Non-quantitative GIS[1]

Chapter 2 in
"Qualitative GIS: A Mixed Methods Approach to Integrating Qualitative Research and Geographic Information Systems"
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Sage Publications, London, UK.

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Pavlovskaya 2009 SageQualGIS3revised.doc 11/12/2012 22:57:00

ABSTRACT

Despite its relatively weak quantitative functionality, GIS is primarily associated with statistical and quantitative spatial analysis. This creates a particular representation of GIS as linked to traditional understandings of science and technology and, critically, to corporate power and institutions of control. In addition, constructing GIS as solely quantitative prevents it from being used for qualitative analysis, non-quantitative spatial analysis, and progressive research that often (although not always) relies upon non-quantitative research methods.

GIS is, however, well suited for particular forms of qualitative research. For example, it allows for a rich visualization of information in the form of maps and other types of graphic data representation. In this sense, cutting-edge research in geovisualization is directly supporting non-quantitative uses of GIS. In addition to geovisualization, other recent research illustrates that a qualitative GIS is not only possible and growing but that it fulfills an important epistemological function. This function consists of the ability to visualize and investigate social phenomena that cannot be represented by quantitative databases (whether governmental, commercial or user-created) or analyzed by traditional quantitative and statistical techniques. Not only does qualitative GIS contribute to furthering our scientific understanding of the world by expanding the range of usable epistemologies but it also supports research agendas that are committed to progressive politics and challenge the status quo. Finally, qualitative GIS also contributes to advances in social theory because it easily incorporates space into our thinking about the world and allows us to ask research questions that can only be addressed through mixed-methods research.

Revised 5/18/2008.

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[1] Some parts of this chapter, especially a section on "openings," were previously published in Pavlovskaya, M. E. 2006. Theorizing with GIS: A tool for critical geographies? *Environment and Planning A* 38, (11): 2003-20. Here they appear thoroughly revised.

INTRODUCTION

Just a few years ago, critical GIS (Geographic Information Systems or Science) scholars had to argue that a qualitative GIS was even possible and that it could contribute to a valid and robust research methodology (Kwan 2002a; Pavlovskaya 2002, 2006; Matthews et al. 2005; Bell and Reed 2004; Knigge and Kwan 2006; Knigge and Cope 2006). Today, we are contributing to a textbook on qualitative GIS written for a wide audience of students, academics, and GIS practitioners. This remarkable development is related to and enhanced by the recent powerful re-entry of qualitative and ethnographic methods into human geography after a period of relative undervaluing of the humanistic tradition. Major recent methodological texts now include thorough discussions of qualitative research (e.g., Babbie 2000; Tashakkori and Teddlie 2002; Clifford and Valentine 2003; Cloke at al. 2004; see Crang 2002 for an overview) and politics of doing such research today are widely discussed (Crang 2002, 2003; St. Martin and Pavlovskaya forthcoming b).

A recent emphasis on mixed methods research has also contributed to the emergence of qualitative GIS. Previously opposed to quantitative methods, critical human geographers have re-envisioned their use in conjunction with qualitative modes of explanation (Lawson 1995; McLafferty 1995, 2002; Kwan 2002a,b,c; Elwood 2006a; St. Martin forthcoming; Sheppard 2001). Similarly, and also a result of growing availability of digital spatial data and user-friendly software for its viewing (e.g., GoogleEarth), geo-spatial technologies are increasingly incorporated into mixed-methods approaches. Combining GIS with qualitative methods allows critical human geographers to use the analytical and representational power of GIS as well as get around its limitations with respect to certain forms of analysis (see Introduction by editors).

Qualitative GIS also made relevant to GIS research the debates in critical human geography about the political nature of production of knowledge and representation initiated by feminist and post-structuralist critics of science (Foucault 1980; Haraway 1991; Rose 1992; Katz 2001). Its effects are felt throughout the whole processes, from defining research problems and choosing methods to producing findings, interacting with research participants, assistants, and colleagues. In the words of Cindi Katz (1992), knowledge production "oozes with power." This could not be more important in case of GIS which is, at once, a powerful research and representational tool, a charismatic technology, and a multi-billion industry. It is also a powerful narrative of 'what is GIS' that defines what it can or should and cannot or should not do (St. Martin and Wing 2007). Therefore, GIS is also a result of silencing certain research practices and uses that do not fit these definitions.

This chapter argues for qualitative GIS as a powerful research strategy by exposing some of the silences that are produced by the prevailing narrative of GIS as a quantitative tool. While this narrative grants irrefutable scientific authority to GIS, it also silences its non-quantitative functionality that, I argue, actually constitutes its core in many respects. Breaking silences around the affinity of GIS with qualitative analysis opens it up to ethnographic and mixed methods research. The chapter begins by examining GIS as a power relation negotiated in broader epistemological struggles within geography. It then proceeds to deconstruct the prevailing notion of GIS as a quantitative tool and highlight its capabilities for qualitative research, including rich functionality for visualization. In the end, I use examples from recent research that illustrates that qualitative GIS is not only possible but can fulfill an important epistemological function that quantitative research cannot.

GIS AS POWER RELATION

GIS indeed represents power to most audiences: it stands for funding, jobs, information, student enrollments, mesmerizing images on the computer screen, best solutions and locations, and the power to convince. This power derives from the position of GIS at the intersection of science, technology, and visuality. First, GIS is firmly associated with quantitative analysis and the scientific method. Second, its flesh and blood are computers and digital information. And, third, it expresses the very fascination of Western science and geography with vision, seeing, and looking as a primary and supposedly objective but indeed embodied and masculinist way of knowing (Haraway 1991; Rose 1992; Sui 2000; Cosgrove and Daniels 1988). Similar to cartography (Crampton 2001), the power of GIS lies in its ability to create visual images of the world based on scientific information, to unveil previously hidden natural and social landscapes with an authority of science. The prevailing image of GIS as a powerful juncture of science, technology, and authority serving big business and the government has been created and sustained by many actors. They include academic departments where it is taught, corporations where the technology is developed, and various groups of users from grass-root organizations to businesses and governments worldwide (Longley et al. 2005; Schuurman and Pratt 2002; Kwan 2002a; St. Martin and Wing 2007). As a representational tool and a socially embedded technology, GIS is "oozing with power."

