The Discourse and Discipline of GIS

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Abstract

Despite the many alternative insights produced within human geography since the height of the spatial science tradition of the 1960s and those within geographic information systems (GIS) itself, we still observe in our classrooms, hiring committees, and textbooks a dominant and singular understanding of GIS that fixes its meaning in ways that marginalize "non-GIS" geography. We are concerned about the effect that this valuation of GIS and devaluation of its others might have on the discipline of geography. In what follows, we report on our examination of the dominant discourse of GIS across a variety of sites in numerous academic, commercial, and educational sources where we found it to be repeatedly performed in ways that give particular meaning and power to "GIS." We identify four characteristics attributed to GIS by and through this widespread discourse. We then discuss the effect of this discourse and, in particular, what it might mean to the discipline of geography. Finally, we suggest an exploration of "heterodox GIS" as a discursive strategy that we should deploy in our classrooms, departments, and beyond, as well as a political project aimed at destabilizing a singular and orthodox GIS. Such strategies should not strive to undermine or negate GIS but, rather, should aim to negate the notion that GIS is a single thing, linearly progressing, inherently expanding, and universally applicable.

Keywords: geographic information systems (GIS), discourse analysis, critical GIS, feminist geography, economic geography, public participatory GIS (PPGIS), society and technology, GIS education, commercial GIS, innovation diffusion

Résumé

Depuis l'apogée des sciences spatiales dans les années 1960, un grand nombre de nouvelles idées ont été proposées en géographie humaine et pour les systèmes d'information géographique (SIG) eux-mêmes. Toutefois, dans les salles de classe, les comités d'embauche et les manuels, on note une vue dominante et singulière des SIG qui fixe sa signification de manière à marginaliser la géographie « non SIG ». On se préoccupe de l'effet que pourraient avoir cette opinion des SIG et la dévaluation des autres formes sur la discipline de la géographie. Dans l'article qui suit, on examine le discours dominant sur les SIG dans une variété de sources théoriques, commerciales et éducatives. Dans ces sources, le discours est présenté de telle manière qu'il donne une force et un sens particuliers aux « SIG ». Quatre caractéristiques ont été attribuées aux SIG dans ce discours général. On parle de son effet et, plus précisément, de sa portée possible sur la discipline de la géographie. On suggère aussi d'explorer les « SIG hétérodoxes » comme stratégie discursive à déployer dans les salles de classe, les départements et ailleurs, et en tant que projet politique visant à déstabiliser un discours singulier et orthodoxe lié aux SIG. De telles stratégies ne devraient pas viser à ébranler ni à annuler les SIG, mais plutôt à réduire la notion selon laquelle les SIG seraient une chose unique et d'application universelle, qui progresse linéairement et s'élargit de par sa nature.

Mots clés : systèmes d'information géographique (SIG), analyse du discours, SIG critiques, géographie féministe, géographie économique, SIG participatifs, société et technologie, enseignement des SIG, SIG commerciaux, diffusion des innovations

> GIS is showing the world that geography is a modern tool and it is creating a demand for geography students. I would not have stayed in geography if GIS did not exist because non-GIS geographers usually spend their career in academics and research, not problem solving daily issues like GIS does.
>
> —Anonymous student, senior-level geography, 2006

Introduction

The debates over GIS in geography are beginning to have the flavour of history, of a struggle that is somehow over. Indeed, commentary is now focused on the debates themselves (Schurmann 2000) rather than on further explication of either the promise or the dangers of GIS relative to geography and/or society, and many seem to think it is time to move on (e.g., Sui 2004). Indeed, many researchers have successfully bridged the gap that once separated the two protagonists in the debate, GIS and social theory. In terms of GIS theory and development, there has been a concerted effort to rethink questions of GIS representation and ontology (e.g., Agarwal 2005; Ahlqvist 2004; Miller 2000; Schuurman 2004, 2005; Schuurman and Leszczynski 2006; Sui and Goodchild 2001, 2003) and software design (e.g., Miller and Wentz 2003; Sieber 2004) that at least partially addresses social theoretic concerns; and, in terms of applications, there are now many examples in which even standard GIS methods and procedures are central to critical, particularly feminist, research in human geography (e.g., Cieri 2003; Crampton 2001; Kwan 2002a, 2002b; Pavlovskaya 2002; Robbins 2003). Noting the clear slowdown in confrontational engagements between GIS and social theory (Schuurman 2000), as well as the progressive and important work that has emerged from the interaction of GIS and social theory, one might have good cause to suggest that the early critiques of GIS from the late 1980s and 1990s have been effective and that critical concerns are being addressed through mutual efforts both within and outside of GIS.

Yet, the statement quoted above, from an end-of-semester essay by an undergraduate geography major,[1] speaks to an ongoing disciplining of geography into a GIS/non-GIS binary where the first term is valued, practical, and powerful while the second, as represented by the "non-GIS geographers" whose work would appear to be largely irrelevant to real-world problem solving, is devalued and marginalized in the imaginations of, at least, our students. In addition, the GIS that is desired by our students, despite our best efforts as GIS instructors inspired by innovative developments within GIS and alternative applications of GIS, is closely aligned with a particular understanding of GIS as essentially positivist, quantitative, and based on a Cartesian spatial logic, the very GIS that was central to early debates (e.g., Dobson 1993; Lake 1993; Openshaw 1991; Smith 1992; Taylor 1990; Taylor and Overton 1991; Pickles 1993, 1995) and which most would agree that we have "moved beyond." While we are enthusiastic that well over half of our undergraduate majors look to GIS for a career,[2] we are dismayed that they continue to see GIS as essentially separate from much of what we understand to be contemporary human geography.

Despite the many alternative epistemological, ontological, and methodological insights produced within human geography since the height of the spatial science tradition of the 1960s (Peet 1998) and those within GIS itself (Schuurman 2004, 2005), it is a particular GIS aligned with a narrow rendition of spatial science that now constitutes fundamental understandings of space (Miller 2000; Miller and Wentz 2003), as well as what can be considered legitimate geographic data, to a rapidly growing audience both within and outside academic geography (Pickles 1997). Despite the blossoming of critical, feminist, and participatory GIS, as well as new understandings of GIS emerging from within GIScience itself (e.g., Sui and Goodchild 2001, 2003), we observe a dominant and singular understanding of GIS that fixes its meaning in ways that marginalizes both critical reinterpretations of GIS and "non-GIS" geography generally. How this particular GIS is produced and maintained is the subject of this article, which examines the foundations of this dominant vision of GIS and how it is resistant and impermeable to alternative meanings. The work presented here makes clear the mechanisms by which GIS and critical human geography, despite advances that attempt to bridge, merge, or hybridize the two (Kwan 2004; Pavlovskaya 2006; Sui 2004; Schuurman and Pratt 2002; Sheppard 2005; Yapa 1998), are repeatedly and effectively distanced from each other in the imaginaries of our students, our colleagues, and university administrators.

The goal of this article is to explain the separations that underlie and support GIS. To do so, we refer to GIS not as a tool, a technology, or an emerging science but as a product of discourse, a *discourse of GIS* that is performed across a variety of sites, both academic and non-academic (Wing 2004). We contend that the dominant discourse of GIS not only constitutes GIS but also attributes to it particular characteristics that make the ongoing definition of GIS as positivist and quantitative possible, as well as a progressive distancing of social theory and other approaches in human geography. What is at stake, and what may have been at stake in the debates of the 1990s to all participants (compare Schuurman and Pratt 2002), is not the acceptance or rejection of GIS as a method, technology, or science per se but how GIS will be understood relative to other practices of geography; how it will come to represent space, society, environment, and economy at the expense of other representations; and how

it will come to represent geography itself (as it now does across a variety of sites).

