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Who's Mapping the Mappers?: Ethnographic Research in the Production of Digital Cartography

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Introduction

To describe how geospatial technologies are emerging as a domain of technological expertise, particularly in environmental science and policy, one must engage in conversation with producers, users, and their technologies. This paper reports on the analysis of a cadre of in-depth ethnographic interviews with developers of mapping software and users of online mapping techniques that work specifically in the mapping of industrial pollution at a national/transnational scale. In creating an ethnographic map of users and producers of complex multi-sited technologies such as GIS, it readily becomes apparent that to produce a detailed picture of technological emergence the ethnographer, at some point, needs to directly interrogate the technology itself, i.e. a *technographic* methodology. Therefore, this research also includes an analysis of hands-on "interviews" with GIS technologies and brings this analysis into conversation with field data collected from interviews with producers and users.

The collection of interviews used here, primarily focused in the US, sets out to assemble answers to two questions: 1) How are geospatial technologies, particularly Geographic Information Systems (GIS), emerging in the environmental domain? 2) What are the emerging decision points and domains that producers and users of environmental GIS face? In analyzing the results to these questions across various social scales, I will generate a description that will 1) contribute to the historical record and ethnographic understanding of the ways information technology is transforming the sciences policy arenas and public involvement with governance, and 2) will provide a map of likely decision points emerging with the development of GIS in the environmental domain. This ethnographic map will help decision-makers anticipate upcoming decisions and think systematically about choices and possible decision outcomes.

Methods and Conceptual Framework

Ethnographic Methods

This investigation uses ethnographic methods to research the production of scientific and technological knowledge (technicoscientific) systems, as studied by the field of Science and Technology Studies (STS). Ethnographic methods, such as in-depth interviews or participant observations, help clarify the social and political contexts that support and direct technicoscientific inquiry. The multi-sited nature of technicoscientific systems, particularly across a network, requires extending and adapting traditional anthropological conceptions of the site (the primary unit of analysis), which is a spatially and culturally constrained notion of a site. (Marcus 1997, Marcus an d Fischer 1999, Fortun 2001) The definition of the distributed production of the map as the "site" is done with an eye toward questioning the design of the map as a common reference point. The digital map, as developed through the use of a GIS, is the interface where the producers, educators, decision-makers, and stakeholders come together to define spatially significant domains of collective interest.

Technography

Studying how technicoscientific knowledge is embedded into a technical system, particularly in the case of GIS, requires investigating the technical system under consideration first hand. The ethnographer must directly question the technology as well the community of users/producers to obtain a sense of how decision domains develop and eventually "lock-in" to a specific mode of practice. Going technologically deeper than traditional participant observation, technography then, is the reflexive investigation of how a technology is learned as an epistemic tool in addition to how one becomes a practitioner within a technicoscientific community. Studying how one learns the technology as an epistemic system, in this case GIS, becomes a means for understanding how decisions are embedded in the technicoscientific system. Learning the technology firsthand provides a foundation for understanding what knowledges, literacies, and resources are necessary to participate in the technicoscientific system. Throughout the investigation, the technographer must note the directions one's attention is taken, where a system's technological and epistemic limitations are being made explicit and where they are hidden, where costs are being taken into account as a limitation to inquiry, the epistemic possibilities that are presented, and other deciding/ordering factors in prioritizing knowledge production. By learning technology intentionally in a reflexive manner, an ethnographer can better understand how *epistemic cultures* (Knorr-Cetina 1999) shape and are shaped by their technicoscientific engagements.

Technography:

1. Inquire technology reflexively.
2. Experience learning a technology for a specific decision domain and desired outcome.
3. Elucidate knowledges, literacies and resources needed to learn the technico-scientific system, and express limitations.
4. Help decision-makers anticipate upcoming decisions and think systematically about choices and possible decision outcomes.

