GIS, Geography, and NCGIA: Response to Jerome Dobson*

Changing Visions

In 1983, when Jerome Dobson's vision of an "automated geography" appeared in the pages of this journal (Dobson 1983), the IBM PC was two years old. We wrote out our papers longhand and gave them to secretaries to type. We computed on mainframes, stored data on cards and tape, and communicated with our colleagues by mail, or occasionally by phone. A software product called ARC/INFO had recently appeared and was attracting interest among those resource management agencies that could afford the $300,000 price tag for appropriate hardware. Dobson rightly argued in his 1984 pre-proposal to NSF that a center dedicated to providing access to hardware, software, and data could be of enormous benefit to geographers and others concerned with the analysis of spatial data (see Dobson 1993).

But times have changed, and it would be wrong to argue that the objectives and mission of the National Center for Geographic Information and Analysis (NCGIA) should not change with them. Since 1983, the speed of the personal computing workstation has consistently doubled every year, while remaining roughly constant or even dropping in price. The $5,000 personal computer of 1983 had no hard disk and could process less than a million instructions per second; the $5,000 workstation of 1993 has a hard disk capacity of hundreds of megabytes and a speed in excess of that of the $300,000 mainframe of 1983. GIS products have grown much more powerful, and the GIS marketplace has become more competitive. Low-cost educational products are available, such as the excellent IDRISI from Clark University; and GRASS, the Army Corps of Engineers GIS now widely used for environmental management and modeling, is available free over the electronic mail network, Internet.

The past 10 years have also seen enormous advances in the accessibility of spatial data, thanks in no small degree to continuing support for the U.S. federal policy of distributing public data at the cost of reproduction. CD-ROM is eminently suited as a distribution medium for geographical data because of its stability and cheapness, and agencies such as the National Oceanic and Atmospheric Administration (NOAA), the U.S. Geological Survey (USGS), and the Army Corps of Engineers are making increasing use of this medium for spatial data. In September 1992, the Defense Mapping Agency began distribution of the Digital Chart of the World (DCW), a global database created from the 1:1,000,000 Operational Navigational Charts.

Even though a CD-ROM dataset can be produced for less than $10 a copy, it requires an investment of $500 to $1,000 in a reader and the use of mail for distribution. Internet is likely to have a much more significant impact in the long run because of its support for the electronic distribution of data at zero cost. Anonymous file transfer protocol (ftp) allows users to obtain data from other sites over the network and is now widely used in the research community for distributing data. NCGIA maintains the Internet node "ncgia.ucsb.edu" for distribution of many of its reports by anonymous ftp and has also made substantial data sets available where appropriate. The EROS Data Center of USGS is hoping to distribute much of its spatial data over Internet, using a client-server approach code-named GLIS that allows the remote user to explore a catalog of available data sets geographically. A similar development is under way at the National Aeronautics and Space Administration (NASA) for the distribution of imagery and other NASA data. Wide Area Information Service (WAIS) is another Internet-based client-server system for remote access to databases and supports graphic interaction within its standard protocol.

Internet's impact on data distribution is matched by the dramatic effect it is having on communication among scholars. Our ability to communicate with colleagues is no longer limited by cost or distance, or time, and list servers such as GIS-L (a GIS list server supported from NCGIA Buffalo) have radically altered the sociology of science by allowing frequent, rapid, and informal communication between scientists at zero cost.

Even by late 1987, when our NCGIA proposal was written, it was clear that the vision of a center providing access to hardware, software, and data over a network was no longer as appropriate. The idea that "for the sake of efficiency, the NCGIA should maintain a collection of the databases most commonly required by large numbers of geographers" (Dobson 1993, 209) no longer made sense given the explosion of spatial data that had occurred in the 1980s and the vast improvements being made in its accessibility. So although NSF's solicitation identified a hardware, software, and data "central clearinghouse" as one possible function of the center, the UC Santa Barbara/SUNY Buffalo/University of Maine consortium chose to downplay this particular aspect of the center's outreach in the winning proposal. On the other hand, transfer of technology was and is central to NCGIA's mission. From the start of funding in 1988 to October 1991, NCGIA published 346 papers and 12 books, 70 NCGIA Technical Papers, and three newsletters, invited over 250 participants to its Specialist Meetings, interacted with most GIS vendors, and was influential in the development of many GIS products.

