribute information through VGI services, I suspect we will see especially high levels of contradictory or contrasting information. Most existing discussions of VGI frame these differences in information contributed as problems of accuracy and reliability. A critical GIS-informed reading of these differences would suggest that these contradictions in volunteered information may well be indications of social and political difference. An important dimension of VGI research could be examining how these contradictions might inform new understandings of the places and people represented in this information.

A third way in which critical and participatory GIS might inform VGI research is through its rich evidence of how spatial data access, management, and sharing are socially and politically constructed. Research from PPGIS/PGIS and critical GIS has developed detailed accounts of the social and political structures, practices and relationships mediate geospatial data access, sharing, and administration. For example, research in this arena illustrates that locally and nationally situated laws, institutional policies, and political or organizational cultures affect what data are integrated into spatial data infrastructures, as well as public access to these data (Craglia and Masser 2003; Harvey and Tulloch 2006; Rajabifard et al. 2006). Other research in this arena shows how spatial data integration and sharing is affected not just by the technology-rooted procedures used to do so, but also by the sorts of practices that are used to ensure consistency and interoperability, such as data standards or metadata standards (Nedovic-Budic et al. 2004; Schuurman 2006). PPGIS/PGIS research emphasizes the capacity of unequal social and political relationships to influence spatial data access and sharing (Onsrud and Craglia 2003; Tulloch and Shapiro 2003; Weiner and Harris 2003). My own work suggests that in local political cultures that restrict access to information or in the face of relationships of mistrust, inequality and exploitation,



spatial data comes to function as a commodity, a resource to be traded upon for influence or political power. This political commodification of information produces strong disincentives for spatial data access and sharing (Elwood 2008).

Many of these same socio-political structures and mechanisms may well affect the production, sharing, and administration of VGI. Further, investigating how they operate in this new context is an important first step in understanding the nature and genesis of limits or barriers in producing and using VGI. As well, many of the potential new knowledge practices or 'patchwork' uses of VGI that are envisioned in these discussions are presented with the caution that their possibility rests upon the ability to consistently share or integrate these data. Critical and participatory GIS offer a framework to guide our interrogation of the socio-political side of this equation. Some research is already drawing on these ideas, as in Zook and Graham's (2007a) demonstration of how search and retrieval algorithms may be altered in response to government pressure, such that they retrieve only certain spatial information about a place.

But this research on the socio-political construction and administration of spatial data in a distributed environment is also useful in highlighting the limits of existing practices to deal with new challenges posed by VGI. For instance, consider the expressed concerns about ensuring consistency and reliability in volunteered information. Research on SDIs, data standards, and metadata standards has well documented that these existing structures are quite limited in their capacity to foster consistence in traditionally-conceived and managed spatial data (Nedovic-Budic et al. 2004; Onsrud et al. 2005; Schuurman and Leszczynski 2006). The potential heterogeneity of VGI and the openness of many platforms for collecting and visualizing it may mean that existing structures and practices for ensuring spatial data consistency and completeness are even less appropriate in this context.

In this section, I have charted some ways in which conceptualizations and findings from critical, participatory and feminist GIS might fruitfully inform VGI research. It also bears noting that ideas from these research trajectories do not map onto VGI research needs exactly. Grappling with the phenomenon of VGI also requires us to rethink and rework some of ideas from these research areas, and

branch out to fill critical gaps. For example, GIS and Society research has developed detailed accounts of how hardware, software, data, and expertise needed to use GIS can function as barriers to spatial data access. But the hardware, software, data, and expertise needed to contribute or use VGI are quite different. Uneven access to high speed Internet connectivity, for example, is likely to be tremendously important in shaping the impacts of VGI, but has been given less attention in the context of GIS. In another example, PPGIS/PGIS research clearly points to the difficulty of integrating spatial data that originate from different epistemologies, as 'local knowledge' and 'official knowledge' often do (Weiner and Harris 2003; Dunn 2007). But this research area has focused very little on the challenges of integrating local and official knowledge, which will surely be a central concern in VGI research. Much of critical GIS research on the production, administration, and sharing of spatial data has focused on government and academic data producers and users, such that this existing work may be limited in conceptualizing the engagement of ordinary citizens and their local knowledge in VGI development and use. As Budhathoki et al. (this issue) assert, the phenomenon of VGI pushes us to re-think our conceptualization of 'the user'.