Communities of Practice

In this study *epistemic cultures,* as focused around the design and use of technicoscientific systems, are theorized through what Etiene Wenger terms *communities of practice* (Wenger 1998). In this case, the community of practice is described through mapping the social and political relations of a variety of GIS related *decision domains*. (Fortun forthcoming) Following Wegner's analytical framework, there are three "dimensions of practice" that shape and define a community: "1) Mutual engagements: engaged diversity, doing things together, relationships, social complexities, community maintenance. 2) A joint enterprise: negotiated enterprise, mutual accountabilities, interpretations, rhythms, local responses. 3) A shared repertoire: styles, stories, artifacts, actions, tools, discourses, historical events, concepts." (Wenger 1998) Keeping these three "dimensions of practice" in mind will further elucidate how the community of GIS practitioners co-develops across technology, pedagogy and practice.

Location: "the site" of GIS

Locating GIS as a site in this case study means describing thoroughly its technical and social foundations in a manner that define it as a coherent unit of analysis. GIS as a whole is far too distributed, networked, and diverse to constitute a bounded and useful unit of analysis. Therefore, descriptions of "the site" of GIS will be focussed on elucidating decision domains and decision points that constitute GIS in a particular context. In this case study the context of GIS is specifically in environmental risk communication.

Decision domains are essentially problems and decision networks that develop as a field of technicoscientific expertise develops. (Fortun forthcoming) Describing GIS as a decision domain is inseparably tied to the context in which it is being used, i.e. the content being mapped. Decision points are those points that narrow and limit the focus and range of inquiry within a domain. For example, a question to answer regarding decision points in GIS is to look at how inquiry is being directed by the limitations of the technology. Questioning action toward a decision point works to notice if there is a "pipeline" effect regarding the focus of user intentions, the scale of problems, the access to data, the costs in producing more data, etc. This will help to determine points where decisions are being made and how those decisions are being limited by technical, financial, logistical, epistemological, or social restrictions.

Participation in Analysis and Design across the Multi-sited Network

How can ethnography work on bridging participation across a network of sites? Participation is particularly relevant when there are few people at each node of mapping production, but has a wide user base that produces various political and functional interpretations of the maps. Elucidating descriptions, suggestions, and best practices of those individuals intensely engaged in the production of maps that are in the public's "best interest" (such as health/environment interactions) opens up the potential for inducing where public participation is most needed and most useful. Such a dataset of descriptions would constitute a viable archive for evaluating the discursive practices of politicizing participation. While this method is not overtly participatory in that the ethnographer does not have available multiple experts together in the same room working on the same project, it is participatory in that it brings into conversation multiple experts into a common epistemological space (that of the ethnography). This notion of participation is particularly relevant when studying distributed technicoscientific systems such as the production of a variety of network sites about possible environmental exposures, like Scorecard.org or the EPA's EMPACT web assemblage of online sites monitoring and visualizing real-time environmental data.

The use of ethnographic methods in these cases becomes a way for producing participation where it is physically impossible. Granted, the internet can function as a mode for bringing parties into conversation with each other and often does an excellent job of it. What happens, though, when experts do not politically see eye to eye, are on different scales of political power, and generally don't wish to engage in discourse, but have things to say to and learn from each other? Ethnographic methods become useful in overcoming such hurdles of discursive practice. (Roe 1994) Participatory analysis and production are optimal ways in accounting for the voices of multiple stakeholders and in fairly representing the interests and insights of local knowledge in the production of public policy, particularly as it regards epidemiological data. There is no one mode of participation, and participation in and of itself does not mean that it is a good policy. Participation needs to be considered where and when appropriate, for example it is particularly relevant to the double bind between health data privacy and a history of environmental exposures that relies on public data.

Geographic Information Systems as Interface

Interface, as I am working with it as a concept here in a most general sense, is a technology that works between (or in bringing together) scopic and discursive regimes. *Interface* is unfolded here to describe the multiple ways one engages with a GIS. The combined use of a database program, mapping software, mathematical modeling software, internet access, satellite access, and other such components constitute the use of a GIS interface. GIS is more than a map—it is both a scopic and discursive system of analysis for the visual production of spatial models. Access to the interface requires a specific (biased) user at the interface, the forced (scopic) perspective of the map, the technical components, the languages (discourses), the data (statements), and the subjects of the data. When the map is used/referenced the perspective of the map becomes the baseline for political actions/decisions. Such a qualification of perspective is particularly salient where these decisions involve risk communication and analysis.

