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NCGIA Closing Reports on Research Initiatives and Projects

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*NATIONAL CENTER FOR GEOGRAPHIC INFORMATION
AND ANALYSIS*

ANNUAL REPORT

Year 6
(December 1, 1993 - December 31, 1994)

University of California, Santa Barbara
State University of New York at Buffalo
University of Maine

14 May 1995

***NATIONAL CENTER FOR GEOGRAPHIC INFORMATION
AND ANALYSIS***

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SUMMARY

The National Center for Geographic Information and Analysis was announced by the National Science Foundation on August 19, 1988, and awarded to a consortium of the University of California, Santa Barbara; the State University of New York at Buffalo; and the University of Maine, for an initial period of five years. Funding began December 1, 1988 under a five year cooperative agreement with the Regents of the University of California. The cooperative agreement was extended in 1994 for an additional three years, to December 31, 1996. The Center's mission reflects the desires of the NSF, as expressed in the solicitation document: to advance the theory, methods and techniques of geographic analysis based on geographic information systems (GIS) in the many disciplines involved in GIS-based research; to augment the nation's supply of experts in GIS and geographic analysis in participating disciplines; to promote the diffusion of analysis based on GIS throughout the scientific community, including the social sciences; and to provide a central clearing house and conduit for disseminating information regarding research, teaching and applications.

This document reports on the Center's sixth full year of operation. Four research initiatives were closed and their final reports accepted by the Board of Directors: Spatial Decision Support Systems (I6, begun in March, 1990); Visualizing the Quality of Spatial Information (I7, begun in June, 1991); Integration of Remote Sensing and GIS (I12, begun in December, 1990); and User Interfaces for GIS (I13, begun in June, 1991). One major new research initiative was begun, on Law, Policy, and Spatial Databases (I16), and a second was in the advanced stages of planning for its specialist meeting (I15, Multiple Roles for GIS in U.S. Global Change Research). Education programs continued to be directed to K-12, with teacher workshops and the development of instructional materials, and a new initiative promoting GIS in community colleges began. The Center held its first Summer Institute for researchers. The program of collaboration with the European Science Foundation's GISDATA program was in full swing, and planning began for a 1995 joint summer institute with the Europeans in Maine.

In 1994, NCGIA played a key role in the award of funding for the Alexandria Digital Library at UC Santa Barbara, one of six cooperative agreements made by NSF under the joint NSF/ARPA/NASA Digital Library Initiative. The Center also collaborated in workshops offered by NSF on Education and GIS, and GIS in Antarctic research.

Efforts to found a University Consortium for Geographic Information Science moved forward, with a founding meeting held in Boulder, CO in December 1994, with representatives of over 30 institutions.

1. BACKGROUND

1.1 Center mission

On August 19, 1988, the National Science Foundation (NSF) awarded the NCGIA to a consortium of the University of California, Santa Barbara; the State University of New York at Buffalo; and the University of Maine, with funding of \$1.1 million per year for five years. In 1994 the cooperative agreement was extended for a further three years, to December 31, 1996, and augmented with a \$100,000 per year Visiting Scholars Program. The sixth year's operation began officially on December 1, 1993. The decision to establish the Center and the selection process have been described by Abler (*International Journal of Geographical Information Systems* 1: 303-326 (1987)).

NSF's solicitation for the Center in 1987 identified "basic research on geographic analysis utilizing GIS" as the Center's primary mission and suggested five areas as possible research topics: improved methods of spatial analysis and advances in spatial statistics; a general theory of spatial relationships and database structures; artificial intelligence and expert systems relevant to the development of geographic information systems; visualization research pertaining to the display and use of spatial data; and social, economic and institutional issues arising from the use of GIS technology.

In addition to research, the Center was to take steps to "augment the nation's supply of experts in GIS and geographic analysis in participating disciplines; promote the diffusion of analysis based on GIS throughout the scientific community; and provide a central clearinghouse for disseminating information regarding research, teaching and applications". A major peer review of the Center was conducted by NSF in June, 1990, after the Center had been in operation for 18 months, and a second peer review was conducted in 1992 as part of the process of renewal of the cooperative agreement.

In response to continuing trends in the field of geographic information and analysis, and to prepare for an extended process of evaluation by NSF in connection with possible renewal of the Center's cooperative agreement beyond 1993, a strategic planning exercise was conducted in 1991. It led to the adoption of a new mission statement, and new goals and objectives, and these became the basis for a renewal proposal submitted in November, 1991, and covering the period 12/1/93 through 12/31/96. The mission of the National Center for Geographic Information and Analysis is: **the advancement of geographic research of lasting and fundamental significance**. Specifically, we will continue to:

- 1) Advance the theory, methods, techniques and applications of geographic analysis based on geographic information systems (GIS) in the many disciplines and professions involved in geographic research;
- 2) Augment the nation's supply of experts in Geographic Information Systems (GIS) and Geographic Information Analysis (GIA) in participating disciplines;
- 3) Promote the diffusion of analysis based on Geographic Information Systems (GIS) throughout the scientific community and provide a conduit for disseminating information regarding GIS research, teaching, and applications; and
- 4) Interact with individual researchers and organizations on a national and international basis.

Within this overarching mission, the long range goals of NCGIA are to:

- maintain the United States' lead in GIS/GIA technology and applications;
- continue to play a leadership role in geographic research;

- improve, enhance and promote the use of geographic information systems (GIS) and geographic information analysis (GIA) throughout the social and physical science community; and
- improve and enhance the quality of geographic research, education, and applications at national and international institutions and organizations.

The consortium's successful 1988 proposal to NSF laid out a comprehensive research agenda for research in geographic information and analysis, aimed at removing what were seen as impediments to the effective use of GIS technology. The agenda was subsequently published in the *International Journal of Geographical Information Systems* [3(2): 117-136 (1989)]. In 1991 the agenda was rewritten, in conjunction with the strategic planning exercise and the renewal proposal, to reflect better the evolution of the field and the contributions made by research both inside and outside the Center in the previous three years. It is available as *NCGIA Technical Report 92-7*.

In June, 1992, the Center adopted a new, revised research plan that preserved the research initiative as the primary vehicle for organizing work on the research agenda, but with the addition of new vehicles, a more rigorous process of review of proposed initiatives, and more formal mechanisms for collaboration with individuals or groups outside the Center. Full details of the research plan that now guides the research operations of the Center can be found in the Annual Report for Year 4, and are also available from any of the Center sites. Announcements summarizing opportunities for collaboration with the Center, through the Visiting Fellowships Program, Collaborative Grants Program, or through proposals for new research initiatives, appear regularly in the Center newsletter, *UPDATE*, and in other publications.

1.2 The broad context of NCGIA in 1994

During 1994, several developments at the national level indicated continued growth in interest and support for GIS and spatial databases in general. On April 11, President Clinton signed an Executive Order directing the development of the National Spatial Data Infrastructure. The Order required immediate work on three items: the development of a standard for spatial metadata, to encourage and formalize the online documentation of digital data sets, making them easier to share; the identification of the framework data sets that will form the foundation of NSDI; and the development of a National Geospatial Data Clearinghouse, as a virtual national catalog. The metadata standard appeared in draft form in 1994, and stimulated activity nationwide to develop compliance. NCGIA began a list server, NSDI-L, to encourage email discussion of the issues surrounding NSDI; the server is now operated by the U.S. Geological Survey National Mapping Division.

NCGIA contributed to the development of the NSDI framework by conducting a major questionnaire survey in the summer of 1994, under the auspices of Initiative 9. Michael Goodchild and Barbara Buttenfield served on the National Research Council Mapping Science Committee, which developed two further reports on NSDI in 1994 (NRC, 1994, 1995).

The importance of GIS and geographic information analysis continued to grow across the sciences, in part reflecting NCGIA's role as a promoter of GIS/GIA. NSF sponsored a workshop on GIS in Antarctic research in September, under the Office of Polar Programs, and in January sponsored the first Education GIS meeting in Washington, bringing together school teachers, education specialists, cognitive scientists, and GIS specialists. GIS and other spatial data technologies played a key role in the competition for the award of the national Center for Ecological Analysis and Synthesis, and the likely award of the center to UC Santa Barbara was attributable in part to the presence of NCGIA and its links to applications in ecology, as well as to the growing interest in spatial perspectives and theory in that discipline.

In October, one of six awards under the joint NSF/ARPA/NASA Digital Libraries Initiative was made to UC Santa Barbara, to a team led by Terence Smith and Michael Goodchild, both NCGIA PIs, together with

the UCSB Departments of Computer Science, Geography, and Electrical and Computer Engineering, and all three sites of NCGIA. The team will research and build the Alexandria Digital Library as a comprehensive set of services for access to spatial and spatially referenced materials. In brief, Alexandria will provide remote access to a virtual map and imagery library, bringing the extensive resources of the UCSB Map and Imagery Laboratory within reach of anyone with an Internet connection, and also develop geographic location as a new and powerful means of accessing and linking other library materials. Alexandria is funded for four years at \$1 million per year, and involves several industrial partners as well as libraries. Early work under the project focused on development of a Rapid Prototype using commercial, off-the-shelf software. Although spatial data is also important to the DLI project at UC Berkeley, Alexandria is unique among the six DLI projects in its primary emphasis on the potential of this type of information in the digital library of the future.

Over the past few years NCGIA has initiated several discussions of the potential for a more broadly based consortium of academic research institutions with strength in GIS/GIA. In December, 1994 the Center helped to organize a founding meeting of what will be known as the University Consortium for Geographic Information Science (UCGIS). Invitations to the founding meeting were signed by the Presidents of seven institutions, including the three NCGIA sites, and sent to the Presidents of a further 25. All invited institutions responded by sending at least one delegate to a founding meeting in Boulder, CO in December 1994.

REFERENCES

- NCGIA (1989) The research plan of the National Center for Geographic Information and Analysis. *International Journal of Geographical Information Systems* 3(2): 117-136.
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2. SUMMARY OF MAJOR ACTIVITIES

A. Research

Research in the Center takes place within the framework of a series of research initiatives. Each initiative begins with a specialist meeting attended by professionals from outside the Center, in which the most important problems in the subject area of the initiative are identified and ranked and a feasible research agenda for the initiative is defined. Research continues intensively for 24-36 months with teams of faculty (NCGIA or other), postdoctoral fellows, or advanced graduate students, as well as representatives from private industry or government agencies, working in teams on specific problems. Specialist meeting participants and other interested individuals are kept informed of the progress of research through newsletters, symposia, and presentations at conferences. The completion of an initiative is marked by the holding of a national forum to present the research results. Results are also announced in articles in refereed journals, presentations at conferences, bibliographies, algorithms or models for analysis, *NCGIA Technical Papers*, and short courses or workshops. Completion marks the end of significant financial support from NSF funds, but does not imply that the topic has been exhausted or that the Center's interest in the topic has ended. Rather, completion may signal the need to redefine the research agenda, or to initiate related research in new directions.

