Tool or Science? GIS, Technoscience, and the Theoretical Turn
Author(s): John Pickles
Source: *Annals of the Association of American Geographers,* Vol. 87, No. 2 (Jun., 1997), pp. 363-372
Published by: Taylor & Francis, Ltd. on behalf of the Association of American Geographers
Stable URL: https://www.jstor.org/stable/2564375
Accessed: 06-01-2026 02:35 UTC

Tool or Science? GIS, Technoscience, and the Theoretical Turn

John Pickles

Department of Geography, University of Kentucky

In "Demystifying the Persistent Ambiguity of GIS as 'Tool' versus 'Science,' " Dawn Wright, Michael Goodchild, and Jim Proctor suggest that there is a need to put recent debates about GIS in geography on a new footing: the unique role geography plays in GIS means that these debates are "unusually exposed to general view" (p. 346) and are, by implication, damaging to both. Interestingly, the authors quickly put to one side the direct arguments defending or attacking GIS and turn immediately to the "[m]ore interesting" social implications of GIS: "the messages it sends, whom it empowers, and the responsibility its developers should bear for its eventual use" (p. 346). For the authors, these debates arise because of "the ambiguity of GIS as a tool or as a science" (p. 347). Thus, "[b]y examining the tension between GIS as a tool and GIS as a science, a tension that ultimately defines what it means to be 'doing GIS' in geography, we hope to shed some light on the issues . . ." (p. 347). By phrasing the issue in this way and by focusing a complex series of issues on one central question—is GIS merely a tool, is it a tool-making enterprise, or is it a science whose focus is the handling, analysis, and representation of geographic data?—the authors aim to move debate away from a defense of unreconstructed positivism and towards an engagement with issues of importance to contemporary geography. Specifically, they ask us to consider what constitutes science, whether GIS is or is not scientific, and what would be the appropriate theory of science and epistemology for such a geographical information science?

The paper represents the possible beginning of an important theoretical turn *in* GIS. It is among a very few essays from the *mainstream* of the field to address the epistemological assumptions and political and practical commitments of GIS (notable others are Veregin 1995; Sui 1996; Chrisman 1987, 1991). A paper that reflects on, and in turn stimulates, a wider debate about these issues is to be applauded, and provides a useful point from which we can continue the discussion about the poverty and politics of GIS theory.

The paper thus begins with two primary goals: to open the debate about GIS in order to take on-board some of the more trenchant criticisms of GIS from geographers and social theorists in ways that will lead to productive development of the field of GIS, *but* to do so only in terms that fit within the schema of tool use, tool making, and science. The first goal probably appears suspect to many practicing GIS 'traditionalists,' and the second goal will certainly be problematic for most social theorists.

Among the important issues they address, the authors: focus our attention on the need for GIS practitioners to move beyond a view of the field as neutral tool using or tool making; criticize the current status of GIS theory; argue that we need to accept a more thoroughgoing engagement with the possibilities for a renewed and different understanding of GIS, which might emerge from taking seriously new questions about its social implications; ask that we take seriously the development and legitimization of a new science of the social implications of GIS as a valid field of research in university departments; suggest that we work to transform the epistemological foundations of GIS, to be more open to a variety of epistemologies and new developments in the philosophy of science and social science; and accept alternative forms of social explanation to that rooted in hypothetico-deductive models of science. These will be heretical ideas for many in the field (GIS) whose output has been marked by a dogged avoidance of epistemological debate and refusal to engage the intellectual ferment that has characterized contemporary human geography in the past twenty years of postpositivist social theory.

It is, indeed, remarkable that GIS practitioners in geography have not *already* engaged these questions and asked whether GIS is a tool, tool-making activity, or science. It is even more re-

Annals of the Association of American Geographers, 87(2), 1997, pp. 363–372

Published by Blackwell Publishers, 350 Main Street, Malden, MA 02148, and 108 Cowley Road, Oxford, OX4 1JF, UK.

markable to some of us that up to this point, there has been no thoroughgoing discussion by GIS practitioners and theorists about the epistemology of their subject, the ontology of their objects, and the political commitments embedded in their practices.[1] In this context, the authors are to be congratulated for taking on the sacred cows of GIS practice and pushing for a theory of GIS that moves beyond the merely technical.