- Technical components of the interface: the GIS software/program, the data sets, the computer, network access, formulas, printing technology, a 'place' that is being mapped, GPS, the infrastructure that supports remote sensing satellites and aerial photogrammetry, etc.
- Languages and discourses of the interface: cartographic/spatial theories, map projections, math types, geographemes, geographics, geophysics, demographics, statistics, modeling theories, etc.

Describing GIS's technical components and languages/discourses qualifies for us the *shared repertoire* that determines access to participation in the decision domain. There is nothing about these components and discourses, however, that is *a priori* or should be taken and self-evident or obvious. There are numerous historical, cultural, and economic contingencies that pre-form and narrow the intentions and abilities of the user before they ever site down at the interface.

Decisions Narrow Long before the Interface

Considering the historical context of cartography and the geographic sciences (Thrower 1996, Edney 1997, Black 1997, Cosgrove 1999) further clarifies where pre-formed cartographematic contexts and decisions have already been made for the GIS user. As in the early British mappings of India (Edney 1997) the history of cartography demonstrates some of the scientific and political problematics of mapping as an exact form of knowledge production and representation. Following the literature that traces the history of cartography and geoscience from Enlightenment through the Modern era it must be pointed out that cartography and geodesics from the 1700s through the 1940s is a significantly different field than what developed after World War II with the development of satellites for remote sensing (Cloud 2000, 2001).

The early move from "traditional" cartography to GIS – as can be seen, for example, in the Harvard Lab for Computer Graphics and Spatial Analysis started in 1964 by Howard Fisher – was a move that combined data management software with early cartographic software for producing visualizations on-screen and in print. The Harvard lab was significant for not only producing some of the earliest attempts at GIS, and thus methods and frameworks, but also for producing researchers that would later go on to build many of the cornerstones of the commercial and military GIS industry. Jack Dangermond who started ESRI (ArcInfo, etc.), David Sinton of Intergraph, and Lawrie Jordan and Bruce Rado of ERDAS (now Leica GIS & Mapping Division), for example, all came out of the Harvard program[1].

Beyond historical context, the guidance of GIS as a field and as a tool is often based on institutions that support and indeed now require the use of GIS. Knowing what institutions are instigating the mapping is crucial for understanding the political, scientific, and economic predispositions that are brought to the mapping process. As will be described further in the "practice" section, institutions and NGOs such as the World Bank, IMF, WTO, UN, European Union, etc., are often guiding/deciding factors in what gets mapped (economic performance indicators) and towards what end the maps are used. This is particularly significant in how these governing institutions measure and perceive significant statistics of progress in developing nations, such as the case of World Bank pollution maps of Indonesia (World Bank 1994). Institutions and professional organizations within the field of geo/cartographics) is seen as critical for sharing and further producing knowledge claims. The OpenGIS organization, (based on the open source movement in general) demonstrate the institutionalization of GIS metadata standards where none existed. Again, tracing every institution that pre-forms the user at the interface is a tedious process and should be constrained to the decision domain under investigation.

I have noticed that early on in their classroom training GIS developers and users are asked to play (tinker) with data, to gain an intuitive understanding of the interface, and to develop a visual sense for what different analytical methods look like when they are mapped. I would say that in this process they first develop a sense for what or where they are looking at, i.e. the place; then a sense for what they are looking for, i.e. the phenomena. A significant outcome in the transition from traditional cartography to contemporary GIS can be seen in the before and after difference between representations of *place* and *phenomena*. The difference, perhaps subtle, is such that before the transition in the 1940s, *place* and *phenomena* were solely *carto-graphic*, whereas after the move to spatial data analysis, *place* and *phenomena* are produced as *carto-graphemes*[2] as well as *carto-graphics*. The difference can also be seen between map as picture (static representation of spatial contents) and map as model (dynamic or static representation of phenomenon with spatial components). Thus, in a technographic study, if one were to find how and where mapping decisions were already constrained before the interface, one would have to study the development and construction of rules guiding the use of these carto-graphics and carto-graphemes.