Not surprisingly, then, GIS has been passionately debated in geography since the early 1990s (see Schuurman 1999, 2000 for details). These debates concern not only the field of GIS per se but geography's identity as a discipline (Goodchild 1991; Openshaw 1991, 1998; Kwan 2002a; Sui and Morill 2004), practices of knowledge production and representation (Elwood and Martin 2000; Crampton 2001; Bell and Reed 2004; Sheppard 2005; McLafferty 2002; 2005; Elwood 2006a,b; Pavlovskaya and St. Martin 2007), and the relationships between GIS and economic and social power (Pickles 1995; 2004; Smith 1992; Crampton 2003). In other words, the debates about GIS have been intimately related to epistemological struggles over scientific authority. It is a power relation negotiated by different practices of knowledge production in human geography identified with quantitative and qualitative methods. This understanding helps to explain the passion surrounding GIS as well as its never ending transformations, of which a previously unthinkable integration with qualitative methods is a subject of this book.

Historically, the field of GIS has been associated with quantitative and spatial science tradition in geography. Seen as socially and scientifically progressive in the 1950s-1960s, since the 1970s, however, this tradition has been criticized by Marxists, feminists, and later on by post-structuralists for scientific and social conservatism. Scientific conservatism resulted from the positivist epistemology while social conservatism of mainstream social science stemmed from its general support for economic and social institutions of capitalism that the new approaches sought to examine critically. It became unthinkable to practice progressive social science assuming objectivity, a value-free researcher, and separation between the subject and the object of the research. Researchers concerned with class, gender, sexuality, and race denounced not only the conservative politics but also the methodologies that were linked to production of such scholarship, of which quantitative analysis was a major tool. They turned to qualitative methods of humanistic geography now rethought within critical geography paradigms (Livingstone 1992; Katz 2001; Staeheli and Mitchell 2005; Cloke et al. 1991). Choosing a method (e.g. regression analysis or ethnography) represented a choice of not only one's philosophy of science but one's professional and personal politics.

GIS entered geography in the midst of these debates. It was largely constituted by these debates in specific way - as a quantitative tool of spatial science. In various texts, its language is that of science, measurement, spatial data models, spatial analysis, sampling, geocomputation, calculation, databases, data transformation, validation, and so on (examples are Crisman 2002; Clarke et al. 2002; Longley et al. 2005; de Smith et al. 2007). The landscape of GIS community today is very complex but a number of authors have shown that within it both "quantitative" proponents and "qualitative" critics of GIS contributed to this image of the field (Schuurman 2000; Schuurman and Pratt 2002; St. Martin and Wing 2007). For the proponents, the connection of GIS to science, quantitative geography, spatial analysis, and computerization validates its growth and has been a source of pride (Goodchild 1992; Clarke 1999; Longley et al. 2005). Today, many professors and students equate GIS with geography and see it as a scientific solution to most geographic problems and the most important job skill (Openshaw 1998; Flowerdew 1998; Sui and Morill 2004; Longey et al. 2005). The term GIScience (GISc) has replaced the more mundane term GISystems (Wright et al. 1997), implying a transition from simply a tool to a theory of digital representation of the world and its analysis.

The critics, too, linked GIS to spatial science and quantitative geography. In contrast to GIS academics, however, they focused on epistemological and social conservatism embedded in its representational, technological, and scientific authority. For them, GIS was a problem, not a solution. In their view, GIS reduces places and people to digital "dots" and assists those in power to make decisions without involving local communities. GIS serves corporate profits and state interests, facilitates surveillance, control, and warfare, masks social and economic inequality, supports the seeming objectivity of data and analysis, is a male-dominated field, a successor to imperial cartography, and an essentially undemocratic information technology to its high cost, unequal access, and need for expert knowledge (Smith 1992; Sheppard 1993; Pickles 1995, 1997; Goss 1995; Curry 1997; Schuurman 2002; Kwan 2002c; Dobson and Fisher 2003; Crampton 2003; Armstrong and Ruggles 2005; Treves 2005). Together, all these aspects of GIS practice left no room for its application within Marxist, feminist, post-structural, and post-colonial frameworks. Seen as solely quantitative and technocratic, GIS was overwhelmingly denounced by the critical human geographers in the 1990s. In short, despite normative disagreements of those involved in the debates, GIS emerged as a singular tool to be used within a particular practice of knowledge production (Kwan 2002a; Schuurman and Pratt 2002; St. Martin and Wing 2007), a seductive technology firmly linked to quantitative science, power, and capital.

And yet, the situation has begun to change in the last decade or so. A body of knowledge loosely defined as "critical GIS" has emerged that enabled innovative, non-quantitative, and progressive uses of GIS (for overview, see Schuurman 2002; Sheppard 2005). In some ways, critical GIS is a result of the growing theoretical pluralism of the last three decades. With passing dominance of quantitative geography, a range of theoretical traditions (e.g. feminist, Marxist, post-structuralist, post-colonial perspectives) have all established their authority and so did non-quantitative research methods. Partiality of knowledge has become an acceptable epistemological stance that necessitates conversation and makes explicit responsibility for knowledge production practices. Feminist scholarship, in particular, has transformed social sciences by bringing in the excluded subjects and changing forever the research ethnics. These developments encouraged GIS scholars to think about possibilities of GIS within diverse theoretical frameworks.

The assumed vast differences in scientific rigor between quantitative and qualitative methods have also been profoundly rethought on both qualitative and quantitative side (see, for example, Baxter and Eyles 1997; Poon 2004; Crang 2003; Cloke at el. 2004). Qualitative research is no longer considered to be a precursor or an afterthought of a large-scale quantitative study equal in significance to "coffee-table talk" (Openshaw 1998). Both methods today are seen as different but equally powerful research strategies if used appropriately. While one focuses on power of generalization and statistical representation, the other enables explanation, understanding, and theoretical representation. Both, however, are socially embedded practices and, therefore, can be logical or irrational (Barnes 2001), sophisticated or simple, large- or small in terms of amount of data, spatial scale, time, and labor as well as sloppy or rigorous. With qualitative methods regaining their authority, geographers began to "discover" qualitative aspects even in the established quantitative research tools such as GIS – as I will do later in the chapter (see also Kwan and Knigge 2006; Knigge and Cope 2006; Elwood 2006a; Pavlovskaya 2006).

