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An interview with Michael Goodchild, January 6, 1998, Santa Barbara, California

Interviewer: Naifine Schumann
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The debates

NS When was the first instance of printed dissent between critics and advocates of GIS?

MG I think it was the debate between Peter Taylor and Stan Openshaw in *Environment and Planning A* [Openshaw, 1991; Taylor, and Overton, 1991]. There were earlier events: one I remember in particular was a session at the AAG organized by Brian Harley; it must have been in the late 1980s. That was my first encounter with Harley's work in cartography, and it struck me that something was happening in cartography that had been entirely missing up to that point in GIS.

NS You responded eloquently and without rancor to Peter Taylor's 1990 piece titled "GKS" [geographic knowledge systems] in which he characterized GIS use as a "trivial pursuit" geography based on facts rather than knowledge [Goodchild, 1991]. Were you as unflappable as your response indicated?

MG Yes. I thought Peter had it point but that it was based on a simplistic interpretation of what GIS was capable of, and John O'Loughlin asked me if I was interested in writing a response. I was concerned about the labeling of facts as "mere", which seemed inconsistent with the reality that many data in GIS are the output of people's careful science; soil mapping is a good example, and surveying is another.

NS When Openshaw's first commentary was published on the GIS 'wars', what was the general feeling of the GIS community in your view?

MG There was a mixed reaction. On the one hand there was a strong feeling that these issues were of no significant concern to the community, which saw itself as trying to build working systems in response to strong practical needs. On the other hand many people on reflection felt that Taylor and others had a point, or a series of points, and that they needed to be taken seriously.

NS Openshaw states explicitly in that piece that critics of GIS are ill informed about the practice. Was that already evident then?

MG I think that it becomes evident when you try to pin the critique down. In early 1996 NCGIA [National Center for Geographic Information and Analysis] organized a specialist meeting on GIS and Society at Koinonia outside Minneapolis, as the start of NCGIA's Research Initiative 19. For me it was the first chance to hear both sides debate the issues at length. We started to talk about what it is about GIS that is particularly constraining. "Well, it sees the world as a series of layers". That's what you might infer from the front cover of many GIS textbooks, but it's not a correct statement about the field as a whole. GIS was criticized for insisting on crisp boundaries, and again that's not technically correct. This suggested a strategy of fighting the war one issue at a time, by focusing on specific critiques.

NS In a sense, these debates have been conducted in the language of the critics of GIS rather than in the language of GIS. And you are speaking now of instances in which speaking the language of GIS has been useful. Why do you think that people in GIS have not responded using their own language, the language of the discipline?

MG I think many people feel that much of the critique is well founded, and therefore response is going to be muted. I'd put Jonathan Raper in that category, for example.

NS And Nick Christman?

MG Nick Christman, Bill Macmillan. If one tries to respond in the language of GIS, one somehow misses the larger picture. I guess I feel that somehow the language of social theory is the more general language, and that responding in the language of GIS in a sense confirms the point. I can't fight something like Neil Smith's *Progress in Human Geography* [1992] article by talking about how GIS structures space. I can do that to an extent. I guess that's what I tried to do in *Ground Truth* [Goodchild, 1995]. But certainly I have to say that I think Neil's point is valid. GIS and cartography deny or downplay the importance of the military background. He is absolutely right.

NS Yes, but in a sense, Neil's was a limited history as it had nothing to say about remote sensing.

MG Right, there is a history still to be written about the military role in the development of remote sensing. Also Neil and others made much of the parallel to the Manhattan Project, and Oppenheimer's subsequent personal sense of guilt at having helped to make nuclear war possible; but that parallel won't work for GIS. Oppenheimer was intimately involved with making the bomb at Los Alamos, and his personal contribution was indispensable; if one is going to hold GIS researchers responsible for all eventual GIS applications one might as well hold all makers of pens responsible for everything that is written. There has to be some minimal threshold of personal involvement.

NS A lot of people in GIS have simply stopped responding to these debates. Why do you think that is?