During the sixth year one new initiative was begun, and four were completed, leaving a total of five active initiatives at the end of year 5:

8. *Formalizing Cartographic Knowledge*. Leader: Barbara P. Battenfield (Buffalo). Specialist Meeting: Buffalo, October 1993.
9. *Institutions Sharing Spatial Information*. Co-Leaders: Harlan Onsrud (Maine), Gerard Rushton (University of Iowa). Specialist Meeting: San Diego, February 1992.
10. *Spatio-Temporal Reasoning in GIS*. Co-Leaders: Reginald G. Golledge (Santa Barbara), Max Egenhofer (Maine). Specialist Meeting: Lake Arrowhead, CA, May 1993.
14. *Spatial Analysis and GIS*. Co-Leaders: A. Stewart Fotheringham and Peter A. Rogerson (Buffalo). Specialist Meeting: San Diego, April 1992.
16. *Law, Public Policy, and Spatial Databases*. Co-Leaders: Harlan Onsrud (Maine), Robert Reis (Buffalo). Specialist Meeting: Tempe, AZ, October 1994.

Several other initiatives are in various stages of planning and approval, and they and the completed initiatives are included in the following discussion where significant activities have occurred.

Initiative 7: Visualization of the Quality of Spatial Information (began June 1991). The quality of spatial information and spatial information products is multidimensional and complex, and clearly, it varies both spatially and temporally. Communicating this potentially large and complex pool of information to users is a challenge. Visualization has recently been proposed as a technique for making complex information more comprehensible. A primary research objective of this initiative is thus to explore the tools of visualization for communicating the many dimensions of geographic data quality to users in meaningful ways.

The closing report for the initiative has been completed and reviewed by NCGIA Board members. This initiative is now closed. During the past year however, research in this area continued and Kate Beard has been working on visual responses to the basic query - "what is the reliability of the attribute at location A?" The visual response is a function of the reliability measure and the specificity of the location A.

Several graduate students worked on this initiative at Maine. Khaled Hassen is continuing his PhD research on the reference grid concept which employs piecewise linear transformations to mimic the behavior of several geometric GIS processes. The piecewise linear transformation is applied to a grid which captures a graphic picture of the result of positional deformation caused by the GIS process. Jeff Paradis continues work on the "Data Quality Filter". He is developing the filter design for data sets which are heterogeneous with respect to different quality components. One of the primary data sets to be analyzed is the BLM Geographic Measurement Management (GMM) data. This data set incorporates a complete lineage and tracking of positional accuracy for survey measurements of the Public Land survey system. Lori Dolby is completing her masters thesis. As a portion of the thesis she has designed an interface to examine the geological subsurface of Casco Bay. Interpolated Holocene, glacial marine and bedrock surfaces can be examined, and as an integral part Lori has added displays to view the uncertainty of the interpolated surfaces. Bhessem Ramlal is beginning work on a soil information database that would incorporate quality information as an integral part of the data model. The new model is based on measurements as the primary unit as opposed to the standard soil map units which now form the SCS soils database.

Two of Maine's visiting scientists were attracted to work with Kate Beard on I7-related questions. Howard Veregin, Assistant Professor, Department of Geography, Kent State University, visited NCGIA under the NCGIA Visiting Scholars program from June 20 to July 20. He worked with Kate Beard and Ph.D. student Bhessem Ramlal on a project to investigate the accuracy of soil maps. This project compares soil map representations with representations of individual soil properties generated by interpolation from point observations. Three different properties measured for a site in Maine (topography, pH, and depth to bedrock) will be interpolated to generate a map of the individual properties. Difference maps will then be generated to compare the interpolation against the soil map representation of the same property. An abstract on this project was submitted and accepted for Auto-Carto 12.

Carl Amrhein, Chair, Department of Geography, University of Toronto, Canada, visited NCGIA from July 11 through July 30, also under the NCGIA Visiting Scholars program. He and Kate Beard worked on a project that investigates the aggregation problem. The project uses State of Maine data at the town level. From this data random distributions will be generated to match the approximate size of school districts and counties. User generated aggregations produced using Jonathan Hancock's (Syracuse) Look and Link software will be analyzed with respect to the random distributions. A journal article will be prepared from this research. Amrhein also worked with Kate Beard on revising a proposal submitted last year to NIH for re submission to NIEHS. This proposal addresses the aggregation problem with respect to correlation of radon data and lung cancer.

At Santa Barbara, Michael Goodchild and Gary Hunter of the University of Melbourne continued their collaboration on methods for modeling and visualizing error in spatial databases, focusing on errors in DEMs and area class maps. Chuck Ehlschlaeger has extended this work, developing animated visualizations and user tools. Several papers have been presented and published.

Initiative 8: Formalizing Cartographic Knowledge (began October, 1993). The I8 Specialist Meeting was held in Buffalo in October 1993. The goal of the initiative is the development of a testbed for formalized knowledge about the cartographic production process, with a focus on non-thematic maps.

From December 12 to 15, 1993, the Workshop on Map Generalization was held in Compiègne, France, under the auspices of the European Science Foundation GISDATA program. The meeting was attended by many of the I8 Specialist Meeting participants, and by I8 Steering Committee members Weibel, McMaster, Muller, and Buttenfield. Funding for the meeting was provided by the European Science Foundation, which hosted it, with additional funds provided by NCGIA, Intergraph, ESRI, IBM, and Barco. Papers were presented by each participant, and following the meeting, Taylor and Francis agreed to publish a research volume Generalization in GIS. Editors include Jean-Claude Muller (senior editor) and Rob Weibel,

as well as Jean-Phillipe Lagrange, from IGN in Paris. Papers underwent peer review in the spring, and were revised, completed and sent to press in November. The book should be printed by Spring, 1995.

As reported last year, Barbara Buttenfield completed a needs and requirements study at the Library of Congress Geography and Map Division. This work relates to I8 in the context of evaluating formalized knowledge. She presented findings of this project at the Auto-Carto 11 meetings in Minneapolis. Additionally, these findings informed preparation of the evaluation protocols for the digital libraries proposal submitted with the other NCGIA researchers to the NSF/ARPA/NASA solicitation in February, 1994.

This grant was awarded in late summer to NCGIA by NSF, ARPA and NASA. As part of the Digital Libraries Initiative, NCGIA will receive \$1 million per year over the coming 4 years to develop, implement and evaluate Alexandria, a software testbed to perform intelligent content-based browsing on distributed datasets containing digital maps and spatial imagery. Barbara Buttenfield will direct the user evaluation component, which relates to I8 in the context of Knowledge Acquisition and Elicitation. User evaluation research teams have formed at Buffalo, Maine and Santa Barbara, directed by Buttenfield, Egenhofer, and Carver, respectively. User evaluation will proceed in parallel with testbed implementation, with empirical testing to begin as early as Spring 1995 in map libraries across the nation. A conference of federal agency map librarians is being organized now for May 1995, at USGS Headquarters in Reston. Meeting coordinators will include Buttenfield, Carver, and Gary Fitzpatrick from the Library of Congress as well as a USGS staff member to be designated by Joel Morrison.

During sabbatical leave at USGS in Reston (1993-1994), Barbara Buttenfield participated in numerous meetings with FGDC (Federal Geographic Data Committee) members on establishing a set of national coverage "Framework Data Sets". Topics include selection of criteria for including datasets in the framework, integrating data across spatial, spectral and temporal resolutions, and implementing mechanisms for distribution of data via Internet. Infrastructure problems such as data certification and version management are also relevant. Buttenfield's work this winter focused on development of a data model that can accommodate data at multiple levels of resolution. Initial reports were presented at conferences throughout the spring.

To be workable, the data model must retain a consistent geographical meaning while providing flexibility for possibly inconsistent graphical depictions. Additionally, it must be compatible with the various incarnations of DLG, which forms a basis for much of USGS vector data production. Lastly, the computational overhead must remain manageable for both analysis, mapping, and update. Current efforts are based on Noam Chomsky's linguistic metaphor of surface meaning and deep meaning, with the idea of embedding rules for feature behavior that may change with scale. Two other USGS researchers have joined the project, Lee DeCola and Dave Catts. The three are working together to extend rules developed by Catts for generalization of the 1:500,000 New Jersey state map, to apply these rules to two DLG feature categories ("urban built-up area" and "stream/river"), and to implement prototypes to test the data model concept.

This work collaboration continued through the summer. DeCola and Buttenfield rasterized street centerline data at varying levels of resolution to generate urban outline boundaries, and to determine whether this provides a geographically valid map representation. One intention is to determine the feasibility of automating map compilation for specific cartographic features. DeCola presented a co-authored paper at the Phoenix GIS/LIS meetings in November.

Other research activities related to I8 focused on use of emerging technologies for display and exploration of digital cartographic data. A multimedia CD-ROM based on an electronic "field trip" to the Smithsonian monumental core is under development at USGS, and Barbara Buttenfield advised on programming and interface issues. The CD-ROM is targeted for an eighth grade audience, to teach mapping skills as well as introduce history and geography of a portion of Washington DC. The design phase neared completion in the spring of 1994, and in May, Buttenfield organized a meeting bringing two consultants (a

middle school teacher and a multimedia researcher) to evaluate the design. Their advice is guiding final revisions as the project enters its production phase.

Early in the year, Robert Weibel spent a month in residence at IGN in Paris, to pursue research defined at the I8 Specialist Meeting on digital terrain depiction. He worked with Jean-Philippe Lagrange and François Salgé. A paper on his research was prepared for the Spatial Data Handling Meetings in Scotland in August. In addition, Bob McMaster visited Dietmar Gruenreich in Hannover Lab in Germany, and also visited Jean-Claude Muller in Bochum Germany. The purpose of the visit was to learn about ATKIS and associated generalization procedures that utilize ATKIS protocols.

Bob McMaster spent his Fall 1994 sabbatical semester in Europe. He spent several months in residence at the Royal Institute of Technology in Sweden, and collaborating with Hans Hauska on research in raster-based map simplification. His final weeks in Europe were spent in residence at IGN-Paris, collaborating on data modeling for generalization and reporting on his work. Both of these opportunities have developed in part from discussions held at the NCGIA I8 Specialist Meeting a year ago. McMaster returned to North America in December.

In Buffalo, on 3 November, Michael Leitner defended his dissertation proposal "Empirical Analysis of the Impact of Data Quality Displays on Spatial Decision Support". The dissertation committee was supervised by Barbara Battenfield. The topic relates to Initiative 7 (Visualizing the Quality of Spatial Information) and to Initiative 8, in the context of evaluating map design. In a hypothetical site location task, subjects will be presented either with maps of environmental data or with maps showing data and data reliability. Experimental results will address the time required to make the siting decision and the confidence subjects attach to their choice. Data reliability will be symbolized by three separate visual variables, for comparison of graphical designs.

At Maine, Barbara Bicking successfully defended her Master's thesis on "A Formal Approach to Automate Thematic Accuracy Checking For Cartographic Data Sets". Her work formalizes cartographic symbols and symbol relationships on maps as a means to automatically check attribute accuracy and consistency in the conversion to digital representation. She presented a paper on this work at GIS/LIS in Phoenix and will present another paper at AutoCarto 12.

A proposal for a Workshop on Progress in Generalization of Spatial Data has been drafted and circulated to several agencies and organizations for funding. The Organizing Committee includes Rob Weibel (U. Zurich), Dianne Richardson (Canada Centre for Remote Sensing), Jean-Phillipe Lagrange (IGN-Paris), and Barbara Battenfield (NCGIA). The workshop is to be held for 2-3 days just prior to the International Cartographic Congress (ICC) in Barcelona, Spain in August 1995. Its objective is to review research progress, to re-examine the research agenda as formulated in previous meetings, and to identify well-defined technical problems that can be tackled (ideally) by international collaboration. Funding has been identified from the European Science Foundation GISDATA program, Institut Cartographic de Catalunya (hosts of ICC) and NCGIA. Funding has been solicited from the US Geological Survey, Ordnance Survey, Canada Centre for Remote Sensing, and OEEPE Working Group on Generalization. NCGIA will provide travel funds for a small number of North American participants, and will publish the Workshop Proceedings as an NCGIA Technical Report.