But in addition to the above, it is the on-going de-linking between epistemology and methods across social sciences that enabled innovative and non-quantitative GIS practices. Previously firm, the alignments of ontology/epistemology and methods within a particular paradigm (e.g. spatial science with quantitative methods and feminism with qualitative methods) have been destabilized and,both types of methods are increasingly practiced across different epistemological frameworks. Feminist, Marxist, and post-structuralist geographers found ways to incorporate quantitative analysis (see Lawson 1995; McLafferty 1995; Hanson 1997; Sheppard 2001; Plummer and Sheppard 2001) and the strictly quantitative scholars have begun to appreciate qualitative reasoning (Poon 2004). Today, "quantitative" no longer stands for "positivist" even among the social theorists (but see Amin and Thrift 2000) and "qualitative" no longer means lack of science. The choice of methods became more pragmatic but no less rigorous because the responsibility of researchers for their choices is made explicit. It is the internal consistency, transparency, and reflexivity of the methods, their ability to acquire and analyze needed information, either quantitative or qualitative that became most important. In this context, we can de-link GIS, too, from its assumed epistemological home and imagine its valid uses in other research frameworks.

The related rise of mixed methods in social sciences and geography (Tashakkori and Teddlie 2002; Creswell 2003) also opens GIS for new imaginations. In mixed methods projects, researchers use quantitative and qualitative methods either sequentially at different stages or interactively at all stages (Knigge and Cope 2006). They combine methods to cross-reference and triangulate data but also to examine incongruencies in data as research opportunities. Geographers in particular are increasingly keen to combine different methods with GIS when research goals make it appropriate (Nightingale 2003; Robbins and Maddock 2000; Pavlovskaya 2004; McLafferty 2005; Sheppard 2005; Kwan 2007; St. Martin forthcoming). Finally, the so-called "spatial turn" in social sciences and humanities increased attention to spatiality of human experience and also encouraged thinking about space in non-quantitative and visual terms. The language of boundaries, flows, territories, as well as that of cartography and maps have found its way into wider social research and art. Not surprisingly, GIS is now used outside its traditional quantitative and technical fields and being rapidly integrated with the latest multi-media and web-based technologies (Peng 2001; Pavlovskaya forthcoming).

With all these developments in place, it is vital to articulate GIS as a strategy for mixed-methods research that transgresses the established epistemological boundaries. While important work in this direction has already begun (Elwood 2006a,b; Elwood and Leitner 1998p; Craig et al. 2002; McLafferty 2005; Knigge and Cope 2006; Sheppard 2005; Kwan 2002a,b,c, 2007; Schuurman and Pratt 2002; Schroeder 1996; Sieber 2004; Pavlovskaya 2002) it would be too soon to say that GIS has seamlessly joined the diverse practices of knowledge production. The dominant discourse of GIS remains that of a quantitative tool; it tends to alienate and marginalize other research methods; its corporate, military, and state applications prevail; and the industry itself is increasingly dominated by a single corporate developer. Given the representational power of GIS and its rapidly spreading applications, reclaiming geo-spatial technologies for critical geographies, qualitative research, and progressive politics has been at no time more crucial.

OPENINGS FOR NON-QUANTITATIVE GIS

Thinking of GIS as a negotiated power relation in production of knowledge instead of a given unchangeable technique helps to see GIS as "constantly remade through the politics of its use, critical histories of it, and the interrogation of concepts that underlay its design, data definition, collection, and analysis. In other words, futures of GIS are contested and openings exist for new meanings, uses, and effects" (Pavlovskaya 2006, p. 2004). Below I offer one of the strategies for enabling new meaning and uses of GIS. In particular, I will refocus the prevailing narrative of GIS that constructs it as a quantitative technology on commonly overlooked and, therefore, silenced non-quantitative functionality. I will do so by identifying a series of openings or contradictions in GIS practice that break silences and produce possibilities for qualitative GIS. They show that GIS has much greater affinity with qualitative research than we commonly think.

Opening 1. GIS origins are mainly non-quantitative

To begin, the very origins of GIS are mainly non-quantitative. It evolved from a variety of fields besides quantitative geography and combines diverse bodies of knowledge. They include geography (mapping and spatial analysis), computer science (automation and computing), landuse planning and census administration (handling and display of large databases), remote sensing (image processing and landcover analysis), and geodesy and the military (spatial accuracy and georeferencing) (Flowerdew 1998; Clarke 1999). In other words, using GIS requires specialized knowledge but this knowledge is different from the expertise in quantitative analysis.

Opening 2. Computerization is not quantification

Since its early days computer technologies represented science. The beginnings of quantitative geography in the 1950s coincided with and were facilitated by the introduction of computers, and, as an emerging science, it benefited from this association (Barnes 2000, 2001). Computers created an illusion of accuracy in data and calculation, handled large amounts of information, and, just like scientific data, needed systematically organized datasets. GIS, too, handles large and structured databases, offers specific analytical tools, and is part of expanding information technologies. Yet, modern computing supports a whole range of non-analytical and non-quantitative activities (e.g., paying bills or playing games). Researchers, too, use a broad range of software packages, many of which automate non-analytical tasks (e.g., word processing or bibliographic software) or non-quantitative analysis (e.g., graphic display or textual analysis using Atlas/ti).

In early days of computers, the GIS programmers were academics who developed software to automate their spatial analysis. The link between GIS and scientific modeling was prominent (Schuurman 1999). Today, with rare exceptions (e.g., Idrisi), the development of mass GIS software is not in hands of academics but corporations. Knowledge of programming no longer coincides with knowledge of quantitative analysis. Creating any computer application requires programming skills but few applications require quantitative spatial analysis. Moreover, most existing spatial analysis algorithms were incorporated into the software long after they were developed and predate computerization. Thus, the two bodies of knowledge – programming and quantitative analysis are separate types of expertise (see also Crisman's (2002, p.iii) comment about their conflation).

Furthermore, most of GIS' diverse functionality (e.g. data visualization and querying, overlays, etc.), is made efficient by their automation but remain quantitatively and statistically unsophisticated. Remote sensing software is far more quantitative in this sense because even basic image classification techniques use complex statistical procedures (e.g., cluster analysis, maximum likelihood classification, principle component analysis, etc.) and so are many non-spatial statistical software applications (e.g. SPSS or Statistica). Computerization enabled GIS to process digital information but in itself it did not make this information processing more quantitative.

Opening 3. Spatial analysis in GIS is non-quantitative.

