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The epistemology(s) of volunteered geographic information: a critique

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Numerous exegeses have been written about the epistemologies of volunteered geographic information (VGI). We contend that VGI is itself a socially constructed epistemology crafted in the discipline of geography, which when re-examined, does not sit comfortably with either GIScience or critical GIS scholarship. Using insights from Albert Borgmann's philosophy of technology we offer a critique that, rather than appreciating the contours of this new form of data, truth appears to derive from traditional analytic views of information found within GIScience. This is assisted by structures that enable VGI to be treated as independent of the process that led to its creation. Allusions to individual emancipation further hamper VGI and problematise participatory practices in mapping/geospatial technologies (e.g. public participation geographic information systems). The paper concludes with implications of this epistemological turn and prescriptions for designing systems and advancing the field to ensure nuanced views of participation within the core conceptualisation of VGI.

Key words volunteered geographical information (VGI); crowdsourcing; epistemology; geographical information

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Introduction

This paper stems from an epistemological puzzle. Throughout the development of geographic information science (GIScience) as a field of study, there was a clear emphasis on the development of algorithms and rules to optimise geographic data collection. The field was accompanied by claims about accuracy and representational power emerging from the quality of the instruments (e.g. sensors mounted on satellites or a total station), the universality and absolutism of accuracy, and the knowledge that experts in national mapping agencies and other state institutions brought to, for example, spatial data quality standards. Mirroring domains like computer science and statistics, truth tended towards the singular (e.g. the most accurate and precise latitude and longitude) and was sought via Mertonian norms of science, that is, the general expectations of empirical scientists that were codified by Robert Merton (1942). When critical geographic information systems (GIS) emerged in the mid 1990s (Schuurman 2000) and methodologies such as participatory GIS (Sieber 2006) were developed, they were considered marginal and in opposition to mainstream GIScience. Adoption of less-than-hard-scientific and non-authoritative methods of the data collection process were questioned in terms of scientific legitimacy, and the use of unstructured data or the mixing of qualitative and quantitative information was not accepted in mainstream GIS material (e.g. Longley *et al*. 2001).

A surprising about turn emerged in GIScience with the development of the concept of volunteered geographic information (VGI) at a specialist meeting in 2007. Beginning with Goodchild's (2007) definition, VGI is understood as the widespread engagement of large numbers of participants involved in the digital creation of geographic information. Goodchild uses the inevitably value-laden terms 'volunteers' and 'citizens', which we will examine later. For now, these are individuals who are considered to possess few formal qualifications compared with those held by professional surveyors or geographers (Budhathoki *et al*. 2010). These data are characterised by a multitude of data types on diverse hardware and software platforms, which participants may use to provide details about their own location (e.g. through global positioning systems – GPS

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logs) or submit an observation (e.g. as a time-stamped and geotagged photograph) or derive data from another source (e.g. in crisis mapping when digitising from satellite imagery) or submit a long form response (e.g. a geocodable restaurant review). Unlike traditional structured authoritative databases, VGI is content that 'rel [ies] heavily upon qualitative spatial knowledge and everyday forms of spatial reasoning' (Elwood 2009, 257). There have been concerns that not all VGI may be volunteered, which prompted a shift in definition (Elwood *et al*. 2012, 575) to the more simple 'geographic information acquired and made available to others through the voluntary activity of individuals or groups, with the intent of providing information about the geographic world'. What is important for us is the way researchers in GIScience associate truth with these data. Not only is this 'crowdsourced' information explored as an intriguing phenomenon with the GIScience landscape, but the information that is produced through this process became legitimised as a source of authentic objective observation – a kind of truthful evidence about the world.

Accompanying the about-turn in GIScience was an apparent denouement with critical GIS. The varied multimedia opportunities for VGI contributions were hailed, for example, as democratising data, enhancing citizen engagement, and potentially allowing inclusion of feminist methodologies (Roche *et al*. 2013; Lin 2013; Elwood 2008). Alternately, contributions could be instruments of geosurveillance and neoliberalism, and represent an obsession with newness for its own sake (e.g. Leszczynski 2012). We argue that, despite the socially sensitised assumptions of VGI (i.e. from non-experts and representing lived experiences), the reason for the embrace of VGI within GIScience and critical GIS is due to an emphasis on instrumental and quantifiable objective observations. In line with past scientific analysis of geographic information in the form of maps or digital representations, VGI can have qualities of being verifiable, accurate, comprehensive and representative of the world from which it was captured. Whereas the growing literature on VGI offers an alternate conceptualisation of the processes and practices that lead to the construction of information (e.g. Elwood *et al*. 2012), we argue that one of the core ways in which this legitimisation occurs is by separation of means and ends. The process by which individual contributions on specific platforms came into being can be discussed, but for the users of the information, the coordinates and attributes that are accessible within a spatial data repository can be treated as a truthful evidence about the world and not as subjective and situated information. We contextualise this in the social construction of knowledge, that VGI is a concept constructed by geographers who selectively borrow assumptions from GIScience[1] but also from critical GIS scholarship in ways that can constrict self-reflection. We cannot study VGI as a concept, without understanding the ways of knowing in the constructed object, specifically the ways that geographers have built it.

Our aim in this paper is to critique the current epistemology that undergirds VGI, and to argue that the about turn of GIScience that we noted above was done by deliberately ignoring the subjective and situated nature of the information. We first start by looking at the nature of epistemologies that are being used to understand VGI and using this understanding to look at the nature, production and use of this information. We show that there are theoretical and practical implications for both GIScience and critical GIS. We contend that the social construction of VGI by GIScientists and critical GIS scholars (e.g. Warf and Sui 2010 connecting VGI to early critiques of cartography) has established a firewall of acceptable critique (VGI platforms, which are conveniently developed outside the discipline of geography) and less acceptable critique (the data of VGI, which come from the people). We also critique the view from nowhere that allows us to critique others (e.g. large firms like Google) without turning the spotlight on ourselves.

The nature of epistemologies with regards to VGI

Epistemology is a branch of philosophy that focuses on the study of knowledge, and the source, meaning, and truthfulness of this knowledge (Audi 2011; Steup 2005). It becomes a path to how we come to know what distinguishes what is true from false and how we understand the conditions under which such distinction is possible and meaningful. When applied to a specific area of study by domain researchers, that is those who apply philosophical concepts, epistemology frequently represents the manner in which their own knowledge domains are understood.