MG Perhaps they are hoping they will go away; or that there is nothing new to be said. I personally have felt that it is important to engage; yet I think that's bound to be perceived in some quarters as a risky strategy, as selling out. I think many people in GIS have no interest in responding. They are like many scientists in being driven by the immediate problem at hand.

NS Some of the human geographers have partially built their careers upon writing critiques of GIS. How meaningful is participation in these debates for people in GIS?

MG Quite meaningful for geographers interested in GIS. 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. It wouldn't be to come down on either side of it because you have to be able to talk to the rest of the discipline and yet you have to be able to use the technology. I think that some of the people in the debate are well informed on both sides. I think of Michael Curry, for instance.

NS Is it really possible to straddle both side of the debates?

MG Yes, definitely. I think geographers have something unique to offer in the GIS area, that distinguishes their contribution from that of a computer scientist, say. First, I think geographers have the fullest knowledge of the nature of the real world, both its forms and its processes, and are therefore the best possible people to understand the

relationship between the contents of a database and the real world. That means concern for issues of representation, and also for accuracy and uncertainty. Second I think geographers are the people best equipped to comment on the broader implications of GIS; to do what academics do best in reflecting on GIS and its impacts. I think those are two such spaces, both of them located between the traditional concerns of geography and the more general field of GIS.

NS A lot of criticism of GIS has been that it is a view from above and that it eliminates knowledge of those on the ground, local knowledge. How comfortable are you with that characterization?

MG I think that it is an accurate reflection historically, particularly if 'above' is interpreted to mean both vertically from space and hierarchically from an elite position. We have had top-down data production, in the sense that the majority of geographic data have been produced by national governments. I think that traditional arrangement has no more than five years to run in the US. In five years I think the federal government will be almost entirely out of the mapping business. I think the bulk of production of geographic data will be done at the individual level, by the farmer, or the city hall worker.

NS How are these data going to be processed?

MG With cheap, universally available technologies like GPS [global positioning system] receivers, low-end GIS software, general-purpose personal computers, and the Internet. Farmers can already buy time on low-flying pilotless aircraft, and have access to what are known as 'precision agriculture' technologies. I think we must try to anticipate these kinds of technological empowerments, and talk about the restructuring of institutions that is going to have to occur. These trends to local and individual empowerment are already advanced in some fields, like agriculture. The Natural Resource Conservation Service (formerly the Soil Conservation Service) maintains a network of county outreach offices. Traditionally their role has been to dispense federal data; but the trend is toward a reversal; it's now technically possible for the farmer to be a source of data to the federal government. That has the potential to cause massive institutional restructuring.

NS What are the infrastructural and political repercussions of this restructuring?

MG It means that federal agencies will be more and more concerned with coordination, setting of standards, promotion of new technologies, and less with actual data production. It means that mapping will become a patchwork operation, in which some parts of the nation are better mapped because there is greater local interest in detailed geographic information. Technically, we will be faced with the need to ensure comparability across the boundaries of the patchwork, which is a tricky problem.

Epistemology: the debate over positivism

NS Do you want to comment about some of the criticisms that GIS is a positivist science?

MG I don't think it is inherently positivist. GIS is a machine that is capable of a wide range of operations, and these in turn are compatible with a wide range of philosophical positions. And many users of GIS do not have explicitly stated philosophical positions.

NS Why do you think that so much of the criticism of GIS has focused on positivism?

MG Guilt by association, I guess. If GIS can be identified as positivist then it inherits the critiques of positivism. It was tempting to identify GIS as a last echo of the quantitative revolution, as Peter Taylor did in his "GKS" paper. Similarly, if the people advancing GIS are former (or continuing) quantifiers, then their activity can be suspected of inheriting the critique of quantification. Then there's Ian Heywood's editorial [1990] which claimed explicitly that GIS was reviving positivism.