Surprisingly, only a modest share of GIS functionality involves quantitative spatial analysis (Openshaw 1998; Flowerdew 1998; Schuurman 1999; Eastman 2003). Even popular GIS textbooks admit that "…most GIS packages have contained only rudimentary tools for spatial analysis" (Clarke 1999, p.181). Most GIS users, therefore, have access to only basic techniques such as overlay, linear distance calculations, buffering, determining neighbors, or summarizing data within new geographic boundaries. While very illuminating, these techniques do not require knowledge of advanced mathematics from GIS users. Examples include calculating employment opportunities within a certain distance of women's homes (Hanson et al. 1997), overlaying locations of banks engaged in predatory lending with census data to reveal their target populations (Graves 2003), and mapping hazardous accident sites by census units to calculate exposed populations (Margai 2001). In truth, most spatial techniques available in GIS require spatial imagination (e.g. to grasp buffering or overlay), logical thinking (e.g., combining layers in site selection or multi-criteria evaluation) or intuitive grasp (in visual examination) and, therefore, replicate qualitative reasoning common to all geographic research. This affinity with human reasoning has been also obscured for a long time by unfriendly interface in many GIS.

Ironically, much of the recent GIS research seeks to enhance precisely these qualitative aspects. Fuzzy sets theory, artificial intelligence, cellular automata, chaos and complexity theory, agent-based modeling, and Baysean probability (Openshaw 1998; Sheppard 2001; Ahlqvist 2004) all attempt to model human reasoning that involves multiple connections, blurred ontological categories, uncertainty in decision-making, and the pragmatic use of partial knowledge. Ironically, as in the case with buffering, for example, the challenge is not in the mathematical sophistication of the technique itself – it is quite non-quantitative - but in designing and mathematically implementing an algorithm that replicates human reasoning (e.g. decisions under uncertainty) or a conceptually simple spatial operation (e.g. buffering).

Finally, large GIS literature deals with such methodological issues ecological fallacy and modifiable areal unit problems (Openshaw and Taylor 1979; Wong 2003, 2004), questions of appropriate spatial resolution and locational accuracy (Scott et al. 1997), methods for distance calculations (Wang 2000), representation of objects as either continuous or discrete, ontological structure of objects (Fonceca et al. 2000) and so on. While there are GIS specific tasks such as digital spatial data models (e.g. Ahlqvist 2004), other issues, again, are common to geographic analysis in general. Matters of conceptualization, they are not in themselves quantitative problems.

In the end, despite the consistent labeling of GIS as a quantitative tool, its most used functionality is rather qualitative.

Opening 4. Digital data is not always for counting

Digital data representation, including GIS databases (spatial and attribute), is usually associated with large numerical datasets but upon closer examination, also has little "quantitative" content in itself. All information for computer use must be represented digitally and, therefore, appropriately coded. This means that digital data have embedded histories; they are not neutral descriptors of the world but social constructs, they are products of those who created them, their purpose and approach. Furthermore, digital data must be coded disregarding whether it is quantitative or qualitative and whether it is to be analyzed quantitatively or not. In word processors, too, letters are expressed with binary code but not for the use in a regression model. They are digital because they cannot be stored and visualized in the computer otherwise. While coding already implies categorization, fixity, and structured ontology (Lawson 1995; Dixon and Jones III 1996; Jones III and Dixon 1998; Doel 2001), using numbers to express qualitative properties of geographic objects does not yet amount to quantitative analysis. For example, topology lies at the heart of vector models and represents very structured but non-quantitative spatial relationships. Digital data like photograph or sound is non-quantitative too. In short, digital representation does not substitute for quantitative analysis.

Opening 5. Database management and querying

Suggesting its origins in empiricist scientific tradition, GIS easily handles large amounts of data (Flowerdew 1998). Compared to non-spatial database management systems, it organizes data in a unique way - by geographic location. Assembling and structuring spatial "facts" in a geographic database (e.g., land parcel, TRI, or census data) allows for versatile querying and display of datasets comprising thousands of spatial units and variables describing them. Spatial databases also allow for unique merging of information from different sources. As the digital information and especially spatially referenced data continue to explode, the role of GIS in meaningfully organizing these datasets will only increase (Sui and Morill 2004; St. Martin and Pavlovskaya forthcoming a). This extraordinary ability of GIS to manage and query spatial data is, however, conflated with an ability to quantitatively analyze it.

Database development and maintenance, tasks that consume enormous amounts of time as GIS textbooks sincerely acknowledge (Clarke 1999), do not involve quantitative analysis at all. Digitizing and cleaning spatial layers (e.g., snapping nodes, building polygons, or georeferencing satellite data), merging spatial databases, as well as entering, organizing, and verifying attribute data do require knowledge of geodesy, geometry, data structures, and subject matter of the database but do not require knowledge of advanced spatial analysis or modeling. Building a GIS database for a qualitative project would require the same technical skills and expertise as for a quantitative project.

Digital attribute data itself, too, is often qualitative and includes names (e.g., of owners of land parcels, businesses, or street addresses) or types (e.g., of roads, settlements, soils, or polluting facilities). Not suitable for quantitative analysis, such data can, however, be queried and logically manipulated using SQL (structured query language) in order to find geographic features with particular characteristics. Even complex attribute and spatial queries, however, require logical thinking and a spatial imagination rather than statistical or mathematical expertise. SQL also enables numerical manipulation but advanced calculations are less common in a GIS and, as we will see, are most often performed in non-GIS environment.

Opening 6. Mathematical modeling and statistics still outside GIS

Even more revealing, the advanced GIS and quantitative geographers seldom use commercial GIS for analysis. They often need specific algorithms that are either absent in commercial packages or their details are concealed. GI scientists program their own spatial analytical routines and display the results in the existing GIS software (Kwan 1999a,b; Flowerdew 1998; Openshaw 1998). The community of quantitative geographers is quite different from GIScience community (Fotheringham 1997; Poon 2004). They publish in different journals (Miller and Wentz 2003) and use non-GIS quantitative analysis packages (e.g., MatLab, IDL, SPSS, Statistica, or MS Access or Excel), existing specialized models (e.g., for atmospheric circulation, plume dispersion, or crime “hot spot” identification), or write programs themselves (e.g., the geographically weighted regression (GWR) software developed by Fotheringham et al. 2002). This is true even for studies that explicitly focus on spatial processes (e.g., Margai 2001; Poon 2004; Plummer 2000). While these routines may eventually become add-ons to GIS but the point is that they are not among the most widely used or initially available GIS functions.