In what follows we report on our examination of the dominant discourse of GIS across a variety of sites, where we found it to be repeatedly performed in ways that give particular meaning and power to ''GIS.'' We begin by characterizing the dominant discourse of GIS as it appears within the texts, corporate Web sites, and course syllabi that we examined. Our research suggests that particular qualities and characteristics are consistently attributed to GIS; these include an image of GIS as a single thing, as linearly progressing, as inherently expanding, and as universally applicable. We then discuss the effects of this discourse – in particular, how it facilitates an ongoing devaluation of non-GIS practices and theorizations within geography. Lastly, we call for a heterodox GIS that would build upon critical GIS applications but would increase the sites where the production of an orthodox GIS might be disrupted.

> The importance of practice cannot be overstated, as change will not occur through trenchant critiques alone, but through everyday struggle with the technology in GIS labs or ''sites'' of all kinds. (Kwan 2002b)

In addition to interventions within ''the lab,'' there are, as Kwan suggests, other sites in which to engage and struggle, other sites – such as textbooks, Web sites, classrooms, hiring committees, and hallways – that give GIS its meaning. Viewing GIS as discourse helps to locate such other sites and, we hope, points to additional ways by which to produce a critical and heterodox set of GIS practices.

The Discourse of GIS

> The process of analyzing a discourse highlights the contingency of its alignments and reveals it as an attempt at stabilization. It thus simultaneously suggests its vulnerability to destabilization and reconstruction. (Gibson-Graham 2000, 106)

While GIS can be thought of as, for example, a technology, a science, or a set of practices (Schuurman 2004), we choose to examine GIS as a discourse. The discourse of GIS is produced and maintained through a variety of speech acts, texts, institutions, and practices in many locations (e.g., hiring committees in geography departments, undergraduate courses and textbooks, software training programs, vendor advertising and public relations, and professional associations) that share a common understanding and characterization of GIS. We have found a discourse that produces a particular GIS with particular characteristics that cohere across multiple sites and suggest to participants in the discourse the function and potential of GIS. This discourse does not reduce to the work of individual researchers who work with or on GIS; rather, it is a discourse produced by a variety of actors across many sites, not the least of which are the classrooms, committees, and conferences that produce GIS within academia. Within the discipline of geography, the discourse of GIS not only affects students' understanding of the discipline, its future, and their prospects for employment but also works to distance and differentiate GIS from non-GIS. The specific characterization of GIS serves to make clear that which it is not and to make possible its valuation relative to that which it is not (compare Gold 2006).

Critical approaches to GIS that do not employ a discourse approach effectively focus on the negative effects of GIS as an essentially positivist and quantitative tool for the production and manipulation of objects within an absolute space (Lake 1993; Taylor 1990). In these critiques, GIS is also characterized as a tool for imperialist wars of aggression (Smith 1992), as yet another mechanism for capitalist expansion and domination (Goss 1995), and as the tool of choice for invasive forms of surveillance (Curry 1997). Such critiques have produced a single entity that continues to live and grow, perhaps in peace or perhaps not, in geography departments and elsewhere. The omnipresence and the ever-expanding domain of this GIS make it difficult to imagine any alternative notions of what is GIS or how it might be used. That is, despite any qualifications that may or may not be present within these critiques, they are read not as better understandings of GIS's embeddedness and context (compare Chrisman 2005) but as condemnations of GIS as being essentially an extension of oppressive and powerful structures of society and economy.

We do not seek to diminish the importance or the compelling nature of the critiques of GIS. Indeed, we owe an enormous debt to the critical observers of GIS who warned and who continue to warn, albeit with less frequency (Schuurman 2000), of the effects of a narrowly defined and implemented GIS. It is precisely their insights that spur us to destabilize the very GIS to which they point. As teachers and practitioners of GIS, however, we find the essentialist nature of past debate stifling. That is, we find it difficult to both inspire students toward the potential of GIS and encourage them toward its critical rejection. Having students read, for example, Dobson (1993) and Smith (1992) simultaneously simply reinforces an essential and single reading of GIS that must be embraced or critically rejected (or embraced along with a deep guilt that the pleasure of overlay analyses is but the corrupting power of a necessarily positivist science aligned with global capitalism and wars of domination).

In addition, since the GIS debates of the 1990s, critique has turned to critical engagement with GIS technologies. Indeed, critiques from the ''outside,'' once derided by ''GISers'' (e.g., Openshaw 1991), are now also

frowned upon by critical GIS practitioners themselves (e.g., Schuurman and Pratt 2002). While we applaud any critical engagement with GIS technology, we do not want to forgo an interrogation into the discourse of GIS and its effect on geography or on society. That is, while such alternative engagements with GIS technologies recast GIS and give it new meaning, often by refuting the assumed essential characteristics of GIS, there is a host of sites (e.g., classrooms, committees, conferences, hallways, Web sites, and corporate PR materials) in addition to ''the lab'' where the meaning of GIS is produced in strikingly orthodox ways. Engaging with GIS technologies is clearly necessary; it may not, however, be sufficient as a means to alter how GIS is understood, how it is taught, or how it sits within geography more generally.

LOCATING THE DISCOURSE OF GIS

Within the discourse of GIS, the metaphor of GIS as an objective technology reinforces its isolation from a host of other social, economic, and ideological processes (Chrisman 2005). Despite academic work that has attempted to broaden the definition of GIS to include, for example, institutions and social actors, the discourse of GIS repeatedly makes reference to GIS as a single technology emerging from a 1960s interest in quantitative methods for spatial scientific analyses. It may be important to consider the institutional setting in, for example, implementation studies of GIS (e.g., Huxhold and Levinsohn 1995), but these institutions and actors are not redefining GIS, they are merely adopting it (compare Sieber 2000). Everett Rogers' model of the diffusion of innovations (Rogers 1995) is frequently used to describe the rapid and widespread use of GIS (e.g., Chambers and others 2004; Goodchild 1998; Longley and others 2001; Rogers 1993), and it captures well many of the qualities assumed by and within the dominant discourse of GIS.

Rogers' work on innovation diffusion has been cited in many social science studies and by businesses and policy-making institutions to understand the process of adopting innovative ideas, practices, or objects. Indeed, GIS has been viewed and treated as one such innovation by Rogers himself (1993; see also Chambers and others 2004). According to the laws of innovation diffusion, an innovation is adopted at a certain rate described by an S-shaped curve. Early on, *innovators* adopt the new idea or technology. They are followed by *early adopters*, the *early majority*, the *late majority*, and finally the *late adopters* and *laggards*. The stages of adoption correspond to locations along the S-shaped curve, with innovators at the bottom and laggards at the top. Rogers identifies innovators as the leaders in their fields. These earliest of adopters are characterized as venturesome and risk-taking; they are role models for their colleagues. Late adopters are sceptical and adopt a technology only after their innovating peers have brought it into the main stream. Laggards, the last to adopt, are oriented to the past and resistant to new ideas or technologies (Longley and others 2001).

Within the discourse of GIS, GIS is clearly well beyond the stage of initial adoption by innovators and is approaching the top of the curve, the point at which those resistant to this technology are beginning to realize its local potential (Goodchild 1998). As a mature technology, GIS has only to convince late adopters as to its efficiency and inevitability. In this case we must assume that recent developments in/of GIS in fields such as history, feminist studies, and critical social science are not so much innovations as the late adoption of a single technology by those who were initially resistant. The metaphor of technology suggests that today's GIS is the same technology, albeit improved, that emerged in the 1960s. As used within the discourse of GIS, Rogers' model unifies the diversity of understandings and applications of GIS as an ever-widening adoption of a single technology.

We found the story of diffusion consistent with a larger discourse of GIS that we located in a wide variety of texts/sources. We reviewed academic sources, particularly exchanges between critics and advocates within the GIS debates of the last 15 years. These helped us compare characterizations of GIS by those who use and support it with characterizations of GIS by those who, at least partially, reject it. We analysed GIS trade journals, Web sites, and other texts produced by the commercial GIS industry. This let us document the ways in which GIS is defined and characterized by those outside academia, what aspect of the technology they emphasize, how claims about the capability of GIS are made, and how particular companies influence these processes. Finally, GIS textbooks, class syllabi, and implementation/training strategies were also examined to better gauge the GIS to which our students are most often exposed.

