Progress reports

Geographical information science: critical GIS

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I Introduction

A surprising trend in recent research in geographical information science (GISci) is a growing body of work attempting to combine various types of 'critical' human geography with methods and techniques reliant on geographic information systems (GIS). Such work implicitly received early endorsement from Mike Goodchild in an interview with Nadine Schuurman in 1998, when he said, 'If I were advising a new graduate student on how to succeed in geography these days, my advice would be to try to straddle that fence' (Schuurman, 1999a: 4), the 'fence' in question being that between human geography and GIS. Schuurman's own work is perhaps the foremost example of work that successfully straddles the fence, and was further endorsed by Goodchild's foreword to the publication of Schuurman's thesis as a monograph by the journal *Cartographica* (Schuurman, 1999b).

Whether or not the suggestion to 'straddle that fence' is good careers advice is a moot point. In any case, a curious beast known at least for now as 'critical GIS' has staked a claim to the attention of researchers in both human geography and GIS. Perhaps inevitably, given that it 'has emerged at the interface between geographic information science and geographical social theory' (Sheppard, 2005: 5), both themselves subdisciplinary groupings, critical GIS remains a distinctly minority pursuit. There is little sign of a groundswell of critical human geographers wholeheartedly embracing GIS as a tool of their trade even as it becomes commonplace in commerce and government. Equally, it would be wrong to imagine that students of GIS are much troubled by the finer points of actor-network theory, or Foucault and Lefebvre. It seems even less likely that the numerous GIS users in commerce and government are paying very much attention to any of this.

So what then *has* been the contribution of critical GIS? In this review, as well as outlining developments in critical GIS to the wider audience of this journal, I suggest that the more successful examples of critically informed GIS are those where researchers informed by social theory have been willing to engage with the technology, rather than to criticize from the outside. On the other hand, much remains to be done in the area of theorizing GIS, based on a more thorough exploration of the its origins and development.

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II Origins and development of a critical GIS research agenda

The origins and development of critical GIS are covered by Schuurman (2000) and from slightly different perspectives by Pickles (1999), Sheppard (2005) and Chrisman (2005). The overall picture is one where early abrasive exchanges between GIS advocates and social theorists robustly critical of the technology (eg, Openshaw, 1991; 1992; Taylor and Overton, 1991; Taylor, 1991; Goodchild, 1991; Lake, 1993) are succeeded relatively quickly by more thoughtful and considered engagements in the second half of the 1990s (Pickles, 1995; 1997; Sheppard and Poiker, 1995; Wright *et al.*, 1997), setting the stage for a nascent critical GIS.

The one critical GIS artifact with which most geographical information science researchers are somewhat familiar is *Ground truth* (Pickles, 1995). This edited collection was originally planned by Brian Harley and John Pickles, building on Harley's ground-breaking critical work on the role of maps as representations and assertions of power. The volume is often seen in the geographical infor-mation science research community as being a thorough condemnation of GIS and all its works. This perception seems in retrospect to have been rather paranoid. Pickles' own fram-ing chapters are dense and in places challeng-ing for readers not well-versed in social theory, and to those 'GISers' prepared to rise to the challenge, represented a substantial obstacle (see, for example, the reaction of Flowerdew, 1998). For many other active GIS researchers, Pickles' bookend chapters were all the excuse that was needed to dis-miss the rest of the book (see Openshaw, 1997).

Discouraged readers missed out on an unexceptionable collection of critiques, covering such ground as: the ethical difficulties raised by the use of computational tools and data where attribution of authorship and responsibility is problematic (Curry, 1995); the unacknowledged impacts of GIS and information technology on geographic

practice (Veregin, 1995); the relationship between GIS and the mass production of maps (McHaffie, 1995); the unnerving world of geodemographics (Goss, 1995a); and the challenges of using GIS to support community involvement in decision making processes (Harris *et al.*, 1995).

Ground truth and the many negative responses to it tended to hide the more pro-ductive exchanges occurring at the same time in ways that are less apparent over a decade later. The involvement of the US National Center for Geographic Information and Analysis (NCGIA) in brokering discussions was crucial. A meeting in 1993 (Sheppard and Poiker, 1995), was supported by NCGIA. Soon after came NCGIA's Research Initiative 19 'GIS and society: the social implications of how people, space and environment are rep-resented in GIS', and a specialist group meeting in 1996 (Harris and Weiner, 1996), which worked to develop more specific research themes.