Decisions Are Embedded at the Interface

There are two questions that need to be answered in figuring out how decisions are built-in to the interface: what expertise does GIS require of the user? And what does GIS request of its use? (Here is where a technographic methodology becomes necessary in the analysis.) Staring at a blank map of just a geographical object with thin black borders reminded me of staring at a blank page with a blinking cursor. It was, however, even more daunting as it was a geographic and not just textual space that needed to be filled, i.e. I was already feeling constrained by the need to make assertions in a geographically significant manner. It was requesting/begging to be filled (which is perhaps why the color of the base maps is such a flat and boring green or yellow, because it makes you want to fill it with something interesting as soon as possible.) One of the primary decision points is the determination of an appropriate base map. This is one of the first and most obvious constraints in defining a geographic 'local'. Contemporary GIS requires of its user the, at this point ubiquitous, literacy needed to operate a Graphical User Interface (GUI). An ability to read maps and think spatially in a visually significant manner is also necessary. GIS requires an ability to use and read across data types and data programs. Using tab-delimited data, for example, is a standard operating procedure that comes from using spreadsheet software in combination with SQL programming. These and other technical elements require a rather sophisticated set of literacies and abilities that limit who can easily use and produce knowledge claims with a GIS.

Decision point example 1: For example, one decision point is the first choice in mapping techniques that best matches the phenomena under investigation – should I use *raster or vector maps*? Raster appears to be used in problems that are first and foremost based on some sort of physical/environmental feature of the land itself – due to the fact that the math applied to it is based on a strict grid/graticule it lends itself towards what is called a "continuous analysis", that is a raster analysis is based on a picture ('reality') of the land itself. Vector mapping seems to be used for problems that are first as foremost based on datasets that are to be imposed onto the land, such as demographics, where the phenomena under investigation lends itself to an object based analysis. That is, vector analysis is based on the 'reality' of the data. The two forms are not exclusive and are often used in conjunction with each other.

Decision point example 2: Another main decision point is in gathering data and explicitly working with an economic cost in mind. Say I would like to predict the levels of radon in a particular untested area to a certain degree of accuracy. When I map my known points I am able to interpolate what the value of radon levels should be in a particular area, but there aren't enough test points near my unknown to satisfy my degree of uncertainty... say it's 11% and I don't want to be above 6% inaccurate. How am I going to best spend my money to test that area so that I not only have a better sense of what my desired unknown should be, but other unknowns as well. This could best be thought of as a *cost vs. accuracy* decision point.

The two decision points detailed above further exemplify the sort of thought processes GIS requires of its user. The development and refinement of these thought processes, however, is more a pedagogical issue than it is an interface issue.

Pedagogy: Learning/Teaching GIS

An essential description of any community of practice would involve an evaluation of the community's pedagogical framework. In this case, how is GIS learned by users and developers that constitute GIS as a field? To answer this question I have reviewed the literature on GIS pedagogy, participated in a GIS course at Rensselaer Polytechnic Institute (RPI) taught by a geophysicist, and surveyed 20 students of the GIS course. In comparing the survey with the syllabus there appear to be two primary types of users. There are those users that learn GIS for extending a current domain of their expertise, such as geophysics or civil engineering, i.e. where GIS is primarily used as an analytical tool within a scientific or engineering field. Then, there are those users that learn GIS for its use and applicability across data domains, i.e. where GIS is learned primarily as and Information Technology (IT) tool for the sake of a possible career in GIS. These predispositions seem to strongly determine the postures and contexts of students wanting to learn GIS. It is important to note here that at RPI there has been a rapid growth in the amount of people wanting to learn GIS. For example, in 1999 there were 5 people in the course, 2001 there were 25, and in 2002 the professor was teaching two sections with 60 students total. This points to a significant increase in the awareness of GIS as a valuable tool across domains of expertise.

Before Entering the Classroom

According to the survey I conducted, which was completed in the first two weeks of class, students exhibited a variety of professional interests that identify them as possible users of GIS. There are geographers, geophysicists, computer scientists, civil engineers, sustainable developers, environmental consultants, military analysts, and those that work with 3-D visualization[3]. The survey contained a question that concerned what users expected to learn or be able to do once they were done with the course. Answers varied in detail and sophistication from wanting to improve their repertoire of data representation techniques to extending their statistical analysis options as exemplified by one student's response: "flexibility in handling information and using the relevant info from any map." Another answer connected GIS to better communication all around – "the representation of the world is clearly shown using GIS and also, it will lead us to bridge the communication gap throughout the world. I think it will propel the communication area even further." Using GIS as a marketing tool appeared a few times. One student discussed the use of GIS to easily compare historical data with current information in the field of civil engineering. These and other such answers demonstrate that the perceived use of GIS is very diverse indeed and that any single, all inclusive, professional approach to teaching GIS would be a mistake.