The sites where we found the discourse of GIS reflect our own histories and biases. We are academics who teach GIS and use it in research; one of us has worked for a producer of GIS software, and one of us has engaged with GIS from the purview of another discipline (history). Where we find ''GIS'' is, therefore, biased toward those texts and other sites that an academic might encounter: GIS textbooks and training materials; GIS corporations whose software is used in education and research within academia; and the variety of speech acts about GIS that one finds within departments, seminars, conferences, and the self-reflections of geographers. The situated nature of our analysis is acceptable because it is within academia that we are hoping to be heard and to produce an effect, particularly in teaching, which is an important site for the constitution of GIS and, therefore, for critical intervention.

Below we briefly focus on the recurring themes of the discourse of GIS that we found: its characterization as a

singular technology, as progressing along a single and linear path, as inherently expansive, and as universally applicable.[3] The first two themes are related to the inherent qualities of GIS and its development, while the latter two characterize all locations, all possible sites of GIS application, as inevitably open to and compatible with GIS. These elements of the discourse of GIS support essential assumptions of GIS, such as its reification of a particular notion of space and its ability to define what are and are not legitimate geographic data.

A SINGULAR TECHNOLOGY

GIS as a singularity is evident in specific sites where the discourse of GIS is performed. These include corporations, education, academic debates concerning GIS, and histories of GIS. Throughout these locations, GIS is spoken of as a singular technology. In the case of corporations, it is clearly in their best interest to represent GIS as a singularity, one produced and maintained by them. That is, representing GIS as other than the technology they sell and on which they are the experts would counter their goal of capturing market share and profit. They are, after all, trying to convince the buyer that their product is most representative of the essence of GIS and its potential. Software companies promote, develop, and distribute GIS as a non-variant and essentially unchanging object, open only to future perfection.

> During the 1980s ESRI devoted its resources to developing and applying a core set of application tools . . . to create a geographic information system. This is what is known today as geographic information system (GIS) technology. (ESRI 2006a)

In the corporate literature, GIS is treated as a single innovation that diffuses out to ever more sites of application (given the right socio-economic conditions); where GIS is clearly not a single software but is made up of related tools, it is ''a family of software products that form a complete GIS'' (ESRI 2006a).[4] The characterization of GIS as a single technology by corporations that sell software greatly influences how GIS is characterized within the classroom, where GIS is taught as a technological entity that often reduces to a single software product, thanks to the unusually close correspondence between corporate GIS software and GIS as taught. Classroom texts reinforce the singularity of GIS in the way they introduce GIS to students. We noted the prevalence of references to Rogers' model on the diffusion of innovations (Rogers 1995) or to similar stories of the innovation of GIS and its adoption across a standard list of sites (e.g., municipalities, government agencies) in introductory texts (e.g., Longley and others 2001). This narrative is used to explain the dynamic spread of GIS to an ever-widening audience, but, in so doing, it necessarily constructs GIS as a singularity (see also Rogers 1993; Goodchild 1998).

Like standard textbooks for teaching GIS, the academic debates over GIS also produce it as a singular technology that embodies a specific way of doing research. For example, in the first wave of debate (see Schuurman 2000 for a summary of the GIS debates over three waves through the 1990s), critics asserted GIS's ties to the quantitative revolution and the positivist spatial science of the 1950s and 1960s (e.g., Bondi and Domosh 1992; Lake 1993; Taylor 1990). In these critiques, GIS's ''nature'' is to interpret patterns of geographic facts, which, for the discipline of geography, is ''intellectually sterile-high-tech trivial pursuit'' (Taylor 1990, 212). Second-wave critiques may have been more nuanced and more focused on the material and ethical effects of GIS, but within them GIS remains a singularity with an inherent nature (e.g., Curry 1995). There was from the beginning of these debates a mutual understanding as to what is GIS and what its attributes are. Little was done to rectify the discursive treatment of GIS: ''GIS has been somewhat homogenized, regarded as a single entity rather than a loosely defined set of practices'' (Schuurman 2000, 586).

Finally, historical reflections on GIS contribute the same sense of GIS's wholeness and singularity. They present stories of the origin of GIS as a coming together of various spatial analytic ideas and the new computer technologies that allowed for their realization. GIS, once constructed, becomes a sort of magnet that subsumes a wide range of geomatic and spatial analytic practices (e.g., Foresman 1998). What had been a great diversity is captured within and becomes the singularity that is GIS. The image of GIS as unifier is, of course, one of the central tropes of the discourse of GIS and is repeated across the sites where GIS is performed.

PROGRESSING ALONG A LINEAR PATH

Closely related to the first theme, and equally prevalent, is the characterization of GIS as continually progressing and developing. The dynamism and ongoing innovation of GIS, however, proceed along a unitary path originating from a single source, such that underlying technological and ontological conceptions remain intact (e.g., Forrest 1998). For example, despite the possibility of multiple representations of space, the foundational casting of space in Euclidean terms remains dominant (Miller 2000; Miller and Wentz 2003). Since the essential framework for GIS is already established, change and innovation are within the realms of greater efficiency, user friendliness, and application expansion, requiring almost annual updating of software. Corporate sales materials and Web sites link these ''innovations'' closely to client profitability, and much of what passes for innovation is the customization and repackaging of GIS to enable its infiltration of

sites where it was previously unimagined. Once the initial foundations are established, innovation is driven by market forces and commercial competition (Dangermond 1991).

> GIS technology must constantly evolve to meet the changing needs of business, industry, government, and education. (ESRI 2006b)

The narrative of innovation and competition is transferred directly into classrooms, where software choices and decisions by instructors to teach (demonstrate?) the latest ''add-on'' must be made anew each semester. Textbooks reflect this logic in their discussions of GIS innovations and future development. There, technological advances in speed, storage, cost, and ease of use are what should be considered and weighed by GIS users when they come to make their own decisions concerning software options (e.g., Heywood, Cornelius, and Carver 1998). The range of what constitutes innovation in GIS is reduced to a shopping list of criteria that are also the bases for corporate competition. Indeed, since GIS already ''provide[s] secure and established foundations for analysis'' (Longley and others 2001, vii), it has moved beyond the point of reconsidering, for example, its conceptual foundations. This state of affairs is in sharp contrast to advanced research in GIScience where ontological and representational foundations are being rethought (e.g., Agarwal 2005; Ahlqvist 2004; Miller 2000; Schuurman 2004, 2005; Schuurman and Leszczynski 2006). Nevertheless, within the dominant discourse of GIS, innovation is enhancement rather than divergence from foundations.

INHERENTLY EXPANSIVE AND GROWING

The third major theme found within the dominant discourse is that GIS use and application are continually and inevitably expanding. The production of a single and homogenous entity, the object of the discourse of GIS itself, suggests an origin from which GIS emanates and a frontier into which it expands (the rate of which is captured by the diffusion-of-innovation story). The expansion of GIS includes a colonization not only of actual locations (e.g., the growth of GIS in Eastern Europe) and applications (e.g., GIS use in municipal waste management) but of disciplinary sites as well (e.g., economists discovering the power of GIS). Perhaps not surprisingly, it is within corporate enterprises that the discourse of GIS most clearly articulates an inherent expansion and, eventually, the ''enabl[ing of] every business and government worldwide . . . to harness the power of location'' (MapInfo 2004). The goal of GIS corporations is to ''bring GIS to the world'' such that ''every industry benefits'' (ESRI 2006c). To see GIS as expanding to all possible locations is, of course, part of standard corporate and GIS-industry boosterism.