III Progress on the 'GIS and society' research agenda themes

Sheppard (2005: 7) lists seven themes that emerged from Initiative 19, and the discussion that follows is structured around three of these to give a sense of the progress made *en route* to what has become 'critical GIS'. The four absent themes are omitted partly due to lack of space (and time), but also because there is less evidence of progress in the 'missing' directions.[1] Following these 'mini-reviews', the relationship of progress made on these themes to the more current notion of critical GIS is considered.

1 Relevance of GIS for community and grassroots perspectives and lifeworlds

Perhaps the most successful subtheme indicated by Initiative 19 has been public participation GIS (PPGIS, or, more recently, PGIS for participatory GIS). The key text in PGIS is the impressive collection edited by Craig *et al.* (2002; see also Obermeyer, 1998).

It would be hard to exaggerate the breadth and depth of work in the PGIS realm, and it would be harder still in the space available to do justice to that breadth and depth. Craig *et al.*'s collection presents 28 articles drawing on the experiences of groups using GIS in contexts as diverse as resistance to gentrification in San Francisco (Parker and Pascual, 2002) and community forestry in Nepal (Jordan, 2002).

In their introductory chapter (Weiner *et al.*, 2002: 5), the editors suggest that 'the critique of GIS has helped to launch a flood of alternative community-based GIS applications'. However, they are also concerned that the very success of PGIS should not be seen as negating the need for ongoing critical theorizing about the role of GIS: 'we are concerned that the rapid growth of PPGIS might have the . . . effect of submerging a critical theory of GIS. PPGIS is not a panacea, and must not undermine the robust debate on the political economy of GIS, its epistemology, and the philosophy and practice of GIScience' (p. 5). It would certainly be easy to see the range and vitality of PGIS work as a vindication of naïvely optimistic approaches that suggest GIS is an infinitely malleable and neutral technology applicable by any community for the furtherance of their own ends.

One jarring note in the collection is the contribution by Jack Dangermond (2002), owner of the Environmental Systems Research Institute (ESRI), the developer of the dominant commercial GIS. It is hard to see the claim that '[t]he technology is bringing people closer to their worlds and empowering them to define a future that reflects their values, hopes, and dreams' (p. 308)[2] as anything other than the sort of corporate hype bemoaned equally by both early critics of GIS and the editors of this collection!

More sanguine reflections on the lessons learned from experiences with GIS are offered by, for example, Corbett and Keller (2005), who suggest a framework for assessing the extent to which PGIS empowers individuals and communities. Similarly

thoughtful considerations of issues around empowerment are offered by Elwood (2002) and Ghose (2001). Another exploration of lessons learned in PGIS is Kyem's (2004) analysis of the roles of PGIS in resolving conflicts over access to natural resources.

Also emerging out of involvement in PGIS projects and consideration of their implications is a suggestion for 'rewiring GIS' (Sieber, 2004) to enable more flexible GIS tools and representations based on already existing tools by using a combination of XML (eXtensible Markup Language) and UML (the Universal Modelling Language). It is an intriguing thought that the numerous online local and community-based projects stimulated by the introduction of Google Maps (maps.google.com), Google Earth and the associated freely available tools (see www.google.com/apis/maps/) are an ongoing exploration of just this sort of architecture for a 'GIS-2'. More open pathways to rewiring GIS may in time be provided by the Open Source Geospatial Foundation (www.osgeo.org).

2 Gendering of GIS

One non-spatial community of interest that has successfully sought to adopt and adapt GIS and related technologies is to be found in feminist geography. In an appreciation of papers in a special section of *Gender, Place and Culture* (Kwan, 2002a), Susan Hanson (2002) points out how incongruous this conjunction would have seemed only a few years ago. Arguably, however, the role of feminist geographers in working with GIS has been critical in establishing the viability of using GIS to see the world and the individual lives within it differently, whatever restrictions current technology may place on such efforts. In this collection, Schuurman and Pratt (2002) persuasively argue that a feminist perspective's resistance to binary modes of argument may have a key role to play in developing constructive engagements between critical theories and GIS. They 'argue for a form of critique that [tackles]

enframing assumptions while remaining invested in the subject . . . A feminist critique of GIS engages more directly with GIS practices, and need not reproduce the antagonistic dualisms that have characterised debates about GIS and technology to date' (Schuurman and Pratt, 2002: 291).