... I think 'positivism' is often used synonymously with science, or the scientific method, or the activities of scientists, and has been overused as a label for scientific method. I mean that in the broad sense 'positivist science' is redundant. Some of the things that I read grate so much with my own recollections. It's amazing for me to read that positivism died in geography in the 1970s. From my perspective, it's not even been ill. I've spent my professional life at Western Ontario and here [UCSB] and at McMaster. I've always understood that, if you wanted to get support for your research at NSF [US National Science Foundation] or NSERC [Canada's Natural Science and Engineering Research Council], you emphasized the scientific aspects of what you did. It was inevitable that you had a positivist framework (taking the term in its broad sense). The argument applied as well to human geography as it did to physical. The kinds of human geography we have in this department are broad-sense positivist. The kind Rick Church does is the kind I've always done. Helen [Coucleis] is a little bit more philosophical, but Helen has been a strong supporter of scientific method. So I feel that somehow I've escaped the critiques, and it's amazing to me to read that positivism died in human geography almost twenty years ago. I know life would have been very different had I been in some other departments.

NS Like UBC [University of British Columbia]?

MG Yes.

NS Are there very localized geographies of scientific knowledge? Could you give an example?

MG I guess there are. I think one could map the geography of the critiques of positivism and quantitative geography, and perhaps one could show patterns of diffusion, though I think much of the diffusion process has been hierarchical rather than proximity-driven. Berkeley and Santa Barbara are relatively close, but they have had very different influences on human geography over the past two decades.

NS Is GIS then instrumentalist rather than positivist?

MG Yes. One of the greatest issues in positivism has always been the generality of what one discovered, which surfaced in human geography as the debate about generality versus uniqueness. The work on central place theory in the 1960s is a good example. But the proposition that there were fundamental laws of geographic form to be discovered died. It certainly died with me in the 1970s. And yet one could still maintain a positivist view, even though one was doing practical things like optimizing locations of convenience stores in West Vancouver, because one had to take a positivist view of human spatial behavior and try to find generalizable principles on the basis of which one could plan. I found the 'applied geography' concept and community quite compatible with that way of thinking. I used to go to applied geography meetings and publish in their proceedings. When GIS came along it seemed to me to offer a partial resolution of the general/unique debates, because in GIS there is a lot of concern for the unique in the data and how one represents the unique; and at the same time, there's a lot of concern with the general processes that operate on those unique conditions. So I think GIS can accommodate a much broader spectrum of views and approaches in

geography than the early quantifiers ever could. Obviously, we can't go all the way and there are a lot of ways in which the digital environment still filters and limits geographic understanding.

NS How is GIS related to the quantitative revolution?

MG It has reinvigorated something that was in danger of becoming moribund. To take an example, the kinds of methods of spatial analysis that we were developing in the late 70s and early 80s were becoming very abstract and abstruse. We propounded the notion that because they were being published they would eventually be used, but realistically there was no prospect that that would ever happen. GIS came along and initially the notion was that it would allow us to implement these methods and make them easier to use, and so finally they would be usable. In practice what has happened is quite the opposite. GIS has reestablished the importance of intuition and simplicity of exploration over those very hard-core confirmatory hypothesis-testing techniques. Do you know the Peter Gould article in the 1970 supplement to *Economic Geography*? "Is Statistic Inferens the geographical name for a wild goose chase?" It is still very much worth reading because the kinds of things that GIS has enabled help to resolve much of the critique that he develops there.

NS I am interested in your saying that GIS is intuitive. Could you elaborate on that?

MG I think science is inherently intuitive. It seems to me quite out of line to believe that one can formalize every method of spatial analysis, and reduce analysis to the kinds of decision trees one finds inside the front covers of statistics textbooks: "If you have this kind of data, do this. If you have that kind of data, do this". It suggests that it is the method that drives the science, and that one needs to ransack reality to find data that are suitable for analysis.

NS Do you think that there are techniques being introduced in GIS that encourage intuitiveness?

MG I often use the 1987 Stan Openshaw childhood-leukemia example where he combines visual intuition with a statistical method [Openshaw et al, 1988].

NS Do you think that the visuality of GIS encourages this?

MG Yes absolutely.

NS Why do you think that the abstract representational basis of GIS has been ignored by its critics?

MG What do you mean?