> Their [ESRI employees'] contributions have a real impact not only on the next generation of GIS technology and services, but on society and the world, continually extending the power of geography. (ESRI 2006d)

Yet the narrative of expansion and growth of GIS suggests something other than propaganda to encourage corporate investment. Within this discourse, GIS represents not just a new or better product capturing market share but a new way of thinking and representing that is necessary to capture and reflect a new socio-economic reality. Spatial thinking, visualization, and the manipulation of a spatialized socio-economy are clearly on the agenda, and GIS is the necessary technology for mastering these processes and trends. In this sense, GIS is strongly allied with emerging spatial discourses of the economy itself (e.g., globalization) and its development, expansion, and intensification. The conflation of GIS with a global economy is evident not only in the glossy promotional materials of GIS corporations but, perhaps not surprisingly, in those earlier critiques of GIS that saw it as allied with the structures and forces of a global hegemonic regime of power (e.g., Smith 1992; Pickles 1995).

For our purposes, we point to the similar discursive moves that constitute GIS and a global economy. Both the discourse of GIS and that of the economy constitute a singular and homogenous object; both facilitate a vision of development of that object along a unitary path; and both suggest a frontier, a location of pre-development, into which that object can expand and penetrate (compare Gibson-Graham 1996). In so doing, both are seen to transform what came before into more efficient and profitable systems of industrial production, governance, resource management, and public information delivery. For GIS, as for the capitalist economy, the frontier is virtually any site where it is not yet established. These sites, essentially representing the past, either are producing information and maintaining systems of management that are non- (and not yet) spatial or rely on outdated technologies (e.g., analog maps). In either case, GIS is represented as the inevitable digital and spatially savvy future toward which all systems are necessarily evolving. The application of GIS will expand, lest our economy and society move backwards; GIS is the single tool for the spatialization of the socio-economy, and, as such, it is as inevitable as the capitalist economy itself.

GIS textbooks also contribute to this notion of diffusion and limitless expansion. For example, Michael DeMers (1997, 7) writes that ''the potential users of GIS are nearly limitless, and the types and numbers of users are growing at a logarithmic pace. This growth is indicative of the nature of GIS as an empowering technology.'' In this text and others, the expansion of GIS into an infinite number of sites is due to its inherent nature rather than to any corporate marketing strategy, government initiative, or

cultural obsession with digital technology. GIS diffusion will continue, and the technology will "penetrate more deeply," since utilities "have still not completed the implementation of their systems" and "many organizations" have not yet made a full commitment to GIS (Korte 2001, 46).

UNIVERSALLY APPLICABLE

The fourth theme found in the dominant discourse is the characterization of GIS as simultaneously a science producing abstract and universal truths and a mode of understanding and practice that is universally applicable. Its universality, like the other characteristics of GIS described above, is performed in business texts and on Web sites as well as in educational texts and other academic commentaries on GIS.

GIS as a positivist scientific endeavour is, like all science, concerned with the production of universal statements, and we are not surprised that GIS makes such claims for itself. While these claims have been tempered as a result of past debates that have served to produce a good bit of epistemological reflection on the part of GIS practitioners (e.g., Wright, Goodchild, and Proctor 1997; Schuurman 2002), the basic scientific thrust of GIS remains clear. Indeed, the recent redefinition of GIS as GIScience, in academic journals and other sites, could be read as the defence of GIS relative to criticisms that it is merely a "tool" that is, in many ways, concrete, contingent, and local. While "science," rather than "tool," certainly better captures the complexity and sophistication of current GIS practices (Wright and others 1997), it also marks GIS as striving toward, if not already achieving, universal truths and insights. GIS, as science, is in league with other hard sciences, whose products are truths that can be seen and, given the right conditions, applied in all locations.

The discourse of GIS, perhaps because of the dominance of corporate interests, constitutes the universalism of GIS largely in terms of application. That is, the discourse of GIS relies less on a deference to "science" than on the immediate and practical relevance of GIS to all problems of spatial analysis and spatial decision making to suggest its universality. Indeed, "we are in the fortunate position of having both the technical and the political means of bringing the people of the world together to deal with the world's problems" (Jack Dangermond, ESRI CEO, quoted in Bernhardsen 2002, x). Insofar as all sites can be, and increasingly are, read within or relative to a discourse of Cartesian space and the manipulation of objects within that space, GIS is not only useful but inevitable. All sites are necessarily open to GIS and, in many ways, deficient without its ability to produce the ontological frame by which all phenomena can be categorized, organized, manipulated, analysed, and governed. Indeed, GIS can

> analyze river networks on Mars on Monday, study cancer in Bristol on Tuesday, map the underclass of London on Wednesday, analyze groundwater flow in the Amazon basin on Thursday, and end the week by modeling retail shopper in Los Angeles on Friday. (Openshaw 1991, 624)

While Openshaw's now famous remarks about the potential of GIS may exaggerate what GIS practitioners can or care to do, it (as well as repeated references to it) captures well a discursive production of GIS evident in the breadth of texts that we reviewed. There, in more subtle terms, GIS is produced as universal, as applicable to virtually any situation or phenomenon that can be wrestled into a Cartesian grid:

> Our technology helps fight forest fires, determine new national boundaries during peace negotiations, find promising sites for fast-growing companies, rebuild cities around the world, support optimal land use planning, route emergency vehicles, monitor rain forest depletion, contain oil spills, and perform countless other vital tasks every day. (ESRI 2006b)

This discourse of GIS, performed across a number of sites including corporate materials, educational texts, and commentaries and debates about GIS, insists that GIS is a single entity, built on a stable foundation and progressing along a single and linear path. In addition, all possible locations and sites of application are open to that GIS – its inevitability and universal applicability are clear to all. This characterization gives GIS its authority and its power to discipline geographic inquiry into positivist, quantitative, Cartesian understandings of an objective spatial reality.

The Effects of "GIS"

The student comment that begins this article illustrates well several of the most obvious effects of the discourse of GIS, which are important to consider as we negotiate the relationship between GIS and the discipline of geography more broadly. We read the statement as reflective of a discourse that disciplines human geography in particular ways, produces and maintains a GIS/non-GIS binary, and produces a limited imaginary as to what "moving on" might look like.

DISCIPLINING GEOGRAPHY

The elements of the discourse of GIS, once united, for example, in a story of innovation diffusion and performed within the discipline of geography, corporate PR materials, government agencies, and educational settings produces an entity and a mode of doing geography that are recognizable as GIS. In addition, as a singular, universal, and expanding entity or mode of science, GIS is easily cast as the modern face and future of the discipline of geography. In this sense, it performs a similar rhetorical

function to the spatial science of the 1960s, to which it is allied. That is, GIS is positioned as the new orthodoxy, the modern progressive form of geography separate from other, increasingly archaic, forms.

Within this discourse, GIS becomes the active valued term in the GIS/non-GIS binary so clearly articulated by the student quoted above and so often repeated by many others. Indeed, our admonitions against a narrowly defined GIS seem only to deepen students' desire to align themselves with it and to oppose that which it is not; increasingly, when we ask our students, "What is geography?" their answers are given in terms of "GIS." This GIS is made stable, powerful, and attractive by denying its non-GISness, its subjective, qualitative, and contingent nature, which is relegated to other spheres of inquiry that are both devalued and disparate. GIS captures and unites a discipline that our students otherwise find difficult to clearly define or represent. Finally, and most troublingly to us, it is an empowered GIS that, itself, appears to "solve problems" and to be applicable to "daily issues," rather than the geographic ideas, methods, insights, or theories that are deployed through GIS (see Longley and others 2001, vi).