The fact that many statistical techniques including regression analysis simply cannot be applied to spatial data (Getis and Ord 1996) also limits the quantitative capacity of GIS. For example, proximity generates autocorrelation in spatial distributions and this violates fundamental assumptions of data independence in conventional statistics. Initially developed for non-spatial data, these statistics were imported into geography without proper adjustment (Barnes 1998, 2001; Flowerdew 1998; Sheppard 2001). Ignoring locational information, then, cancels out, sadly, the very difference GIS could have made.

Most available statistics, and even spatial statistics, also calculate parameters (e.g., autocorrelation coefficients or regression equations) that apply to the entire study region and ignore local variation in their values. This defeats the purpose of geographic analysis and leads to creation of mis-specified or poorly fitting models (Fotheringham 1997; Fotheringham et al. 2002). In addition, the available methods do not do well in modeling dynamic processes, incorporating individual-level data (Miller 2003), and representing interactions across geographic scales and networks (Poon 2004). Only recently have geographers developed advanced geo-statistical methods that address these and other problems of spatial modeling (Getis and Ord 1996; Fotheringham 1997; Barnes 1998; Sheppard 2001; Poon 2004). These techniques, however, usually are available in software packages separate from GIS or only recently incorporated. Visualizing spatial distributions remains the main functionality that quantitative modelers seek and use in GIS (Fotheringham 1997).

Opening 7. Visualization as qualitative analytical technique

In the end, visualization is arguably the most powerful and widely used function in GIS. Like other tools for graphic data display, GIS makes spatial information immediately accessible to our minds. We must "see" the data, either quantitative or qualitative, in order to assess its quality, suitability, or completeness. We must "see" the results in order to decide whether each transformation or query is correct or not. Even in purely quantitative research mapping value distributions helps, for example, identify model mis-specification problems (Fotheringham 1997). Visual examination itself does not involve mathematical calculation but is a powerful analytical technique.

More importantly, however, visualization is the source of seductive rhetoric of GIS, the rhetoric that combines the power of maps with the power of science and technology. Maps communicate spatial information in a particularly synergistic way. Far from simply conveying data, maps convey power because they express the authority to selectively represent people and places (Harley 1992; St. Martin 1995; Sparke 1998; Edney 1997; Lewis 1998; Crampton 2001). Placing this power into the realm of information technology, GIS further validates maps as scientific constructs (Lake 1993; Sheppard 1993). GIS unveils worlds to researchers, policy-makers, and the public, worlds made "true" by data and visualization.

Not surprisingly, the GIS industry has always focused on display functions as a way to analyze data as well as conquer the hearts. GIS academics, too, have produced vast research on visualization including its technical, computer-related, methodological, cognitive, and social theoretical issues (MacEachren 1994; Kwan 2002a; Knigge and Cope 2006). The recent surge in work on geovisualization and exploratory spatial data analysis (ESDA) in particular demonstrates that visualization is no longer a means to represent analytical results but a means of analysis itself. In the past, cartography served to communicate the results of research to the public as suggested by the map communication model (Robinson and Petchenik 1976). In this model, the cartographer's task was to best communicate (by properly choosing symbols, colors, themes, scale, etc.) the already derived scientific knowledge to the public who was to passively receive that knowledge. In the last decade, however, Alan MacEachren (1994; MacEachren et al. 1999) has advanced the concept of visualization as an analytical tool linked to an automated data display in GIS. Here, the research process itself becomes a focus. Assisted by computerized visualization, a researcher or a GIS user interactively and iteratively analyzes the data and immediately displays the results in a number of ways. She or he explores both the data and analytical techniques and, by directly interacting with a GIS, becomes simultaneously the author and the reader of the map (Crampton 2001). The GIS-based map is transformed from a vehicle for delivering knowledge into an interactive knowledge production practice including the potential to become the primary medium for communication between scientists themselves (MacEachren et al. 2004). The potential of integrating GIS visualization with qualitative analysis is particularly promising (see “grounded visualization” presented in Knigge and Cope 2006 as well as Knigge’s chapter in this book).

Visualization is powerful because it provides opportunities for heuristic (non-logical) understanding of data and processes. While an important component of human decision-making, this understanding cannot be achieved by rational analysis but complements it. The visual impact of GIS also depends upon emotions and other irrational sentiments (Kwan 2002a; 2007) that run counter to the dry logic of quantification. In short, visualization is the most telling non-quantitative functionality of GIS.

To conclude, the most widely used functions in GIS, such as visualization, database development, management, and querying, are not at all quantitative despite that the dominant narratives construct GIS as a quantitative analytical tool. The alternative reading presented above highlights its limited use in quantitative analysis and points to the unacknowledged potential of GIS for qualitative research that I will turn to now.

THEORIZING WITH GIS

The possibilities of a distinctly qualitative GIS within critical human geographic research have been open up by critical GIS scholars. Public participation GIS (PPGIS) scholars, for example, have long been working on making GIS and other geo-spatial technologies including the internet-based geographic information more democratic. They seek to empower unprivileged groups through the use of these technologies (Elwood 2006b; Gilbert and Masucci 2004; Craig et al. 2002). Feminist geographers, however, among the first argued against essentializing GIS as a positivist and masculinist technology and for using it in feminist research (Kwan 2002a, 2004a; Hanson 2002; McLafferty 2002, 2005; Schuurman 2002; Schuurman and Pratt 2002; Pavlovskaya 2002). We are witnessing the emergence of a new mapping subject who is male or female GIS researcher/user working to challenge dominant configurations of social power (e.g. class, gender, race, or heteronormativity) and practicing feminist sensibility and reflexivity in their research (Pavlovskaya and St. Martin 2007). This research is particularly open to qualitative potential of GIS because it aims to incorporate unprivileged and often non-measurable forms of experience not included into quantitative representations. Feminist GIS scholars have also worked to incorporate into GIS qualitative analytical functionality (see Knigge and Cope 2006; also chapter by Knigge in this book).

In this section, I would like to suggest further possibilities for expanding strengths of qualitative GIS. In particular, I discuss how GIS can fruitfully enrich qualitative explanation by incorporating spatiality. I will then discuss the recent work that exemplifies how qualitative GIS can visualize non-quantifiable experiences, feelings, and emotions; harness the rhetorical power of mapping by visualizing unprivileged ontologies; and ask questions that can only be answered though the combination of qualitative data and GIS-based analysis (i.e. a “mixed-method” approach).