NS GIS was characterized by Taylor as "fact-driven." But GIS is very abstract, building abstraction upon abstraction. It is a very abstract representation but little attention has been paid to that. That has simply not been acknowledged.

MG It has to a degree. But we have tried to draw that issue out in the Varenius project.⁽¹⁾ One can ask, for example, whether there are classes of geographic concepts to which the digital world is inherently hostile. I think the answer is yes, there are. It is a question of how one uses the digital world. We tend to see the digital world as highly structured. In order to be digital, you have to codify and formalize. Thus it was

⁽¹⁾ Varenius is the name of a project being funded by NSF to advance GIS. One of its themes is Computational Implementations of Geographic Concepts, led by Max Egenhofer at the University of Maine. That effort asks, among other questions, whether the representation of geographic knowledge in a computer is inherently limiting, and about the nature of those limitations.

a surprise when the FAX machine proved popular, because it transmits text as a picture, without recognising the characters. Essentially everything that can be communicated can be communicated digitally. The question is how structured it has to become before it is communicated.

NS What is lost in that structure?

MG At some levels, nothing. If you digitize the human voice, in principle you lose nothing. In practice, of course, you lose all aspects of human communication that are not expressed in sound, like gesture.

NS What GIS abstractions tend themselves to being viewed as having an epistemology other than positivism?

MG A lot of areas that the cognitive people have become interested in recently are of that nature. There are the questions about qualitative spatial reasoning—defining north, for example. The positivist attitude to that is: "Well, once you define north the problem goes away. It is a problem of definition, just be clear about what you mean." A local example is "Is Santa Barbara north of LA?" Most people would say yes, but the answer would be no under most precise definitions. What David Mark talks about as naive geography tends to fall into that category. It is still science in the sense that it is attempting to deal systematically with phenomena which are clearly real: people's use of words. Yet a scientific traditionalist might feel that the entire enterprise was idle; why not simply demand that people be precise? The work that has been done on fuzzy classification⁽²⁾ of soils fall into that category too: a scientific traditionalist would argue that if a classification cannot be precise and reproducible then it has no place in science.

NS Fuzzy somehow supercedes that...

MG I think it's bogus. Fuzzy methods are very appealing; they are intuitive and simple, and that may account for their popularity. But suppose I tell you that the membership of a certain soil in a certain category is 0.45. The category itself is fuzzy, so there's no agreement between us on what the category consists of. But more than that, we haven't established what the 0.45 measures, and there's no reason to believe that 0.45 to me is 0.45 to you. So what have we established? I can't see any real alternative to the original scientific reaction, which was that there is no point in trying to build data around something which has not been well defined.

NS But the use of fuzzy in GIS is still postpositivist?

MG Yes.

NS Do you think there is a real and knowable world?

MG Yes, I am an unabashed Newtonian. I think that the Earth's surface is the best example we have of a space which is framed by spatial and temporal dimensions.

NS Would you agree that there are simply various ways to know that world? That it exists and there are a number of lenses through which to view it?

MG Personally?

NS Yes.

(2) Fuzzy logic is a system of categorization and calculation which does not depend on absolute categories. When using fuzzy logic, critical limits in classification are eschewed in favor of percentage of fit. For example, a soil sample might be classified as 0.45 clay rather than clay OR not-clay.

MG Personally, I would tolerate an academic community that takes that view and I would encourage activities of people in that community. Personally, my own view is that there is a truth, that individual alternative ways of knowing are not of value if they cannot be communicated. Communication implies a shared understanding of meaning, which is at the core of science. Science is about the ability of two people to communicate in an unambiguous way. If communication has to be ambiguous, then it doesn't exist.

NS But the way that scientists communicate is influenced by culture?

MG Yes, but my view of science is that there are islands of superb objectivity, that are surrounded by a miasma. The miasma will always be there. Our job is to expand the islands as much as possible, to link them as much as possible and to preserve what we know to be true. I don't have any problem saying that pi is an objective value. The Sokal paper⁽³⁾ about pi being a social construction was a very clever spoof. Yes, I think there are different lenses, disciplinary lenses for example, and cross-fertilization is one of the best things that science has discovered for moving itself forward.

