Chapter 5

Gerard Rushton and Quantitative Human Geography

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5.1 Introduction

In this paper I would like to trace the intellectual connections between Dr. Gerard Rushton and me, and the convergences and divergences in our research over the past 50 years. In doing so I hope both to pay tribute to him, and to provide a model of the development of human geography and geographic information science (GIScience) over that period, including debates that have swirled around these fields. My model is of course a personal assessment, and I would not expect every human geographer or GIScientist to agree with me, especially regarding what I present as a recent rapprochement between positions that at one time were diametrically opposed.

5.2 Early Encounters

I arrived at McMaster University in September of 1965 to enroll in the graduate program in geography. I had received a BA in physics from Cambridge University that June, and had immediately left for what turned out to be a very exciting summer exploring caves in the Canadian Rockies, and the first field season of what I had planned to be a Ph.D. in cavern genesis under Dr. Derek Ford. My enthusiasm had waned considerably by September, however: The Province of

Ontario is located a long way from challenging caves, and since I had never studied geography in any depth the department was insisting that I take a qualifying year of undergraduate courses. Derek's Geomorphology was central to my interests of course; Microclimatology was marginally relevant to cavern genesis; and Andy Burghardt's Regional Geography of the US was fascinating; but what was the point of requiring me to take Urban Geography, taught by a very young assistant professor, named Gerard Rushton?

By the end of that year Gerry's course had given me an appreciation of human geography that has lasted all my life. He began by insisting that students learned to program in FORTRAN, a daunting challenge for most of the class. At the time the department had an outstanding group of graduate students, many of whom were eager to collaborate with someone who could program, and to bring the new tools of the quantitative revolution to their own research.

I was puzzled, though, by this concept of quantitative human geography, and the theory of central places (CPT) that occupied much of Gerry's course. Geographers had been ransacking reality looking for settlement patterns that formed hexagons but found none, even in the flat, uniform, and seemingly boundless plains of the US Midwest, let alone Denmark, Southern Germany, Brazil, or Snohomish County, Washington. To a physicist fresh from the Cavendish Laboratory of Ernest Rutherford, a theory that was not empirically verifiable was no theory at all. Patterns of human settlement were clearly not random, and the populations of adjacent settlements were somewhat related; but I was able to show in an early paper that if the assumptions of the theory were even minimally untrue, the entire edifice of nested hexagons collapsed [1].

The philosopher Bertrand Russell was fond of an anecdote about Euclid's axioms. On first encountering them he was puzzled by their lack of logical or empirical foundation – why should he accept them? His mentor pointed out that unless he did, it would be impossible to go further, since discussion would be bogged down in an argument that could have no ending. This issue of the empirical foundations of CPT struck me as similar: If we accepted the assumptions, then the logical consequence was a pattern of great symmetry and beauty, an intellectual sandbox in which we could play endlessly. Moreover, CPT would always provide an abstract norm against which the real world could be compared. Better surely to compare reality to CPT than to a null hypothesis of randomness.

Rushton was clearly concerned about the same issue, as his intellectual migration into behavioral geography occurred at about this time [2]. If the simple assumptions of Christaller [3] and Lösch [4] about human behavior were not accurate, then perhaps the techniques of revealed space preference could provide better alternatives. With colleagues, he began assembling the techniques needed to develop better models of behavior (e.g., [5]), and ultimately a better understanding of how humans learn and make choices within complex environments.

My own thinking took a slightly different track that was more concerned with reconciling my background in physics with the realities of geography. Both physical and human geography must deal with a world that is essentially messy, in which perfect explanation or prediction is never achievable—in which the R-squared of a model can never be unity, and residuals will always be non-zero. There is no doubt, however, that models in the social and environmental sciences will always be underspecified, because there will always be variables that are overlooked. Moreover, Tobler's First Law

[6] ensures that variables will always exhibit positive spatial dependence, including residuals, making any process of estimation problematic. Under such circumstances we should strive not to achieve perfect prediction, but to reduce uncertainty as much as possible.