At the University of Maine, William Mackaness conducted research on the synergy between operators in map generalization. This work looks at the twelve generalization techniques or "operators" that can be used to control the abstraction and overall design of graphics from GIS, and considers issues relating to preference, combination, degree of application and selection of these operators. In addition, questions pertinent to a holistic cartographic expert system for GIS are being considered. Another research project being undertaken relates to transition through abstraction with respect to the selection of independent algorithms that exist for a

variety of generalization processes. This work investigates an acceptable metamorphosis of topology between design transitions and investigates methods of predicting outcomes of application of generalization operators.

Initiative 9: Institutions Sharing Geographic Information (begun February 1992). Geographic information is used to address a broad range of critical problems, and thus the value and social utility of geographic information comes from its use. Sharing of geographic information is important because the more it is shared, the more it is used, and the greater becomes society's ability to evaluate and address the wide range of pressing problems to which such information may be applied. Thus, the demand for efficient, equitable, and timely access to spatial data by the user community will continue to grow. As the need to share grows, there will be a greater need to understand the patterns of institutional, organizational, and individual behavior within the GIS user community. Prospective models and prescriptive strategies for sharing spatial data from the local level to global scales need to be developed. The goal of this initiative is to expand the knowledge base of institutional, organizational, and behavioral issues which will allow development of such models and strategies.

This initiative was organized by a seven member core planning group representing six universities and is led by Harlan Onsrud (University of Maine) and Gerard Rushton (Iowa). The Initiative 9 specialist meeting was held February 26-29, 1992, in San Diego, and focused primarily on behavioral and organizational issues acting as impediments or incentives to the sharing of geographic information among and within organizations. The results of the Specialist Meeting are documented in *NCGIA Technical Paper 92-5*.

Initiative 9 researchers at the University of Maine have been working on a one-year program with the USGS to identify datasets to form the backbone of the National Spatial Data Infrastructure (NSDI). Specifically, the project is aimed at establishing criteria for identifying high priority framework data sets for NSDI, defining minimum technical specifications that must be met by these data sets, including content and positional accuracy, and initiating further discussion of these criteria and specifications. The work included convening a "focus group" of experts in a wide range of areas of application of spatial data to identify and refine questions, conducting a survey of a broad sample of spatial data users, and analyzing the results and compiling them into a major report on framework data specifications. Mike Goodchild and Harlan Onsrud served as co-PIs. Steve Frank, formerly a postdoctoral researcher at UMaine, and now a faculty member at the New Mexico State University at Las Cruces, developed a mail survey and coordinated survey distribution. Jeff Pinto, formerly at UMaine's College of Business Administration, has been advising on survey structure and the analysis of survey results. Among other objectives the questionnaire attempted to identify the technical specifications required by the users of framework data sets, including geographic content, data format, geocoding scheme, positional accuracy, vertical accuracy, updating interval, and need for historical data. Users were also queried about their current sources for data meeting such criteria.

NCGIA at UMaine has started an electronic discussion list to share ideas specific to the National Spatial Data Infrastructure. The list, called NSDI-L, is unmoderated and open to the public. It is now supported by a server at the US Geological Survey.

Steven Frank is continuing progress in his investigation of cataloging paradigms for spatial metadata. "Cataloging Digital Geographic Data in the Information Infrastructure: A Literature and Technology Review" was submitted to *Information Processing & Management* and has been accepted for publication. A further article titled "The National Spatial Data Infrastructure: Designing Navigational Strategies" has been accepted for publication by the *URISA Journal*.

Dr. Zorica Budic, Assistant Professor, Department of Urban Affairs and Planning, Virginia Polytechnic Institute and State University, Blacksburg, VA, worked on Initiative 9 research under the NCGIA Visiting Scholars program, July 16-23, 1994. The major objective during her visit was to work on a joint proposal for funded research to explore the issues related to I9. Initial research ideas were developed and communicated among the collaborators before the actual visit. Her time at UMaine was devoted to 1)

discussing theoretical foundations of the proposed research; 2) composing a conceptual framework to be derived from theory and previous research; 3) establishing clear research question(s) and objective(s); and 4) discussing and developing the research methodology, including the logistics (sampling, timetable and resources needed to undertake the research). The secondary objectives were to 1) get more closely acquainted with the NCGIA, its activities and researchers, particularly at the Maine site; and 2) give a presentation at a student and/or faculty seminar to introduce her research related to diffusion of geographic information systems. The title of her presentation was "Factors affecting diffusion of GIS technology in local governments".

As the closing activity for this initiative, two back-to-back sessions of presentations at the annual URISA conference in Summer 1995 have been planned. Researchers will present results from work undertaken in affiliation with Initiative 9. The first session will include presentations on metadata research, a survey on user requirements for framework GIS data, digital library approaches for sharing geographic data, and developments in sharing geographic data for transportation purposes. Speakers in this session will include Michael Goodchild (University of California - Santa Barbara), Steven Frank (New Mexico State University - Las Cruces), Harlan Onsrud (University of Maine), and Gerard Rushton (University of Iowa). The second session will focus on a range of social science studies that have addressed implementation, organizational, and institutional impediments to the sharing of geographic information. Speakers in this session will include Zorica Budic (University of Illinois), Hugh Calkins and Rick Weatherbee (SUNY-Buffalo), Jeffrey Pinto (Pennsylvania State University-Erie), and Bijan Azad (Massachusetts Institute of Technology.) We also intend to involve in the presentations one or two Europeans doing research in the area.

At Buffalo, Hugh Calkins and Richard Weatherbe have continued to assess the data resulting from case studies at four sites in order to analyze the spatial data sharing patterns, cost management practices, interagency agreements, public/private sector partnerships, leadership issues and organizational concerns at those sites. Mark Salling of the College of Urban Affairs, Cleveland State University visited Buffalo in the Spring of 1994 to collaborate as a Visiting Fellow on related Initiative 9 work.

Initiative 10: Spatio-Temporal Reasoning in GIS (began May 1993). Spatio-temporal reasoning is so common in humans' daily lives that one rarely notices it as a particular concept of geographic analysis. Far more apparent are spatial reasoning problems in the derivation of new spatial knowledge in computerized systems, *e.g.* about topological relations, distances and directions, and connectedness in GIS and other areas such as robotics, vehicle guidance/navigation, and way finding. Spatio-temporal reasoning is a new research area and current methods to infer spatio-temporal information are limited. Major efforts are related to vision, particularly deducing 3D information from 2D models, and only limited resources deal with geographic space and its temporal aspects. The goal of this initiative is to rectify this deficiency and to deal with qualitative information in geographic space, together with its temporal dimensions. Cognitive theory predicts that results from daily experience with different spatio-temporal concepts are integrated and further used metaphorically to reason in other circumstances. Human experience and perceptual cognition will be explored to guide the construction of abstract formal systems and to assess the formalized systems for their usefulness.

The report of the Specialist Meeting, which took place in early May 1993, is now available as *NCGIA Technical Paper 94-9*. Also, a book derived from the papers presented at the meeting is currently in production. Another major publication is forthcoming with Scott Freundschuh (formerly at UMaine and now at the University of Minnesota-Duluth) and Daniel Montello (UC Santa Barbara), in the form of a special issue of *Geographical Systems* with papers on "Spatial Cognition and Geographic Information Systems", for which the two researchers serve as editors.

Research into spatial and temporal reasoning focused on the development of formalizations for spatial relations and the interaction with time through direct-manipulation user interfaces. Max Egenhofer collaborated with David Mark on the testing of formalisms for natural-language spatial predicates. This work included cross-linguistic studies between Spanish and English, and between Malay and English. Max

Egenhofer and Mike Gould (Departamento de Geographica Humana, Universidad Complutense de Madrid) received a grant from the Scientific Division of the North Atlantic Treaty Organization (NATO) to investigate "Cross-Cultural Differences in Spatial Concepts: Application to Spatial Information System Use". The objective of this project is to identify spatial data abstraction primitives—those core concepts that are universal across language groups—in Spanish and English. Visits by David Mark and Scott Freundschuh to Spain are scheduled for January and March 1995, and Gould and Nunez will come to Maine later in Spring '95. To include non-European languages into our work on natural-language spatial predicates, we are now supporting Rashid Shariff as a graduate research assistant at the University of Maine, to test spatial predicates in Malay, the native language spoken in Malaysia that has a different root than Germanic or Romance languages. We are also investigating opportunities to test native-Americans.

Scott Freundschuh and Madhu Sharma undertook research on theories of development of spatial concepts and spatial perception abilities in children and the relationship to the frequency and type of spatial terms/concepts that are used in books for children. Freundschuh presented that theory in a session titled "Orienting Ourselves in Space: Implications for the School Curriculum" at the First Joint Meeting of the North American Cartographic Information Society and the Canadian Cartographic Association held in August 1994 in Ottawa, Ontario, Canada. The focus of this session was to explore how children (and subsequently adults) develop their orientation and mapping skills, and discussed methods for fostering the development of these spatial skills in the school curriculum.

Jung-Hong Hong completed his PhD dissertation "Qualitative Distance and Direction Reasoning in Geographic Space" at the University of Maine. His thesis builds models for qualitative distances (such as *near* and *far*) and qualitative directions (such as *North* and *Southwest*) with two criteria: complete coverage and mutual exclusiveness. These models serve as the basis for the design of a reasoning model, which is based on the transformation between qualitative and quantitative locational relations, and the well-developed quantitative reasoning methods. Qualitative composition can then be defined via the simulation of quantitative locational relations. Three reasoning models—the all-answer model, the likely-answer model, and the single-answer model—are introduced in his thesis to assess qualitative compositions. To evaluate them, data based on the number of qualitative distances, the number of qualitative directions, and the geometric patterns of distance intervals are simulated and tested. The results show that the compositions of qualitative distances and directions are primarily robust and only a few compositions are actually affected by the interval patterns of qualitative distances; therefore, it is possible to build a reasoning mechanism about qualitative distances and directions based on inference rules, instead of analytical calculations in a Cartesian coordinate space.

Tony Sleezer completed his MS "Direct Manipulation of Temporally Constrained Activities for Geographic Modeling" which explored the visual semantics of time in a user interface for complex modeling. By decomposing a complex system into discrete activities, the activities may be represented as temporal intervals. As a result, the model consists of a collection of sequential or concurrent intervals. Graphically, an interval consists of a start point, line segment, and end point, therefore, a relation between two intervals may hold between any of their respective elements. This work will formalize the maintenance of the relation while intervals are translated or stretched. These concepts will be applied in a sample spatio-temporal information system.

Several visitors were involved with I10 research. Stephen Hirtle, Chair, Department of Information Science, University of Pittsburgh, worked on his project "Geometries for Spatio-Temporal Reasoning" under the NCGIA Visiting Scholars Program July 24-August 6, Orono, ME. The plan of the project is to survey the current literature, propose appropriate extensions, and develop a logical framework for the study of geometries. The first stage of the project will focus on developments in the fields of geography, computer science, and psychology that relate to spatial geometries. The second stage of the project will be to formalize these relationships and to develop a logical framework for the study of geometries and topologies of cognitive space. The problem is that not all of the proposals are well-formulated or directly comparable. Furthermore, the goal

would be to develop testable properties of the geometries so that they can be compared with behavioral data. Again, the focus will be on the construction of multi-level geometries.