McLafferty in the same issue points to another shared aspect of GIS and feminist research, which will ring bells for many 'GISers': that 'the fields intersect in their concerns with the grounded contexts of everyday life and in dealing, either implicitly or explicitly, with conceptions of power and empowerment.' (McLafferty, 2002: 265). Anyone who has seen the nods of recognition in an audience when a small area census map of their city is projected on the screen will know what I mean by this: even knowing full well the limitations of aggregated and approximate representations of the social world, it is possible also to know that there is something true about what such maps convey. Working with such data is indeed, as McLafferty suggests, to be concerned with the 'contexts of everyday life', something often unacknowledged by early critiques of GIS. McLafferty goes on to describe work on the Long Island Breast Cancer Project (see also Timander and McLafferty, 1998), a project that evolved from community activism into a major funded research project using GIS tools to understand women's health outcomes. Such work has much in common with PGIS, and McLafferty draws attention to the ways in which the potential for empowerment of individuals and communities by GIS can quickly shift when larger institutional actors get involved (see also Sieber, 2000).

The other papers in this collection (Pavlovskaya, 2002; Kwan, 2002b) point to what a GIS might be like with attempts to fill in the details of everyday life on top of the sketch maps provided by generic data sources such as the census. Mei-Po Kwan's work demonstrates how GIS can be used to present detailed pictures of the life-paths of individual women in everyday settings (Kwan and Lee, 2004). More broadly, she argues in a passage also cited by Sharp (2005: 305) that 'feminist geographers can appropriate GIS methods for illuminating women's spatiality, while recognizing the apparent privilege given to the physicality of the body by GIS methods' (Kwan, 2002c: 653). The precursor to this work is of course the time geography of Torsten Hägerstrand, who noted (1982: 324), that the 'tip [of a space-time path is] a living body, endowed with memories, feelings, knowledge, imagination and goals – in other words capabilities too rich for any conceivable kind of symbolic representation'. In spite of those difficulties, it seems that the answer to Kwan's question (2002b), 'Is GIS for women?', is a resounding 'yes'. More recent work by Matthews *et al.* (2005) confirms the potential of detailed spatial activity data combined with ethnographic fieldwork.

3 Privacy, access and ethics

Such work bears directly on the third of the 'GIS and society' themes considered here. Concerns about the intrusion of GIS and geodemographic analysis into individual private lives were an important component of the original critiques of GIS (see Goss, 1995a; 1995b), and such concerns only become more acute as detailed individual data become mappable.

Related to privacy concerns are questions of who has the right to access data held on individuals, and the ethics of subsequent manipulation, display or analysis of these data. Curry's work has been influential in suggesting how the ready availability of spatial data forces us to reconceptualize privacy and associated ethical codes (Curry, 1998; 1999). In a less theoretical vein, Onsrud has suggests appropriate and practical ways for those working with GIS to act ethically in a rapidly changing context (Onsrud *et al.*, 1994; Onsrud, 1995; 2003; see also Crampton, 1995). For some, such concerns seem to have dropped out of view or, at any rate,

some academic users of GIS now appear comfortable working with 'lifestyle' databases as an adjunct to more traditional sources such as the census (Longley, 2005).

Whatever we make of those developments, it is apparent that the individual level tracking data used in work such as that of Kwan and Lee (2004) raises considerably larger privacy concerns. The now almost ubiquitous mobile phone makes this a serious privacy and ethics issue for society as a whole, when even those working with GIS in tightly controlled academic settings are struggling to develop appropriate responses.

Concern for privacy of individual level geocoded data in health settings has led to consideration of the issues in that context (see, for example, Cromley *et al.*, 2004; Rushton *et al.*, 2006). The difficulties presented by mobile phones, GPS and other geospatial technologies, and emerging location-based services remain, however. Some technical work in this area tackles the problem head on with frameworks for the obfuscation of location data (Duckham and Kulik, 2005), although (inevitably) the context for this work is that the diffusion of location-based services is being slowed by privacy concerns.

Taking another tack, suggestions have been made for standards of ethics related to privacy issues (Armstrong and Ruggles, 2005). However, given the current context of heightened concerns over security (Crampton, 2002), combined with the potential for positive outcomes such as real-time traffic management (see Ahas and Mark, 2005) it is difficult to believe that technical fixes and codes of practice will forestall for long a situation where 24-hour surveillance of much of the population becomes feasible. While the term 'geoslavery' proposed by Dobson and Fisher (2003) may seem alarmist, its use by two stalwarts of the GIScience community is thought-provoking.