The survey demonstrated that, outside of application, new users of GIS are influenced by a variety of social and economic factors that motivate them to learn the systems. A sampling of answers demonstrates the desire to: further their career, begin their career, learn GIS as a primary skill or as a secondary skill, listen to family advice, listen to institutional advice, listen to advice from their advisor, follow through on social concern or advocacy that benefits from further articulation through maps, and or the desire to play with maps. It is interesting to note that in the survey very few students appear to have been strongly advised to learn GIS by their advisors and have taken it up primarily because they encountered it somewhere in their previous experiences and saw value in learning the technology. This indicates that advisors/professors are not yet recommending GIS as an essential tool, even though the students perceive it as such.

GIS in the Classroom

Decision domains and methods for working through decision points certainly develop in the classroom. The framing for teaching and learning GIS apparently need be to broad enough to cover the diverse interests of students, thus what gets emphasized most is the data/information component of GIS. The expertise being generally taught towards is one that is, in some way or another, spatially/geographically significant and data intensive. (Note: what is meant by "spatial" is not necessarily terra-graphic in nature and can be abstracted as mathematical surfaces or dimensions).

In the classroom there is a strong emphasis on noticing the difference between maps and information. We are told that "we are not just going to make maps, but create what can only be described as models. We are asked to think in a predictive manner. We are instructed we should look for problems that can yield spatially relevant correlations between data types. We are encouraged to think "beyond mapping."[4] The primary point here is to get students to think beyond describing where something is spatially located into how events are spatially correlated, that is, to get beyond the production of carto-graphics and into the development of carto-graphemes. We are asked to play (tinker) with data, to gain an intuitive understanding of the interface and what different analysis methods can do. Developing a sense first for what we are looking at, then as we develop our final projects, a sense for what we are looking for.

Questioning Critical Learning at the Interface

What results as the student progresses in their expertise is what I would call "a construction of the geo/cartographic gaze". The questions that become centrally relevant to further pedagogical analysis regard making this geo/cartographic gaze a critical one. That is, how can the production of GIS knowledge be taught in a manner that is reflexive?

Building a reflexive mode of questioning into GIS that would extend beyond the classroom into everyday practice would entail beginning with pedagogy. Part of the purpose behind identifying decision points is to recognize where critical questions need to be inserted into the process. Answering the following questions would be such a step towards a critical evaluation. When is learning taking place? What is getting lost in the representation? Can the phenomena be visualized better for readability across a wider audience? Should and can we look to the funds behind the map? Should and can we look at the populations affected by the map? How have the data subjects (as in the case of breast cancer mapping) been worked with? To what extent is the data thoroughly representative of the phenomena? What/who is getting localized and what/who is being left out of the construction of the 'local' as it is represented on the map?

> *Decision point example 3*: The move to define a 'local', is essential in determining the scale of the map/analysis. It is a decision point that constitutes what gets mapped and what gets left off. This will usually be determined by the parameters of the phenomena under investigation.

Learning to read the social context of map production would be a big step in critically reading the negative space of the map being produced or just read, i.e. determining the social features that are specifically not represented or are under represented. What then, would constitute an ethical map? For one, it would depend on how the mapper is constructing the 'local'. For example, an unethical map, of say possibly rich oil territory, would not take into account the local delicate geological formations and ecosystem disturbed by the very act of creating the map itself, let alone acting on what the map reveals[5]. Training users to question the negative space of cartographic information are the sorts of questions that rarely, if ever, come up in GIS production. These negative spaces, however, are not *empty* – they are full of social and environmental features that may or may not directly have anything to do with what is being put on the map. The challenge in creating an ethical map would be to determine where and how such distinctions are making a difference – and to produce a map that allows for a wide variety of interpretations, not just one.