Non-philosophers also interpret this notion of epistemology as a worldview or paradigm. These are the underlying assumptions – the prejudices, biases and prior knowledge – that are foundational to the specific epistemology and the sets of practices that become institutionalised into norms of that epistemology. For these reasons, epistemology is often viewed through the lens of social constructivism. Social constructivism refers to how epistemologies are produced through the choices of individuals in a domain and how those choices are institutionalised into the norms of that domain (Searle 1995; Latour 1987). Searle (1995, 1) calls these truths institutional facts: 'facts by human agreement. Institutions include the regimes, the regulations and rules governing what we know. However, some rules do not merely regulate, they also create the very possibility of certain activities' (p. 27). He uses the

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example of chess, which before the rules, is just pushing bits of wood across a flat surface. It becomes chess only after the rules of movement and hierarchy are applied. Searle (1990 1995) uses the phrase collective intentionality to describe this production by individuals, where '*I* am doing something only as a part of *our* doing something' (Searle 1995, 23, italics in the original). Therefore chess is not an individual invention but results from the co-production and agreement of numerous individuals – the crowd, as it were – that formalise the rules.

Michael Jones, Google Earth's Chief Technologist, provides a demonstration for the epistemology of VGI. He argues that VGI represents a path to a new way of knowing. By 'providing access to GIS tools, you'll end up with a big number of users converging on the truth' (Jones 2007). This singular statement meets many of the criteria discussed above. Jones argues that VGI is a kind of truth, in this case because of crowdsourcing like the model used in Wikipedia. VGI, through crowdsourcing, represents a kind of collective intentionality but it also suggests that VGI as a concept was collectively developed to allow for affordances like crowdsourcing. Google Maps/Earth is a major software platform for VGI and Google was a participant at the initial research meeting on VGI (Elwood 2008), where the concept of VGI was co-developed. Private sector involvement injects norms of monetisation of those voluntary contributions. The possibilities afforded by digital earth platforms, social networking, web scraping, and mashups 'create the very possibility of certain activities' (Searle 1995, 27). VGI includes assumptions about the source of information (e.g. from non-experts), the nature of the information (e.g. claims to accuracy and the sheer number of contributions) and the processes that lead to its production (e.g. the labour relations of those non-experts). Thus, the socially constructivist epistemology of VGI reveals the process and assumptions by which we assemble our collective abstraction of VGI.

Digital geospatial information is arguably different from other kinds of social constructions. To explicate one major way the epistemology of VGI is constructed, we need to look at how it comes to be linked to reality and represented. Borgmann (1999, 2010) presents both an ontology and epistemology of digital information. He signifies three types of digital information: natural, cultural and technological. Natural information is defined as *information about reality*, for example, the way in which the curvature of a river influences the way we choose a route on its banks as we observe and sense it while walking towards it. Scientific information that describes the movement of the earth or the functioning of a cell is also included in this category. Natural information is created to understand the functioning of reality. Cultural information is information that is being used to *shape reality*, like engineering design plans used to construct a bridge or music sheets that are used to produce sound through musical instruments. Both natural and cultural information, while existing in digital form, have a dialogue with reality and are part of human practice and understanding.

For Borgmann, the third type of information is fundamentally different and exposes the problems that emerge when considering topics that are inextricably linked to information and communications technologies. Technological information is *information as reality*, one impact of which is a decreased human engagement with fundamental aspects of reality. The illusion of live performance that a well produced music file can reproduce through a digital audio system is an example of information technology suggesting itself as a replacement of reality. For Borgmann, the fundamental process that allows technological information to create this separation from reality is 'The Device Paradigm' in which many high technologies that replace previous, manual, engaging and multi-faceted processes do so by reducing the purpose of the activity to specific functions that can be reproduced. Here the device is foregrounded and its paradigm emphasises efficiency and productivity over wider humanistic values. The wider experience of a live performance is essentialised to the transmission of music from the performer to the listener that open up the promotion of digital music as an equivalent experience. Importantly, this is done through the separation of the means (e.g. the performance, venue, gathering for a gig) from the ends (transmission of sounds).

Borgmann deals directly with geographical information and GIS as 'the paradigm of technological information' (1999, 171) For Borgmann, GIS epitomises technological attempts to encompass reality by capturing the endlessness of reality in bits and bytes. Technological geographical information is being utilised in the human efforts to make reality transparent and precipitous. The ongoing development of data capture techniques, combined with the increased capacity to store and manipulate geographical information, can be interpreted as an attempt towards improved ability to capture reality in ever greater detail. The use of this information as reality can be seen in the way that GIS analysis is used to set tasks for police forces or in precision agriculture when it is used to set the application of fertilisers. Whereas paper maps or even digital static maps are clearly examples of cultural information; the path that one selects on them must be interpreted through reality. When they transition to providing navigation, digital maps move to technological information. Borgmann's analysis predates the emergence of VGI. However, we can draw a parallel and notice how VGI can be understood as an example of technological information. As we shall see in the following paragraphs, regardless of what came before, the

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heterogeneity of perceptions and values, VGI epitomises the device paradigm by turning the information into standardised elements. The elements are separated from their origin, thus emphasising efficiency (as far as the information user is concerned) and reduction of the experience to machine-readable code. This separation reverberates through the research on VGI. The epistemology of VGI emerges when researchers' focus remains on the ends (the transmission, storage, the shaping); whereas, the means (the process that led to VGI) is of lesser importance. We argue that this separation occurs whether the reading of VGI occurs in GIScience or in critical GIS.

There is considerable theorising of epistemologies and ontologies of geographical information, for example, regarding the concept of neogeography – the digital representation of everyday geography mixed with the innovation culture of technology enthusiasts – the Geospatial Web 2.0 or the Geoweb – the integration of geographic technologies with Web 2.0. This theorising frames our discussion and the interested reader can explore Crampton (2009), Warf and Sui (2010), Leszczynski (2009a 2009b)[2] and Wilson (2009). The conclusion that emerges from the literature is that geographers cannot describe neogeography or the Geoweb without critiquing the embedded societal practices. It does not make sense in geography these days to describe the social implications of neogeography because the interrogation is explicit in geography and the critique is an affordance of the concept. By contrast, one can discuss and research the social implications of VGI. Or one can consider the process of VGI production (e.g. Crutcher and Zook 2009). Through a variety of concatenations, VGI as a concept becomes ontologically encapsulated, an enclosed social fact onto which a process like production is layered. It is very much the error attributed in Wilson (2009): the overemphasis on the ontological instead of the epistemological in much critical GIS writing.