5.3 Normative Thinking and Applied Geography

Even so, another line of thinking turned out to be equally or even more productive: Rather than try to explain the complexity of human behavior and settlement patterns, why not develop techniques for *designing* patterns to achieve desirable objectives? Geography as a discipline might therefore be usefully engaged in improving the world in addition to understanding and explaining it. In the public sector it is often possible to allocate people to central facilities, such as schools, without being concerned with modeling the somewhat chaotic behavior of people who have choices. In the private sector, modeling of consumer spatial behavior, while not perfect in its predictions, might at least reduce uncertainty sufficiently to be useful. In the words of George Box [7, p. 424], "all models are wrong but some are useful."

By the time Rushton left McMaster University for Michigan State University, Bryan Massam and I were busily programming the university's IBM 7040 to design optimal arrangements of central facilities, following this essentially normative approach and with Gerry's guidance and encouragement. Our first paper compared Ontario's actual system of regional centers to systems designed to achieve specified objectives, such as minimizing the average separation of centers and the public [8]. The term *location-allocation* became current at about this time, with a seemingly infinite range of assumptions, objectives, and applications

about how to locate central facilities to serve a dispersed population. The field of applied geography eventually focused much of this activity.

When Rushton returned to the University of Iowa in the late 1960s he began supervising a group of graduate students focused on this combination of behavioral and normative geography. In 1973 he organized an event that turned out to be career-defining for many young geographers. This was an extended two-week institute on the instructional use of computerized algorithms for solving location problems, funded by the National Science Foundation (NSF). He invited me to participate as an instructor.

In 1977 Jonathan Halpern and I organized an international symposium on locational decisions in Banff, Alberta, the first of the triennial ISOLDE conferences. This helped to broaden the disciplinary base of location-allocation, by including management scientists, civil and industrial engineers, and economists, alongside geographers. Another thread emerged around this time when Rushton obtained funding, initially from the Ford Foundation, to apply some of these methods to design networks for the provision of public services in rural India. He invited me on many of these trips, which involved adapting our code to run on the very simple minicomputers and microcomputers that became available in India during a period of embargo on foreign-sourced hardware.

This idea of using geographic techniques for normative ends proved to be a very useful product of the quantitative revolution. However, the tide turned in the 1970s and an extensive critique of scientific or 'positivist' geography emerged. Even so, some of us were able to maintain successful careers around location-allocation, geographic information systems (GIS), and other approaches that were more oriented to practical usefulness. These approaches were

ultimately more successful than previous work in demonstrating the importance of geography and geography's perspective on problem-solving.

Coincidentally, one of the persistent themes explored by Rushton in his urban geography course at McMaster was the Hartshorne/Schaefer debate (e.g., [9], [10]). This was at the time and still is today a key element in discussions over the philosophy of geography. Should geography be devoted to the search for universal truths, in the style of physics, or to the detailed description of the unique properties of places?

From a normative perspective, one might respond that geography should be concerned both with finding universal truths that support a useful level of prediction, and with documenting the properties of places to serve as initial or boundary conditions for those predictions. For example, to design a new shopping center one needs to be able to predict spatial behavior with respect to proposed locations at an adequate level of accuracy, and also to have detailed demographic information about the surrounding population. To this new generation of normative geographers, therefore, the Hartshorne/Schaefer debate was largely resolved: Clearly one needs both if one is to use geographic principles to intervene in the real world by devising improved designs. In GIS, one would identify the software as representing general truths, and the database as descriptive of local conditions.

5.4 The Fork in the Road

By the late 1970s it was clear that another theme had emerged to divide the discipline. This was between the remnant quantifiers, now pursuing both normative and scientific paradigms, and the critical social theorists and their allies, who rejected quantification and sought humanist alternatives to the scientific geography of Bunge [10] and

others. Initially trained in geography, these latter critics had by the late 1980s begun to be trained in cartography [11] and later GIS [12].