4 And missing in action . . . ?

On the remaining four themes in the 'GIS and society' agenda, there is less to report. Two of these, 'GIS, environmental justice, and political ecology' and 'GIS and human dimensions of global change', were perhaps too broadly drawn for clearly focused research programmes to emerge. Another agenda item to explore 'alternative kinds of GIS' has arguably been pursued in disparate ways by different research communities, among them PGIS researchers and feminist geographers, who were partially animated by the concerns that critical GIS brings to the fore. Alternative GIS has also been explored from the 'technical end' of GIScience research in work aimed at introducing variously time (see my previous report, O'Sullivan, 2005), ontology, semantics and the representation of vagueness and uncertainty into GIS (each of which merits a progress report on its own). Whether and how these developments might converge in a 'GIS-2' that becomes a new 'mainstream' is hard to predict.

That last point brings me to the most visibly absent of the 'GIS and society' themes, namely 'the social history of GIS as a technology'. Histories of GIS from an insider perspective do exist (see Foresman, 1998), but this research theme envisaged a more complex and nuanced picture exploring social, economic, political, cultural and institutional factors that drove development of GIS and influenced the paths along which it developed (Sheppard, 1995).

It is difficult to explain this absence, other than as the result of diverging research trajectories on the part of many of the more interested earlier investigators such as John Pickles, Jon Goss and Patrick McHaffie. A theme issue of *International Journal of Geographical Information Science* on the social construction of GIS (Harvey, 2000) points to one direction for progress in this area, and McHaffie's (2000) contribution is very much in keeping with the hopes expressed for this component of the Initiative 19 research agenda. The closest approach to an overview critical social history of GIS may yet be Jeremy Crampton's *Mapping: a critical*

introduction to GIS and cartography (2006), although the emphasis of this work is on the broader framework of mapping, rather than on the details of the development of GIS itself.

The relative lack of progress on a social history – or a political economy – of GIS is unfortunate. While Sheppard's paper (1995) proposing a research agenda on 'GIS and society' (pp. 6–9) explicitly called for a historical examination of those directions in which GIS was *not* developed as a way to understand what *was*, the 'GIS and society' agenda tended strongly to emphasize the impacts of GIS on society rather than influences in both directions. Sheppard (2005: 8) states that 'much of the research carried out under the "GIS and society" banner has either looked at the impact of society on GIS or looked at the impact of GIS on society – with much less attention to the former relationship'. Chrisman (2005) echoes this concern calling for much closer examination of the social and institutional drivers of GIS.

IV From 'GIS and society' to 'critical GIS'

While the preceding discussion is organized around themes that constituted an explicit research agenda for 'GIS and society', it also serves as an overview of the most vital elements in 'critical GIS'. Critical GIS does not have a research agenda *per se*, although agenda-setting is clearly going on in the many journal special and theme issues discussed, and to some extent in sympathetic introductory GIS texts (Chrisman, 2002; Schuurman, 2003). A recent special issue of *Cartographica* (Harvey *et al.*, 2005) carried seven articles under the theme of 'Critical GIS', which give a good feel for where this research programme is now. Articles examine the origins and aims of critical GIS (Sheppard, 2005; Chrisman, 2005), the relationship between feminist geography and GIS (McLafferty, 2005), the inherent limitations on GIS imposed by issues of representation (Schuurman, 2005), the privacy issue (Armstrong and Ruggles, 2005), the application of GIS in detailed ethnographic

research (Matthews *et al.*, 2005) and PGIS (Corbett and Keller, 2005).

The point already made about the failure to make clear progress on a social history of GIS, as a key component of any critical GIS research programme is made by both Sheppard (2005) and Chrisman (2005). In fact, a spoof character in the GIS 'big book' highlights the importance of any such history moving outside the academy: 'the mainspring of everything important that has happened in GIS is business and the profit motive' (Lobley, 1999: 19). True or not, it remains the case that one of the more revealing accounts of the US Bureau of the Census's early involvement in GIS is in a journalistic account of the marketing industry (see Larson, 1992; and, for a disturbing account of more recent developments, Albrecht and McIntyre, 2005). These are aspects of the development of GIS that we need to understand more fully.