In addition, Mike Worboys (University of Keele) visited UMaine to work on a taxonomy of spatial change. This work has been complemented by a recently developed categorization of temporal identity by Khaled Al-Taha (Louisiana State University) and Renato Barrera (Intergraph Corporation), both formerly with NCGIA-UMaine, who submitted an article to a refereed journal. Vincent Schenkelaars (University of Rotterdam, The Netherlands) stayed at Maine for two months and developed new methods to interact with space when browsing through large collections of spatial data sets. This work links with our digital library research.

A series of conferences and workshops on I10 topics were co-organized by the initiative co-leaders. Following the Workshop on Spatio-Temporal Reasoning in September 1993 (organized by Cohn, Egenhofer, Frank, and Freksa), several European participants formed a "network group" and submitted a proposal to the European Science Foundation. In the meantime, this project called SpaceNet got funding for several meetings in Europe. European Artificial Intelligence researchers (primarily Freksa and Ligozat) are now interested in a collaboration with U.S. scientists.

An I10 related session titled "Spatial and Temporal Reasoning" was co-organized by Reginald Golledge and Max Egenhofer (co-chairs) for the 1994 Association of American Geographers (AAG) Annual Meeting in San Francisco. Participants included Helen Couclelis, UCSB; Barbara Tversky, Stanford University; Michael Worboys, Department of Computer Science, University of Keele; Daniel Montello (paper presenters); and Stephen Hirtle, Department of Information Science, University of Pittsburgh (as discussant). In addition, two other I10-related sessions were given at the AAG titled "Sources of Spatial Knowledge and the Resulting Cognitive Representations: Part(s) I and II" with participants from both the geography and psychology community, and organized by Scott Freundschuh and Daniel Montello. Participants included Reginald Golledge; Robert Lloyd, Department of Geography, University of South Carolina; Stephen Hirtle, Department of Information Science, University of Pittsburgh; Lynn Liben, Department of Psychology, The Pennsylvania State University; Clark Presson, Department of Psychology, Arizona State University; David Warren, Department of Psychology, UC Riverside; Jeanne Sholl, Department of Psychology, Boston College; and Holly Taylor, Department of Psychology, Texas Christian University (paper presenters).

Two international conferences will be held in Summer/Fall of 1995 on I10 topics. NCGIA is a co-sponsor of the Fourth International Symposium on Large Spatial Databases, to be held in Portland, Maine (General Chair: Egenhofer; Program Chair: John Herring, Intergraph Corp.).

At Buffalo, May Yuan and Feibing Zhan completed their dissertations on I10-related topics. May Yuan's work, entitled "Representation of Wildfire in Geographic Information Systems", focuses on semantic data modeling of the spatial and temporal information needs of various users of wildfire information. Four distinct and linked spatiotemporal models are needed. A locational snapshots model for risk assessment; a fire entity model for fire spread modeling; an entity snapshots model for fire histories; and a fire mosaics model for environmental impacts. A paper derived from her dissertation won the student paper competition of the GIS Specialty Group, Association of American Geographers, and she also presented a paper, co-authored with David Mark, at the ESRI Users Conference in Palm Springs in May, that appeared in the proceedings. Ms. Yuan successfully defended her project in July 1994, and the following month she began a tenure-track appointment in Geography at the University of Oklahoma.

Feibing Zhan's dissertation is on an old and important topic in spatiotemporal human behavior: periodic markets. The dissertation, entitled "Spatio-Temporal Location Models of Itinerant Trading and the Organization of Periodic Market Places", was successfully defended in July 1994, and preliminary results were presented at the 1994 AAG meeting in San Francisco. Simulations are being run, mainly based on game theory, over random and structured sets of sites, and resulting spatiotemporal patterns are compared to

observed periodic market schedules from the literature. Mr. Zhan is currently working on a transportation research project at the University of Tennessee.

Ann Deakin and David Mark are conducting research on the effects of the January 1994 Northridge earthquake on both motorists that frequent those freeways and on neighborhoods that received the displaced motorists. The research focuses on several major east-west boulevards that parallel the Santa Monica Freeway, as well as official detours. Several of these routes run through neighborhoods comprised primarily of African Americans and Hispanics and therefore offer substantial socioeconomic difference between motorist and neighborhood. Motorist and neighborhood responses are being surveyed using interviews, questionnaires, and direct observations. Approximately 4000 vehicle license plate numbers were obtained at 7 sites on these boulevards and detours in mid-March 1994. Fieldwork was supported by an NSF dissertation enhancement grant. Questionnaires were mailed to about 3,500 addresses obtained from the California Department of Motor Vehicles, and about 500 have been completed and returned. One set of questions addresses how the motorists decided on alternate routes immediately after the earthquake, and others examine changes in their mental maps due to their new travel patterns. The patterns of addresses of the observed motorists also are being analyzed using Geographic Information Systems (GISs) and statistical methods.

Mark continued his human subjects research on spatial relations between lines and regions in geographic space, in collaboration with Egenhofer and with assistance from Zhan and Deakin. Mark and Egenhofer have begun a project to study spatial relations in Norwegian in collaboration with Professor Jan Terje Bjorke, University of Trondheim, Norway, who spent several months at NCGIA Buffalo in the Fall of 1993. Similar collaborations will be developed in Spain and Taiwan.

In July, Mark, Egenhofer, and Freundschuh participated in the *First International Summer Institute in Cognitive Science: Multidisciplinary Foundations of Cognitive Science* held in Buffalo, NY, July 5-30, 1994. Mark and Freundschuh taught a 3-week course on "Geographic Organization of Space". Mark, Egenhofer, and the Lake Arrowhead participants Tversky and Cohn participated in a workshop on "Ontology of Space". Also, Egenhofer, Mark and Cohn presented papers in a workshop on "Topology for Cognitive Science".

In Santa Barbara, work on the cellular automata package GeoCellular was continued by Catherine Dibble and Terry Figel. With the end of the Hitachi joint research program, a paper based on the use of the package for modeling the development of urban heat island was submitted. Danette Coughlan began work on the design of a system for determining instantaneous water depth based on hydrographic and tidal data, and the appropriate data models.

Egenhofer and Mark served on the program committees of Spatial Data Handling (Edinburgh), the ACM Workshop on Advances in GIS, and the International GIS Workshop on Spatial Data Modeling and Query Languages for 2D.

Initiative 12: GIS and Remote Sensing (began December 1990). Remotely sensed images continue to offer a cost-effective and popular source of data for GIS. At the same time GIS data is increasingly used as a means of improving image classification. However the coupling of the two technologies raises many questions. Following planning meetings in May and August 1990, the specialist meeting was held December 3-6, 1990 in Sioux Falls, SD, at EROS Data Center (USGS). Discussion centered on five topics for the integration of remote sensing and GIS: institutional issues, data structures and access, data processing flow, error analysis, and future computing environments. Papers on each of these five themes were presented for discussion at the specialist meeting, and later revised to appear as a special issue of *Photogrammetric Engineering and Remote Sensing* in June 1991.

Two books are being published based on I12 research. A monograph on integrating GIS and remote sensing is to be published by Cambridge University Press, and includes chapters by many of the participants in

the research initiative. A second volume of contributed chapters on scaling is being edited by Dale Quattrocchi and Michael Goodchild, and will be published by Lewis Press. The closing report of the initiative was accepted by the Board of Directors at its December 1994 meeting.

Progress on the NCGIA Remote Sensing core curriculum is continuing. Funding has been received from NASA and EOSAT, and the effort will begin in earnest in early 1995.

Initiative 13: User Interfaces for Geographic Information Systems (began June 1991). This initiative addresses human-computer interaction methods and related issues in the design and implementation of user interfaces for GIS and other geographical software. The research initiative has as its broad goals: to investigate ways for people to interact with computers when solving problems concerning geographic space and spatial phenomena; to model some of the ways in which disciplinary background and training, problem domain, culture, natural language and individual differences influence such interaction; to establish criteria and methods for the design of user interfaces for geographic software; and to devise and test prototype interface development tools. The prioritized research agenda for Initiative 13, a report on discussions at the specialist meeting, and the 35 specialist meeting position papers were published as *NCGIA Technical Paper 92-3*.

Clayton Lewis, Professor, Department of Computer Science, University of Colorado, Boulder, CO, worked on "Collaboration on Design of Extended Direct-Manipulation Interfaces for GIS" under the NCGIA Visiting Scholars program, July 5-30. The project had two related objectives. The first objective was to extend the map-overlay interface concept developed by Max Egenhofer and colleagues to support a wider range of GIS operations. Since the map-overlay idea offers an attractive user interface for many GIS operations this work may contribute to significant progress in GIS interfaces. The second objective was to use the extended map-overlay design problem as a case study for the development of improved design methods for GIS user interfaces. While great progress has been made in the evaluation and comparison of user interfaces, the initial development of new interface ideas remains an art with little conceptual guidance. But recent work of Mackinlay, Casner, and others suggests that there are principles that can guide the development of new interface ideas at a high level. The project seeks to develop these ideas in a form appropriate to the design of GIS interfaces. Another visitor, Vincent Schenkelaars from the Department of Computer Science, Erasmus University, The Netherlands, worked with Max Egenhofer on "Browsing Tools for Digital Spatial Libraries".

Tom Bruns completed his master's thesis on "Direct Manipulation User Interfaces for GIS Map Algebra". This work presents an iconic language for map algebra operations, and extends the earlier design of the Geographer's Desktop. A summary appears in the IGUG newsletter and a companion paper has been accepted for the IFIP workshop on Visual Database Systems.

The International Meeting at the close of Initiative 13 was a NATO Advanced Research Workshop (ARW) held in Palma de Mallorca (Spain), 21-25 March 1994, and entitled "Cognitive Aspects of Human-Computer Interaction for Geographic Information Systems". Timothy Nyerges (Geography, University of Washington) was Director of the ARW, and Mark was the co-Director. NATO provided only about half of the funds requested to conduct the Workshop, but Nyerges obtained a grant from NSF's International programs and Max Egenhofer (NCGIA Maine) obtained a grant from ARPA, also to support the meeting. Because about 2/3 of the funding was from US sources, NATO relaxed its usual 20 percent ceiling on participants from any one country, and allowed us to have almost half of the participants from the US. The meeting has led to a book edited by Nyerges, Mark, and Egenhofer and to be published by Kluwer.

The initiative closing report was prepared in the Fall of 1994 and received Board approval at the December 1994 Board of Directors Meeting. Work on user interface design for GIS is continuing under the Alexandria Digital Library project at Santa Barbara; Mark and Egenhofer are both participating in this continuing research.

Initiative 14: GIS and Spatial Analysis (begun February 1992). Consideration of the spatial dimension in statistical analysis creates a unique set of analytical problems; spatial analysis is not simply aspatial analysis performed on spatial data. This initiative focuses upon impediments to the accurate use of spatial analytic models in a GIS environment. Representative topics that fall within this initiative include spatial sampling methods, methods of spatial interpolation, the modifiable areal unit problem, spatial autocorrelation, and the interface between the computation of spatial statistics and GIS data structures. The specialist meeting for I14 was held April 15-18, 1992, at Humphrey's Half Moon Inn, San Diego. There were 28 academic participants and 9 participants from the government and private sectors. The technical report on the Specialist Meeting is available as *NCGIA Technical Report 92-11*.