We are concerned about the effect that this valuation of GIS and devaluation of its others might have on the discipline of geography. That is, at a disciplinary level, the stability and impermeability of GIS make it not only resistant to social theory but active in the devaluation of social theory (insofar as social theory remains the other of GIS). It is not so much that GIS ignores the last several decades of advances in a social theory–informed human geography (Pickles 1997) but that those advances are devalued not only in the eyes of geography students but across a wide spectrum of sites where geography becomes defined as/by GIS. We have seen this dynamic before:

> And, at a disciplinary level, witness how spatial analysis has been constructed over and against alternative versions of geography. The power operative in the designation "spatial analysis" is of a disciplinary form. It includes both the power to mark a shift in geography – "did it start with Schaefer or before?" – and the power to designate which forms of research shall in the future qualify as spatial analysis. This sort of power is precisely what enabled spatial analysis to sanction regional geography as the Other to its categorical designations: objective, explanatory, quantitative, rigorous, analytical. And though different binaries are at work today, spatial analysis continues to enjoy the fruits of its association with the natural sciences and with "hard" social sciences such as economics, as well as with technologies such as GIS and remote sensing. (Dixon and Jones 1998, 253)

Similarly, Neil Smith (2005), writing more than a decade after his often-cited article aligning GIS with the Gulf War and with global hegemonic structures generally (1992), reminds us that GIS continues to expand, discipline, and subject despite several years of debate and an eventual critical engagement with GIS:

> The multiplicity of social theoretical perspectives makes [the discipline of geography] an enviable domicile compared with the doctrinaire narrowness of economics, say, or political science. Gone since the postwar era is the withering definitional retort: "but is it geography?" And yet a significant backlash has already set in. Some of it rides on the back of Geographical Information Sciences (GISci), reasserts the power of a narrow scientific positivism, and reframes the discipline as a spatial science in the service of technocratic power. The disciplinary power of GISci is undoubtedly greatest in the United States, but it is also strong in East and South Asia as well as Eastern Europe. (Smith 2005, 889)

We join Smith in his concern for the power of GIS to discipline, to produce geography and other sites in its own image. Contrary to Smith, however, we emphasize the discursive and always ongoing constitution of GIS (compare Chrisman 2005); we are interested to see an alternative discourse of GIS emerge, one in which the diversity of GIS is not only evident in individual, and marginal, cases but enacted across all sites where GIS is performed.

While the discourse of GIS facilitates a binary and ongoing devaluation of non-GIS within geography, recasting GIS as discourse also opens up GIS to new understandings, theorizations, and applications; it transforms GIS into a potential site for "radical heterogeneity" (Gibson-Graham 2000). Doing so requires an ongoing rereading of GIS, which we briefly contrast below with a palpable desire by many, both inside and outside GIS, to reinvent and/or reclaim GIS.

REINVENTING AND RECLAIMING GIS

The discursive production of GIS as singular, universal, and expanding makes difficult an imaginary of GIS as mutable or diverse (see also Sieber 2000). To suggest a GIS that incorporates, for example, the interests or vision of various critical social theoretic perspectives is, then, to suggest an alternative GIS, a new software and institutional entity that might be related to but would be fundamentally different from what is now known as GIS. The discourse of GIS itself produces not an imaginary of transformation of GIS (for it is GIS that gets to transform) but its replacement by a "GIS/2" (Sieber 2004). The call to reinvention, particularly to produce a new GIS that is aware of and somehow responds to social theory concerns, has been proposed by both GIS practitioners and social theorists (e.g., Wright and others 1997; Pickles 1997). Others have suggested innovations in the software itself as a way to address the concerns highlighted by social theorists (Sieber 2004). While we applaud any effort in the direction of a GIS/2, we do not want to wait for

the installation of a GIS/2 to realize a disruption of or critical engagement with GIS (compare Gibson-Graham 1995, 1996).

Rather than reinventing GIS, others have worked to reclaim an existing GIS and have deployed it in critical ways. In particular, feminists have taken the lead in reclaiming GIS methods and blurring the boundary between GIS and social theory (e.g., Cieri 2003; Kwan 2002a, 2002b, 2002c; McLafferty 2002, 2005; Rocheleau, Thomas-Slayter, and Edmunds 1995; Pavlovskaya 2004; Schuurman and Pratt 2002). This work makes clear that there is no necessity for GIS to be a conduit for positivist, quantitative, or instrumental research (Pavlovskaya 2006; Schuurman 2002); there is no essential or immutable GIS. Rereading GIS is, of course, not limited to feminist interventions. See, for example, the work being done in participatory GIS (e.g., Craig, Harris, and Weiner 2002; Harris and others 1995; Sieber 2006), political ecology (e.g., Robbins 2003; St. Martin 2005; Yapa 1991), cartography (e.g., Crampton 2004), and, increasingly, other social science and humanities disciplines where the use and limits of GIS are being critically reinterpreted. The effect of producing alternative understandings and alternative uses of GIS is captured by the current term ''critical GIS'' (Harvey, Kwan, and Pavlovskaya 2005; Kwan 2002b; Sheppard 2005). Yet the discourse of GIS, as performed in a host of sites, continues to produce a particular and essential GIS (positivist, universal, expanding), despite critical GIS interventions. The power of GIS may be harnessed by local initiatives or grassroots organizations, but GIS, within the dominant discourse, remains unchanged by such projects (Sieber 2000). In this sense, GIS repositions critical interventions as within its potential, as part of its universal applicability, rather than as disruptive of its essential nature. If this is the case, are we to assume that post-structural feminists rethinking of GIS is but another application, rather than transformative of GIS itself? It is imperative that we not stop at the knowledge that a critical GIS exists, or might exist, alongside or subordinate to an orthodox GIS, such that the latter alone continues to garner power, funding, and students' attention.

We note the strong parallel within the discipline of economics, which harbours a hegemonic and orthodox theory of economy (i.e., neoclassical economics) as well as alternative ''critical'' approaches (e.g., Marxian or feminist economics). The latter have been positioned as marginal within economics (Garnett 1999; Wolff and Resnick 1987), while orthodox approaches expand and colonize other disciplines (Zein-Elabdin and Charusheela 2004). We hear the arrogance and imperialism of economics echoed within the discourse of GIS (Taylor 1990). While critical approaches have always effectively refuted essentialist understandings of economy (and the discipline of economics), their potential has recently been enhanced by an emerging discourse of economic diversity and disciplinary plurality, a call within economics for ''heterodoxy'' in research and teaching (Fullbrook 2002; Garnett 2005). While critical GIS expresses well and emerges from the concerns of critics of GIS (of its limitations and essential nature), the term ''heterodox economics'' within economics suggests a disciplinary project and a strategy to produce a future in which economics is open and open to multiple readings of the economy. For this reason we are concerned to ''move beyond'' the debates of the 1990s by, as in economics, instituting a disciplinary call to heterodoxy as well as a celebration of ''critical GIS'' applications.[5]

We would like to suggest and explore the initiation of a ''heterodox GIS,'' an alternative discourse of GIS performed throughout our discipline that presumes and insists upon an understanding of GIS as diverse. To be clear, we are not calling here for the use of a new term to replace ''critical GIS''; rather, we are pointing to what we think is a useful concept (borrowed from economics) that captures not only an ongoing critique of GIS technology and application but also, importantly, a *disciplinary-level* redefinition and repositioning of GIS. The latter is a discursive strategy that we should deploy in our classrooms, in our departments, and beyond as well as a political project aimed at destabilizing a singular and orthodox GIS. In addition, as in economics, the representation of GIS as multiple might also provide a way to critically re-conceptualize the expansion of GIS into other disciplines and social sites as other than a ''GIS imperialism'' (compare Fine 2002).

Adopting GIS

While there are many strategies to represent GIS differently, to contribute to the production of a heterodox GIS, we will here focus briefly on two. The first is a strategy of re-representing recent ''adoptions'' of GIS as rereading GIS such that it is open to a variety of epistemological and ontological starting points. To return to the story of innovation diffusion, these are not examples of ''late adoption'' of a single and monolithic technology, or sites of ''GIS imperialism,'' but the work of innovators who choose to rethink and alter what is possible with GIS. Indeed, sites of recent colonization are precisely where the discourse of GIS is most tenuous, where fissures and openings may be most obvious. It is here that the end of a GIS imperialism may be in sight. The second strategy is that of re-representing GIS within the classroom. As a site where we can effect change and produce relevance, the classroom is often overlooked in favour of sites where we can directly affect, for example, public policy (Staeheli and Mitchell 2005).

COLONIZATION OR EXPERIMENTATION?