Practice: Using GIS in Environmental Risk Communication and Analysis

Analyzing GIS in practice further elucidates the "mutual engagements" and "joint enterprises" of the community off practice and is essential to answering the question of where and how is GIS politicized. Looking at practice clarifies where decisions are being made and how the audience is being conceived in the production of maps and models. To keep this analysis within a contained decision domain I am studying the use of GIS within the context of environmental risk communication and analysis. Thus far this has involved researching the institutions specifically involved in the production of environmental information, in-depth interviewing of developers working with GIS to further environmental risk communication, and developing my own maps that compare breast cancer rates in the US with data about a variety of specific toxic releases (TRI) in an attempt to see if there is a significant correlation.

GIS at the Nexus of Environmental Communication and Risk Awareness across Social Scales

In environmental communication and risk awareness GIS is used at various institutional scales, from national and international governing bodies to small online communities that rely on the efforts of a single person.

In the U.S. we have the Environmental Protection Agency (EPA) at the national/federal scale with various mapping projects such as EMPACT, AirNow, and the Toxic Release Inventory (TRI). These projects are a push from the EPA to work on building publicly accessible mappings of environmental data sets that are particularly relevant to environmental and public health. The EPA (approximately 18,000 employees) is led by an Administrator appointed by the President of the U.S. (EPA 2001) and represents the U.S. Government's interests in protecting the environment as a National resource. The EPA, as a rule, produces its own findings, its own science, and relies on its own experts. The scope of the EPA's power is in the production of standards, enforcement of compliance with the standards, and to provide information to the public—all towards the goal of improving "environmental quality". The TRI, most significant to my case study, requires all Federal facilities to file a yearly release report no matter their facility size or SIC category. The facilities that need to report are mostly military bases, national labs, and/or are transportation related. This does not, however, account for individual State run facilities. AirNow is a project that produces real time maps of air quality at measuring points throughout different urban regions. The maps change throughout the year as the weather does, and their representations are based on the Air Quality Index (AQI). EMPACT, no longer being funded under the Bush administration, was a program that promoted the local production of environmental data to be mapped real time and made accessible through the internet.

At the national/international NGO scale we find institutions such as Environmental Defense (EDF) successfully using GIS in environmental risk communication. Projects such as Scorecard US and Scorecard Canada as well as Factory Watch U.K. (not a part of EDF) go a long way towards communicating and providing further information about a variety of environmental and public health hazards.

At the scale of local communities we find a variety of advocacy groups that develop and share information across a network. Organizations such as Clary-Meuser Associates, West Harlem Environmental Action (WE ACT), Communities for a Better Environment, California (CBECal), and Silicon Valley Toxics Coalition (SVTC) use GIS for communicating risk advancing epidemiological arguments, and strategizing resources towards taking further action.

Looking at the Practice, Experiences, and Points of Deliberation in Environmentalists' Use of GIS in Communication of Toxic Knowledges

Interviewing a variety of experts reveals the complexities and surprises involved in rendering environmental risk coherent. In my discussion with David Gulliano, a developer of the EPA's AirNow system, it became apparent that, while AirNow was not a perfect system it was certainly a useful start toward developing environmental communication systems for the public-at-large.

> "Well if they're communicating risk, they should communicate the level of risk and the level of response that is appropriate based on what we know now. There are some things we won't know for years. But that's one thing. I would also hope that it would be relevant and timely. I don't want to be the gatekeeper for environmental projects and I would hope that people would have access to as much information as they possibly can. Let them ultimately make their own choices. But a system such as ours has a certain goal and it needs to keep the ideas of context and data relevance and time relevance in mind. I'd like to see everybody be able to get the information for themselves and pollution information, whatever they want to find out" (Guiliano interview, Schienke 2001).

Speaking with Bill Pease, the head of the EDF team that developed Scorecard.org, revealed that successful communication can stem from unexpected sources.

> "Well you have to look at the decision making context. Here again is another lesson from Scorecard where we learned the audience was much bigger than we thought it was. We actually thought that we were solving the problem that I described at the beginning, like stopping the phone calls to me by community based organizations, and instead putting the information in the hands of organizers who are concerned with community based toxics campaigns. That usage is going on but it's a very very small part of the overall picture of Scorecard's impact because I don't think we had a wide enough understanding at the beginning of what are all the decision making contexts in which delivery of a service like Scorecard, particularly pointed delivery of a service like Scorecard, might have an impact? We thought, well it will empower community organizers. Well it also empowered the press! The ability to help the press write stories much more easily than they'd ever done in the past was probably much bigger in terms of the amount of pressure brought about in any local community about any company's pollution behavior" (Pease interview, Schienke 2001).