There were many dimensions to the critique. Smith [13] argued that much of the funding and innovation that led to GIS originated with the military, and yet the literature of GIS and especially its textbooks were apparently reluctant to acknowledge the fact. Jordan [14] called GIS "non-intellectual expertise," arguing that it had no place in the academy. Departments resented the investments they were being asked to make in support of courses in GIS. Curry [15] saw GIS as a central element of the "surveillant society." Others criticized GIS as a tool of power, leading to further marginalization of the less advantaged sectors of society. GIS was naïve and simplistic in its representation of the world, replacing subtle gradations with sharp boundaries and Boolean logic. And in the words of Peter Taylor, GIS was the "quantifier's revenge" [16]. Much of this was coincident with the establishment in 1988 of the National Center for Geographic Information and Analysis (NCGIA), a major investment by NSF dedicated to advancement of GIS and its promotion throughout the social and environmental sciences.

There was clearly a need for rapprochement, and the two sides were brought together at important meetings in 1993 and 1995. GIS was evolving rapidly, and many of its developments could be seen as addressing elements of the critique. Initiatives such as public-participation GIS aimed to bring the technology to the community, while the entry cost of GIS continued to plummet, so that today it is available in limited form to anyone equipped with a smart phone. Community-based GIS is widely available in the form of OpenStreetMap, Ushahidi, and other tools that have proven remarkably influential in dealing with crises and promoting change. Today the GIS services that are delivered to the

public through smart phones are no longer limited to the "god's-eye view" of the empowered. These GIS service are also much more centered on the specific needs of the consumer for current, relevant, and helpful information services.

Nevertheless, critique is perhaps more important now than it ever was. Surveillance is pervasive, whether from street cameras or drones, aided by dramatic advances in face-recognition technology. GIS is widely available, and widely abused. The tools being produced by the private sector and the open-source community are seldom if ever subjected to peer review. While the development of GIS and other geographic technologies are the responsibility of academics, the private sector, and increasingly the general community, only the academic community has the recognized responsibility to reflect on the technology and its uses and societal impacts.

If GIS might be labeled as non-intellectual button-pushing and as having no more fundamental academic value than a word processor, then the other side could clearly claim the academic high ground. In the early years of NCGIA we were much exercised to make the intellectual case for GIS, and more broadly for scientific geography. David Simonett, the founding Director of NCGIA, was adamant that GIS should develop theory and principles, a theme that I explored [17]. These principles I anticipated could come from research in geography – what empirical principles structure the geographic world, and enable the development of effective representations in GIS?; cognitive science – how do people reason and learn about geography, and how can that knowledge improve the GIS user's experience?; spatial statistics – how can we model the uncertainty that is present in all geographic information, and present knowledge of uncertainty to the GIS user?; and of course computer science

– spatial databases, computational geometry, etc. Since then GIScience has been widely recognized as a useful term, and much progress has been made in identifying both its empirical and its theoretical principles (e.g., [18]).

5.5 Assessment

So what can we learn from all this? First, I was extremely lucky to find a young, stimulating assistant professor in quantitative human geography at a department that I selected for entirely different reasons. I cannot imagine how my career would have turned out if I had not been required to take Rushton's undergraduate course at McMaster University in 1965. Although cavern genesis is interesting and gave me a very satisfying topic for my doctoral dissertation, I would certainly not have found the fertile and ever-expanding ground in karst geomorphology that I found in human geography and the GIScience to which it led.

Second, I was fascinated by Rushton's ways of thinking and argument, which differed so strongly from the modes I had experienced in physics, and were constantly evident in his class and in conversation. His reasoning is intuitive, rather than grounded in mathematics, and he is strikingly persistent in how he worries a problem to a solution. He is renowned for his critical faculties, and for the outstanding series of graduate students who have emerged from his supervision and gone on to careers in many disciplines and fields.

Third, he has been a pillar of the school that emerged during the quantitative revolution of the 1960s, migrated to behavioral geography, and then adopted the principles of GIScience in the 1990s. Without him and others who followed similar paths, it is doubtful that quantitative human geography could have survived, or achieved the rapprochement that occurred at the end of the century.

Looking around the world, it is evident that quantitative human geography is alive and well in the US, but it would be hard to say the same about many other developed countries that have equally long or longer traditions of geography.

Looking back, it is clear to me that all of my encounters with career-defining mentors have had an element of happenstance rather than design. At McMaster both Rushton and Dr. Derek Ford were strong mentors, and champions when I ran afoul of some of the senior and more traditional faculty. I hope I have been able to deliver adequately on the promise both saw in me.

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