Nonetheless, ideas from critical, participatory, and feminist GIS are centrally important as we formulate a VGI research agenda. Many of the same questions posed in the GIS and Society research agenda are equally important to ask of VGI as we develop a research agenda that includes considering the social and political impacts of this phenomenon. The central issues raised in *Ground Truth* (Pickles 1995) and other early agenda-framing publications from GIS and Society (Smith 1992; Lake 1993; Sheppard 1995) suggest a multitude of questions for VGI research. What are the mechanisms through which VGI will tend to alter participation, power, and knowledge? What kinds of representations of world can these mapping interfaces be used to produce, and how is the authority of these representations produced and challenged? What institutions originated the hardware, software, and interfaces that are used to create and share VGI, and how do these origins shape the socio-political construction and impacts of VGI? How are challenges of cartographic representation, data storage and retrieval and data integration

handled in various VGI environments and initiatives, and with what consequences? What new forms of interaction, communication, or political practice may be advanced through VGI and VGI services? What is the potential of these new forms of information and technological practice to advance emancipatory projects, and how might they worsen existing digital divides, unequal ‘information politics’, and other exclusions? Finally, the converse is true as well: VGI research will have much to contribute to other research areas in GIS. As Sui (2008) describes, GIS and spatial data handling are themselves being fundamentally altered by the emergence of new geo-enabled technologies. As such, the data and practices fostered through VGI services are an increasingly central consideration in GIS practice, suggesting the necessity of situating VGI research in close conversation with a diversity of GIScience research.

## Conclusion

In this article I have sought to identify and detail some key directions for the VGI research agenda, with specific emphasis on how we might examine the societal impacts of VGI services and the information they are used to gather, produce, and disseminate. The existing literature on VGI suggests that an essential mechanism through which this phenomenon will impact society is the data themselves—their content and use; the technological structures used to obtain, store, and share them; and the situated knowledge claims and politics they may be used to advance. I have argued that the societal impacts of these data and practices in VGI requires an integrated approach that examines this phenomenon as social *and* technological, and many of the foundational propositions that inform critical, participatory and feminist GIS can motivate key questions for VGI research. I would add here that VGI research will need to draw upon a tremendous range of other research. As many of the other articles in this collection show, research from across the full spectrum of GIScience and from fields as diverse as cognition, social psychology, and human–computer interaction studies can be brought to bear on our efforts to understand the impacts of VGI and to facilitate its development and use in socially inclusive ways.

Beyond the issues that have occupied most of this article, I would also note that our study of the societal impacts of VGI must also consider the social and political processes in which it is used. For instance, what sorts of social and political interactions are supported and promoted through VGI? Most of the commercially-developed web platforms that support development and geovisualization of volunteered information enable users to collectively generate data sets and sometimes to annotate or amend one another’s content. We know relatively little about how this potential for new forms of collaboration and interactivity is actually being taken up by the individuals, organizations, and social groups using VGI services in exponentially growing numbers, nor how they may use this interactive potential to create new social and political practices. We may also need to consider how planning paradigms and decision making practices might need to shift if they are to incorporate and use volunteered information in meaningful ways. As argued above, VGI initiatives have the potential consequence of vastly expanding diversity, heterogeneity, contradiction, uncertainty, and concerns about accuracy and verifiability in these data resources. Many of the societal practices that might especially benefit from these new resources of citizen-generated information—such as urban planning and policy-making—tend to rely on decision making models that prioritize consensus, verifiable information, and finite and known data sets. If volunteered information is to be usefully engaged in such contexts, we must consider models for democratic practice that are effective in the face of uncertainty, contradiction, and diversity in spatial knowledge and spatial data.

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