Many researchers who explore VGI comment on the inadequacy of the term itself to ontologically encapsulate the full phenomena. Elwood (2009, 256), for example, points out that emergent technologies and data have been 'referred to with a plethora of terms, including neogeography … web mapping … volunteered geographic information … ubiquitous cartography … and wiki-mapping'. Crampton (2009) adds *spatial media*, *locative media*, *spatial crowdsourcing*, *geocollaboration* and *map hacking*. There is also a conflation of the information and the enabling software platforms, for example, 'tools and technologies variously known as the Geoweb or volunteered geographic information' (Crampton 2013, 70). Sui and DeLyser (2011) consider VGI to be information distinct from the Geoweb, its platform. Above, Elwood *et al*. (2012) provide a simpler definition but they recursively use the word volunteer in their definition of VGI. Parker (2014, 12) critiques this lack of coalescence:

> Neither do [the numerous authors] present a distinction between the types of data type or technique being described. The lack of agreement on terms by these and other authors…highlights the lack of consensus in terminology, leading to multiple authors using various different phrases to describe the same thing.[3]

Instead of definitional clarity, VGI becomes constructed from components of other terms as well as being rooted in concepts from GIScience and technological information. Ours is a critique of how VGI has been built within the geographic community, by the GIScientists and also by their critics.

The components of VGI as a socially constructed epistemology

To set the stage for how the epistemology has been constructed in VGI, we begin with its epistemic origins, which most strongly draw on GIScience. GIScience is focused on digital technology, relying on geographic information that is fundamentally represented as a set of numbers in digital formats (e.g. pair or triplet of coordinates for a point) even if VGI begins as a placename or a long digital post about a vacation. The locational annotation makes the data 'true' for those who work with geographic content. However, the process that led to their creation and coding are very different. One can analyse the aggregated or crowdsourced results and ignore the process that led to their creation. We shall see that attention to process is significant to understand the path by which people come to see VGI as valid sources of geographic content.

In GIScience, the implicit assumption has been that information is provided by an authoritative source. There is a knowable and observable truth (brute facts) in the world that can be captured. Moreover, as it is based on collecting and manipulating facts about observable properties of the world, the epistemology of geographic information is that through accurate measurement, data capture and manipulation, the world can be known. GIScience draws on a positivist epistemology (Wilson 2009) that follows norms of science as described by Merton (1942): communalism (part of a science community activity), universalism (impersonal and objective), disinterestedness (verifiable independent of politics, culture, race, gender, and personal agenda), originality, and scepticism. Positivism tends to be the dominant critique of GIS and the Geospatial Web 2.0, although Leszczynski (2009a) argues that positivism has been constructed largely as a strawman. She deconstructs the original critiques of the positivist

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assumptions, asserting that the GIS critics have misunderstood GIS and that it denies the materiality of the technology, particularly its connection to the being (the ontological formulations) of computation. Leszczynski (2009a) and Elwood (2008, 178) argue that critical GIS research, like feminist GIS, has been 'challenging assumptions about inherent linkages between GIS and any specific epistemology'. Despite the fact that GIS is opened up to different epistemological readings, outside critical GIS, where most of GIS use occurs, assumptions about scientific use of GIS hold that spatial data represent a fact that was observed in reality.

This view is deeply embedded in GIScience[4]. In the paper that describes the move from GIS to GIScience (Goodchild 1992), the discussions about data capture, spatial statistics and data modelling call for universal methods that can function with any application of GIS. Research into quantifying uncertainty, understanding error propagation processes in GIS (Heuvelink 1998), or evaluating spatial data quality (Shi *et al*. 2002) usually assumed that each dataset attends with sufficient information that will describe its quality for the whole dataset. If we know the Ordnance Survey (OS) specification for their most detailed map product, OS MasterMap, then we can use the data for any part of the UK without the need to evaluate aspects such as spatial data uncertainty for each area. We transform the local place into a homogenous space; even if it differs in the details, it is represented in the same way. Data quality standards and metadata standards were devised to provide information at the dataset level to potential users. Via context, geographic information can be related to reality with a good knowledge of the truth that it is representing, and thus is use *as reality*.

Over time, GIScience has shown less interest in data capture itself, leaving it to surveyors, photogrammetrists and remote sensing experts to devise instruments and methodologies to allow accurate and precise measurements of geographic phenomena. They focused more on the manipulation, organisation, and visualisation of geographic information (compare Goodchild 2010 with Goodchild 1992). This distanciation from data collection strengthens the assumption that the data are grounded in some truthful observation of reality, as the GIScientist usually relies on the products of others who have converted reality to digital formats. Importantly, this distance from data collection opened up the use of VGI and other Geoweb sources. As constructed in the GIScience mould, once validated, VGI becomes another source of cleansed information that can, for example, enrich authoritative databases (e.g. Jianga and Liua 2012).

The emergence of VGI brought about an apparent challenge to this epistemology. As Keen (2007) noted in *The cult of the amateur*, Web 2.0 means that professionals no longer control the collection, analysis and visualisation of information. The response of GIScience has been to understand how geospatial data can be used within the GIScience framework. Content fell into standardised ways of knowing, and the availability of the content in familiar digital formats made it easy to do so. Heretofore, GIScientists have operated under the assumptions of linearity and hierarchy in the process of creating geographic information, but with VGI, noise, incompleteness, heterogeneity are inherent and expose the assumption of knowledge that were always there but ignored. Within the positivist-like interpretation of GIScience, it is assumed that through VGI the world can be rendered transparent and known (Borgmann 2010). In opposition to the contextually rich yet subjective case studies that cover qualitative information and concepts like community empowerment that are common in public participation geographic information systems (PPGIS), VGI allows the analysis of 'objective' data to tell us about the world and thus become suitable for spatial analysis. What follows are the specifics of the epistemology VGI focusing on the source, nature and production of knowledge.