From speaking with Michael Meuser, of Clary-Meuser Associates (MapCruzin.com) I learned about the difficulties in locating and translating data into a usable format.

> "So I found superfund data in one place, toxic release inventory in a different place, water pollution permit compliance data in a different place, and I'm always looking for them to map them, so I have to find them with latitude and longitude, which is often tough. It's finding this data from disparate sources. Even some, I've had to find, like EPA's Worst Case Scenario maps, they won't release the data in digital table form, all they have is these text reports, so I've had to download 16,000 text reports, write a program that goes through it, extracts the data that I want, puts it into a table and then I'll be able to map it" (Meuser interview, Schienke 2001).

Presenting even a brief introduction to the descriptions from people practicing GIS in the environmental communication domain reveals a picture of similarities in a complex domain. Further analysis of the data reveals suggestions and strategies for furthering public pedagogy towards better short and long term risk communication. One of the more significant points regards the standardization of visualizing risk. Discussions such as these would be wise to continue pursuing if we wish to further develop and improve ethical forms of mapping.

Multiple Forms of Knowledge Are Exhibited in Developing GIS for Public Environmental Information Access

One noticeable and important trend across developers of these public environmental risk communication systems is that they usually have multiple background expertise both in scientific fields and in information technologies. Specifically, their expertise requires a strong knowledge of environmental science and information technology. Their expertise is often followed up with or are driven by and overt political practice and social ethos. They also tend to produce maps that are more ethical, i.e. open to multiple interpretations by multiple users.

At the time of this writing (March 2002), and in continuing with a technographic methodology, I should note that I am currently engaged in a project that attempts to argue the relation of breast cancer rates to the output of toxic releases, xeno-estrogens in particular. This project will provide me with a foundation for interviewing breast cancer advocacy groups using GIS to better understand how environmental interactions can increase a woman's risk of getting breast cancer.

Conclusion: GIS and Reflexive Practice

This introductory paper first locates the site of GIS, i.e. what constitutes the nexus of practice. Next, pedagogical methods were evaluated as it matched the desires of students learning GIS and then questioned as to how that process could be made more critical. Finally, this analysis briefly exemplified the practice of GIS in the decision domain of environmental risk communication.

Continuing research in the development of GIS includes looking at where reflexivity can be further built into GIS as it regards the social system of users, developers, and the public-at-large. Some examples of possible points for further investigation are as follows:

- Furthering the effectiveness of reflexivity in the pedagogical process that will carry-over into practice.
- Further advancements in thematic map making and interactive map making should take advantage of what the technology offers in conjunction with what appears to be a growth of cartographic literacy in the public.
- Open up the description of constraints on the local by what is getting mapped. Look at phenomena relevant to other social scales, not just the scale of the phenomena.
- New mapping technology provides an opportunity to demonstrate the extent of local interests and social networks that sustain these interests in the site under cartographic investigation. Mappers and their institutions have developed a geographic baseline this is highly detailed, yet attention to the social is often abstract or market driven at best.

I would like to conclude with the following thought as it eludes to the earlier description of a map's negative space – what can be revealed by the map should be, but more so. Mapmakers have an opportunity to present, quite literally, a worldview in a manner that more deeply expresses social and environmental considerations in rendering a rich representation of the 'local.'

Notes

[1] For a useful timeline on the history of GIS, please visit www.casa.ucl.ac.uk/gistimeline

[2] *Carto-grapheme* is used here as a to tie into Hans-Jörg Rheinberger's concept of graphematic spaces.(Rheinberger 1998).

[3] 3-D visualization is an emergent sub-field of GIS and it is used in combination with Virtual Reality systems.

[4] This brings up an interesting question: how many people have a strong mapping predisposition?

[5] This example is taken from the Bush administrations mapping of oil rich nature preserves in Alaska.

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