In a slightly downbeat piece, Schuurman and Kwan (2004) suggest that whatever gains were made in encouraging social perspectives on GIS during the 1990s have since been lost, perhaps partly as a result of the 'rebranding' of GIS as geographical information science (GISci). They discover, for example, that ignoring two important collections early in the period (Pickles, 1995; Sheppard and Poiker, 1995) only about 4% of articles in four leading *GIScience* journals from 1995 to 2003 made reference to social or theoretical aspects of the technology. It is interesting to speculate that the label of 'science' has legitimated a move toward more abstract and theoretical technical work in GIS, far removed from the complicated social settings in which GIS is deployed.

More optimistically, I would add the suggestion that developments in the last decade or so fully bear out the truth of Kwan's (2002a: 262) suggestion that, '[t]he 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'. The success of emerging work in

feminist GIS and PGIS where communities of interest have engaged with GIS to appropriate it for their own ends, ironically enough vindicates *both* sides of the early abrasive debates: the GIS advocates who argued that critics ought to 'get their hands dirty' and engage with the technology before dismissing it; *and* the social theorists who argued that GIS was above all a set of practices and social processes, that should be closely scrutinized. On this optimistic note, I can only conclude by echoing Schuurman and Kwan's own closing remarks and welcoming a 'new era of socially and politically engaged GIScience' (2004: 2).

Acknowledgements

Notes

1. I am using Sheppard's (2005) rephrasing of the themes' titles rather than the originals from Harris and Weiner's (1996) report.
2. At the prices ESRI charge for their software, it is hard to see how the technology can empower anyone not already empowered!

References

Ahas, R. and **Mark, U.** 2005: Location based services – new challenges for planning and public administration? *Futures* 37, 547–61.

Albrecht, K. and **McIntyre, L.** 2005: *Spychips: how major corporations and government plan to track your every move with RFID.* Nashville, TN: Thomas Nelson.

Armstrong, M.P. and **Ruggles, A.J.** 2005: Geographic information technologies and personal privacy. *Cartographica* 40(4), 63–73.

Chrisman, N. 2002: *Exploring geographic information systems.* New York: Wiley.

— 2005: Full circle: more than just social implications of GIS. *Cartographica* 40(4), 23–35.

Corbett, J.M. and **Keller, C.P.** 2005: An analytical framework to examine empowerment associated with participatory geographic information systems (PGIS). *Cartographica* 40(4), 91–102.

Craig, W.J., Harris, T.M. and **Weiner, D.,** editors 2002: *Community participation and geographic information systems.* London and New York: Taylor and Francis.

Crampton, J. 1995: The ethics of GIS. *Cartography and geographic information systems* 22, 84–89.

— 2002: Guest editorial: The risks of security. *Environment and Planning D: Society and Space* 20, 631–35.

— 2006: *Mapping: a critical introduction to GIS and cartography.* Oxford: Blackwell, in press.

Cromley, E.K., Cromley, R.G. and **Ye, Y.** 2004: On-line reporting and mapping of spatially aggregated individual records selected by user queries. *Cartographica* 39(2), 5–13.

Curry, M.R. 1995: GIS and the inevitability of ethical inconsistency. In Pickles, J., editor, *Ground truth,* New York: Guilford Press, 68-87.

— 1998: *Digital places: living with geographic information technologies.* London: Routledge.

— 1999: Rethinking privacy in a geocoded world. In Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W., editors, *Geographical information systems: principles, techniques, management and applications,* New York: Wiley, 757–66.

Dangermond, J. 2002: Mutualism in strengthening GIS technologies and democratic principles: perspectives from a GIS software vendor. In Craig, W.J., Harris, T.M. and Weiner, D., editors, *Community participation and geographic information systems,* London and New York: Taylor and Francis, 297–308.

Dobson, J.E. and **Fisher, P.F.** 2003: Geoslavery. *IEEE Technology and Society Magazine,* Spring, 47–52.

Duckham, M. and **Kulik, L.** 2005: A formal model of obfuscation and negotiation for location privacy. In Gellersen, H.W., Want, R. and Schmidt, A., editors, *Pervasive Computing Third International Conference, PERVASIVE 2005, Munich, Germany Proceedings,* Lecture Notes in Computer Science 3468, Berlin: Springer, 152–70.

Elwood, S.A. 2002: GIS use in community planning: a multidimensional analysis of empowerment. *Environment and Planning A* 34, 905–22.