Even so, "Demystifying the Persistent Ambiguity of GIS as 'Tool' versus 'Science,' " while opening the space for discussion, does not uniformly succeed as an entry into or a mapping of that space. In reading the paper, one begins to suspect that the authors themselves are torn between a strong commitment to opening discussion, while recognizing the theoretical and political necessity of such engagement, and a deep-seated uncertainty about how to engage the issues. As a result, the paper tacks back and forth between positivist defense and postpositivist reworking of GIS assumptions and epistemology; at one moment open to new possibilities, at another moment fleeing back into a more familiar instrumental reason and reductionist logic that has been the foundation for the very technicism they seek to overcome.

In What Ways Can Science Be Thought Separately from Its Tools and Tool-Making Practices?

The authors argue that GIS currently "gains meaning only by its goals, which generally involve the application of knowledge by scientists, but not science itself" (p. 349). In this view, while science, tool making and tool use are posited as occurring along a continuum with fuzzy boundaries between each, science and application are thought of as independent domains of practice.[2] Traditional GIS is seen to have focused primarily on the domain of problem solving, not the domain of science. Instead, the authors argue, GIS must focus on the process of discovery and the understanding of problems if it is to claim to be a science itself.

The authors seem to be suggesting a hierarchy of generalizability, with each step in the hierarchy deepening the claim to scientific validity: from geographic information systems, to the *science of geographic information systems*, to the *science of geographic information*. A science of geographic information systems would take GIS as its object and focus on issues such as the rules governing the creation of the spatial models, measurement and modeling of error propagation, and proofs or theorems of data structures. A geographic information science would focus on the "most primitive" concepts used by all GIS systems and applications: "issues of recognition and measurement in the field, the choice between alternative representations, the roles of generalization and multiple representations, the representation of uncertain information, methods of analysis and modeling, problems of describing the content of geographic data and evaluating its fitness for use, and methods of visualization" (p. 357). Such issues require multidisciplinary approaches to the science of geographic information, linking geography with geodesy, surveying, cartography, photogrammetry, remote sensing, statistics, cognitive science, information science, library science, and computer science (p. 357).

This shift from tool use and tool making to a science of geographic information is important for practical reasons: the authors hope to influence the ways in which GIS is treated in departments and what is seen to be legitimate areas of research by GIS scholars.

In important ways, however, the heuristic categorization of tool use, tool making, and science mis-specifies the issue. Modern science is now so thoroughly shot through with technical apparatus and so closely tied to various ways of controlling nature and society that it is thoroughly technological. Such a relation cannot be avoided or overcome by wishing or defining it away, an effort in futility we would have to characterize as idealism. If we take seriously the technical and material embeddedness of modern science, two basic questions arise. The first question has to do with the rationality claim of science: is this technoscience rigorous and can we make it more fully rational by insisting that scientists account for their assumptions and concepts? In one sense then, "Demystifying . . ." serves as a serious indictment of the failure of GIS to develop a theory of its object and practice and as a clarion call to do the hard work of interrogating the assumptions that underlie contemporary GIS and rejecting those that cannot be sustained. The second question has to do with the open, contested nature of science, with science as a social enterprise: can we change the nature of the commitments that have emerged within technoscience as a result of its failure to question its own foundations and effects? That is, can we contest the assumptions

and practices of technoscience and ask, with David Harvey (1974), what kind of geography, by whom, and for whom?

Sheppard (1995) has already shown us how the technology of mapping and the science of cartography has always been tied to broader projects of political economy and geopolitics. How, for example, are we to think about Galileo's development of the telescope in the schema proposed by the authors? Would the development and use of the telescope be thought of as part of an emerging science of astronomy and physics, or would it be merely the technology of stargazing? Clearly, astronomy would not be possible in its post-Galilean form without the telescope, which allowed us to see more and to see differently, and as a result transformed our view of the universe and our place in it. But it would also not have been possible without the broader context of need and demand, and legitimization of its practices, generated by so mundane a matter as sea travel and commercial expansion. Moreover, its success would have been unlikely without a host of parallel and related developments in mathematics, physics, geology, and philosophy, themselves tied, at least indirectly, to specific social contexts of production. Moreover, what notions of world, earth, and space have been sustained and enhanced by the emergence of an abstract science of stellar mapping and a metaphysics of a God's-eye view? In this sense, the tool and the science are mutually related, and it makes no sense to think of astronomy as the science of interstellar space without the telescope providing the conditions of possibility for the measurement and location of light sources within a scopic regime on which future stellar observations could be built, and as a result of which our world has been transformed. Such a claim does not close down discussion of the tool and the technology. Instead, it opens up both technology and science to analyses of the material and cultural politics, as well as the intellectual struggles, that provide the real context for their emergence.