NS Is GIS an island?

MG Some of its basic principles are, yes, but as a whole, no.

NS But it does encourage communication between disciplines?

MG Yes.

Ethics

NS Is concern with ethical use necessarily the domain of the scientist?

MG So much of science is done on a team basis, with the individual scientist often submerged in a team. I wonder what kind of ethics an individual member of the Manhattan Project might have been able to sustain, or to what extent the ethics of global warming research can be individual. Science has to have collective responsibility, because there is so little that one can do at an individual level. I guess one can ask the question collectively; that makes a lot more sense because the collective of GIS researchers ought to be concerned with the uses of the technology. Whether that means that every individual hammering one particular rivet into the body necessarily inherits the whole responsibility... no, that is obviously a very difficult case to make. I think Openheimer as the leader of the Manhattan Project had a responsibility that he wouldn't have had as an individual. Perhaps what we need is a much more active collective discussion.

NS Can you think of implementations of GIS which have escaped the control of its developers?

MG And that have had serious ethical implications?

NS Yes, potentially.

MG I can think of databases that should never have been built. For example, some years ago a CD was developed and marketed that contained a large amount of information

(3) In 1996 Alan Sokal, a physicist at New York University, published an article in *Social Text*. In it, he purported to be making a claim for the absolute discursive and contingent nature of scientific knowledge. On the day of publication, however, he published a disclaimer in *Lingua Franca* in which he claimed the entire article was a hoax designed to demonstrate the gullibility and lack of scientific expertise of the editors of *Social Text* who were identified, in this instance, with a postmodern approach to science.

on individuals. There was an outcry, and the CD was withdrawn. But today I suspect every item of that data can be found and accessed on the Internet. The fact is that GIS has allowed the linking of databases through geographic location, and this has created the potential for massive invasion of privacy. As long as the phone book was confined to the paper medium, it was virtually impossible to identify the name and address corresponding to a given phone number, because the book was sorted by name, not by number. But it is now easy to scan the phone book, and invert the file digitally. And this is just the tip of the iceberg.

NS Which of these issues are specific to GIS? How?

MG GIS uses geographic location as a common key to link data, which is one reason why privacy has become an issue for GIS. Another is spatial resolution. It is acceptable for me to have an image from space of your backyard, or is there a threshold of resolution that defines acceptability? Is 30m resolution acceptable, or 10m, or 1m?

NS Where are those things worked out?

MG I've been trying to push for a National Research Council study of privacy in the context of GIS. There is resistance to it, perhaps because people are not convinced that the problem is in any way specific to GIS. But that is the only mechanism that I can think of.

NS How do people in GIS feel about being held morally responsible for the sociological effects of their research?

MG It depends. That's the kind of issue that we were trying to address in the *Annals* article [Wright et al, 1997] about what it meant to be doing GIS. There is the person who is using the technology and data to come up with specific decisions or insights. There is the person who runs the MapQuest site and makes it possible for anyone to get a map of where anybody lives. Perhaps the sponsors of the site bear some responsibility when their maps are used in ways that invade privacy. There is the person who is doing GIS in the sense of devising new algorithms, of putting a new rivet in the GIS body, and here I would say no, I don't think that person ought to feel responsible.

NS Could you elaborate on this distinction? How much carry-over is there between the people who drive rivets by devising algorithms... those algorithms get into industry programs at places like ESRI [Environmental Systems Research Institute].

MG But GIS applications require data as well as algorithms: it's surely the combination that defines responsibility, not the creation of the algorithm alone.

NS Is there a tendency for GIS users to think of algorithms written by others as black boxes? Do GIS users always know exactly what happens inside the GIS?

MG No, and I think that's the source of a real problem in GIS. There ought to be a tradition of critical evaluation of technology, of commercial technology.

NS What would such an evaluation look like?