Our example emerges from a larger project in which we assessed late adopters and their definitions and uses of GIS. We reviewed research initiatives from history, geography, anthropology, religious studies, and East Asian studies that displayed characteristics contradicting the discourse of GIS. We attended specialized conferences and monitored electronic discussion forums to document the most recent projects and future directions. It became clear that late adopters are not people or disciplines that are slow to adopt an orthodox GIS. They are, rather, initiators of a critical reinspection and rereading of GIS. Instead of asking why it has taken so long for some people to adopt GIS or to conform to the technology, we have investigated the discursive constitution of GIS and how that has produced barriers to alternative readings and uses of GIS. Late adoption is here reinterpreted as an overcoming of those discursively produced barriers and as evidence of the possibility of a heterodox GIS.

The standard late-adoption story is problematic when we examine the specifics of the late adopters and what they are adopting. That is, their adoption of GIS is invariably contingent upon an alteration of the discourse of GIS; some aspect of the discourse is disrupted. For example, late adopters used it as a template for subjective mapping (e.g., St. Martin 2005), to represent alternative notions of space (e.g., Bol 2004), to counter hegemonic forms of representation (e.g., Cieri 2003), or to facilitate democratic decision making (e.g., Craig and others 2002). What is evident is not the expansion of GIS, its penetration into all sites, but the emergence of multiple sites of negotiation and experimentation with GIS.

We briefly turn here to an example from the discipline of history, where GIS is viewed with suspicion. For example, Robert Sweeny (2004) suggests that the spatial structuring of GIS "can deny the significance of long established ways of knowing" in different societies, as documented by historians. To illustrate the incompatibility, Sweeny points to the complex and culturally grounded sense of Montreal's place in the world throughout the nineteenth and twentieth centuries, a construction of place that would be essentially unrecognizable within GIS. GIS's "positivistic assumption of a real world that is ontologically distinct from culturally laden understandings soon proves unworkable [for historians]" (Sweeny 2004). Similarly, William Thomas (2004) argues that GIS is antithetical to the goals of "spatial history," and the positivism and empiricism that the GIS discourse promotes are rejected.

Peter Bol notes similar limitations of GIS in his work. He argues, however, that the claims of GIS should be counteracted by promoting an open-ended and cumulative form of GIS. Bol studies conceptions of space in Chinese history; "the representation of space as bounded territory on Chinese maps is a Western import, in contrast [to] the Chinese tradition of locating oneself relative to a hierarchy of settlements," and for many centuries the Chinese "saw little to be gained from drawing borders" (Bol 2004). Rather than rejecting GIS as incompatible with representations of Chinese ontologies of space, however, Bol developed the China Historical GIS whereby a hierarchy of administrative centres is represented as points rather than as bounded territories. The digitized points provide "a base GIS platform for researchers to use for spatial analysis, temporal statistical modeling, and representation of selected historical units as digital maps" (Bol 2004). Searches of the database are carried out using typical GIS constructions and existing GIS software, but the database itself and the corresponding maps have been modified to reflect the unique conceptions of space held by Chinese administrators 1000 years ago. Without the GIS, Bol would not have been able to catalogue, comparatively map, and analyse historical Chinese sociopolitical, religious, physical, and economic geographies.

Other disciplines are "adopting" GIS, assimilating it relative to their own needs and understandings of, as in the case above, space. It would seem, however, that researchers outside of geography are not subject to the discourse of GIS, insofar as they do not see it as a single entity, immutable and penetrating. They reread GIS as a partial answer, as containing elements they can use and others they reject or clearly qualify. Might the age of imperialism, the exportation of GIS (as is), be ending? Are we now seeing, or can we conceive of, a "reverse imperialism" whereby content is being imported into GIS from other fields and sub-fields of geography (compare Davis 2004)?

TEACHING HETERODOX GIS

An intervention that opens GIS to a variety of possibilities is vitally needed. Today, thousands of geography students in almost every department of geography are being introduced to GIS, as are innumerable clients of GIS training and certificate programs. In these environments, designed to teach techniques for spatial analysis and, in many cases, competence in a particular GIS software package, a single and specific way to understand space and spatial processes is also taught. Lessons and exams test students' mastery of spatial science techniques, quantitative methods, objectivist ways of knowing, and positivist methods for decision making. Such work establishes not only what is GIS but, to increasing numbers of students, what is geography. Other understandings of space, ways of knowing, and approaches to knowledge production or policy intervention are marginalized in the employment and career imaginaries of inductees to GIS.

We, as academic geographers, are in a unique position insofar as our departments teach GIS, hire GIS instructors

and researchers, outfit labs with GIS software, and consult as GIS experts; yet, while in these positions, we continually suggest that GIS is invariable and stable, despite what is clearly a great degree of variation, adaptation, customization, and diversity of applications. We perform its fixing and centring, contrary to our more recent disciplinary traditions. We wonder why, given many years of critique, given innovative critical work in GIS, and given the desire on the part of all parties in the GIS debates to engage productively with each other, we continue to teach and otherwise reify in our departmental duties an orthodox GIS. More specifically, why has there been so little discussion of instruction as a site for the transformation of GIS?

Recent trends within economics again offer a useful comparison here. The economics curriculum is, by some accounts, closed and singular, dominated by neoclassical economic understandings that have come to be equated with economics itself. Challenges to this orthodoxy are emerging, and much of what is called for is decidedly feminist in tone and content: an attention to questions of subjectivity, qualitative methodologies, revaluation of that which has been devalued, and an alternative pedagogical strategy (Feiner 2002; Nelson 2001). Similarly, Grahame Thompson (1999) suggests addressing the limitations of an orthodox neoclassical understanding of economy by directly teaching its limitations along with its basic principles. Here the point is not to negate neoclassical economics but to teach it along with its limitations and its Others, thus revealing economics to be heterogeneous.

If we, all geographers, are to "adopt" GIS, and we think that we should (in the sense that "adoption" implies not only embracing something but making it one's own), then we need to alter the production of an orthodox GIS through teaching, hiring committees, and other departmental strategies. Such strategies should strive, not to undermine or negate GIS, but to negate the notion that GIS is a single thing, linearly progressing, inherently expanding, and universally applicable.

Conclusion

> [I]t is important to develop alternative vocabularies and metaphors that facilitate the movement between purified binaries and allow the possibility for a geographer to be both a social theorist and a spatial analyst at the same time. (Kwan 2004, 759).

The attributes of GIS that define it within the GIS debates and beyond are here seen as the constitutive elements of a discourse of GIS, a discourse whose repeated performance not only defines a particular GIS but also works to distance alternative interpretations as to what it is or can become – and, increasingly, what geography is or can become. Shifting the central metaphor of GIS from technology to discourse suggests that GIS is a set of practices and understandings that are always becoming, always being negotiated, and always open to experimentation. It implies that GIS is malleable not just by those who are engaged directly with the technology but also by those who speak GIS/geography in a host of sites and situations. In particular, we should not look only to single innovative applications of GIS for evidence of its closer alignment with contemporary human geography; rather, all geographers should strive to produce GIS as open to such alignments and experimentation in their research, teaching, departmental hires, public presentations, and elsewhere.

The move from an orthodox to a heterodox GIS should broadly parallel the recent history of geography. That is, geography is now a heterogeneous discipline unbound by its once imperialist designs to colonize *vis-à-vis* a homogeneous disciplinary identity and singularity. The abandonment of (a desire for) a singular geography did not result in the demise of geography (at least not everywhere); instead, it opened up geography to a variety of epistemological and ontological entry points for research and knowledge production. Might GIS not follow a similar path? Let us aim to produce a GIS in the image of geography itself: diverse, multiple, dynamic, interdisciplinary, and heterodox.

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Notes

1. The essay was written for a mandatory senior level "capstone" course on the history and theory of geography; students were asked to reflect upon their understanding

of the discipline of geography and their position within it. The quoted passage summarizes the attitudes and career ambitions of many of our geography majors in recent years.