A two-day conference on GIS and Spatial Analysis was co-organized by Mike Batty and Paul Longley and held in Bristol, UK, in June, 1994. It served as the closing event of the initiative. The conference was sponsored by the Economic and Social Research Council of the UK, and the NCGIA.

Trevor Bailey and Tony Gattrell have completed a book manuscript on the subject of interactive spatial analysis. It is forthcoming from Longman, and due to appear in the first half of 1995. It is noteworthy that the collaboration was stimulated directly by the I14 specialist meeting, and the book will refer to the initiative.

Stewart Fotheringham worked with PhD students Ge Lin and Pat Pellegrini on the sensitivity of choice model parameter estimation to choice set specification. He also worked with Andrew Curtis on spatial information downloading. Fotheringham has a paper forthcoming with Timothy Pitts on directional variation in distance decay parameters.

Fotheringham presented the Regional Research Lecture at the conference on GIS, Spatial Analysis, and Public Policy, in Northern Ireland, in May, 1994. The conference was sponsored by the Ulster Business School.

Two substantial publications resulting from the Initiative specialist meeting appeared in the Spring of 1994. These works are the book *Spatial Analysis and GIS* (Taylor and Francis: Fotheringham and Rogerson, eds.), and a special issue of the journal *Geographical Systems* (Fotheringham and Rogerson, Guest Editors). Both publications include subsets of the papers prepared for the initiative specialist meeting.

Rogerson's work on GIS and population analysis appeared as a chapter in *The Geographical Analysis of Population*, a Wiley book that appeared during Spring, 1994 (co-authored with David Plane). Rogerson has also worked on empirical Bayes estimation and mapping of small scale grade progression ratios in school enrollment projections.

The closing report for this initiative was drafted for presentation to the June 1995 Board of Directors meeting.

Initiative 15: Multiple Roles for GIS in US Global Change Research (approved in detail, June, 1993). The general context for this initiative is provided by the apparently widely held perception that GIS and related technologies will play an important role in global change research. Remote sensing will clearly be the most important source of data for global change research, at least within its physical dimensions, because of its potential for uniform, high resolution coverage of the surface of the Earth. GPS is clearly important to all kinds of field observation. The importance of GIS, on the other hand, can only increase as global change research becomes more computationally and data intensive, as it moves from studies of single processes to integrated modeling, and as it struggles to link human and physical processes. We see four major areas of application as currently driving interest in GIS among the global change research community:

- collecting, manipulating, and preprocessing of data for models, including resampling, aggregation, and generalization;
- integration of data from disparate sources with potentially different data models, spatial and temporal resolutions, and definitions;
- monitoring global change at a range of scales; and
- visual presentation of the results of modeling in a policy-supportive, decision-making environment.

While these four areas of application may explain current interest in GIS, in our view they are neither expressions of the longer term potential for GIS in global change research, nor the basis for a sustainable research program. Instead, we have proposed the following five scientific objectives of the initiative:

- to identify technical impediments and problems that obstruct our use of GIS in global change research, and our understanding of interactions between human systems and regional and global environmental systems;
- to assess critically the quality of existing global data in terms of spatially varying accuracy, sampling methodologies, and completeness of coverage, and to develop improved methods of analysis and visualization of such data;
- within the context of global change, to develop theoretical/computational structures capable of building up from knowledge at smaller scales and lower levels of aggregation;
- to develop methods of dynamically linking human and physical databases within a GIS and for exploring the regional impacts of global change; and
- to develop methods for detecting, characterizing, and modeling change in transition zones where assumptions of spatial homogeneity are untenable.

Approval in principle for this initiative was given by the Board of Directors at its December 1992 meeting. Approval in detail was given in June 1993. A first specialist meeting, with participants drawn from across the broad spectrum of disciplines involved in global change research, will be held in Santa Barbara March 9-11, 1995. A second specialist meeting will build on the first by addressing the initiative's technical agenda.

The Steering Committee was formed and met on September 26 in Washington DC at the USGS National Mapping Division. Steering Committee members include John Townshend, University of Maryland; Francis Bretherton, University of Wisconsin; Roberta Miller, CIESIN; Jerry Garegnani, NASA; Cort Willmott, University of Delaware; Peter Thacher, World Resources Institute; Jeff Dozier, UC Santa Barbara; Catherine Gautier, UC Santa Barbara; Berrien Moore, University of New Hampshire; David Kirkland, USGS; Dorsey Worthy, NOAA; and Bob Corell, NSF. Subsequent meetings of the Steering Committee were by conference call.

The Steering Committee identified eight broad areas of global change research, and participants at the Specialist Meeting will be drawn from all of them. They are: atmosphere and climate; oceans, ocean-atmosphere coupling, and coasts; biogeochemistry; hydrology and water; ecology and biodiversity; demography, population, and migration; production and consumption; and policy and decision-making.

At Buffalo, Jennifer Robinson and NCGIA graduate assistant David Howes have been setting up an environment for looking at global interannual climatic variability as affecting biospheric function at the decadal scale, with the ultimate goal of working at monthly time resolution and something like 25 km spatial resolution. Set up activities include learning to work with data formats chosen by agency sources, including HDF and meteorological station data formats, and setting up to work with high volume multi-date, multi-format, continental-to-globe scale data streams. Preliminary data analysis reveals striking spatio-temporal patterns in continental greenness, with regionally very strong correspondence with ENSO climate patterns. In some regions, ENSO-related climate phenomena (probably clouds) appear to cause systematic distortion of satellite based observations. Through hands-on confrontation with the cartographic (*e.g.*, map projections), informational (*e.g.*, data quality), cognitive (*e.g.*, data presentation) and computational problems (*e.g.*, data storage and overlay, global geographical information analysis) we are rapidly advancing from speculative to pragmatic and operational understanding of the problems and opportunities for using GIS in global change analysis. A pre-proposal has been submitted to NASA for continuation of this work. Joel Michaelson at UCSB will be co-investigator.

Jennifer Robinson has made invited presentations at the Western Regional AGU, a NATO Workshop on Fire in the Sedimentary Record, and a workshop on North American El Niño research sponsored by UNESCO and NCAR. Collectively, these provided opportunities for building and strengthening ties with persons doing global change research in the paleo-, geophysical, and climatological communities.

At Santa Barbara, Robert Raskin was Visiting Scholar in Spring 1994, and worked on a compendium of techniques of spatial analysis and statistical estimation for the sphere. The work has been published as an NCGIA Technical Report and provides a useful benchmark of the state of the art in this area. Waldo Tobler and PhD candidate Uwe Deichmann worked on building a population database of the Earth based on five minute quadrilaterals. This database will be the first large scale and geographically consistent estimate of the planet's population density surface. The work is being funded by ESRI and CIESIN. In preparation for the I15 Specialist Meeting, graduate student Ashton Shortridge has prepared an annotated bibliography on GIS and global change research. It will be published as an NCGIA Technical Report and made available to the participants.

Initiative 16: Law, Public Policy and Spatial Databases (begun October 1994). As evidenced by the rapidly growing computer law literature, society and the legal system are having great difficulty in dealing with the ramifications of technological advances. Nowhere is this more evident than with citizen reaction to spatial databases. The goal of this initiative is to advance scientific understanding of the law and public policy within spatial database environments in order to develop a body of legal and public policy knowledge which government, private industry, and other institutions will find valuable as they cope with the legal and social ramifications of GIS.

Research on I16 began with the Specialist Meeting and the Conference on Law and Information Policy for Spatial Databases. Thirty-nine participants attended the Initiative 16 Specialist Meeting held October 29-30, 1994, at the Arizona State University College of Law in Tempe, AZ with co-leaders Harlan Onsrud and Robert Reis (SUNY-Buffalo). The meeting immediately followed the NCGIA Conference on Law and Information Policy for Spatial Databases, organized by Harlan Onsrud. The meeting explored four interrelated aspects of information law critical to the handling of geographic information; namely, (1) access rights of citizens to publicly held information, (2) intellectual property rights in spatial databases, (3) privacy rights and principles, and (4) liability in the use, sharing, and distribution of geographic information system data and analysis results.

The scientific objectives of the specialist meeting and subsequent research are to:

- advance scientific understanding of the law and information policy within spatial database environments;
- raise the quality and content of the debate about law and GIS by identifying issues in concrete terms with a high degree of specificity;
- report observations of the law in action in order to explore the affect of spatial databases on public information policy and law and, conversely, report observations of the law's acceptance of GIS uses and practices;
- identify emerging problems at the interface of law, information policy, and spatial databases in order to address those problems prospectively, with particular focus on legal issues relevant to the National Spatial Data Infrastructure; and
- divulge, test, and contribute knowledge useful in the improvement of public policy and formulation of law with respect to the use of spatial databases and related technologies.

A primary goal of the specialist meeting was to develop an agenda of research questions and recommendations for the broader research community and to identify priority areas within that agenda.

We are currently in the process of preparing a transcript from the tape recordings made of all the specialist meeting sessions. This document will be used in conjunction with the small group reports to prepare the final research agenda arising from the meeting. All participants will have the opportunity to review the document prior to publication. We hope to publish a proceedings from the specialist meeting in early 1995. Papers for the proceedings were peer reviewed by other participants and are now being revised for inclusion in the document. We will also include extended abstracts for those individuals who did not prepare full papers. In addition, we have asked authors to make their papers or abstracts available to us for an on-line collection that will be accessible over the internet.

Jurimetrics: Journal of Law, Science, and Technology will produce an expanded issue that will include several selected papers from the meeting. These papers are primarily by law professors since the readership of *Jurimetrics* is primarily legal scholars and the legal community. The editor of *Jurimetrics* has agreed that all papers appearing in *Jurimetrics* may also be published in full in the proceedings.

Research activities by faculty and graduate students to date have consisted primarily of background investigations and planning. Xavier Lopez, PhD candidate at Maine, has developed a draft thesis on "The Impact of Law and Information Policy on the Dissemination and Commercialization of Scientific and Technical Databases: A North American - European Community Comparative Study". The research focuses on international issues relative to the interplay of access, copyright, and cost recovery issues relative to geographic databases. He has begun interviews with Canadian agencies and will continue with U.S. and European agencies over the next several months. His proposal was one of two recently selected as Best Proposed Research by the International Geographic Information Foundation. He also assisted in the survey mailing and data collection of the NCGIA/NSDI Framework Data Questionnaire. He presented his research, "Impact of Government Information Policy on the Dissemination and Commercialization of Spatial Databases", to the NCGIA Board of Directors at their June 1994 meeting at the University of Maine, Orono.

Jeffrey Johnson, MS candidate at Maine, is focusing on comparative studies of geographic data access and pricing approaches within U.S. local governments. His methodology consists primarily of detailed interviews with local government GIS administrators to gather evidence on the downstream benefits and drawbacks of using alternative access and pricing approaches. Because of difficulty in finding "open access" sites for comparison purposes, he has recently added a survey to his research plan. A short questionnaire is being sent to an extensive list of municipal and county government GIS managers in order to gather initial

explicit information on their access, revenue generation, and pricing policies. In addition to his thesis work, he provided assistance in preparations for the NCGIA I16 Conference and Specialist Meeting.

C.J. Cote, PhD candidate at SUNY-Buffalo, is currently exploring a range of GIS legal issues with Robert Reis and Harlan Onsrud in furtherance of her dissertation topic. She is likely to focus on an international study and will spend time at the University of Maine to interact with other personnel working on similar topics.