One important question in this regard has to do with the effects of the tool status, use value, and practical commitments from which GIS emerges, and whether these are necessary relations or can be overcome in the next phase of struggle over the direction of our inquiries? But here the authors' selection of ancillary disciplines appropriate to a new science of geographic information systems and geographic information remains firmly rooted in the technological sciences of earth measuring and mapping, the very sciences that have given us our present notions of world-space and parametric sciences of the earth (Pickles 1985). While such engineering sciences are now essential for building what Eric Sheppard has called "better mousetraps," they may not be the sciences we need to deepen our understanding of the social implications of GIS. Indeed, this selection of ancillary sciences seems to belie the authors' own attempts to open GIS to the "winds of change" blowing through the social sciences and social theory.

Scientific Method and the Rights of the Individual in GIS

"Demystifying the Persistent Ambiguity of GIS as 'Tool' versus 'Science' " is organized around the results of a simple content analysis of e-mail messages posted to GIS-L in late 1993, and this usage is instructive in at least two very important ways. The significance of e-mail lists like GIS-L as sources of information for scholarly reflection is, I think, questionable, particularly since e-mail seems to lend itself to quick, unreflective, and unedited responses—more like discussion at a workshop than carefully thought-out scientific writing, as the authors point out (p. 348). Several scholars have found the content of such lists useful (Mark and Zubrow 1993), some (we are told) have even referred to such electronic lists as 'invisible colleges' (Crane 1972), and we know from research traditions ranging from social geography to cultural studies that the mundane, the vernacular, and the apparently trivial can be sources of importance for demystifying the given and taken-for-granted worlds of the everyday and science. The authors themselves claim that the GIS-L discussions are useful because they reflect the uncertainty faced by younger scholars about whether departments will accept GIS as a topic of scholarly research.

The value of the 'text' and the significance of the 'comments' registered in the messages remains unclear, however. This concern is registered by the authors themselves, who on page 348 argue that "[M]any of the discussants do not have the time, the inclination, or perhaps the energy to research the positions they adopt on such topics as, in our case, philosophies of science, geographic methodology, or the interplay between science and technology." Putting aside whether lack of time, inclination, and energy

constitute good reasons for professional speech, we are nonetheless presented with unreflective discussion in a medium renowned for immediacy of response, and we are asked to believe that this discussion somehow gets at the epistemology and science underpinning GIS.

Regardless of whether we accept the claim that e-mail discussions are valuable texts for debating science, the treatment of the GIS-L points to a second important issue. The authors argue that mailings posted to a public e-mail must be treated with care to protect individual rights to privacy and confidentiality. Individuals who posted messages to GIS-L were contacted, consulted about the goals of the paper, and offered the opportunity to withdraw from the research or review the texts they posted. Permission from authors to quote from their messages on GIS-L was also sought.

This care to address issues of confidentiality and the rights of individuals is to be applauded. But there is some irony here. Much GIS draws on databases that use individual-level information, a point made by Sheppard (1993, 1995) and Curry (1995, 1996). But in practice, developers and users of GIS have not paid much attention to the rights of individuals to control information about themselves, to withdraw from databases involving themselves, and to review the information available and the ways in which it is being used. Instead, in cases other than those involving criminal and victim identification (and in some cases even there), the field of GIS (as far as I am aware) has no substantive protocols or methodological principles that govern the use of information about individuals or guarantee (in ways similar to that in which GIS-L participants were protected) the rights of individuals included in databases to remove themselves or to see the results of the analysis (see, for example, Goss 1995; Curry 1994, 1995, 1997). In this light, the methodological care exhibited for the contributors to GIS-L might seem disingenuous. It is one thing to exercise appropriate and careful methodological concern in dealing with a small group of individual subjects who are, by and large, colleagues, but having demonstrated the validity and importance of checking with human subjects that they agree to be part of the analysis and offering them the opportunity to read and edit the texts used, I cannot see how GIS researchers can avoid accepting the necessity of generalizing this principle to all data about all individuals.