The source of knowledge

Goodchild (2007) distinguishes between GIScience and VGI in that traditional geospatial information emerges from individuals who are trained in and paid for their expertise in geographic data collection. By contrast, the path to knowledge in VGI arrives via the non-expert or non-credentialed individual. As we noted, this represents a puzzling turn for many GIScientists, although certainly not critical GIS scholars who can find value in data that do not come from the authority assigned by modern society and the institutional framework supporting that authority (e.g. Schuurman 2000).

One defining assumption is that the information is presumed to be sourced from individuals of their own free will and without direct financial compensation or labour relationship (Brabham 2008; Zook *et al*. 2010). Volunteerism is therefore seen as evidence for lack of personal gain, which might reduce the trust in the information, unless it has been produced professionally. The argument is that if the contribution is compensated and done within an organisational framework then it is assumed to be authoritative. Compensation is dual-edged in VGI: if VGI forms part of a labour arrangement or is coerced then it is suspect (or, at minimum, not amenable to the VGI validity tests being developed). Conversely, compensation is equated with accuracy, which may not be the case as Haklay (2010) and Koukoletsos *et al.* (2012) demonstrated in accuracy comparisons of OpenStreetMap (OSM) and the UK Ordnance Survey information. Concerns about the act of volunteering suggest why considerable research in GIScience assesses the motivations of contributors (Coleman *et al*.

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2009 2010; Budhathoki *et al*. 2010). This may generate value statements; in other words, whether one's sources contribute content for the 'right' reasons. An example of this can be found in perceptions of the validity of data that are collected within the context of environmental justice struggle. In such cases, the role of community activism in that motivation creates suspicion among authoritative forces (see Rowland 2012).

Despite questions of the source, VGI posits that the non-expert and uncompensated individual can produce reliable and usable geographic information. A major source of this truth attends from those who are closest to phenomena, both in time and space in terms of empirical observation and the use of instrumentation like GPS receiver as a validator. We refer first to accuracy, in the context that these individuals are *in situ*. They can report when an acute temporal event like a crisis occurs and where authorities may lack the resources to quickly respond (Zook *et al*. 2010). These individuals have lived in an area for extended periods and presumably can sense subtle changes like shifts in the spatial extent of habitats. This is the citizens as sensors argument (Goodchild 2007), of which a well known example is the non-expert reporting of wildfire extents and severity in California (Pultar *et al*. 2009). Second, we refer to authenticity of observations. The observations presumably reflect the lived experience of an individual who 'knows' a place well. Indeed, the goal of VGI need not be accuracy. It can take on the affordance of truth. Opinions and sentiments may have greater relevance to the researcher or practitioner, for instance in obtaining 'accurate' perceptions of vacation experiences by aggregating tourist reviews (Johnson *et al*. 2012).

The nature of knowledge

VGI extends our notion of scale and scope in geographical information. Scale manifests in many forms, most directly from cartographic scale of the area that is captured. But it also can manifest in the data sense, from the sheer volume of observations (e.g. from streaming or big data), and in the social sense, from the breadth and sheer number of contributors (whether or not they contribute to precision) and the scope of what is captured and where. The information can be from a small plot of land to the entire world as in the case of Wikimapia, which allows the user to add information about any place on a georeferenced global grid. Many VGI applications are driven and displayed over digital earths (e.g. Google Earth, Bing Maps or OSM), which follow former US Vice President Al Gore's vision of 'A multi-resolution, three dimensional representation of the planet, into which we can embed vast quantities of geo-referenced data' (from www.digitalearth-isde.org cited in Ehlers, 2008). There is a sense in VGI that the data need be seamless. At the same time VGI is generally local or hyperlocal, that is highly localised and disaggregated, with a relevance to a specific building or business. This hyperlocal information gains its validity by being provided at a global extent and in a standardised format. Central to enabling a seamless view of the world is that in VGI, as in GIScience, space substitutes for place in its more cultural and contextual interpretation. GPS traces, for example, can produce content from a walk in the park or a globe-spanning journey of a jet in the same format and captured in the same database.

Because of the sheer variety of digital content tied to geography, VGI has been conceptualised as fluid, nonlinear and heterogeneous. It is temporally contingent, in that VGI is frequently most valued only when it is current. It exists in 'perpetual beta' that is always tentative and open to updates and change; one might say that it is only true if it remains unfinished. This is most clearly observable with real-time streaming data from software platforms like Twitter or hardware like geosensors. Here, the original linked nature of hypertext of Ted Nelson (1980) collides with the palimpsest of place (Graham 2010). Hypertext reordered reading as a nonlinear linked activity; Graham argues that place is continually (re)constituted from the concrete and experienced. In a sense, Web 2.0 enables the accretion of memories and observances to incrementally build a place. Considering that data mining aligns with VGI, information accumulates not just from a single source but from a combination of data sources. VGI provides a new knowing of place, which is partial and sedimentary.

Elwood and Leszczynski (2013, 548) argue that VGI/Geoweb (in its participatory and civic engagement sense) differs from GIS in that:

> GIS has often been deployed to transpose narrative descriptions of events or conditions into (mostly quantitative) forms stored in a spatial database or represented cartographically. Such translational approaches to GIS seek to legitimise narrative or experiential accounts against efforts to reject them as anecdotal, or produce representations that claim legitimacy on the basis of showing a larger spatial or temporal context.

Particularly on location-aware devices, VGI can emancipate the geographic from the cartographic. The GIScience research community have constructed the concept of VGI to extend beyond its representation on, for example, a digital earth to focus on the underlying geographic information.

It is a mistake to see Elwood and Leszczynski's assertion as allowing unstructured information into the social construction of VGI. VGI maintains control over its contribution through multiple routes: verification through the instruments that are used (qualitative

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content may still rely on GPS or a geotag to identify the actual location, as without the GPS or geotag such locations remain unknown) and, importantly, by reading VGI as contributed through processes that follow the assumed disinterestedness, independence of observations and verification that scientific observers are expected to follow. Instruments are a critical source of knowledge. They are seen as more reliable than humans in VGI by relying on GPS signals that provide technological information about the location. The same is true with the embedded coordinate information in the header of digital photos taken by a cellphone. The information is captured automatically by machines of which uncertainty and precision can be quantified and therefore it is trustworthy.