But Dobson's main emphasis is on interaction between NCGIA and the community of academic geographers, and on how a center can serve the needs of that community in particular (Dobson 1993). NSF solicited a multidisciplinary center that would promote the use of GIS and GIS-based analysis throughout the sciences, research and develop new methods and techniques for the GIS vendor community, and provide conceptual and theoretical leadership to all users of GIS, irrespective of discipline. Much of NCGIA's research goes on in the Department of Surveying Engineering at the University of Maine, and in other departments at all three NCGIA sites. But while academic geography is only one of the communities NCGIA was asked to serve, it is clearly the most important from a philosophical and methodological viewpoint, and this is reflected in the fact that the Geography and Regional Science program acts as the home of NCGIA at NSF. Moreover, promotion of GIS and GIS-based analysis across the sciences is clearly in the long-term interests of geography. Finally, the context provided by Dobson's paper (Dobson 1993) compels us to take a geographic perspective in this response.

Over the past four years, NCGIA has developed a set of teaching materials in GIS (the "Core Curriculum in GIS"; Goodchild and Kemp 1990) and distributed them to over 1,000 universities, agencies, and companies worldwide. Several other volumes of lab materials are also designed to help departments strengthen their GIS offerings (Dodson 1991; Dodson et al. 1991; Veregin 1991). We have also completed a set of six case studies of GIS labs to provide templates for departments seeking to develop and maintain GIS teaching environments (Palladino and Kemp 1991). In all of these, the focus is largely, but not exclusively, on the needs of academic geography and on helping departments to make cases to their own administrations, or other funding agencies such as NSF's ILI program, to support GIS. In essence, our objectives have been the same as Dobson's in 1983–1984, but we feel that our approach has been the appropriate one for the context of 1988–1992.

The cooperative agreement that funds NCGIA will expire in November 1993, and at the time of this writing NSF had not reached a decision on the center's application for renewal through 1996. But whatever form the center takes in the future, input from the academic geography community on NCGIA's activities and plans will continue to be essential to its success. Dobson is correct in arguing that such input and debate is critical if NCGIA is to be a national center for geography rather than a national center for GIS.

Geography and GIS

Is NCGIA a center for GIS or geography? Debate seems pointless when both terms are poorly defined. Certainly GIS is a potentially useful tool for many kinds of geography, spanning all four of Pattison's traditions (Mark and Dickinson 1991). But the idea that GIS is a tool, however valuable, for automating geographical practice seems to sell it short for two reasons. First, much recent research in human geography has focused not so much on analysis and modeling as on the social context within which these are embedded, and has argued that

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research without context is incomplete and even futile. Why has GIS been embraced so completely within such federal agencies as the U.S. Environmental Protection Agency (EPA) or the U.S. Forest Service, or by state and local governments? Who does GIS tend to empower, and what are the implications of its adoption for surveillance and privacy? Geographers are only just beginning to discuss these issues, which are a vital part of the interface between geography and GIS (Smith 1992).

Second, tools have a way of impacting practice in unforeseen ways. For the first two decades of its use in scientific research, the computer was seen largely as a calculating device. More recently it has had a profound impact on the way data are collected, managed, and distributed. We are now seeing a fascinating trend away from mathematically based models written in Fortran and C to object-oriented models constructed visually with graphic icons. Visualization and simulation are becoming more and more significant as paradigms for research on complex systems. Finally, the cognitive issues of spatial reasoning will become increasingly important as GIS tries to bridge the gap between scientific modeling and policy formulation. In all of these areas, powerful new tools are provoking new thoughts that go far beyond the objectives of the toolmaker.

We believe that it is entirely proper that NCGIA concentrate on Dobson's "theory, methods, models, and techniques required to conduct geographic research and analysis." By developing better tools within the context of geography, and by examining the power of those tools to stimulate and provoke, we think that NCGIA best serves the long term interests of the discipline. Substantive geographic research on specific landscapes and humanity's interactions with them is best done by specialists with specific, detailed knowledge of those landscapes or interactions, and with access to the most appropriate tools.

Whatever they mean individually, GIS and geography are clearly tightly intertwined in an intellectual sense, and we find Dobson's attempts to distinguish them (items 1 through 4 versus item 5) artificial (Dobson 1993, 210). Geography is firmly in the intellectual driving seat of GIS. We can imagine "advances in GIS alone" being made by computer scientists, but not by geographers or a multidisciplinary center focused on geography, and we cannot understand why Dobson raises the specter of "clerks handling data for the ecologists, political scientists, economists. . . ." Of all the disciplines involved in GIS, surely geographers are the least likely to accept the role of spatial data clerks? Shouldn't a discipline that focuses on space see GIS, and the interest in GIS in other disciplines, as an opportunity to extend its influence and strengthen its intellectual core?