Wright, Goodchild, and Proctor have opened the window to ethically responsible research practice, but I am not sure they can practically accept what comes through that window! If they are correct to treat their subjects with the care they themselves explain and justify, then how can they not extend such concern to all subjects within the domain of GIS research? The conundrum is not a serious one for most practitioners of social science: we have long accepted that the rights of researchers to use information about individuals supersede—in the name of a greater public good—the rights of individuals to control the kind of information collected about them and the uses to which that information can be put. Of course, where the use of individual-level information produces obvious dangers of intrusion or harm, there are some protections, such as restrictions on the use of individual-level census information or personal credit information. The conundrum nonetheless is a real one and makes an important point: if a rigorous treatment of publicly disseminated discussion lists necessitates methodological procedures to protect individual privacy and confidentiality, how can we avoid extrapolating those principles to other aspects of current GIS practice? If the methodological claims to protect privacy and access to the work of a researcher are meaningful, they need to be upheld in situations where the consequences of not accepting ethical and methodological limits on data use have much more serious consequences for individuals than use of public notes on an e-mail list.

Such a methodological principle would, of course, bring contemporary GIS to a crashing halt, since few, if any, socioeconomic databases are constructed on such principles. We must also ask, however, what the consequences of a failure to incorporate such principles and protections might be for the development of geographic information *science*? Geographic information *systems* deployed in wide-ranging applications are governed by the ethical and methodological standards of the application domains and the legal context that governs each. Geographic information *science* would be bound by different and stricter ethical and methodological principles. The authors are correct to insist on the right of individuals to have access to, and in the final analysis to control, the information generated about themselves,[3] but we do not yet know what a science that accepts such principles would look like.

Why Are We Asking Whether GIS Is a Tool or a Science at This Time?

> Surely the desired end from all perspectives is the building of an intellectual foundation for GIS by geographers and members of allied disciplines alike, which will ensure its survival long after the novelty of the technology has worn off (p. 358).

While writing this essay I have been reviewing Derek Gregory's *Geographical Imaginations* (1994) and Anne Godlewska and Neil Smith's *Geography and Empire* (1995), and teaching David Livingstone's *The Geographical Tradition* (1992). It is an astonishing contrast to work through these texts while responding to this paper. The gap between the discursive and theoretical worlds inhabited by the various authors is astonishing. But the conventional explanation of this difference—that social theory has become esoteric and caught up in impenetrable languages—is simply inadequate. The rigor of argument and the breadth of exposition in the three books on the very issues that exercise the authors of "Demystifying . . ." poses for me a fundamental question about the possibility of geographic information science, one to which I shall return later in this essay: how did it take the field of GIS thirty years to begin to ask fundamental questions about its own practice and intellectual and practical commitments? And it is this question that seems to me to be the most important one the authors ask us to consider.

Given that the questions that have exercised contemporary critical human geography for at least the past twenty years have not been seen as interesting or important within the field of GIS, it is important to ask why Wright, Goodchild, and Proctor elected to raise the questions they do about GIS and its practice now? That is, why is whether GIS is a tool, a tool-making activity, or a science a question for us today? The authors argue in several places that there are practical reasons why it is necessary for a science of GIS to emerge: to protect the field when the fad of technology wears off, to provide stronger intellectual grounds for the wider enterprise, to ensure that the special role played by geography is maintained, and to address the more interesting questions posed by the uses of GIS rather than the merely technical questions about how to improve the software. But these arguments are not systematically developed, and they are not located within any broader political economy of information technology or geopolitics of knowledge. In what follows, I shall outline a part of this broader canvas against which we need to assess their specific claims.

In the 1990s, GIS has been generalized in ways in which even strong advocates in the 1980s could not dream. It has been generalized throughout the geography curriculum either directly in terms of courses and textbooks or indirectly in terms of a more general familiarity with and use of languages and images of geographic information systems.[4] But it has also been generalized in other ways: it has become the tool of choice among many nongeographers whose work demands that they handle spatially-referenced information (ranging from botanists to transport engineers), it has merged technically with other image processing and data-capture technologies (ranging from the theoretically simple GPS of the surveyor to the more intellectually challenging three and multidimensional virtual representations and simulations of geography, architecture, geology, atmospheric physics, fluid mechanics, and even the arts), and it has become the province of commercial software and hardware developers and vendors whose relations with researchers at universities have become, of late, increasingly tenuous.

While, in the late 1980s, Michael Goodchild could rightly argue that GIS is big business—both in geography (where the double meaning of the phrase is not lost on keen observers) and in other academic and applied fields—the degree of success by the mid-1990s is now cause for soul-searching about the future roles that geographers are likely to be able to play in so highly generalized an enterprise. Digital spatial data systems have been rapidly adopted in commercial and public settings ranging from local planning, infrastructure developments, military logistics, health care provision, and commercial insurance, to facilities management. GIS has arrived! Where its practice still has to live up to its promise (in many areas indeed), new technologies coming on-line continue to hold out the possibility that its promise may be more fully achievable and accessible to more people. Already there is talk of a GIS being embedded within Windows, just as spreadsheet, graphing, and word-processing programs already are. Such success has brought enormous personal and professional benefits.