Incorporating non-Cartesian spatiality

Unending concern with space and scale continue today in critical geography as debates about spatio-temporalities of human worlds (Harvey 2006; Herod and Wright 2002; Marston at al. 2005) as well as in GIScience as ontologies research (Foncesa et al. 2000). The waves of "spatial turn" have brought space as a key category into social sciences and humanities that also turn to using GIS and other geo-spatial technologies (Bol 2004; Chambers et al. 2004; Pavlovskaya forthcoming). It is a very good moment for GIS to realize its potential as a representational tool of critical geography. But GIS is associated with an absolute concept of space defined by a Cartesian grid while critical human geography views space as produced by social relationships and experiences (see Miller and Wentz 2003 on space in GIS and Harvey 2006 on absolute, relative, and relational space in critical human geography). Can a GIS view space in non-Cartesian terms?

Space is conventionally conceptualized in GIS as "absolute" or Euclidean or Cartesian space that contains clearly defined objects with precise location and where processes operate on a number of fixed and analytically separate scales (e.g. local, regional, national, or global). This absolute space, associated with spatial science, enables formal analysis of spatial patterns and relationships (e.g. distance decay function). As Miller and Wentz (2003) show such conceptions prevail despite that other representations of space within GIS are possible. Accordingly, GIS most often is used to do exactly this – to map and analyze spatial patterns in Euclidian space. Occasionally, it is used to visualize processes defined by relative position of places and geographic objects - connections, flows, networks, and movement. Mainstream GIS, however, has very limited capabilities for modeling flows and movement (mainly as cost-distance or network analysis). In critical geography, "relational" space along with time is inseparable from social processes (Massey 1985; Harvey 2006) and may embrace non-measurable properties of place, human experience, and social power. Understanding these aspects of space requires qualitative modes of explanation prominent in Marxian, feminist, post-structural and post-colonial approaches. GIS, however, is rarely used to represent "relational space." Furthermore, GIS does not represent people well either because its objects are spatial features with attributes (e.g., discrete vector features or raster cells). It is difficult to model people's behavior or connect experiences to discrete spatial objects (Openshaw 1998; Dorling 1998; Poon 2004; Kwan 2004b; Miller 2003). And people, obviously, are the main concern of human qualitative geography.

And yet, despite these major challenges, GIS also offers possibilities to qualitative modes of explanation. It does so precisely because it creates inherently spatial representations. It is possible, I believe, to find use for these representations in critical human geography or extend the representations themselves beyond the absolute space of spatial science. To do so, many important questions need to be addressed, both within human geography and GIS. How to represent spatially the complex connections, power relations, and collective meanings? How to open up the partiality of GIS representations to contestation and dialog with other partial representations? How to create alternative mappings that include the disempowered social actors whose spatial experiences are not commonly represented? How to make less exclusive the authority of GIS-based representations? How to represent the results of qualitative analysis of space? How to create powerful geographies of relational spaces using the absolute space of current GIS? Graphics often aptly communicate concepts but representing a theoretical argument spatially is rare. Examples below illustrate some of these challenges.

Visualizing non-quantifiable experiences

In order to overcome the bias of GIS databases towards numerical information, feminist and other critical human geographers begun to use creatively unconventional data such as narratives, in-depth interviews, hand drawn maps, graphics, photographs, videos, as well as voices and sounds (Dorling 1998; Sheppard 2001; Kwan 2002a). Using these new data, they created analytical representations of people's experience, movement, and even such hard to quantify phenomena as emotions or webs of daily economic practices. Looking to model daily movement through urban space, Mei-Po Kwan (2002a) revived Torsten Hägerstrand's space-time geography approach that she applied to her analysis of women's daily travels. To implement GIS-based modeling of their movement, she combined urban landuse and street network data with qualitative information from travel diaries kept by the respondents. Kwan visualized the three-dimensional lifepaths representing daily travels of women from different ethnic and socio-economic groups (Figure 1). She concluded that not only are the uses of urban space gendered (a fact obscured by conventional urban models) but that the differences between women from different class and racial backgrounds are also profound (Kwan 1999a,b, 2002a). In another project, Kwan visualized in a GIS variations in the safety of urban space as perceived by a Moslem woman after "9/11." In this project, Kwan used emotion as a main type of data to be modeled and mapped. She acquired this data through ethnographic research (Kwan 2007). In a project that explicitly combines GIS with an ethnographic study of low-income urban households, Matthews et al. (2005) designed a database that summarizes in-depth interview information and links it to places that people talk about in their interviews. This work has augmented the presentation of ethnographic data and added context by displaying census and crime information for the neighborhoods where the respondents lived. Matthews et al.'s work advances the interdisciplinary framework of a "geoethnography" that combines geo-spatial technologies with urban ethnography. Hong Jiang (2003), in a non-urban context, combined an ethnographic study of villagers in Inner Mongolia with a remote sensing analysis of landscape change. She found that these approaches complemented each other such that she could weave a more compelling and complex story of landscape change.

Kevin St. Martin (2005, 2008, forthcoming, and with Hall-Arber 2007, in press) integrated GIS with ethnographic research while studying the potential for community management in the fishing industry of the US Northeast. In this participatory research project, community researchers (primarily women who were themselves fishermen, fishermen's wives, or local advocates of their fishing communities) interviewed fishermen about their fishing histories, communities, and local environmental knowledge using GIS maps as referents. National Marine Fisheries Service vessel trip report data (geocoded data reporting fishing trip locations) was analyzed quantitatively using density mapping and percent volume contour (PVC) calculations to delineate the fishing territories of particular fishing communities. Project participants were asked to comment on the accuracy and meaning of the resulting maps relative to community. Did project participants see these fishing grounds as sites of common histories, shared knowledge, cooperation, and community formation? Did the maps depicting a shared space produce community where none may have existed?

Marie Cieri (2003) examined the sense of place produced by queer tourist industry propaganda in comparison to that experienced by lesbian tourists. She juxtaposed commercial tourist maps and tourist guide narratives with the hand drawn spaces and stories told by her respondents (Figure 2). She found that the queer tourist industry conflates lesbian and gay male spaces and reduces both to spaces of consumption in contrast to spaces with multiple meaning lived by the lesbian women.