The production of knowledge

The production of VGI comes closest to the definition of epistemology in how we assert the truth of what we know. With VGI, the knowledge is produced from many (individuals) to one (dataset, observation) via a collective agreement that 'may combine facts with other dimensions of human experience, such as opinions, values, and spiritual beliefs' (Dede 2008, 80). VGI borrows the 'many to one' concept from crowdsourcing. Coined by Howe (2006, 5), crowdsourcing refers to a:

> function once performed by employees and outsourcing it to an undefined (and generally large) network of people in the form of an open call. This can take the form of peer-production, (when the job is performed collaboratively), but is also often undertaken by sole individuals. The crucial prerequisite is the use of the open call format and the large network of potential laborers.

Nothing prevents us from assigning importance to a single observation. However, in crowdsourcing, the predominant production process of VGI, the truth lies in the aggregation. Lewis (2010) calls it the 'accuracy of a multitude of subjectivities' or, according to Eric Raymond (2001), 'given enough eyeballs, all bugs are shallow'.

The production of knowledge, therefore, requires the negotiation of facts that are provided by other participants. Those individuals may be unbeknown to each other. VGI is construed as form of knowledge production that requires little to no formal coordination (Budhathoki *et al*. 2010). Unlike government production of framework data (e.g. roads, cadastres, land cover, and hydrography), VGI is likely produced in an *ad hoc* and inductive way (e.g. a community developed folksonomy of places). Indeed, the purpose may be undefined (e.g. geolocated tweets) until the data are extracted, aggregated and put to some use by a third party. Paraphrasing Latour (1987), it is not when content is true then it holds; instead when the content holds then it is true. That is, only once people validate that knowledge as legitimate or useful, does it finally become truth.

Thus VGI must include mechanisms by which collective intentionality is achieved; for instance how a cluster of points becomes an undiscovered roadway. Within VGI activities, there are structural (software coded) mechanisms to dictate what and how information is collected. Even in seemingly more open systems like OSM, a collective agreement on how information is encoded is enforced by the codes that are integrated into the rendering engine. If a contributor fails to follow these codes, the information will not be displayed. Yet these structures and agreements focus on the attribute of graphical objects. In contrast, there is the given precision of the location side that emerges from the contributor pointing to a location on a map, or most frequently by the algorithm of the GPS receiver. For example, TomTom's Mapshare enables participants to upload points of interest or correct base data in the system. Here there is a need to reconcile precision and accuracy, and frequently a statistical method to find an average location is used.

The validation of the knowledge must emanate from some source. Epistemologically, validation proceeds from verificationism, a critical early component of epistemology where legitimacy of an assertion requires a method to ascertain whether that assertion is true or false (Ayer 1936). In the case of VGI we can identify four types of validation processes that are being used. The first is by comparison to a referent, presumably authoritative, dataset (e.g. Haklay 2010). A second way is to substitute precision for accuracy, which is the reliance on Linus's Law of multiple observers observing the same data (Haklay *et al*. 2010). This utilises a reduction, via some central tendency, of the observations and their richness to 'agreed' coordinates. The third is through a rating system so that, even with scant observation, the contributions are trusted by the status of the individual. This mirrors the scepticism of Mertonian norms of science in which peer review is done by the community. In this case peer review can comprise the community of the many or the community of the few influential leaders, or a community in which the machine algorithm ranks and thus establishes the credential of the participants. Measures of fitness by way of completeness may also apply: not the amount of points but the promise of detail or spatial extent. That is the promise of OSM that is highlighted on websites like 'Best of OSM' (http://bestofosm.org/), where places that are mapped down to an individual tree are highlighted.

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Risks consequent to the way VGI has been socially constructed

Using this analysis of what is included in the epistemology of VGI, we can start to understand the challenges it poses to its creators in GIScience and critical GIS.

Risks to GIScience

VGI research places a high premium on methods to validate knowledge (e.g. Flanagin and Metzger 2008; Devillers *et al*. 2010). This returns us to a classical view of epistemology, where new knowledge comes from expertise, even when encapsulated in a computer algorithm. Prior to Web 2.0, a classical model of 'knowledge consists of accurate interrelationships among facts, based on unbiased research that produces compelling evidence about systemic causes' (Dede 2008, 80).

The trouble with abandoning the classical model of geographic information production is twofold. First, reliance on non-experts can crowd out experts by increasing the general distrust of information. For example, users of Google Maps cannot tell which bit of the map that guided them in the wrong direction came from authoritative or from VGI sources. Another risk is the illusion that VGI reduces the need for consistent and professionally collected information (Keen 2007). Keen argues that the real danger in emphasising non-expert content is that it might undercut the fiscal base of the research scientist or national mapping agency surveyor. Reduce expert staff or rid the organisation of its revenue base – he points to the impact of Craigslist on newspapers' revenue from classified advertising – and institutions may not be able to rehire staff even if needed. GIScience has built into the epistemology of VGI the assumption that it offers an opportunistic source of information without cost to the experts. A significant danger is that with the Geoweb and VGI who needs experts or GIScientists?

Let us revisit the notion of the construction of VGI as representing a new source of information contributed by non-experts. Despite its framing, or indeed the romanticism of the notion of the volunteer, there is no restriction on the expertise or labour relation of individuals who create the information. With anonymity, it is difficult to parse the source of information and whether the individual contributors felt justified in believing the information to be true. Anyone can contribute; the anonymous or pseudonymous nature of contributors goes to the egalitarian heart of user-generated content where the distinctions between expert and non-expert, producer and consumer, blur. Brabham (2012, 399) openly questions 'the factual basis for the amateur label', demonstrating numerous examples where contributors felt that the label 'professionals' was more fitting, although it was strategic for them to appear as volunteers. In Johnson and Sieber (2012), government officials acted like citizens so that officials at higher jurisdictional levels would take notice. In McConchie and Klinkenberg (2010) credentialled individuals frequented crowdsourcing sites to bolster specific policies (McConchie and Klinkenberg 2010). Yet GIScientists have largely constructed VGI as sourced from non-experts. This runs contrary to the way that Web 2.0 has been conceived (e.g. O'Reilly 2005; Keen 2007), from which VGI drew its epistemology. These authors consider Web 2.0 to represent a levelling of expertise and non-expertise. VGI furthers the dichotomous-isation of experts and non-experts, even as anonymisation fails to allow for a distinction between the two.