Such success is not without problems, however. First, the institutional success of GIS has generated strong opposition from others in the profes-

sion. The ability of GIS to capture institutional resources for equipment, software, licenses, and faculty and staff positions in departments throughout North America stunned faculty and job applicants alike. For several years, the vast majority of job ads in "Jobs in Geography" in the *AAG Newsletter* required GIS skills of applicants, as departments big and small jumped on the bandwagon of revival and growth through technology. Terry Jordan's (1988) presidential comments rejecting the intellectual value of GIS reflected the sense of 'dis-ease' that characterized the attitude of large parts of the profession towards GIS at the time.

Second and related, the enormous new demand for faculty and staff with GIS skills meant that many individuals were hired from relatively small pools. Such hiring practices are not uncommon in unregulated labor markets, but they have been particularly marked in GIS and other computerized information-related fields throughout the late 1980s. By 1994–1996, however, many of those hired in the mid–late 1980s had come up or were coming up for tenure. A sense emerged within the GIS community in the U.S. that success at the entry level was not matched by equal success when it came to retention. Partly because young GIS scholars found themselves inundated with external funding possibilities, partly because they often preferred, or were required, to 'plug and fix' lab after lab, but also partly because of their initial interest and training in things technical rather than scholarly, many of these first-wave fully trained GIS practitioners expressed concern in discussions such as those on GIS-L about tenure and promotion. Research publications and the development of sustained research programs leading to national reputations eluded quite a few of this first wave. Thus, ironically, by the early 1990s, as graduate students without GIS skills were terrified (some might say paralyzed) by the prospect of no jobs, graduate students with GIS skills were increasingly concerned about whether the promotion and tenure process was 'fair' to GISers.

Third, success in developing new applications meant that the center of gravity in GIS shifted rapidly in the late 1980s from universities to private corporate developers with residual ties (if any) into universities through original algorithm developers. A new institutional configuration emerged to dominate both the development and the use of GIS as a tool, and in these corporate settings, the role of academic geographers was uncertain. Moreover, the broadening of the range of applications of GIS beyond geography to other research and applied fields fostered a gradual loss of the geography in GIS usage, or more accurately, a reduction of what the geographical entailed within GIS (now reduced to locational attribute, terrain feature, and landscape content). It was no longer the case that everyone in the field of GIS looked back to common origins, such as the Harvard Graphics Lab, the work of Tomlinson in Canada, and the Minnesota Land Management Information System.[5]

GIS had indeed become big business. Technological and institutional convergence meant that "big science" was a possibility for GIS, but it came at the very time that other larger fields had become players in developing and shaping the future of the software and the research agenda. As GIS became an integral part of the restructuring and modernization of economic, political, and social life, the number and power of players entering the 'field' increased rapidly, and the core definition of GIS began to merge with other spatial-information processing and imaging technologies. Geographers have been well placed to participate in this emerging big science, whether it is in the global change research sponsored by NSF, NASA, or EPA, or in the creation of a National Center for Geographic Information Analysis (sponsored by NSF).

In order to consolidate this comparative advantage and compete more effectively in these areas with other social and natural sciences, GIS needs a much stronger theoretical self-understanding, as Goodchild has repeatedly reminded us (1992, 1993, 1994). No longer able to lead the commercial field of software development and application, university researchers find themselves in an interesting situation: at the very time that GIS is being generalized and is entering the domain of 'big science,' this sense of optimism about new possibilities is paralleled by the need to redefine the role for geography in GIS or to become marginalized. Marginalization has emerged as a threat *within* the discipline as GIS faculty have been asked to carry out technical services for the departments and universities in which they work, *within* the wider academy as other disciplines have begun to participate effectively in the development and deployment of GIS in their research, and *beyond* the discipline as software development and cutting edge research is increasingly occurring in corporations and major research centers (such as NASA), not university departments.