In my own research on urban transformations under post-socialism (Pavlovskaya 2002; 2004), I created maps of the multiple economies of Moscow households using ethnographic information from in-depth interviews (Figure 3). These maps show that in each household, a wide range of economic activities is present both under socialism and, especially, after its collapse, in the market-based economy. These activities included formal and informal employment for wages, informal and unpaid domestic production of goods and services (e.g. cooking, childcare), and exchanges of goods and services via networks of family and friends. While formal work for wages remains the primary concern of urban and economic policy and research, most other necessary and very time and labor intensive economic practices remain invisible and, therefore, under-theorized and ignored. Mapping networks of support in single- and two-parent households also revealed that single parents were often successfully employed because they had to secure networks of extended family and friends in order to have any kind of work. That was in contrast to two-parent households where traditional division of labor that privileges male employment over female employment remained intact (Figure 4).

Integrating interview data into a GIS in the above examples also served to include the respondents as co-authors of representations based in their experience. These alternative representations different in important ways from the conventional depictions of economies, households, danger and crime, natural resources, or consumption patterns that are based on indicators computed from large and impersonal statistical datasets.

Visualizing unprivileged ontologies

No less important is a visualization strategy that creates social ontologies that are invisible for conventional theories and methods. Mapping such phenomena, relationships, and landscapes (e.g. the daily paths of women, experiences of Muslim women, territories at sea used communally, lived lesbian spaces, informal household economies, or daily networks of support) makes them visible and, therefore, "real" and significant theoretically and politically. In other words, "positioning" these unprivileged phenomena on the map using GIS that merges scientific authority with visual impact performs an ontological function: it "creates" the landscapes produced by these processes and legitimizes them. The power of GIS to constitute such worlds is particularly appealing for critical geography because of its concern with including and representing the excluded.

Mixed Methods

Thinking of a qualitative GIS as a mixed method opens further possibilities. The effect of combining quantitative and qualitative methods with geo-spatial technologies goes beyond gaining more by adding different types of knowledge or even complementing partial knowledges. Mixing these methods can achieve two more important (although related) goals. One is the ability to ask research questions that could not be asked if only one method is used. The second is to actually look for inconsistencies in partial knowledges produced by different techniques and treat them as research opportunities as opposed to an error or incompleteness of data. In this case, discrepancies become openings into an inquiry about social power configurations that produce these different representations and their effects (Nightingale 2005).

A feminist political ecologist Andrea Nightingale (2005) specifically focused on the inconsistencies in the accounts of changes in forest cover based on aerial photography and ecological histories of villagers in Nepal. She found that villagers participating in community forestry programs tended to emphasize positive changes that occurred under community management. They were invested in keeping the forest under local control as opposed to its possible transfer to a national-level management. Not a matter of fact or truth, an analysis of discrepancies becomes a story of political power and control over local resources.

Kevin St. Martin's work (2001, 2008, forthcoming) on fishing territories in New England reveals, for example, that the gridded ocean space of the National Marine Fisheries Service comes from its concern with the maintenance of quantities of fishing stock in a borderless ocean while oceans of fishermen have much more intricate and complicated geographies. These discrepancies are evident in the struggles between fishing communities and government management over seasonal closures of particular areas. The closures are designed to protect fish populations from predating fishermen who are thought to be endlessly mobile individuals capable of catching unlimited quantities of fish. This is in contrast to thinking about them as embodied men (and women) who fish in particular places they know best and whose livelihood depends on access to these places. This second vision of fishing territories as bounded and harvested by local communities makes a case for greater involvement of these communities into fisheries management.

Work by Paul Robbins (2003) and with Tara Maddock (2000) also focuses on differences in definitions of forest by remote sensing professionals and villagers in India. What professional foresters identified as forest on a satellite image was not a forest for local villagers because it consisted of replanted (indeed, invasive) species that did not provide the same livelihood as the original forest. The discrepancies in representation between satellite images and ethnographies of community resource use indicated that multiple truths about the "forest" expressed a politics of control over resources.

The above examples show that GIS may incorporate experiential and other unprivileged spatialities that are best elicited by ethnographic and other qualitative methods. Using mixed methods GIS also opens the inconsistencies in data derived from different sources to investigation of social power dynamics that produce different representations. In other words, GIS may provide ways to address relational spaces of power whether they are or not bound to a Cartesian grid. These questions are at the core of current human geography concerns.

Conclusion

This chapter approached the subject of using GIS in qualitative research by treating GIS, similar to other research methods, as a power relation. The dominant view of GIS as a quantitative technology, then, is not grounded in its innate properties but is a result of negotiations between the opposing practices of knowledge production. A critical examination of the functionality of GIS presented in this chapter reveals that in many ways GIS is intimate with non-quantitative data and modes of analysis while its application in quantitative geography and spatial analysis has been surprisingly limited. Most academic and other users rely on its functionality that can equally serve well qualitative researchers (e.g. visualization, integration of different types of data, querying, basic spatial analysis, etc.).

The challenge is to open GIS to qualitative research so that complex relationships, non-quantifiable properties, unprivileged ontologies, and fluid human worlds can be represented spatially and better understood. Re-imagining GIS as a flexible tool for creating diverse human geographies not solely confined to the "absolute space" of spatial science has already began. As the examples above show, GIS could be used by critical human geographers engaged in qualitative research and focusing on relational spaces of social power. While far from providing answers to all questions, GIS can be fruitfully combined with other research strategies. It can incorporate experiences elicited through ethnographic work and other qualitative research methods. It can use non-quantitative and non-conventional data (e.g. moving image, sound, narrative) in combination with more standard datasets (e.g. census). As a powerful representational tool, GIS can constitute the unprivileged social ontologies by placing them within the authoritative field of science and technology. It also enables mixed-methods approaches that integrate geo-spatial technologies with qualitative and quantitative research. And, finally, as a mixed methods medium GIS encourages researchers to seek understanding power dynamics and authority clashes that produce always partial and often conflicting spatial representations of human worlds.

ACKNOWLEDGEMENTS

I am grateful to the editors, Sarah Elwood and Meghan Cope, as well as the two anonymous reviewers and Kevin St. Martin for their constructive and very helpful comments. Thinking and writing time for this chapter was made possible in part by funding from Gender Equity Project at Hunter College (NSF ADVANCE grant).