2. This estimate is based upon informal polls of geography majors in our classrooms over several years. Our statement may be particular to the universities where we have taught or to the status of the discipline in the United States, but we believe that it reflects a more general trend.
3. We owe a great debt to J.K. Gibson-Graham (particularly Gibson-Graham 1995, 1996), whose work on the discourse of economy is the model for our characterization of the discourse of GIS.
4. Our statements about how corporations, educational materials, and other sources represent GIS are the aggregate result of our research. While we have inserted some representational quotations and references, our analysis is of the discourse of GIS as a whole. It is not our intention to single out particular software providers, textbook publishers, or authors as individually responsible for the discourse we are describing.
5. We first used the term "heterodox GIS" as part of the title of a paper and panel session ("The Possibility of Heterodox GIS") that we organized at the Association of American Geographers Annual Meeting in Denver in 2005. While the sessions provided valuable feedback for our project, they also made us keenly aware of the politics of supporting any use of the prefix "hetero," thanks to a tendency to associate it with a heterosexual normativity. We use the term in this paper in order to stress the parallel between our desires for GIS and the emergent disciplinary shift in economics by the same name (i.e., heterodox economics).

References

Agarwal, P. 2005. "Ontological Considerations in GIScience" *International Journal of Geographical Information Science* 19: 501–36.

Ahlqvist, O. 2004. "A Parameterized Representation of Uncertain Conceptual Spaces" *Transactions in GIS* 8: 493–514.

Bernhardsen, T. 2002. *Geographic Information Systems: An Introduction*. New York: Wiley.

Bol, P. 2004. "Putting History in Geography: The Challenges of Creating a GIS for the History of China." Paper read at the Smith Center Conference on History and Geography: Assessing the Role of Geographic Information in Historical Scholarship, 25–27 March, Chicago, IL.

Bondi, L., and M. Domosh. 1992. "Other Figures in Other Places: On Feminism, Postmodernism, and Geography" *Environment and Planning D: Society and Space* 10: 199–213.

Chambers, K.J., J. Corbett, C.P. Keller, and C.J.B. Wood. 2004. "Indigenous Knowledge, Mapping and GIS: A Diffusion of Innovation Perspective" *Cartographica* 39/3: 19–31.

Chrisman, N. 2005. "Full Circle: More Than Just Social Implications of GIS" *Cartographica* 40/4: 23–35.

Cieri, M. 2003. "Between Being and Looking: Queer Tourism Promotion and Lesbian Social Space in Greater Philadelphia" *ACME: An International E-Journal for Critical Geographies* 2/2: 147–66.

Craig, W.J., T.M. Harris, and D. Weiner, eds. 2002. *Community Participation and Geographic Information Systems*. New York: Taylor & Francis.

Crampton, J.W. 2001. "Maps as Social Constructions: Power, Communication and Visualization" *Progress in Human Geography* 25: 235–52.

———. 2004. "GIS and Geographic Governance" *Cartographica* 39/1: 41–53.

Curry, M. 1995. "GIS and the Inevitability of Ethical Inconsistency" In *Ground Truth: The Social Implications of Geographic Information Systems*, ed. J. Pickles. New York: Guilford. 68–87.

———. 1997. "The Digital Individual and the Private Realm" *Annals of the Association of American Geographers* 87: 681–99.

Dangermond, J. 1991. "The Commercial Setting of GIS" In *Geographical Information Systems: Principals and Applications*, ed. D.J Maguire, M.F. Goodchild, and D.W. Rhind. New York: Longman Scientific. 55–65.

Davis, J.B. 2004. "The Turn in Economics: Neoclassical Dominance to Mainstream Pluralism?" Amsterdam Research Group in the History and Methodology of Economics Discussion Paper.

DeMers, M.N. 1997. *Fundamentals of Geographic Information Systems*. New York: Wiley.

Dixon, D.P., and J.P. Jones, III 1998. "My Dinner with Derrida, or Spatial Analysis and Poststructuralism Do Lunch" *Environment and Planning A* 30: 247–60.

Dobson, J. 1993. "Automated Geography" *Professional Geographer* 35: 135–43.

ESRI. 2006a. ESRI GIS and Mapping Software: Company History. Available at http://www.esri.com/company/about/history.html

———. 2006b. Welcome to ESRI. Available at http://www.esri.com/company/index.html

———. 2006c. GIS in Our World. Available at http://www.esri.com/company/about/facts.html

———. 2006d. Corporate Citizenship. Available at http://www.esri.com/company/about/corporate-citizenship.html

Feiner, S. 2002. "Toward a Post-Autistic Economics Education." *Post-Autistic Economics Review* 12: article 2. Available at http://www.btinternet.com/~pae_news/review/issue12.htm

Fine, B. 2002. "Economic Imperialism: A View from the Periphery" *Radical Political Economics* 24: 187–201.

Foresman, T.W. 1998. *The History of Geographic Information Systems: Perspectives from the Pioneers*. Upper Saddle River, NJ: Prentice Hall.

Forrest, D. 1998. "Canada Today" In *The History of Geographic Information Systems: Perspectives from the Pioneers*, ed. T.W. Foresman. Upper Saddle River, NJ: Prentice Hall. 331–47.

Fullbrook, E. 2002. "The Post-Autistic Economics Movement: A Brief History" *Journal of Australian Political Economy* 50: 14–23.

Garnett, R.F., ed. 1999. *What Do Economists Know?* New York: Routledge.

———. 2005. "Whither Heterodoxy?" *Post-Autistic Economics Review* 34: 2–21.

Gibson-Graham, J.K. 1995. "Waiting for the Revolution, or How to Smash Capitalism While Working at Home in Your Spare Time" In *Marxism in the Postmodern Age*, ed. A. Callari, S. Cullenberg, and C. Biewener. New York: Guilford. 188–98.

———. 1996. *The End of Capitalism (As We Knew It): A Feminist Critique of Political Economy*. Cambridge, MA: Blackwell.

———. 2000. "Poststructuralist Interventions" In *A Companion to Economic Geography*, ed. E.S. Sheppard, and T.J. Barnes. Cambridge, MA: Blackwell. 95–110.

Gold, C.M. 2006. "What Is GIS and What Is Not?" *Transactions in GIS* 10: 505–19.

Goodchild, M.F. 1998. "What Next? Reflections from the Middle of the Growth Curve" In *The History of Geographic Information Systems: Perspectives from the Pioneers*, ed. T.W. Foresman. Upper Saddle River, NJ: Prentice Hall. 369–81.

Goss, J. 1995. "Marketing the New Marketing: The Strategic Discourse of Geodemographic Information Systems" In *Ground Truth: The Social Implications of Geographic Information Systems*, ed. John Pickles. New York: Guilford. 130–70.

Harris, T.M., D. Weiner, T. Warner, and R. Levin. 1995. "Pursuing Social Goals through Participatory GIS: Redressing South Africa's Historical Political Ecology" In *Ground Truth: The Social Implications of Geographic Information Systems*,, ed. John Pickles. New York: Guilford. 196–222.

Harvey, F., M.-P. Kwan, and M. Pavlovskaya. 2005. "Introduction: Critical GIS" *Cartographica* 40/4: 1–4.

Heywood, I., S. Cornelius, and S. Carver. 1998. *An Introduction to Geographical Information Systems*. Upper Saddle River, NJ: Prentice Hall.

Huxhold, W.E., and A.G. Levinsohn. 1995. *Managing Geographic Information Systems Projects*. Oxford: Oxford University Press.

Korte, G.B. 2001. *The GIS Book*. Albany, NY: Onword Press.

Kwan, M.-P. 2002a. "Feminist Visualization: Re-envisioning GIS as a Method in Feminist Geographic Research" *Annals of the Association of American Geographers* 92: 645–61.

———. 2002b. "Introduction: Feminist Geography and GIS" *Gender, Place and Culture: A Journal of Feminist Geography* 9/3: 261–62.