Thus, the problem of consolidation and legitimacy has emerged as the wider discipline has begun to move away from awe to outspoken criticism and as the central role of geographers in software (tool) development has diminished: GIS was not sufficiently scholarly, had not produced anything new, tended to be applied and not cutting-edge research, and was a field dominated increasingly by techies, not scholars. GIS practitioners were even talking about forming their own discipline and institutional field. Such heresy was bound to raise the hackles of traditionalists within geography. Others even suggested that there were problems with GIS at its very heart: its development had been (and possibly still was being) paid for by Defense funding for arms research; the technology was creating new capacities of surveillance and was being used to control social groups and populations; GIS presupposed certain types of objects and notions of space and these, tied to its own epistemological commitments, placed serious limitations on the kinds of questions that could be asked. Indeed, how scientific was a field which had steadfastly refused to engage in any rigorous reflection on its own assumptions and practical commitments, and which had buried its head in the sand vis-à-vis the vigorous epistemological and ontological debates that had occurred in the discipline in the 1970s and 1980s?—a point made by geographical theorists throughout the late 1980s and early 1990s (Taylor 1990; Taylor and Overton 1991; Taylor and Johnston 1995).

Geographic Information Science and the Theoretical Turn

For all these (and other) reasons, the basic parameters of GIS have to be extended. The role of the geographer in designing and implementing a series of spatial-data handling and imaging tools has to be redefined so that the scholar/researcher/scientist replaces (or complements) the GIS practitioner and toolmaker. In effect, the authors seem to be calling for Geographic Information Science to give theoretical and analytical legitimacy to GIS, in much the same way that Regional Science emerged in the 1960s to provide an intellectual setting within which spatial analysis and spatial science could develop and to serve as a support to regional economics, regional planning, and geographical analysis. The GIS in which technical rationality dominates so thoroughly now must give way to a science of GIS: the scholarly investigation of its origins, logics, systems, new capacities, and new uses. Geographical Information Science is to emerge to deal with the demands of a booming field of geographic information systems and their uses.

This new science is to be more open and flexible than present-day GIS. For the authors, there is a real possibility that multiple epistemologies and ways of knowing might be more productive than maintaining a dogged commitment to a single positivist view of science, and here the authors are suggesting something quite radical for GIS:

> In this context, GIS may represent a new kind of science, one that emphasizes visual expression, collaboration, exploration, and intuition, and the uniqueness of place over more traditional concerns for mathematical rigor, hypothesis testing, and generality . . . (p. 358–59).

The authors argue that "[a] lengthy foray into the philosophy and sociology of science is beyond the scope of this paper, but some consideration of these matters is unavoidable in order to know what scientists do, the significance of what they do, and the relationship of science to other knowledge-generating mechanisms" (p. 353). To achieve these goals, however, it will be necessary to engage directly and more substantially the complexities and abstractions of philosophies of science and the theories of knowledge and society associated with them. The authors, in fact, make no references to any works in the philosophy and sociology of science. Whether this is an oversight or a purposeful attempt by the authors to begin a discussion about 'science' again under conditions of a new technological ensemble is hard to say. Either way, the effect is to give to a reader a sense of *déjà vu*, of old ground being replowed, and of complex issues being mapped onto preexisting theoretical frameworks without reference to the kinds of literature and scholarship from which they derive.

This reticence to engage with the philosophy and sociology of science seems to arise out of a genuine sense of confusion in the face of "theory proliferation." For the authors, "there are probably as many definitions and viewpoints of science as there are scientists, and not all of these are necessarily correct" (p. 353) and "[a] concise definition of science cannot hope to capture the full meaning of the term" (p. 353). Moreover, the problem is not only that there are many different

theories, but that, for the authors, theory choice is reduced to a matter of personal preference: "Depending on one's inclination, there are several different approaches to science, each with its own ontology, epistemology, and methodology. These so-called -isms are defined variously by geographers . . . 'positivism,' 'humanism,' 'structuralism,' 'empiricism,' 'relativism,' 'critical rationalism,' 'Marxism,' 'structuration theory,' 'realism,' 'postmodernism' . . . ." (p. 353).

Having missed the vigorous debates that flourished in the 1960s and 1970s about how we understand the social sciences (Kuhn, Popper, Lakatos, Feyerabend, Althusser, and Adorno among others come to mind), any emergent science of geographic information must now wend its way into and through long-standing debates and theoretical frameworks of great complexity. These attempts will have to engage not only philosophers of science such as these, but also a variety of new writings and ideas on issues such as digitality and computer information, science as a social practice, and gendered knowledge-systems, as well as ideas that have already made their appearance in the first theoretical turn in geography: for example, Jacques Ellul's work on technology and society (1964), humanist geographers' engagement with Heidegger on the nature of technology and dwelling (1977a, 1977b), discussions arising from the publication of *Positivismusstreit* (Adorno 1976), and Habermas's criticism of the penetration of the lifeworld by instrumental reason and science (1970, 1987).