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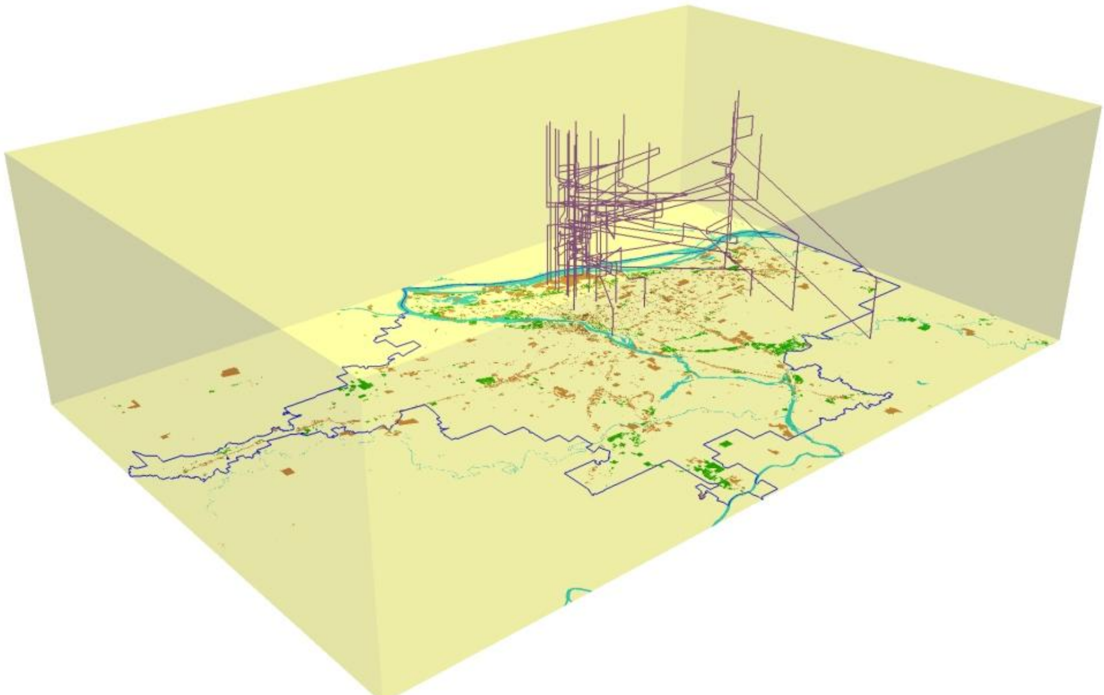
FIGURES

Figure 1. The space-time paths of a sample of African-American women in Portland, Oregon.



Source: Kwan 2002a. Reprinted with permission

Figure 2. NW Philadelphia and Center City: Superimposed maps by three lesbians.
Source: Cieri 2003.

NW Philadelphia and Center City:
Superimposed Maps By Three Lesbians

- 45-year-old single lesbian, longtime Philadelphia resident
- 50-year-old single lesbian, longtime
- 59-year-old lesbian with a partner
- Places in memory, no longer exist

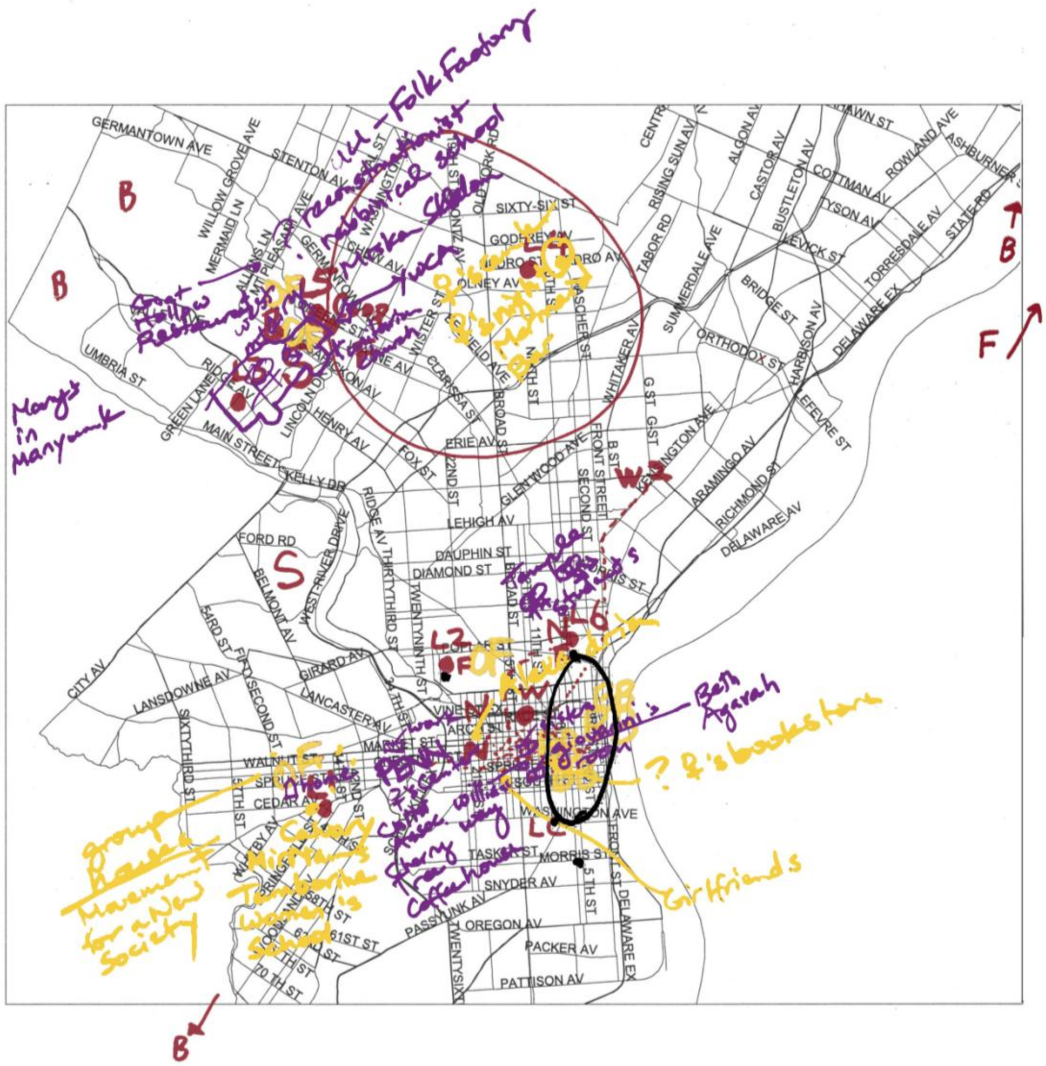


Figure 3. Multiple economies and households, 1989–1995, downtown Moscow.

Source: Pavlovskaya 2004. Reprinted with permission

Figure 4. Networks and female employment in single-parent households in Moscow in the 1990s.

Source: Pavlovskaya and St. Martin 2007