Harlan Onsrud's article on "Protecting Personal Privacy in Using Geographic Information Systems" co-authored with Xavier Lopez and Jeffrey Johnson has been accepted for publication by *PE&RS* and another article on "Identifying Ethical Conduct in the Use of GIS" by Onsrud has been submitted to *Cartography and GIS*. "Balancing Information Privacy with Efficiency and Open Access" by Lopez appeared in *Government Information Quarterly*. In addition, Lopez and John Sheppard recently authored "Issues of Data Access, Pricing and Copyright: Impacts on the European GIS Community", a Consultant's Report to Eurostat's Task Force on Spatial Statistics, Luxembourg: Commission of European Communities (CEC) Publications Office. Finally, an extensive bibliography divided into the major topics to be addressed by the initiative was prepared by Onsrud, Lopez, and Jeffrey Johnson and was published in the NCGIA Technical Reports series. It is available by both ftp and in hardcopy.

Harlan Onsrud presented a talk on a "Model for Open Access to Geographic Information" at the New England Regional Conference on State Land Information Networking held in Worcester, MA on November 5 and presented another talk on "The Effects of State Sales of Geographic Information on Access" at the Maine meeting on Public Access to State Government Information Services in Augusta, ME on December 2. Xavier Lopez also presented a talk on his research at "Integrating Spatial Information Technology: Getting Connected to NASA" on November 15 in Portland, Maine.

Research activity at Buffalo during the summer of 1994 included identification, preliminary review and analysis of published bibliographies and materials, including, but not limited to cases, legislation, texts, state and federal committee and task force reviews concerning spatial databases, metadata, institutions of property rights, liability, access to and distribution of information, use of spatial and non-spatial data and cost recovery systems. Research and review of these materials continued into the fall and included the preparation of a preliminary draft of fundamental legal issues regarding Geographic Information Systems and Analysis.

Initiative 17: Collaborative Spatial Decision Making (to begin 1995). I17 received approval in principle following the June 1993 Board meeting and approval in detail at the June 1994 meeting. The objectives of this initiative are to: (1) examine the body of theory on the design, implementation and use of computer supported cooperative work (CSCW) environments and evaluate their utility for GIS/GIA; (2) identify impediments to the development of highly interactive, group-based spatial modeling and decision-making environments; (3) develop methods for eliciting, capturing, and manipulating knowledge bases that support individual and collective development of alternative solutions to spatial problems; (4) develop methods for supporting collaborative spatial decision-making (CSDM), including methods for managing spatial models; and (5) extend capabilities for supporting multicriteria decision-making in interactive, CSDM environments.

Marc Armstrong and Paul Densham spent the summer months in residence at SUNY Buffalo working on arrangements for Initiative 17. Preliminary plans are to hold the Specialist Meeting in Santa Barbara, CA in 1995. Armstrong and Densham have produced two papers acknowledging Initiative 17: "Toward the development of a conceptual framework for GIS-based collaborative spatial decision-making" in the *Proceedings, 2nd ACM Workshop on Advances in Geographic Information Systems*, and "Cartographic support for collaborative spatial decision-making" in the *Proceedings, Twelfth International Symposium on Computer-Assisted Cartography (Auto Carto 12)*.

B. Education

1. General

The Center continues to support GIS education on a variety of fronts including the K-12 schools in its Secondary Education Project, the Core Curriculum and other university level GIS education materials, and a new project focusing on GIS in the Community Colleges. Year Six also included the first NCGIA Summer Institute aimed at providing an opportunity for academics to intensively interact with NCGIA research and researchers.

2. NCGIA Core Curriculum

The NCGIA Core Curriculum continues to sell well. In 1994, the NCGIA distributed 150 copies, and orders continue to be received at the rate of 2 to 3 per week. Internationally, the final Hungarian version was published this year and includes an additional fourth volume with local application examples prepared by a large number of Hungarian commercial organizations. Active progress continued on the Russian version, and a French translation was made at Laval University in Quebec for distribution in francophone countries.

Given clear evidence that the Core Curriculum continues to sell well despite its increasing age, a decision has been made to initiate a project to revise the Core Curriculum. At the end of the year, discussions had been initiated with the GIS community to determine what form this project should take, how it can be funded, how the revision should be managed and what media should be used for the revised version. Decisive action on this project is expected in 1995.

The success of this model curriculum development has led to a similar project for remote sensing. As announced in *Photogrammetric Engineering and Remote Sensing* in June 1993, with funding recently granted by NASA, the NCGIA is now cooperating in the development of a Remote Sensing Core Curriculum. Using a development model similar to that used for the GIS Curriculum, the RS team, headed by Dr. Timothy Foresman at the University of Maryland, Baltimore County, will develop 4 volumes of teaching materials, including laboratory exercises with the necessary digital and photographic images, for topics covering airphoto interpretation and photogrammetry to digital image processing. Based on our experience with the GIS Curriculum, the NCGIA will provide input and advice in the development of the materials and in their evaluation. It is hoped that the final product will be available for distribution through the NCGIA Publications Office by the fall of 1997.

3. NCGIA Summer Institute 1994

The first NCGIA Summer Institute was held in Santa Barbara in August, 1994. It provided a unique opportunity for researchers and instructors from a broad range of disciplines to investigate the latest findings of Geographic Information Science. The Institute was designed to serve academics that regularly use GIS in their research and instruction, but wanted closer contact to cutting edge GIS research and researchers in order to probe the possible role of those GIS theoretical and practical frameworks in their own endeavors.

Twenty researchers from the US, Norway, Mexico, and Brazil attended the one week 1994 Summer Institute. Activities included seminars by NCGIA researchers, Dr. Michael Goodchild (Data Accuracy and Error Visualization), Dr. Max Egenhofer (Knowledge Representation for Spatial Data), and Dr. Paul Densham (Spatial Decision Support Systems); guest lectures by Dr. Waldo Tobler and Dr. Gary Hunter; computer-based demonstrations; and short research interest presentations by the Institute participants.

Based on the success of this first Summer Institute, the NCGIA is investigating the possibility of holding another institute in the summer of 1996 or 1997. Since the NCGIA is involved in the 1995 NSF-ESF Summer Institute, we have temporarily suspended the NCGIA Summer Institute series.

4. GIS in the Community Colleges

Although GIS use and instruction is becoming commonplace in many institutions of advanced learning, certain sectors are still in need of critical guidance and support. One group of these are the two-year colleges and technical schools. During 1994, it appeared that these schools were rapidly becoming aware of GIS and many were seeking help to begin to provide GIS education courses and GIS technician training programs. It is just this flexibility for both education and training that appears to be propelling the use of GIS in these environments. The NCGIA, recognizing the need these schools have for initial guidance, is seeking to support efforts to provide GIS learning experiences in these colleges.

Steve Palladino, NCGIA Education Projects Manager, is keeping a master list of community college GIS instructors and other interested parties. The NCGIA is also sponsoring sessions on GIS in the community colleges at professional meetings. At the 1994 GIS/LIS conference in Phoenix, the Center organized a panel reviewing examples of GIS courses and programs in the colleges. This was an initial networking opportunity for community college GIS instructors. Additional sessions will be organized by the NCGIA in 1995 at the Association of American Geographers Annual Meeting and at the GIS in Education International Symposium. As well, during 1994, the NCGIA Education Program began to work with various groups on grants and projects to develop GIS instruction in and materials for the community colleges.

5. Secondary Education Project

The SEP continues to function as the nexus for information, activities, and materials for using GIS in the pre-collegiate classroom. All three NCGIA sites are continuing outreach activities to schools and the SEP is developing additional materials for GIS education.

The efforts of the first two and a half years of the SEP were in part responsible for a national invitational conference on GIS in Education. This January 1994 meeting in Washington, DC was supported by the NSF and organized by TERC (an educational research group) with considerable input from the NCGIA. A group of experts on GIS, remote sensing, science education, geography, computers in learning, spatial cognition, and classroom practice were invited. The conference explored the uses of GIS in the schools and provided an excellent outlet for the findings of the SEP.

The SEP has been developing a set of example instructional materials and GIS modules for use in the schools. Color Your World is the latest addition to this set of resources. This game-like module introduces students to geographic data and the geographic information system, ArcView 2.0 which is a commercially available GIS produced by ESRI. Color Your World uses ArcView 2.0 sample data and additional thematic data sets to demonstrate the ability of GIS to integrate cartographic data, tabular records, and images. It leads the player through a series of rounds that test knowledge of country names, location, and thematic attributes. This particular game was conceived, designed, and written by Paul Sutton, Paul Van Zuyle, and Steve Palladino at the NCGIA, Santa Barbara. The project was support by a generous gift from ESRI.

At each of the three NCGIA sites various forms of GIS outreach are taking place in schools. For example, at Santa Barbara, the NCGIA continues its efforts to expose local teachers and school children to GIS through opportunities such as the National Geography Week. In this week NCGIA researchers go out into the schools and demonstrate GIS. Another activity is a GIS day which NCGIA put on for K-12 teachers attending the Southern California Geographic Alliance Summer Geography Institute at UC Santa Barbara in the summer of 1994.

At Buffalo, NCGIA and the SUNY Geography Department have been working with one of the inner-city K-6 magnet schools to implement the recently published National Geography Standards in the school curriculum. The NCGIA will provide support for the exploration of GIS as a part of this curriculum.

At Maine, NCGIA staff participated in the 1994 Maine Geographic Alliance Summer Institute. The theme of that Summer Institute was "Geography: The Great Integrator" and included an introduction to GIS. NCGIA Maine has also been working with the Maine Mathematics and Science Alliance to produce a geographical information system for local educational agencies for the State of Maine, and is working with a number of Maine and New England High Schools on GIS projects.

C. Outreach

1. General

An NCGIA brochure was produced to illustrate the work of the Center, for distribution to potential funding sources and others. Much of the work on the design was carried out by Kathleen Hornsby at Maine, and Kathleen also oversaw the production.

Barbara Battenfield was voted President-Elect of the American Cartographic Association (1500 members) in March 1994, for a 3 year term. Hugh Calkins, with the assistance of the students in his GIS class, completed a needs analysis of Erie County departments as part of the County's move toward a county-wide GIS. Thanks were given to the participants by County Executive Dennis Gorski in his State of the County Message of February 17, 1994. Peter Rogerson prepared a Report on Kindergarten Enrollment Projections for the Amherst School District, January 1994. He has also worked on enrollment projections for the Clarence, Williamsville and Frontier Central School Districts of Western New York. He also served as a member of the Panel to Evaluate Alternative Census Methods, National Academy of Sciences, Committee on National Statistics, 1992-1994.

David Mark is serving as North American Co-Chair of the second Conference on Spatial Information Theory (COSIT'95), to be held in Austria in September 1995. He was a member of the program committees for Advanced Geographic Data Modelling (ADGM'94) Workshop "Spatial Data Modelling and Query Languages" held in Delft, Netherlands, 12-14 September, 1994; the Sixth International Symposium on Spatial Data Handling held in Edinburgh, Scotland, September, 1994; and the Twelfth International Symposium on Automated Cartography (Auto-Carto 12), to be held in Charlotte, North Carolina, in February 1995.

Paul Densham served as a member of the Editorial Committee for the Sixth International Symposium on Spatial Data Handling, 1994 (SDH '94) (Edinburgh, Scotland Sept. 5-9, 1994). He is also serving as a member of the Scientific Committee of the Second UNAM-Cray Supercomputing Conference on Numerical Simulations in the Environmental and Earth Sciences, June 21st - 24th, 1995, Mexico City, Mexico.