But in this project they will, I think, be ill-served by their efforts to locate such theories within a liberal ideology of "multiple and equally valid worldviews." Earlier I suggested that this relativizing of theory (as thoroughly pluralistic) and the fetishizing of science (as distinct from technology) needs a critical theory of the contemporary forms of technoscience and its embeddedness in a host of liberal assumptions.[6] Bruno Latour has posed this in particularly sharp form. In *We Have Never Been Modern*, Latour (1993) argues that in the debates between Boyle and Hobbes, there emerged a split in thinking so fundamental that it continues to shape our own worldview today. In this debate, two distinct notions of representation emerged: the representation of ourselves and the world as objects of scientific investigation, and the political representation of subjects by those designated with the power to speak for us. Representational epistemology and representational politics emerge at the same time, and each draws its particular meaning from the existence and form of the other. In other words, science and politics are two sides of the same coin, and they are necessarily related.

In this sense, the crisis of technological science (and I locate GIS in this context) is also a crisis of liberal legal and political theory. What constitutes appropriate methodology in the social sciences is thoroughly conditioned by the broader representational systems of political belief on which liberalism is founded. This is the Pandora's box that critical human geographers opened from the 1970s onwards (and, it might be argued, some are now trying to close again). As the authors of "Demystifying . . ." demonstrate, it is now high time that the practitioners of GIS accept the call to the hard theoretical work that will change their thinking, the forms and uses of their geographic information systems, and, we hope, the worlds in which they are deployed. "Demystifying . . ." calls for the hard work of theory to begin. But it also illustrates, as well as any argument could, the necessity of carrying out this hard work through the traditions of thought in which the questions have already been asked. It calls, that is, for a theoretical turn in GIS that matches the theoretical turn in geography that began in the 1970s and was consolidated in the 1980s and 1990s. In contemporary geography, the critical theorists of GIS might well yet find a home that sustains their intellectual pursuits and professional goals.

Notes

1. My comments have their own practical commitments, and these need to be acknowledged. For the past two years, I have been working with a small group of social theorists in an NCGIA-funded Initiative 19: How GIS Represents People, Space, and Environment (more commonly referred to as the GIS and Society Initiative). In this context, Michael Goodchild and we have been working together to create a forum for civil yet critical discussions about the nature and future of GIS. At the time of writing this essay, I am also writing a chapter on the work of the Initiative for the second edition of *Geographical Information Systems: Principles, Techniques, Management, and Applications*, edited by Longley, Goodchild, Maguire, and Rhind. This commentary is further complicated by the fact that much of my own writing has been devoted to questioning the self-understanding and implications of technoscience and instrumental rationality for disciplinary in-

quiry and social life. In this essay, these two commitments are clearly in tension with one another.

2. For more on the centrality of this distinction in modern geography, see Pickles (1988).
3. The issue, of course, is not as simple as this claim suggests. The right to privacy and the removal of personal information from the public domain has always been tempered to some degree by the right of the public to know: that is, the right of the public to obtain private information under certain legally defined circumstances. Such rights are the basis for much contemporary environmental regulations, for example.
4. An interesting example of the writing of geographic theory in terms of the lexicon of GIS and through a geographic vision greatly influenced by GIS is Abler, Marcus, and Olson (1983).
5. It is, I think, not surprising that this sense of impending marginalization should lead to the publication of precisely such foundational histories of GIS (Petchenik 1988).
6. See Pickles and Watts (1992) for a similar argument couched in terms of paradigmatic and postparadigmatic science.

References

Abler, R. A.; Marcus, M.; and Olson, J. eds. 1992. *Geography's Inner Worlds: Pervasive Themes in Contemporary American Geography.* New Brunswick, NJ: Rutgers University Press.

Adorno, T. W. 1976, ed. *The Positivist Dispute in German Sociology.* Trans. G. Adey and D. Frisby. New York: Harper Torchbooks.

Chrisman, N. R. 1991. A Geography of Geographic Information: Placing GIS in Cultural and Historical Context. Mimeo.

———. 1987. Directions for Research in Geographic Information Systems. *Proceedings of the International Geographic Information Systems Symposium* vol. 1, pp. 101–12.

Crane, D. 1972. *Invisible Colleges.* Chicago: University of Chicago Press.

Curry, M. R. 1997. The Digital Individual and the Private Realm. *Annals of the Association of American Geographers.* Forthcoming.