VGI implies an informal or a lack of coordination, the 'invisible hand' of big data. We argue that a successful VGI application may require significant coordination, many times on the part of volunteers, for sites to be sustained over time and with sufficient precision and spatial extent. One reason that this coordination is overlooked is because it occurs in the platform design, which in some cases (e.g. OSM) comprises another form of user-generated content in software development. OSM and Wikmapia both are examples of 'micro-volunteering', in which developers structured ways of enabling minimal amounts of contributions. We need to internalise the method of control into how we see VGI. If the VGI is repurposed from the original platform then this platform 'context' is lost.

Despite domain differences, GIScience always has maintained a strong connection to authoritative data (hence a distancing from fields like PPGIS). If truth no longer involves control over geographic content, in that GIScientists and others are justified in believing that the content is true, then GIScience is driven to *arrange* geographic content, for example with validation, interoperability of heterogeneous data types, and demonstrate that algorithms and sampling useful to authoritative and standardised data still work for this new data source. Additionally, the VGI construct has gifted GIScientists a new territory to expand approaches to validation. It has become useful to fit the new epistemology with the appurtenances of the old.

Trouble in the heartland of critical GIS

We borrow the title from Schuurman (2000), who reported on the challenges posed by critical geographers to GIS researchers. With VGI, we may see a retreat in which critical GIS scholarship is subtly co-opted by GIScience and potentially fails to be self-reflective of its own assumptions.

Initial discussions of VGI focused on content and characteristics of geospatial data production; these were soon accompanied by analyses of socio-political implications of VGI, including uneven geographies of VGI production (Crutcher and Zook 2009) and forms

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of spatial knowledge production (e.g. the Dionysian intoxications of Kingsbury and Jones 2009). Much of discourse around VGI asserts its political implications (e.g. the knowledge politics of spatial media in Elwood and Leszczynski 2013). As Leszczynski (2012, 73) noted, a 'fundamental premise that within any economy, there is a system of (re)distribution, and this (re) distribution is always political'. Use of VGI can represent a shift from state to non-state actors, and those power relationships are such that the contributors hold very limited power. For instance, governments may employ VGI strategically, to dismiss various datasets as non-representative when they wish and value said dataset when it is convenient. The loss of Canada's mandatory long census form in favour of a voluntary census (Egan 2012) could allow the federal government to further neoliberalism and efficiency at specific levels of government (e.g. federal, state/provincial) since it is cheaper to invite people to participate instead of employing staff to conduct a census. Similar arguments have been seen in the British Columbia, Canada government's advocacy of the Geoweb for the collection of ecological data (Klinkenberg and McConchie 2010). Government also can trumpet citizen emancipation since data collection is no longer mandated but voluntary. VGI offers a political success for powerful actors, be it the government or corporations.

Leszczynski (2012) was not critiquing VGI but instead the software platforms and the labour relationship with the developers of the platform. Indeed, numerous articles now treat the platforms as politically problematic (Leszczynski and Wilson 2013 hosted a special issue of the subject). What interests us is the deep embeddedness, 'situatedness' of problems being conferred to the Geoweb, where VGI fails to share this same level of embeddedness. The Geoweb becomes a foci of a political economy of actors, of which VGI is simply outcome. However, the data cannot be apolitical objects, even as the data are allowed to be stripped of politics when they are dissected for motivations (e.g. individual empowerment) or aggregated up and then repurposed (e.g. furthering neoliberalism).

The conceptualisation of volunteerism is problematic. One epistemological underpinning of VGI lies in the emancipatory power of contributors. This resembles PPGIS with its emphasis on empowerment of marginalised and excluded groups and communities. PPGIS is defined as the application of geographic information and/or geographic information technologies; used by members of the public, that is 'non-officials', both as individuals (private citizens) and grassroots groups; for participation in public processes (data collection, mapping, analysis and/or policymaking) that affect their lives; and a normative field that should 'do good': whether it empowers marginalised peoples, promotes social inclusion, builds capacity or furthers democracy (Sieber 2006; Tulloch 2008). VGI is often conflated with web-based PPGIS (Miller 2006): PPGIS resembles VGI when it is a mapping activity that is online and is spatially or computationally distributed (Brown *et al*. 2014). Depending on the research, PPGIS and VGI may completely overlap (Brown *et al*. 2014; Brown and Pullar 2012; Hall *et al*. 2010). However, these two concepts, as constructed, are not identical.

As manifest in GIS/2 and later PPGIS (Schroeder 1996; Sieber 2006), VGI is advertised for the democratisation potentially emanating from it (Roche *et al.* 2013). Al Gore's vision of digital earths upon which much VGI is collected 'embraces a philosophy that any citizen of the planet, linked through the Internet, should be able to freely access a virtual world of information and knowledge resources' (www.digitalearthisde.org cited in Ehlers, 2008). verPlanke *et al*. (2010, 189) contend that this new content 'redistributes the rights to define and judge the value of the geographic information and of a new production system'. Referring to Dodge and Perkins (2008), verPlanke *et al*. (2010) continue that the repurposing of images and data – countermapping – can shift the panopticon to citizen control. Thus VGI evokes interlaced concepts of a revolution, a civic sphere that transcends jurisdictions, a space of radical inclusion, and a democracy of intellectual practice (Han 2010). These are endpoints, the aspirations of VGI, which overlap with those of PPGIS. Concepts like democratisation also articulate the means to an end, the epistemic process of how data are continually emancipated from expert control and how individuals seek access to new data sources and control over the infrastructure of those data (e.g. via APIs). PPGIS articulates the process of broadening participation in knowledge creation: how non-experts and local people come to have a voice. VGI leaves it to the device, for example how the graphical user interface manages the digital divide or whether the platform furthers the power of the private sector. The separation of means from the ends partially explains VGI's lack of embeddedness.