The people who promoted NCGIA within NSF and the broader community, and those who have contributed to it over its first four years of operation, have had to find appropriate balances between several pairs of potentially conflicting objectives. One, the balance between substantive research in, say, regional geography, and the development of theory, methods, and tools to support such research generically, has already been discussed. Another is the conflict between the needs of academic geography, for better access to GIS, with the need to promote GIS, and thus geography, to other sciences.

But ultimately the justification for the center does not lie in these arguments, however carefully they are balanced, but in the case that can be made for a center rather than a collection of independent, individual research efforts—not in whether there should be a center for this, or a center for that, but in whether there should be a center at all. Only a center can be Dobson's "institutional symbol of geography," "helping to identify geography as the core discipline of GIS methodology and research." A center can open communication with vendors of GIS software and have an impact on software development. It can act as a focus for academic interest in GIS and promote academic interests within the GIS community. We hope we have been modestly successful at doing this over the past four years, and that NCGIA has justified the work that Dobson and others devoted to its establishment. But NCGIA needs to continue to justify investment, and we need the help of the geography community in determining how to optimize return.

Where Next?

We have argued that the vision of NCGIA did indeed change, and appropriately, in the years following Dobson's 1983 article and pre-proposal in 1983–1984. GIS continues to change rapidly, and visions should continue to evolve. What is the appropriate vision for NCGIA from the perspective of 1993, or more specifically, what aspects of that vision are relevant to the issues raised by Dobson?

First, the proposal for renewal of NCGIA submitted to NSF in November 1991 contains a significant change in the center's mission statement. In 1987 we followed the NSF solicitation in proposing a center for the advancement of "geographic analysis utilizing GIS" and maintained the GIS/GIA acronym throughout to discourage the labeling of NCGIA as a "center for GIS alone." The 1991 mission refers simply to "advanced geographic research," reflecting our feeling that GIS and geography are now both intellectually and practically intertwined.

Second, we have reached the point in 1993 where most geography departments now support and teach some form of GIS, and GIS is part of the education of most geography students. While there will always be a need for newer workstations and more staff, there are other ways in which we can further the interests of geography that may have more lasting impact. One is in promoting the notion that GIS is now a campuswide issue, and thus should have access to campuswide support and resources. On many campuses there is now active interest in GIS not only in geography but also in civil engineering, anthropology, ecology, geology, sociology, political science, and a range of disciplines with interests in spatially distributed phenomena. It is time to develop institutional strategies for GIS, covering curriculum, laboratory space, and equipment.

Third, we need to develop GIS as a component of the secondary school curriculum. GIS has a role as a teaching tool for environmental and social science as well as for geography and should be taught as an increasingly important feature of everyday life. It is also an attractive way of interesting students in geography and more generally in the importance of spatial thinking. In the next few years we hope that NCGIA will be working with the Geographical Alliances, NCGE, and other groups to develop ideas and materials for GIS in the secondary school curriculum. In the long run, we think that GIS can have a highly beneficial impact on the teaching of secondary school geography, and, in turn, on the preparation of students for university geography.

Fourth, as GIS continues to become more central to geography, we would like the discipline to have a stronger role in defining NCGIA's research agenda. The areas of research identified in 1987 were devised by the consortium in a competitive setting, and not widely debated. Since then, the process of defining new research initiatives for the center has become progressively more open, and in June 1992 the center adopted a new process that includes comprehensive external input and review. We hope this will help to make the center more responsive to the needs of geography by providing a mechanism for the debate that is central to Dobson's paper. ■

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Commentary on "A Rationale for the National Center for Geographic Information and Analysis"

Introduction

Since its creation in 1988, the National Center for Geographic Information and Analysis (NCGIA) has played a crucial role in advancing geographic information systems technology and its uses. In particular, the NCGIA has been effective in recognizing and rectifying impediments to the successful application of geographic information technology.

Dobson's article (Dobson 1993) clearly articulates the opportunities that still exist for the NCGIA. Through an analysis of the center's evolution and related impact on geography, Dobson provides a basis for discussion on how to enhance the contribution of the NCGIA and ensure its continued success.

Through geographic information systems, the geographer's integrative role in spatial analysis has been clearly articulated to the scientific community. I believe GIS is simply applying integrative geographical analysis to relational databases through automated (computer assisted) methods. As the discipline's sophistication in spatial analysis approaches evolves, so does our ability to handle complex spatial questions through GIS. At the same time, through operations involving elaborate databases, GIS allows the geographer to address a wider range of spatial science questions than would be possible to address through alternative means. Through GIS, geography has strengthened its scientific milieu, resulting, as Dobson states, in "spatial intelligence ranking on par with linguistic and mathematical intelligence."