———. 1996. Digital People, Digital Places: Rethinking Privacy in a World of Geographic Information. Paper presented at the Conference on Technological Assaults on Privacy. Rochester Institute of Technology, Rochester, NY.

———. 1995. Rethinking Rights and Responsibilities in Geographic Information Systems. *Cartography and Geographic Information Systems* 22:58–69.

———. 1994. Image, Practice and the Hidden Impacts of Geographic Information Systems. *Progress in Human Geography.* 18:441–59.

Ellul, J. 1964. *The Technological Society.* Trans. J. Wilkinson. New York: Vintage Books.

Godlewska, A., and Smith, N. 1995. *Geography and Empire.* Oxford: Blackwell.

Goodchild, M. 1992. Geographical Information Science. *International Journal of Geographical Information Systems* 6:31–45.

———. 1993. Ten Years Ahead: Dobson's Automated Geography in 1993. *The Professional Geographer* 45:444–45.

———. 1994. GIS and Geographic Research. In *Ground Truth: The Social Implications of Geographic Information Systems,* ed. J. Pickles, pp. 31–50. New York: Guilford.

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. J. Pickles, pp. 31–50. New York: Guilford.

Gregory, D. 1994. *Geographical Imaginations.* Cambridge, MA: Blackwell.

Habermas, J. 1987 [1981]. *The Theory of Communicative Action,* Vol. 2, *Lifeworld and System. A Critique of Functionalist Reason.* Trans. T. McCarthy. Boston: Beacon Press.

———. 1970 [1968]. *Toward a Rational Society: Student Protest, Science and Politics.* Trans. J. J. Shapiro. Boston: Beacon Press.

Harvey, D. 1974. What Kind of Geography for What Kind of Public Policy? *Transactions of the Institute of British Geographers* 63:18–24.

Heidegger, M. 1977a. *The Question Concerning Technology and Other Essays.* New York: Harper & Row.

———. 1977b. Building Dwelling Thinking. *Basic Writings,* ed. D. F. Krell, pp. 319–40. New York: Harper & Row.

Jordan, T. 1988. The Intellectual Core: President's Column. *AAG Newsletter* 23:1.

Latour, B. 1993. *We Have Never Been Modern.* Cambridge: Harvard University Press.

Livingstone, D. 1992. *The Geographical Imagination.* Oxford: Blackwell.

Mark, D., and Zubrow E. 1993. Join the GIS-L Electronic Community! *GIS World* 6:56–57.

Petchenik, B., ed. 1988. Special Issue on the History of GIS. *The American Cartographer* 15:249–322.

Pickles, J. 1985. *Phenomenology, Science, and Human Geography: Space and the Human Sciences.* Cambridge: Cambridge University Press.

———. 1988. Knowledge, Theory and Practice: The Role of Practical Reason in Geographical Theory. In *A Ground for Common Search,* ed. R. Golledge, H. Couclelis, and P. Gould, pp. 72–90. Santa Barbara: Goleta Press.

——— and Watts, M. J. 1992. Paradigms for Inquiry? Criticism and Explanation in Contemporary Human Geography. In *Geography's Inner Worlds: Pervasive Themes in Contemporary American*

Geography, ed. R. A. Abler; M. Marcus; and J. Olson, pp. 301–26. New Brunswick, NJ: Rutgers University Press.

Sheppard, E. 1993. GIS and Society: Ideal and Reality. Proceedings of the Geographic Information and Society Workshop, NCGIA, Friday Harbor, WA, pp. 1–12.

———. 1995. GIS and society: towards a research agenda. *Cartography and Geographic Information Systems* 22(1):5–16.

Smith, N. 1992. Real Wars, Theory Wars. *Progress in Human Geography* 16:257–71.

Sui, D. Z. 1994. GIS and Urban Studies: Positivism, Post-positivism, and Beyond. *Urban Geography.* 15:258–78.

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

——— and Johnston, R. J. 1995. Geographic Information Systems and Geography. In *Ground Truth: The Social Implications of Geographic Information Systems*, ed. J. Pickles, pp. 51–67. New York: Guilford.

——— and Overton, M. 1991. Further Thoughts on Geography and GIS. *Environment and Planning A* 23:1087–94.

Veregin, H. 1995. Computer Innovation and Adoption in Geography: A Critique of Conventional Technological Models. In *Ground Truth: The Social Implications of Geographic Information Systems*, ed. J. Pickles, pp. 88–112. New York: Guilford.

Correspondence: Department of Geography, University of Kentucky, Lexington, KY 40506-0027.