Grand claims about democratisation, empowerment and emancipation may be disputable for PPGIS and the use of VGI. VGI can reinforce existing structures of haves and have-nots in what areas and activities are or are not mapped (Haklay 2010). Most participation in VGI may be passively volunteered and therefore constitute neither participation nor volunteerism. Early in the framing of VGI, Tulloch (2008) described the potential for passive VGI. Instead of data produced from individuals actively engaging in contributing GPS traces of roads, data on travel paths can be harvested automatically from individuals' in-car navigation devices, with or without their knowledge. Passive VGI is also known as iVGI, involuntary geographic information (Fischer 2012), with its unintended coercive implications. By

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definition, to volunteer is to actively contribute, regardless of the actual content, as well as to possess some sense of the ends to which that contribution will be put. PPGIS embeds the contradictory tendencies of these processes, for example that the participation can simultaneously empower and marginalise (Harris and Weiner 1998). Paradoxically, VGI can be framed as embracing these tendencies and also independent of them. We argue that the assertions for VGI of democratisation, participation, engagement and empowerment are mostly banal and shallow compared with those we associate with PPGIS, which at least consider whose knowledge should be included, whether there is homogeneity of costs and benefits, and who defines the parameters of participation and its outcomes (Harris and Weiner 1998; Sieber 2006).

A key problematic in the social construction of VGI lies in the word volunteer. VGI emphasizes the individual, for example, his/her motivation to contribute. This unit of analysis constitutes a different form of collectivity from that in PPGIS, which can consist of, for example, publics, communities and volunteer organisations. Although often used in its aggregate, analysis at the level of the individual ignores communal and societal aspects. For example, we may assume agency on the side of the individual, which is sometime true but other times can occur as a passive side effect of activities like using a cellphone. Construing VGI as individual engagement diminishes the importance of social networks (e.g. for sharing, learning; see Elwood and Ghose 2004). It diminishes or at least fails to preserve institutional memory, a key component of the production of knowledge (Elwood and Ghose 2004). VGI echoes Sherry Turkle's *Alone together* (2011), a mere simulation of collective interactivity in the face of continually reproduced individual alienation. More importantly for VGI, the atomisation of participation facilitates a kind of disempowerment. When the unit of analysis is the individual, this can serve to divide and conquer, for instance appealing to individual vanity as a method of weakening collective effort.

The unit of analysis also considers the relation of individual data-point to dataset. We may wax rhapsodic about a single volunteered contribution. But the value of VGI rests in aggregation of data-points to a dataset. A single vertex means little in OSM; value is accrued in a road and ultimately a road network. Ironically, VGI is only about individuals in the aggregate. Since VGI incorporates assumptions from crowdsourcing, VGI can serve to stereotype individuals in place. We may well wonder what is lost when lived experience is subject to generalised schema and heed Duff (2010, 882) who argues that generalised places become thin, 'offer[ing] nothing to hold the self in place, and no memorable or resonant command of placial experience'. The volunteer is not merely a source of data but embodies a whole process.

VGI's references to the individuated term 'citizen' in citizen sensors denotes personal connections to place and a responsibility to democratic participation in relation to that place. Citizen sensors refer to a 'large collection of intelligent, mobile sensors, equipped with abilities to interpret and integrate that range from the rudimentary in the case of young children to the highly developed skills of field scientists' (Goodchild 2007, 26). As a concept, citizen sensing pays homage to citizen science and the empowerment pursuant to placing science in the hands of eager non-experts; usage of the term citizen also offers a refreshing departure from framing the participant as 'prosumer' (Bruns 2008). However, this definition can transform citizenship from a process of understanding one's role vis à viz state-sanctioned authority into an instrumental value. Citizen sensors become a highly underutilised resource and a utilitarian project. Utilitarianism refers to the value of an action or consequence deriving solely from its usefulness in maximising utility and minimising negative utility. Silvertown (2009, 467) points us to the 'increasing realisation among professional scientists that the public represent a free source of labour, skills, computational power and even finance'. Rather than advancing the social contract of citizenship (i.e. of individual rights and civic duty), in its extreme, citizens may become 'cogs' in the machine, which maximises utility for the users of the data.

Goodchild (2008) asserts that the skills of the cartographers are enshrined in the platforms from which VGI is created. If so then institutional power relations should be enshrined into the fabric of VGI. Prevailing ideologies of VGI can be encapsulated through crowdsourcing and the open source community. These embed the techno-libertarian view, which assumes that technology obviates the need for central government control; individual control and self-directedness are all that is required. It is from there that the false potential of democratisation is conflated with empowerment and inclusion. VGI may render the messy process of democratic participation into a hobby that is only open to those who have time, knowledge and education, of which the contributors eventually may tire. The social construction, therefore, needs to recognise this potential shallowness.

Finally, VGI is increasingly framed in terms of a volume of contributions. The concept of VGI has effectively merged with big data (Fischer 2012). This differs significantly from PPGIS, in which projects involve relatively few individuals. As the neogeographer Sean Gorman stated in a conference panel pitting 'paleogeographers' against 'neogeographers' (Sieber *et al*. 2010), 'You deal with 10's of people; we deal with millions', wearing that difference between so-called

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'small data' and big data as a badge of honour. That comment overlooked how in PPGIS the focus is on cultural information; whereas, in VGI the attention is on technological information. VGI has become so attractive because of big data that there have been recent attempts to reintroduce small data into VGI (Thatcher and Burns 2013). Whether VGI would ever approach the smallness of PPGIS projects is debatable. Smallness is relative. Goodchild's (Shelton *et al*. 2013) example of small data was federal Census data. Not only is VGI valued in terms of big data but PPGIS, to retain legitimacy, may become evaluated in relation to a property of VGI.

We have argued that VGI has been constructed to harness components of PPGIS without appreciating the implications of that appropriation. With 'V' (volunteer, volunteerism) and 'C' (citizen), VGI as conceived could actually stifle any realisation of its empowerment potential. We may need to create a pVGI, a participatory VGI. The 'p' and 'V' appear redundant but they are not. In a well considered epistemology of VGI it should be inconceivable to consider the 'societal implications of VGI' in the same way that it is unimaginable to consider the 'societal implications of PPGIS'. The societal implications are embedded in the epistemology and thus any investigation into VGI has to at a minimum consider the way the social processes influence the information itself.