———. 2002c. "Is GIS for Women? Reflections on the Critical Discourse in the 1990s" *Gender, Place and Culture: A Journal of Feminist Geography* 9/3: 271–79.

———. 2004. "Beyond Difference: From Canonical Geography to Hybrid Geographies" *Annals of the Association of American Geographers* 94: 756–63.

Lake, R. 1993. "Planning and Applied Geography: Positivism, Ethics, and Geographic Information Systems" *Progress in Human Geography* 17: 404–13.

Longley, P., M.F. Goodchild, D.J. Maguire, and D.W. Rhind. 2001. *Geographic Information Systems and Science*. New York: Wiley.

MapInfo. 2004. MapInfo home page. Available at http://www.mapinfo.com/location/integration

McLafferty, S.L. 2002. "Mapping Women's Worlds: Knowledge, Power and the Bounds of GIS" *Gender, Place and Culture: A Journal of Feminist Geography* 9/3: 263–69.

———. 2005. "Women and GIS: Geospatial Technologies and Feminist Geographies" *Cartographica* 40/4: 37–45.

Miller, H.J. 2000. "Geographic Representation in Spatial Analysis" *Journal of Geographical Systems* 2/1: 55–60.

Miller, H.J., and E.A. Wentz. 2003. "Representation and Spatial Analysis in Geographic Information Systems" *Annals of the Association of American Geographers* 93: 574–94.

Nelson, J.A. 2001. "Why the PAE Movement Needs Feminism." *Post-Autistic Economics Review* 9: article 1. Available at http://www.paecon.net/PAEReview/wholeissues/issue9.htm

Openshaw, S. 1991. "A View on the GIS Crisis in Geography, or, Using GIS to put Humpty-Dumpty Back Together Again" *Environment and Planning A* 23: 621–28.

Pavlovskaya, M.E. 2002. "Mapping Urban Change and Changing GIS: Other Views of Economic Restructuring" *Gender, Place and Culture: A Journal of Feminist Geography* 9/3: 281–89.

———. 2004. "Other Transitions: Multiple Economies of Moscow Households in the 1990s" *Annals of the Association of American Geographers* 94: 329–51.

———. 2006. "Theorizing with GIS: A Tool for Critical Geographies?" *Environment and Planning A* 38: 2003–20.

Peet, R. 1998. *Modern Geographical Thought*. Malden, MA: Blackwell.

Pickles, J. 1993. "Discourse on Method and the History of Discipline: Reflections on Dobson's 1983 Automated Cartography" *Professional Geographer* 45: 451–54.

———. 1995. *Ground Truth: The Social Implications of Geographic Information Systems*. New York: Guilford.

———. 1997. "Tool or Science? GIS, Technoscience, and the Theoretical Turn" *Annals of the Association of American Geographers* 87: 363–72.

Robbins, P. 2003. "Beyond Ground Truth: GIS and the Environmental Knowledge of Herders, Professional Foresters, and Other Traditional Communities" *Human Ecology* 31/2: 233–53.

Rocheleau, D., B. Thomas-Slayter, and D. Edmunds. 1995. "Gendered Resource Mapping: Focusing on Women's Spaces in the Landscape" *Cultural Survival Quarterly* 18/4: 62–68.

Rogers, E.M. 1993. "The Diffusion of Innovations Model" In *Diffusion and Use of Geographic Information Technologies*, ed. I. Masser, and H.J. Onsrud. Dordrecht, The Netherlands: Kluwer Academic. 9–24.

———. 1995. *Diffusion of Innovations*, 4th New York: Free Press.

St. Martin, K. 2005. "Mapping Economic Diversity in the First World: The Case of Fisheries" *Environment and Planning A* 37: 959–79.

Schuurman, N. 2000. "Trouble in the Heartland: GIS and Its Critics in the 1990s" *Progress in Human Geography* 24: 569–90.

———. 2002. "Reconciling Social Constructivism and Realism in GIS" *ACME: An International E-Journal for Critical Geographies* 1/1: 73–90.

———. 2004. *GIS: A Short Introduction*. Cambridge, MA: Blackwell.

———. 2005. "Social Perspectives on Semantic Interoperability: Constraints on Geographical Knowledge from a Data Perspective" *Cartographica* 40/4: 47–61.

Schuurman, N., and A. Leszczynski. 2006. "Ontology-Based Metadata" *Transactions in GIS* 10: 709–26.

Schuurman, N., and G. Pratt. 2002. "Care of the Subject: Feminism and Critiques of GIS" *Gender, Place and Culture: A Journal of Feminist Geography* 9/3: 291–99.

Sheppard, E. 2005. "Knowledge Production through Critical GIS: Genealogy and Prospects" *Cartographica* 40/4: 5–21.

Sieber, R.E. 2000. "Conforming (to) the Opposition: The Social Construction of Geographical Information Systems in Social Movements" *International Journal of Geographical Information Science* 14: 775–93.

———. 2004. "Rewiring for a GIS/2" *Cartographica* 39/1: 25–39.

———. 2006. "Public Participation Geographic Information Systems: A Literature Review and Framework" *Annals of the Association of American Geographers* 96: 491–507.

Smith, N. 1992. "History and Philosophy of Geography: Real Wars, Theory Wars" *Progress in Human Geography* 16: 257–71.

———. 2005. "Neo Critical Geography, or the Flat Pluralist World of Business Class" *Antipode* 37: 887–99.

Staeheli, L.A., and D. Mitchell. 2005. "The Complex Politics of Relevance in Geography" *Annals of the Association of American Geographers* 95: 357–72.

Sui, D.Z. 2004. "GIS, Cartography, and the 'Third Culture': Geographic Imaginations in the Computer Age" *The Professional Geographer* 56/1: 62–72.

Sui, D.Z., and M.F. Goodchild. 2001. "GIS As Media?" *International Journal of Geographical Information Science* 15: 387–90.

———. 2003. "A Tetradic Analysis of GIS and Society using McLuhan's Laws of the Media" *The Canadian Geographer* 471: 5–19.

Sweeny, R. 2004. "Understanding Boundaries: Interdisciplinary Lessons from the Montreal, l'Avenir du Passé (MAP) Project." Paper read at the Smith Center Conference on History and Geography: Assessing the Role of Geographic Information in Historical Scholarship, 25–27 March, Chicago, IL.

Taylor, P.J. 1990. "Editorial Comment: GKS" *Political Geography Quarterly* 9: 211–12.

Taylor, P.J., and M. Overton. 1991. "Further Thoughts on Geography and GIS" *Environment and Planning A* 23: 1087–90.

Thomas, W. 2004. "Is the Future of Digital History Spatial History?" Paper read at the Smith Center Conference on History and Geography: Assessing the Role of Geographic Information in Historical Scholarship, 25–27 March, Chicago, IL.

Thompson, G.F. 1999. "Strategy and Tactics in the Pedagogy of Economics: What Should Be Done about Neoclassical Economics?" In *What Do Economists Know?*, ed. R.F. Garnett. New York: Routledge. 223–35.

Wing, J. 2004. "Beyond Laggards: Rereading GIS Late Adopters." MA thesis, Rutgers, the State University of New Jersey, Piscataway.

Wolff, R.D., and S.A. Resnick. 1987. *Economics: Marxian Versus Neoclassical*. Baltimore: Johns Hopkins University Press.

Wright, D.J., M.F. Goodchild, and J. Proctor. 1997. "Demystifying the Persistent Ambiguity of GIS as 'Tool' versus 'Science'" *Annals of the Association of American Geographers* 87: 346–62.

Yapa, L.S. 1991. "Is GIS Appropriate Technology?" *International Journal of Geographic Information Systems* 5: 41–58.

———. 1998. "Why GIS Needs Postmodern Social Theory, and Vice Versa" In *Policy Issues in Modern Cartography*, ed. D.R.F. Taylor. Oxford: Elsevier Science. 249–69.

Zein-Elabdin, E.O., and S. Charusheela, eds. 2004. *Postcolonialism Meets Economics*. New York: Routledge.