Flowerdew, R. 1998: Reacting to *Ground truth. Environment and Planning A* 32, 289–301.

Foresman, T.W., editor 1998: *The history of geographic information systems: perspectives from the pioneers.* Upper Saddle River, NJ: Prentice-Hall.

Ghose, R. 2001: Use of information technology for community empowerment: transforming geographic information systems into community information systems. *Transactions in GIS* 5, 141–63.

Goodchild, M.F. 1991: Just the facts. *Political Geography Quarterly* 10, 335–37.

Goss, J. 1995a: Marketing the new marketing: the strategic discourse of geodemographic information systems. In Pickles, J., editor, *Ground truth,* New York: Guilford Press, 130–70.

— 1995b: 'We know where you are and we know where you live': the instrumental rationality of geodemographic information systems. *Economic Geography* 71, 171–98.

Hägerstrand, T. 1982: Diorama, path and project. *Tijdschrift voor Economische en Sociale Geografie* 73, 323–39.

Hanson, S.M. 2002: Connections. *Gender, Place and Culture* 9, 301–303.

Harris, T.M. and **Weiner, D.** 1996: GIS and society: the social implications of how people, space and environment are represented in GIS. *Report of the Initiative 19 Specialist Meeting, March 2–5, 1996, Koinoinia Retreat Center, South Haven, MN*. Technical Report 96-7. Santa Barbara, CA: National Center for Geographic Information and Analysis.

Harris, T.M., Weiner, D., Warner, T. and **Levin, R.** 1995: Pursuing social goals through participatory GIS: redressing South Africa's historical political ecology. In Pickles, J., editor, *Ground truth*, New York: Guilford Press, 196–222.

Harvey, F. 2000: The social construction of geographic information systems. *International Journal of Geographical Information Science* 14, 713–16.

Harvey, F., Kwan, M.-P. and **Pavlovskaya, M.** 2005: Introduction: critical GIS. *Cartographica* 40(4), 1–4.

Jordan, G. 2002: GIS for community forestry user groups in Nepal: putting people before the technology. In Craig, W.J., Harris, T.M. and Weiner, D., editors, *Community participation and geographic information systems*, London and New York: Taylor and Francis, 232–45.

Kwan, M.-P. 2002a: Introduction: feminist geography and GIS. *Gender, Place and Culture* 9, 261–62.

— 2002b: Is GIS for women? Reflections on the critical discourse in the 1990s. *Gender, Place and Culture* 9, 271–79.

— 2002c: Feminist visualization: re-visioning GIS as a method in feminist geographic research. *Annals of the Association of American Geographers* 92, 645–61.

Kwan, M.-P. and **Lee, J.** 2004: Geovisualization of human activity patterns using 3D GIS: a time-geographic approach. In Goodchild, M. and Janelle, D., editors, *Spatially integrated social science*, New York: Oxford University Press, 48–66.

Kyem, P.A.K. 2004: Of intractable conflicts and participatory GIS applications: the search for consensus amidst competing claims and institutional demands. *Annals of the Association of American Geographers* 94, 37–57.

Larson, E. 1992: *The naked consumer: how our private lives become public commodities*. New York: Penguin.

Lake, R.W. 1993: Planning and applied geography: positivism, ethics, and geographic information systems. *Progress in Human Geography* 17, 404–13.

Lobley, J. 1999: It's all about money stupid! In Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W., editors, *Geographical information systems: principles, techniques, management and applications*, New York: Wiley, 19.

Longley, P.A. 2005: Geographical information systems: a renaissance of geodemographics for public service delivery. *Progress in Human Geography* 29, 57–63.

Matthews, S.A., Detwiler, J.E. and **Burton, L.M.** 2005: Geo-ethnography: coupling geographic information analysis techniques with ethnographic methods in urban research. *Cartographica* 40(4), 75–90.

McHaffie, P.H. 1995: Manufacturing metaphors: public cartography, the market and democracy. In Pickles, J., editor, *Ground truth*, New York: Guilford Press, 113–29.

— 2000: Surfaces: tacit knowledge, formal language, and metaphor at the Harvard Lab for Computer Graphics and Spatial Analysis. *International Journal of Geographical Information Science* 14, 755–73.

McLafferty, S. 2002: Mapping women's worlds: knowledge, power and the bounds of GIS. *Gender, Place and Culture* 9, 263–69.

— 2005: Women and GIS: geospatial technologies and feminist geographies. *Cartographica* 40(4), 37–45.