Database Access and Research Themes

Dobson argues that one of the original goals of the center was removed by the National Science Foundation (NSF) Geography and Regional Science Program Director prior to the final solicitation. In particular, the focus on access to geographic information and analysis technologies was not specifically stated but assumed to be part of the NCGIA. Dobson feels the original intent was for NCGIA to also maintain a collection of the databases most commonly required by geographers. Such an effort, however, would seem to overlap initiatives being made by various federal and state agencies such as the U.S. Geological Survey and the U.S. Bureau of the Census.

Dobson also suggests that the research menu suggested by Abler during his program directorship at NSF misses many of the hard issues faced daily by geographers who want to incorporate GIS into basic and applied research. I do not agree. The Abler input and NCGIA have included a wide range of opportunities for geographers to incorporate GIS analysis in their research. Unfortunately, some geographers are not keeping up with GIS advances. They still think of GIS as a computer tool with limited analytical capability, rather than realizing that GIS is computer-based geographic analysis that facilitates asking complex spatial questions through modeling of geographic place and process.

Dobson also argues that NCGIA has focused on the theory, methods, models, and techniques required to conduct geographic research and analysis at the virtual exclusion of topical and regional geography. This seems to suggest that once GIS theory, methods, models, and techniques are pursued by NCGIA, geography researchers will not use these approaches without demonstration or initiatives by NCGIA regarding geographic research questions in general. I do not believe that this is true. Geographers, for example, are playing a lead role in the Global Change Database Project (Kineman et al. 1990) as part of the International Geosphere-Biosphere program (IGBP). The NCGIA has provided training and evaluation leadership while support software has been developed by geographers at Clark University (IDRISI).

In addition, the wider geography community is receiving support for addressing central geographic questions through GIS. NASA, NSF, USAID, and numerous state and local agencies have supported this. Geographers lead the way in research on global change and other restructuring questions using GIS and related spatial approaches. For example, Estes (University of California-Santa Barbara) served on the committee that organized NASA's Mission to Planet Earth program, and Dozer (NASA Goddard Space Flight Center) led the science and instrumentation panels (NASA 1988).

Dobson suggests that no geography department has the full complement of systems and databases to accomplish adequate automated geography of its own region, much less other areas. Perhaps Dobson has not seen the widespread dramatic development of spatial databases for numerous U.S. regions or the improvements and reductions in costs associated with hardware. The Geographic Information Systems/Spatial Analysis Laboratory (GISSAL) at Kansas State University and the Center for Application of Land Management Information Technologies (CALMIT) at the University of Nebraska are two examples of many such facilities that have evolved in the past few years. Regional, state, and local units of government look to GIS and geography programs equipped to perform GIS analysis for directions on addressing social, economic, and environmental questions in this information age, a time period in which a prime interest in geography also has developed (Nellis et al. 1992).

I also feel that the lack of emphasis on technology transfer by NCGIA is not necessarily an issue for geography researchers. Num institutes and corporations, such as ESR DAS, Intergraph, and Clark University developed and provided refinement i graphic information system software. N has worked closely with GIS vendors a facilitated the evolution of basic software for addressing complex geographic que GEOLINEUS is one example of this Available through NCGIA-Santa B GEOLINEUS is a productivity tool tha plifies GIS application development an spatial database management for us ARC/INFO on the SUN4 and SPARC stations (Parker 1992).

Dobson believes few geography depart have more than rudimentary GIS cap Again, he has seriously underestimated t complishment of individuals and pro outside NCGIA in advancing geog analysis through GIS and the sophistica these approaches. Also, I believe com pursuing GIS software development hav significant advances in the last year or enhancing the software's capability for a cal data-supported integrated systems, p larly with spatial statistics as applied to based systems. I think universities in con tion with regional, state, and local e along with the NCGIA, are driving the velopments due to demands associated numerous complex government planni sues like water quality assessment and gency preparedness.

Certainly Dodson's support of the S Data Transfer Standard (SDTS) and th eral Geographic Data Committee (FGI worthy. Data standards, as some State G itiatives Task Forces have already realize defined (e.g., Kansas where the Kansa State Initiative has developed statewid data standards), are crucial to facilitatin highest level of spatial data integration (1992). Such data integration should allow effective use of GIS for addressing a range of societal issues.

Conclusions

Through its mandate by the National S Foundation, the NCGIA has played an i tant role in articulating and facilitatin development of GIS theory, methods, m and techniques required for geographic

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