Conclusion: implications for the social construction of VGI

We have argued that geographers created VGI by borrowing from various related concepts that were in turn filtered by disciplinary biases. The resulting epistemology reasserts the importance of the discipline of geography into emerging practices in which geographers and traditional GIS firms no longer seem to matter. We described how VGI encapsulates a distinct epistemology from datasets generated via traditional GIScience approaches, and information that emerges through critical GIS (primarily PPGIS). The merger of the GIScience and critical GIS approaches to geographic information production is neither smooth nor simple. By treating VGI within Borgmann's notion of technological information, we can see the separation of means and ends prevent a full consideration of impacts. Borgmann's 'device paradigm', provides a powerful lens to scrutinise this epistemology. The device paradigm posits that the deeply meaningful and socially embedded 'cultural information' that is generated through the PPGIS process mutates into lifeless VGI 'technological information' that can then be treated as if it is the reality. Moreover, by appropriating PPGIS, the epistemology of VGI reduces the space for resistance to technological logic and powerful actors.

Our aim was to render the discords visible and to argue that VGI should be approached differently when it is studied or used. This paper concludes with implications of this epistemological turn for how we now conduct VGI research, how we frame civil society participation via VGI, how we design systems, and how we advocate for the advancement of the field that assures nuanced views of participation in the face of non-participatory pressures.

GIScience researchers recognise differences between VGI and traditional data but, to a large extent, current research imposes an existing epistemology of knowledge production onto a new epistemology. In this epistemology, data are constructed by non-experts and data are continually (re)constituted. How facts are negotiated via the emergent traditions in a community like OSM can ostensibly be derived with algorithms. However, the inferences can be incorrect and erase the particularities of place. The social construction of VGI places inordinate emphasis on the elements that transform negotiation into technological information such as position. This occurs even when data-driven boundaries are deemed sufficient for many large firms. Compared with the myriad place descriptions online, geometry can replace that more nuanced understanding of place that cannot be easily processed.

The social construction holds implications for system design. GIScience may seek universal geospatial methods that can be applied deductively to big data but methods may lack uptake as insights are produced inductively with non-geospatial statistical inference analysis. GIScience can offer robust integration of the quantitative/qualitative divide and, for instance, explore ways that particularities more fully explicate big data. One is reminded of Rundstrom (1995) who related how indigenous people find insight in the noise, the outliers, thus revealing the problematic nature as knowledge becomes formalised at the data structure level. System design needs to integrate societal value. Rather than emphasising accuracy and precision, for example, we may wish to anticipate potential geolocational privacy violations and embed masking techniques to obscure location (Cavoukian 2012).

Outsourcing the production process to the crowd means separating volunteers not only from scientific norms but also institutional practices. The production of knowledge implies an entire underlying institutional structure of ethics, best practices and regulations that we should assess to understand the implications. We understand the organisational culture and the institutional frameworks under which geospatial data are generated (e.g. Nedovic-Budic 1998); these may not hold (or not be transparent) for digital communities of interest. VGI is

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not free of these structures, and the ethics and practices that are used even by seemingly egalitarian organisations need to be interrogated.

Further implications are seen in the 'V' aspect of VGI. Framing a civil society participation via VGI (and its mobile permutations) requires a conscious effort to render the technology and the way that it is used in a specific social context relevant to the values of an organisation or case study. Certainly VGI holds significant implications for PPGIS, the anonymity, the spatial distribution of contributors, the disconnection from physical activities and the heterogeneity of software and hardware platforms. Other work (Johnson *et al*. forthcoming) demonstrates that effective participation is a complicated and resource-intensive process. The process requires trust building to initiate and sustain contributions. This supports Malcolm Gladwell's (2010) contention that participation, resulting in societal impact, requires strong physical ties and not weak ties based solely on digital networking. Rules and regulations, some for good reasons like ensuring equity in representation, may prevent uptake of online content in favour of face-to-face meetings. Even as platforms advance, digital inequalities will remain and likely grow if they are left to the market.

Throughout this paper, this epistemological turn holds implications on how to conduct VGI research: the need to be aware that it is not yet another GIScience dataset or the path to a slightly updated PPGIS. We would suggest that Elwood's (2008, 174) argument that:

> existing discussions about VGI assume that their societal impacts, for better or 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 …

emphasises the use and (re)purposing of the data but misses the profound ways societal implications are woven throughout the social construction. We need to be reminded that VGI cannot be considered as 'just another data source' bereft of the societal implications embedded in it. We call for deep embeddedness of the social implications of VGI and its epistemic turn. To start, the epistemology of VGI has to be built to embed a labour relation (volunteer as free labour), a credentialed relation (expert versus amateur) and a governance relation (volunteer as citizen). Ultimately this reconstruction may require a retreat from big data, since these practices demand a level of attention and situatedness that is not reproducible at larger scales of data production.

We therefore advocate for the advancement of the field that ensures nuanced views of participation in the face of non-participatory pressures, for example by pointing to the limits of the epistemology in VGI in surmounting digital divides and the drive to instrumentalise and desecate geographical experiences through the device paradigm. A field that explicitly implicates the involvement of non-experts in the emancipation of data from expert sources and the empowerment of the citizenry should design into the system a greater offline voice in issues that impact their lives. We should learn from Leszczynski (2009b cited in 2009a) who attributes the effectiveness of critical GIS in a way that embeds the critiques directly within the frameworks of the device. All VGI research would do well to embed the social critique rather than rendering it exogenous to the core production of this new terrain of geographic knowledge.

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Notes

1 We recognise that the field of GIScience encompasses disciplines besides geography. Here we focus on the domain of geography within GIScience.
2 We accept Leszczynski (2009a)'s argument that critiques of the epistemology of GIScience or GIS enter a metaphysical muddle in which epistemology is conflated with ontology. In this article, we also are somewhat subject to the epistemology/ontology conflation and privileging of epistemology. We do not wish to deny that VGI has materiality, for which a privileging of epistemology enables. However, we take the broader equalisation of epistemology to the worldview by which truth or knowledge is produced.
3 Thank you to Matt Tenney for his assistance here.
4 Wright *et al*. (1997) were explicit on the science turn in GIS research. GIScience itself was a deliberate social construction to take on the mantle of science, which better reflected the true intent of GIS researchers. This had the added benefit of conferring greater legitimacy to the field, in terms of recognition and resources. As recent as 2014, the GIScience conference to this day discourages 'the submission of papers dealing with GIS applications' (www.giscience.org/). It should be noted that we have no argument with social construction *per se* nor with the science turn in GIS.

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