Obermeyer, N.J. 1998: The evolution of public participation GIS. *Cartography and Geographic Information Systems* 25(2), 65.

Onsrud, H.J. 1995: Identifying unethical conduct in the use of GIS. *Cartography and Geographic Information Systems* 22, 90–97.

— 2003: Access to geographic information: openness versus security. In Cutter, S., Richardson, D. and Wilbanks, T., editors, *Geographic dimensions of terrorism*, New York and London: Routledge, 207–13.

Onsrud, H.J., Johnson, J. and **Lopez, X.** 1994: Protecting personal privacy in using geographic information systems. *Photogrammetric Engineering and Remote Sensing* LX, 1083–95.

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.

— 1992: Further thoughts on geography and GIS: a reply. *Environment and Planning A* 24, 463–66.

— 1997: The truth about *Ground truth. Transactions in GIS* 2, 7–24.

O'Sullivan, D. 2005: Geographical information science: time changes everything. *Progress in Human Geography* 29, 749–56.

Parker, C. and **Pascual, A.** 2002: A voice that could not be ignored: Community GIS and gentrification battles in San Francisco. In Craig, W.J., Harris, T.M. and Weiner, D., editors, *Community participation and geographic information systems*, London and New York: Taylor and Francis, 55–64.

Pavlovskaya, M.E. 2002: Mapping urban change and changing GIS: other views of economic restructuring. *Gender, Place and Culture* 9, 281–89.

Pickles, J., editor 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.

— 1999: Arguments, debates and dialogues: the GIS social theory debate and the concern for alternatives. In Longley, P.A., Goodchild, M.F., Maguire, D.J. and Rhind, D.W., editors, *Geographical information systems: principles, techniques, management and applications*, New York: Wiley.

Rushton, G., Armstrong, M.P., Gittler, J.D., Greene, B.R., Pavlik, C.E., West, M.M. and **Zimmerman, D.L.** 2006: Geocoding in cancer research: a review. *American Journal of Preventive Medicine* 30(2S), S16–24.

Schuurman, N. 1999a: An interview with Michael Goodchild, January 6, 1998, Santa Barbara, California. *Environment and Planning D: Society and Space* 17, 3–17.

— 1999b: Critical GIS: theorizing an emerging science. *Cartographica* 36(4), 1–99 (Monograph 53).

— 2000: Trouble in the heartland: GIS and its critics in the 1990s. *Progress in Human Geography* 24, 569–90.

— 2003: *GIS: a short introduction*. Malden, MA: Blackwell.

— 2005: Social perspectives on semantic interoperability: constraints on geographical knowledge from a data perspective. *Cartographica* 40(4), 47–61.

Schuurman, N. and **Kwan, M.-P.** 2004: Guest editorial: Taking a walk on the wild side of GIS. *Cartographica* 39(1), 1–3.

Schuurman, N. and **Pratt, G.** 2002: Care of the subject: feminism and critiques of GIS. *Gender, Place and Culture* 9, 291–99.

Sharp, J. 2005: Geography and gender: feminist methodologies in collaboration and in the field. *Progress in Human Geography* 29, 304–309.

Sheppard, E. 1995: GIS and society: toward a research agenda. *Cartography and Geographic Information Systems* 22, 5–16.

— 2005: Knowledge production through critical GIS: genealogy and prospects. *Cartographica* 40(4), 5–21.

Sheppard, E. and **Poiker, T.**, editors 1995: GIS and society. Special issue of *Cartography and Geographical Information Systems*, 22(1).

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.

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

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

Timander, L. and **McLafferty, S.** 1998: Breast cancer in West Islip, NY: a spatial clustering analysis with covariates. *Social Science and Medicine* 46, 1623–35.

Veregin, H. 1995: Computer innovation and adoption in geography: a critique of conventional technological models. In Pickles, J., editor, *Ground truth*, New York: Guilford Press, 88–112.

Weiner, D., Harris, T.M. and **Craig, W.J.** 2002: Community participation and geographic information systems. In Craig, W.J., Harris, T.M., Weiner, D., editors, *Community participation and geographic information systems*, London and New York: Taylor and Francis, 3–16.

Wright, D.J., Goodchild, M.F. and **Proctor, J.** 1997: Demystifying the persistent ambiguity of GIS as 'tool' versus 'science'. *Annals of the Association of American Geographers* 87, 346–62.