Peter Rogerson is serving as a member of Geography and Regional Science Panel, National Science Foundation. Mike Batty is editor of the Journal *Environment and Planning B*. Barbara Battenfield was guest editor of a special issue of *Cartographica* on Mapping Data Quality, and of a special issue of *Cartography and GIS* on Spatial Data Standards. Stewart Fotheringham and Peter Rogerson were co-editors of a special issue of *Geographical Systems* on GIS and Spatial Analysis. Peter Rogerson serves on the Editorial Board of the *Annals of the Association of American Geographers*.

Kate Beard, William Mackaness, and Sarah Clapham, research associate with the Department of Forestry, UMaine, gave a workshop on "Geographic Information Systems: Modeling the Environment and How Math Helps" to fifth and sixth grade Master Math Class students at the Garland Street Middle School, Bangor, ME, May 26. In early July 1994, Kathleen Hornsby participated in the 1994 Maine Geographic Alliance Summer Institute at the College of the Atlantic, Bar Harbor, ME. The theme of this year's Summer Institute was "Geography: The Great Integrator" and Kathleen gave teachers an introduction to GIS. Kathleen has also been invited to participate in a dialog with educators in Connecticut who are attempting to integrate GIS into their K-12 curricula. Kathleen Hornsby and Rick Ozog, a graduate student in Surveying Engineering, have been working with the Maine Mathematics and Science Alliance to produce a geographical information system for local educational agencies for the State of Maine.

Kate Beard and Rick Ozog are collaborating with Joann Kovacich from the UMaine School of Nursing on building a GIS for a Maine Healthy Start Taskforce Database. This database has information relating to community and rural health for the State of Maine.

During 1994 all three NCGIA sites established home pages on the World Wide Web, accessible via NCSA Mosaic or Netscape. The URLs are as follows:

Santa Barbara: <http://www.ncgia.ucsb.edu/>

Buffalo: <http://ncgia.geog.buffalo.edu/>

Maine: <http://ncgia.umesve.maine.edu/>

Information on the NCGIA-related research and graduate programs at the three sites can also be found by accessing any of these servers, as well as details on NCGIA conferences, staff, research initiatives, and other activities.

William Mackaness and Kate Beard received honorable mention from the journal *Cartography and Geographic Information Systems* 1994 Andrew McNally award for their paper "Use of Graph Theory to Support Map Generalization". This award is given for the best research published in the previous year.

On two occasions during Fall 1994, the Maine site had high school students from throughout the state visit the department and see demos of World Wide Web. They were shown how they can access the web and find data useful for their projects, *etc.* This is also put in the broader concept of their studies at UMaine and research in general.

Maine's work with teachers has had an interesting spinoff, in that the site is now working with a number of education-related groups in the state. Kathleen Hornsby and Rick Ozog, a graduate student in Surveying Engineering, have been working with the Maine Mathematics and Science Alliance to produce a geographical information system for local educational agencies for the State of Maine. They also assisted them with a proposal to DOE EPSCOR regarding Internet connections and training for Maine schools and teachers. In addition, they are collaborating with the Center for Research and Evaluation in the College of Education at the University of Maine, who are undertaking a study in conjunction with the Maine State legislature, UMaine and the University of Southern Maine to create a comprehensive database which will be used to evaluate Maine's progress in reaching its goals for education. This database will help the legislature make better decisions for school funding formulas.

2. Conferences

The second **Annual MAC/UB Geography Graduate Conference** was held on March 11-12, 1994 at McMaster University, Hamilton, Ontario. NCGIA-Buffalo served as a co-sponsor of this conference, which was designed to increase the interaction between the graduate students in Geography at the two neighboring universities. The conference also served as a "dry-run" for student presentations for the AAG Annual Meeting. NCGIA faculty attending the conference included Pete Rogerson and Stewart Fotheringham. Graduate students presenting included Andrew Curtis ("Location specific variations in spatial cluster formations"), Andre Skupin ("The SDTS Browser - lessons from a hypertext approach for the introduction of a federal information processing standard"), Yichun Xie ("Relationships between city size and urban socio-economic development in the People's Republic of China"), Ge Lin ("Physician's practice location: an analysis of factual and attitudinal factors"), and Pat Pellegrini ("Defining spatial choice sets: a sensitivity analysis").

Mike Batty and Paul Longley of the University of Bristol organized a 2 day workshop on **GIS and Spatial Modelling**, a workshop supported by ESRC and NCGIA held at the University of Bristol, UK, June 7-8, 1994. Rick Church from NCGIA Santa Barbara, Art Getis from San Diego State University, and Dan Griffith from Syracuse University were supported by NCGIA to attend this workshop. The edited proceedings will be published by Longman in 1995.

The Center at Buffalo helped sponsor the **41st North American Meetings of the Regional Science Association International**, held in Niagara Falls, Ontario, November 17-20, 1994.

3. Visiting Fellows

January-June: John Odland, Indiana University, spent six months at the Santa Barbara site working on topics related to Initiative 10, in the areas of longitudinal and cross-sectional data analysis.

February 7-18: Mark Salling, College of Urban Affairs, Cleveland State University was the first visitor to the Buffalo site under the NSF Visiting Fellows Program. He worked principally with Hugh Calkins and his PhD students on issues related to Initiative 9: Institutions Sharing Geographic Information. While in Buffalo, he and Hugh Calkins identified three articles to write and expected to have two submissions completed by May 1. Dr. Salling also delivered a colloquium address to faculty, staff and students of the NCGIA and Department of Geography on "The Spatial Association between Race, Income, and Industrial Toxic Emissions in Cuyahoga County" on Fri., Feb 11.

March 12-14: David Wong, Department of Geography and Earth Systems Science, George Mason University conducted research in cooperation with Stewart Fotheringham on the role of spatial autocorrelation in the modifiable areal unit problem (Initiative 9).

April 19-20: Faye Duchin, Director, Institute for Economic Analysis, New York University worked principally with Sam Cole and Mike Batty on world economic models (input-output models). Dr. Duchin delivered a seminar "Ecological Economics and World Economy Modeling" on Tuesday April 19.

June-August: Robert Raskin, UC Santa Cruz. His research efforts were directed in the area of spatial analysis techniques on the sphere, including spatial statistics and mathematics on the globe. The framework of his research provided support for issues related to I-15. His research efforts also resulted in the preparation of *NCGIA Technical Report 94-7: Spatial Analysis on the Sphere: A Review*. This report examines the use of spherical analysis in conjunction with global geographic information systems. Dr. Raskin worked primarily with Michael Goodchild and Waldo Tobler.

June 20 - July 20: Howard Veregin, Assistant Professor, Department of Geography, Kent State University, Kent, OH, worked with Kate Beard and Ph.D. student Bheshem Ramlal on a project to investigate the accuracy of soil maps. This project compares soil map representations with representations of individual soil properties generated by interpolation from point observations. Three different properties measured for a site in Maine (topography, pH, and depth to bedrock) will be interpolated to generate a map of the individual properties. Difference maps will then be generated to compare the interpolation against the soil map representation of the same property. An abstract on this project was submitted and accepted for Auto-Carto 12.

July 5-30: Clayton Lewis, Professor, Department of Computer Science, University of Colorado, Boulder, CO, worked on "Collaboration on Design of Extended Direct-Manipulation Interfaces for GIS." The project had two related objectives. The first objective was to extend the map-overlay interface concept developed by Max Egenhofer and colleagues to support a wider range of GIS operations. Since the map-overlay idea offers an attractive user interface for many GIS operations this work may contribute to significant progress in GIS interfaces. The second objective was to use the extended map-overlay design problem as a case study for the development of improved design methods for GIS user interfaces. While great progress has been made in the evaluation and comparison of user interfaces, the initial development of new interface ideas remains an art with little conceptual guidance. But recent work of Mackinlay, Casner, and others suggests that there are

principles that can guide the development of new interface ideas at a high level. The project seeks to develop these ideas in a form appropriate to the design of GIS interfaces.

July 11-30: Carl Amrhein, Chair, Department of Geography, University of Toronto, Canada, worked with Kate Beard on a project that investigates the aggregation problem. The project uses State of Maine data at the town level. From this data random distributions will be generated to match the approximate size of school districts and counties. User generated aggregations produced using Jonathan Hancock's (Syracuse) Look and Link software will be analyzed with respect to the random distributions. A journal article will be prepared from this research. Amrhein also worked with Kate Beard on revising a proposal submitted last year to NIH for resubmission to NIEHS. This proposal addresses the aggregation problem with respect to correlation of radon data and lung cancer.

July 16-23: Dr. Zorica Budic, Assistant Professor, Department of Urban Affairs and Planning, Virginia Polytechnic Institute and State University, Blacksburg, VA, worked on Initiative 9 research with Harlan Onsrud. The major objective during her visit was to work on a joint proposal for funded research to explore the issues related to I9. Initial research ideas were developed and communicated among the collaborators before the actual visit. Her time at UMaine was devoted to 1) discussing theoretical foundations of the proposed research; 2) composing a conceptual framework to be derived from theory and previous research; 3) establish clear research question(s) and objective(s); and 4) discussing and developing the research methodology, including the logistics (sampling, timetable and resources needed to undertake the research). The secondary objectives were to 1) get more closely acquainted with the NCGIA, its activities and researchers, particularly at the Maine site; and 2) give a presentation at a student and/or faculty seminar to introduce her research related to diffusion of geographic information systems; title of her presentation was "Factors affecting diffusion of GIS technology in local governments."

July 22-August 8: Marc Armstrong, Department of Geography, University of Iowa visited the Center at Buffalo. He worked with Paul Densham on issues related to the newly approved Initiative 17, Collaborative Spatial Decision Making.

July 24 - August 6: Stephen Hirtle, Chair, Department of Information Science, University of Pittsburgh, PA, worked on his project "Geometries for Spatio-Temporal Reasoning." The plan of the project was to survey the current literature, propose appropriate extensions, and develop a logical framework for the study of geometries. The first stage of the project focused on developments in the fields of geography, computer science, and psychology that relate to spatial geometries. The second stage of the project was to formalize these relationships and to develop a logical framework for the study of geometries and topologies of cognitive space. The problem is that not all of the proposals are well-formulated or directly comparable. Furthermore, the goal would be to develop testable properties of the geometries so that they can be compared with behavioral data. Again, the focus was on the construction of multi-level geometries.

July 25-30, and August 14-19: Jeremy Crampton, Department of Geography, George Mason University visited NCGIA Buffalo to work on issues arising from the "Friday Harbor" meetings on Geographic Information and Society. He worked principally with David Mark.

July 28-Aug. 1: Britton Harris visited the Buffalo site to work on issues related to spatial decision support systems and their relation to planning support systems, particularly with the computational aspects (Initiative-17 topics). On August 1, Dr. Harris delivered a luncheon talk "Optimizing and Satisficing: An Illustrative Example" to NCGIA and Department of Geography faculty, staff and graduate students.

Nov. 10-17: Dr. David Plane, Department of Geography and Regional Development, University of Arizona visited SUNY Buffalo. He worked principally with Pete Rogerson. Dr. Plane's research involves developing a GIS-based metropolitan growth and development simulation game, "METGRO". Dr. Plane also delivered a talk at the Graduate Group in Demography's Colloquium entitled "Spatial Focusing of Recent U.S. Internal Migration".