MG It would insist on full documentation of every GIS algorithm, so that users could meet the scientific norm, of responsibility for describing their analysis in sufficient detail that others could replicate their results. Algorithms could be evaluated for their accuracy in applications using real data.

NS How does the black box of industry algorithms affect operations like modeling—operations which are potentially politically sensitive?

MG I suspect that the uncertainty introduced by inaccurate or approximate data is by and large greater than the uncertainty due to poorly documented algorithms, but not in all cases. But I think there is a more serious problem, which has to do with the acceptance of the academy's role as an independent commentator and evaluator. There have been a couple of incidents on e-mail lists and discussion groups where comments were made about commercial software products, and it was made very clear that such comments are taken very seriously by industry—that one runs the risk of a lawsuit if one makes an ill-considered comment on a product.

NS The GIS-L list?

MG Yes, I think this is a significant problem for an academic community that sees its role in part as a source of independent comment on GIS. I try to instill that concept in my classes—that one role of education is to encourage a healthy skepticism among GIS students. One way to do that is to have practical sessions where students are encouraged to find faults and weaknesses in software products.

NS Are you liable for doing that?

MG No, I don't believe so. Students must base their evaluations on replicable facts about software behavior, not opinion—and these results are not likely to be published openly.

NS Are people going to stop using GIS if they know they can't put their own model on the front end, that they have little control over the assumptions contained in the code?

MG Yes, and they regularly do. There are many more people in science using geographical data than use GIS. There are much more rigorous expectations of the mathematical and statistical packages, and also much healthy skepticism.

NS Oceanography has developed its own raster system ...

MG Right. I suspect that GIS is most likely to be used in areas where data from different fields or disciplines have to be merged, and where the person doing the merging is not necessarily an expert in each field. An oceanographer working only with oceanographers, and using data collected by oceanographers, is not as likely to invest in GIS as someone who must integrate a wider range of data to make decisions or do science.

NS Do you think that the corporate and academic parts of GIS have changed over the last decade?

MG Personally, no. But what does intrigue me is the variation across the industry, from company to company, particularly in their approach to the academic community.

NS The corporate culture?

MG Yes, the ways in which prominent companies like Intergraph or ESRI or Autodesk have approached the academic community over the years vary enormously, and I think have a lot to do with long-term corporate success.

NS How does that difference manifest itself?

MG Some companies see the academic sector as a significant application, and approach it with a sales pitch. Others see it as a source of future employees, and work to make sure its students have access to its products. Others see it primarily as a source of research results. I suspect Jack Dangermond [ESRI] sees the academic sector also as helping to develop the vision of GIS. Students see a GIS visionary in Jack as well as a successful entrepreneur.

GIS and geography

NS Could you tell me a little about your perception of the history of GIS and its relationship to discipline of geography?

MG The relationship has always been fairly strong. I think, although geography is only one of the threads in the development of GIS. It is entirely possible to work in GIS and recognize only one or two of those threads. I come across people in GIS whose view of GIS development is very different from my own, and may not involve geography at all. Someone in the AM/FM area [automated mapping/facilities mapping] might have a background in engineering and have no knowledge of the people I think of as crucial to GIS. My view of the history of GIS is definitely the geography view, and it's perhaps also colored by the years I spent in Canada; it assigns much of the initial credit to Roger Tomlinson and the Canada Geographic Information System. It's an argument from the mid-1960s about the difficulties of making measurements of land resources from maps, and about how even then it was demonstrably cost-effective to computerize map-based analysis. There's also the role of the Census Bureau and the DIME project of the 1970 Census, which showed how important topology could be in managing the census and correct errors. Those two threads, and many others, came together at a conference near Boston in 1977, which many people think of as a key event in the development of GIS. But these arguments are lost on people who came to GIS from remote sensing, and so missed the critical significance of topology, or seeing the world as layers of nonoverlapping, space-exhausting polygons. Topology is important in any application where one property—soil class, ownership, agricultural crop, tree cover type, census tract number—is assigned to every point on a map. Those were exactly the types of data needed in natural resource and census applications, and so that world view became the norm in many GIS applications, and in many products, including ARC/INFO. Later that world view had to be extended, to cover networks and points. So points were handled as polygons with zero area, and line as boundaries between non-existent polygons.

NS Do you think that within geography we are ever going to lose this perception that topology is so important. Or do you think it has just become a part of our structural framework?

MG I'm worried that some aspects of GIS, and topology is one, have become so central to our teaching in GIS. I worry that students may see topology as essential, rather than as one of many options.

NS But if GIS is a science then it has to introduce new ways of thinking, so in a sense GIS could introduce those changes....

MG Yes, I agree that it's our responsibility to keep reinventing GIS, to avoid creating a narrow, self-reinforcing view of the world.

NS Do you think that if alternate views become embedded in GIS, that this will influence the rest of geography so that we start thinking in different terms...?

MG Oh yes.

NS So the whole discipline could change as a result.

MG Yes. Geography is a small discipline, and easily influenced by new ideas. I think the social critique of GIS is one such idea, that had an important influence on the discipline as a whole.

NS To what extent was the future of GIS secured, within the discipline of geography, by the funding that Ron Abler got?

MG I think that it was tremendously important, and especially important that it was NSF funding. It put us in the US in a much stronger position than GIS in Britain, where the equivalent funding was spread much more thinly and had much less long-term impact. I think NCGIA funding helped enormously in securing GIS within geography. But it's now eleven years later, and GIS is a much larger enterprise. The question today is a bit different—it's no longer whether geography can secure the future of GIS, but whether geography can maintain its leading role in a field that is now much bigger than the discipline. Right now I'd say GIS is doing a lot for geography's image.

NS Would that have happened through industry?

MG I don't think so. Many academics are deeply distrustful of industry, and so would not give much attention to a field that seemed driven by industry. Also funding from industry is often held to be suspect, and very different from funding through NSF.

NS To what extent do you think that competition for funds in geography has influenced the critiques of GIS?

MG I can't believe that the social theory community is interested in substantial funding. But on the other hand an area that can garner significant funding for research inevitably attracts critique. GIS is not the first area in geography to have attracted big funding—remote sensing has always been supported well, and there were very large urban projects in the 1960s. But GIS overlaps with human geography much more than does remote sensing, so perhaps that explains the different level of critique. Or perhaps it's a matter of timing, since GIS and the critical method arrived in the social sciences at about the same time.

NS I noticed that in your 1991 edited compilation [Maguire et al. 1991], which Keith Clarke called the Big Book, and also in your introduction module for the NCGIA [educational] stuff that's on the net, that you talk about GIS as a discipline. Is that part of a broader movement to take GIS outside of geography on its own somehow?

MG [Laughs] Well, let me clarify what I mean by discipline. I think that disciplines and departments are now essentially decoupled. Disciplines are communities of interest, increasingly made possible by e-mail and other forms of communication that don't require physical proximity. If these trends continue it's possible that in future departments will be little more than administrative structures: one might find oneself in department A. Disciplines on the other hand have journals, grand challenges, heroes, and other icons that have little to do with physical collocation. So one can apply fairly widely accepted tests to determine whether something is a discipline—are there grand challenges to GIS? I tried to deal with this in the keynote I gave in Zurich in 1990 at the Spatial Data Handling meeting, in which I suggested that there were areas of interest in many disciplines that could be brought together under the title of geographic information science. I think that has happened to a degree: the GIS research community has embraced people with backgrounds in cognitive science, library science, and computer science. I think the grand challenge question still remains: what are the really big and deep problems of geographic information science? I think of GIS as framed by two layers: a layer of basic science, and a layer of domain applications. I think we have a fairly successful interaction between the two layers at this point.

NS Where does the epistemology of GIS fit in there?

MG As part of the basic science I think.

NS Was there a need for NCGIA Initiative 19 [to study the social implications of GIS]?

MG Oh yes, to get a debate going, to show that it was possible to bring the two sides together to discuss the issues on a reasonable basis. I think the GIS side had to hear more about the critique, in a setting that was less confrontational than the published literature, and the social theory side had to hear more about GIS. I think there is a very real difference between critique in the abstract, and practice. The problem became clear to me in the Marxist period of the late 1970s, when there were instances of quantitative studies using a Marxist perspective. I had a strong 'so what' reaction then—that at the practical level it was very difficult to see the difference between a study that had been framed by Marxism, and a conventional quantitative study. Perhaps it's because one's view is so much determined by the methods, and not by the intellectual framework. The same thing happened for me in the context of I19, over the question of whether one could create a more socially aware GIS, with successful case studies that were immune to critique. The answer of course is no; though the critical ground may shift a little, it is very difficult to see the difference at a practical level. Perhaps this simply confirms the neutrality of GIS, as some have argued, or perhaps it confirms that one's view is always dominated by the technology. I remember a discussion at a Public Participation in GIS workshop [PPGIS] at Maine that was held under I19. One of the ideas we discussed was whether in the debates over old-growth forest it was possible to build a database which supported everybody's different view of what old growth was. So, if somebody came along and said, "no this is all wrong; I believe this", you could analyze that with the database. It served to indicate to me how strongly concepts of shared knowledge, replicability, and other aspects of scientific objectivity were ingrained in our social and legal system. Personal opinion, presented as such, simply does not carry the weight of objectively defined information. The popularity of GIS in many agencies has been due to its ability to reduce decisionmaking to procedure, and so to make it replicable and defensible. A GIS analysis creates a record of a decision, and beats a decision based on personal opinion every time.

NS Why is this so?

MG I think the principles of scientific method are very deeply ingrained in our society, which works on principles of fairness, trust, shared meaning—Jeffersonian principles if you like. We may not acknowledge them as 'science', which has a very different standing in our society, but they are inescapable in our legal system.

NS In 1991 you wrote that "there is a real need for studies of GIS as a phenomenon, of its causes, and of its influence on the place of geography and geographical information in human existence". Given the events of the last seven years, could you elaborate on how such research would look today?

MG It would look like a critical social history, and I think it would reveal some interesting things about the roles of individuals, places, funding decisions, agencies, past practices. NS Initiative 19 is working on a critical history of GIS. Do you think that there is space for an independent history of GIS outside of that institutional framework?

MG Yes, Nick Christman was recently funded by NSF to do something along those lines. Also NCGIA and I19 are strongly grounded in geography, so it would be interesting to see a history of GIS from a nongeographic perspective. I have a very strong feeling that there is a contradiction between the academic status of geography and the general role of space in geography and society. I hear sensible people say that they've

reading at the university level and yet spatial thinking is among the most intuitive forms of thinking that we know. Something is wrong here. What that says to me is that we haven't correctly appreciated the role that space and geography can play in society and the role that geography as a discipline can play. Disciplines inevitably tend to look inward, to drag their practitioners into a narrower and narrower focus, often at the expense of connection with the outside world. This is a fundamental problem in academe: How do we avoid our work becoming more and more abstract, more and more esoteric and yet, at the same time, not sacrifice quality and intellectual depth? I think this problem shows in the agony geographers display over the importance of information and fact; this fear that if we start talking about the names of capes and bays we'll destroy ourselves. Geography is an information-rich discipline, and as I argued in response to Taylor, facts are not inherently 'mere'. We have to find an appropriate balance between the general and the special, and I've seen GIS as a way of doing that. I wonder why we are so much more fascinated with vehicles exploring Mars than with studying the Earth, and why NASA has such trouble promoting 'Mission to Planet Earth?' in Congress. There seems to be a deep-seated attitude that Earth is a lost cause, and a deep-seated antipathy to factual geography. I wonder if the attitude to geography comes from the same sense that it's easy, that anyone can do it, that underlies our approach to primary education and the miserable salaries we pay to our primary school teachers. The Earth is incredibly complex, and its health is critically important. The same can be said about the human body. Yet society has very different ways of valuing the two kinds of expertise: that of a geographer, and that of a radiologist, for example.

NS Thank you for this interview. I appreciate it.

MG Sure.

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