4. Collaboration with the European Science Foundation GISDATA program

The European Science Foundation GISDATA program was launched in January 1993 as a four year program of collaborative research with the support of fifteen member countries of the foundation. Its objectives are:

- "1. To enhance existing national research efforts and promote collaborative ventures overcoming European-wide limitations in spatial data integration, data base design and social and environmental applications.
2. To increase awareness of the political, cultural, organisational, and technical and informational barriers to an increased utilisation and inter-operability of GIS in Europe.
3. To promote the ethical use of integrated information systems, including GIS, which handles socio-economic data by respecting the legal restrictions on data privacy at the national and European level.
4. To facilitate the development of appropriate methodologies for GIS research at the European level.
5. To produce outputs of high scientific value.
6. To build-up a European network of researchers with particular emphasis on young researchers in the GIS field."

The program includes collaboration with U.S. scientists, through participation on the Steering Committee, in workshops and conferences, and through two jointly organized Summer Institutes for young scholars.

In August 1994, the National Center for Geographic Information and Analysis was awarded \$40,000 to support collaboration in the program by U.S. scientists, and NSF indicated its expectation of continuing support in FY95 at \$30,000.

The first six of a planned 12 specialist meetings have been held, and the following sections detail U.S. participation, as organized through NCGIA, and plans for publication:

GIS Diffusion in Local Government in Europe (Knutsford, UK, 10/27-31, 1993)

The study of GIS diffusion in Europe was chosen as the first topic because it highlights the extent to which the take-up of a universal technology like GIS is shaped by national circumstances and provides an obvious starting point for subsequent discussions on geographic data availability and data integration at the European level. U.S. participant: Harlan Onsrud (University of Maine), leader of NCGIA initiatives on GIS diffusion, data sharing, and legal issues. A book will be published by Taylor and Francis, edited by Ian Masser and others.

GIS and Spatial Analysis (Amsterdam, 12/1-5, 1993)

There is wide agreement in both the GIS and the modeling communities that the future success of GIS technology will depend, amongst other factors, on the extent to which it can

incorporate more powerful analytical and modeling capabilities. Spatial analysis, which in its widest sense is the description, explanation, and prediction of spatial and aspatial phenomena occurring in spatial or space-time systems, offers a wide range of methodologies and procedures which are highly relevant to GIS research. U.S. participants: Luc Anselin (West Virginia University), previous Associate Director of NCGIA at Santa Barbara, and Noel Cressie, spatial statistician from Iowa State University and author of *Statistics for Spatial Data* (Wiley, 1993). A book is in preparation, titled *Spatial Analytical Perspectives on GIS into Environmental and Socio-Economic Sciences*, edited by Manfred Fischer, Henk Scholten, and David Unwin, and published by Taylor and Francis.

Generalisation (Compiègne, France, 12/15-19, 1993)

The lack of automated generalization tools to manage, model and communicate spatial information at different levels of resolution, scale and accuracy has been long recognized as a major impediment to the development of true flexible GIS. Hence an obvious part of the GISDATA cluster on Database Design was the organization of a specialist meeting on generalization. U.S. participants: Barbara Buttenfield (University at Buffalo), leader of the NCGIA research initiatives on multiple representations, cartographic knowledge, and visualization of data quality; Robert McMaster (University of Minnesota), authority on generalization; and Scott Morehouse (Environmental Systems Research Institute, Redlands, CA). A book is in preparation, titled *Generalisation and GIS*, edited by Jean-Claude Muller, Philippe Lagrange, and Robert Weibel, and published by Taylor and Francis.

GIS and Multimedia (Rostock, Germany, 5/25-29, 1994)

Developments in the field of multimedia are occurring at such breath-taking pace that the research community still needs to have a clear view of the potential of this emerging technology and how best it can be coupled with existing tools such as GIS in a wide range of applications domains and research areas. U.S. participants: David Dibiase (Pennsylvania State University), a cartographer with particular interest in multimedia and animation; and Mike Shiffer (MIT), an urban planner with interests in multimedia and decision support systems.

Spatial Conceptual Models for Geographic Objects with Undetermined Boundaries (Baden, Austria, 6/8-12, 1994)

While traditional approaches to spatial databases require spatial objects to be precisely defined, many practical applications must deal with objects that are fuzzy, or otherwise lack precise footprints on the surface of the earth. This meeting brought together cognitive scientists interested in how people perceive geographic phenomena, statisticians, and GIS specialists interested in advancing the range of options available for dealing with this issue. U.S. participants: Helen Couclelis (UC Santa Barbara), Associate Director of NCGIA at Santa Barbara and a specialist in planning; and Lynn Usery, University of Georgia, a GIS specialist with particular interest in this problem. A book is in preparation, titled *Spatial Conceptual Models and Paradigms*, edited by Peter Burrough and Andrew Frank, and published by Taylor and Francis.

European Data Strategic Review (Malgrate, Italy, 6/30-7/3, 1994)

This meeting was organized as part of a strategic review of European data policy issues, and as such it was not thought appropriate to include U.S. participants.

A further six specialist meetings are planned before the end of the GISDATA program in 1996. It is likely that these will interlock closely with GIS research concerns in the U.S., as U.S. participants have been active in the GISDATA planning meetings and strategic reviews held to date. Final details of topics and dates are not yet available. The same mechanism will be used to select U.S. participants, who will continue to be drawn widely from the GIS and geospatial data research communities.

Michael Goodchild represents the U.S. on the GISDATA Steering Committee. Due to ill health, he was unable to attend the December 1993 meeting in Milan, but Robert McMaster (University of Minnesota) attended in his place.

Three U.S. representatives attended the First Strategic Review of the GISDATA program held in Aalborg, Denmark, September 21-24, 1994: Michael Goodchild, (UC Santa Barbara), Director of NCGIA; Harlan Onsrud (University of Maine), chair of the NCGIA Science Policy Committee; and Robert McMaster (University of Minnesota). The meeting included a full and frank review of all aspects of the program, and extensive discussion of future directions for specialist meetings and summer institutes.

Because of the high level of representation at the Strategic Review and conflicts with schedules, there was no U.S. representation at the Steering Committee meeting in Brussels in November 1994.

Ian Masser (University of Sheffield), coordinator of the GISDATA program, is a member of the NCGIA Science Policy Committee, and he or a substitute have attended each meeting of the committee since the beginning of the GISDATA program, to discuss and review all aspects of the collaboration.

The GISDATA program includes two joint NSF/ESF Summer Institutes for Young Scholars. The 1995 Institute is planned for July 26 to August 3 at the Wolfe's Neck Center of the University of Southern Maine, near Freeport, ME. It will include some 40 participants, with an equal number of instructors and young scholars from the U.S. and Europe. Young scholars have been selected through open competitions.

The second Summer Institute is planned for Berlin in 1996.

5. Technical Papers published

93-12: GIS, Cartography, and the Information Society: An Annotated Bibliography, compiled by William Dowdy, UCSB, a collection of approximately one hundred references collected by the compiler for specific use as support material at the NCGIA's Workshop "GIS and Society" held at the U of Washington's Friday Harbor Research Center.

94-1: The 9-Intersection: Formalism and Its Use for Natural-Language Spatial Predicates, edited by Max Egenhofer, U. Maine; David Mark, SUNY-Buffalo; John Herring, Intergraph Corp, contains two papers, plus supplementary material. The first paper develops and presents the formal mathematical definitions of the 9-intersection. The second paper reports on cognitive testing, based on the mathematical mode presented in the first paper. Lastly, it contains the complete set of stimuli used in Mark and Egenhofer's experimental work up to January 1994.

94-2: Selected Bibliography on Law, Information Policy, and Spatial Databases, compiled by Harlan J. Onsrud, Jeffrey Johnson, and Xavier Lopez, U. Maine. A selected bibliography prepared as part of the preparation for an NCGIA Initiative of Law, Information Policy, and Spatial Databases. Articles are placed within the following categories: Freedom of Information, Open Records, and Government Charges for Information; Privacy, Copyright, Patent, and Trade Secrets; Computer Contracts, Licensing, Electronic Document Interchange, and Encryption; Liability and Admissibility; General Books, Articles, and Bibliographies.

- 94-3: Land Information Systems in Developing Countries: Bibliography**, compiled by Harlan Onsrud, Jeffrey Johnson, Patrick Kirby, Ricardo Moreno, and Bheshem Ramlal, U. Maine.
- 94-4: Gap Analysis of the Southwestern California Region** by Frank W. Davis, UCSB. This report describes a geographic information system based Gap Analysis of biodiversity in the Southwestern California Ecoregion. The project is part of an ongoing effort by many groups to provide this regional overview by mapping the distributions of plant community types and vertebrate species habitats and relating these distributions to existing patterns of land ownership and land management.
- 94-5: Integrating Normative Location Models into GIS: Problems and Prospects with the p-median Model**, by Richard L. Church and Paul Sorensen, UCSB, discusses several problems associated with the integration of a normative location model into a GIS.
- 94-6: Final Report for Caltrans Agreement 65T155 (MOU 1)** by Richard Church, Danette Coughlan, Thomas Cova, Michael Goodchild, Jonathan Gottsegen, and David Lemberg, includes four sections: Section I. Overview; Section II describes the major functions of IVHS (intelligent vehicle highway systems); Section III discusses alternative data models; and Section IV examines the design of a distributed navigable map database and the capabilities of current GIS and database management products.
- 94-7: Spatial Analysis on the Sphere: A Review**, by Rob Raskin, UCSC, examines the methods of analysis on a spherical earth. The use of spherical analysis in conjunction with global geographic information systems is detailed. This review is relevant to researchers in geography, global change, and related fields who study processes at global scales; with bibliography.
- 94-8: Topological Relations in the World of Minimum Bounding Rectangles: a Study with R-trees**, by Dimitris Papadias, UCSD, Timos Sellis, National Technical University of Athens, Yannis Theodoridis, National Technical University of Athens, and Max J. Egenhofer, U. Maine, discusses the retrieval of topological relations in Minimum Bounding Rectangle-based data structures.
- 94-9: Time in Geographic Space: Report on the Specialist Meeting of Research Initiative 10**, Edited by Max J. Egenhofer, U. Maine, and Reginald G. Golledge, UCSB. This report describes the Specialist Meeting of the NCGIA Research Initiative on "Spatio-Temporal Reasoning in GIS." This Research Initiative addresses space and time as it relates to objects and people in geographic space. The primary goal of this report is to disseminate the results of the discussions and make them available to other researchers.
- 94-10: Selected Annotated Bibliography on Visualization of the Quality of Spatial Information, Research Initiative 7**, by William A. Mackaness and M. Kate Beard, U. Maine, and Barbara P. Battenfield, SUNY-Buffalo. This bibliography has been prepared in conjunction with NCGIA Research Initiative 7, 'Visualization of Spatial Data Quality,' as an aid to research. Containing over 200 references, this bibliography includes references on issues of uncertainty, quantitative and qualitative descriptions of quality, management and quality control, and impact of quality on decision making.

Other NCGIA publications added December 1993 - December 1994:

Closing reports for Initiatives 6 and 7

Annual GIS Bibliography for 1993, compiled by Steven Frank, Xavier Lopez, Jeff Johnson, and Harlan J. Onsrud, U. Maine.

Annual Report Year 5 (December 1, 1992 - November 30, 1993).

D. Management

Board of Directors. The Board of Directors oversees the reporting of Center activities to NSF, and acts in an advisory role to the other Center committees. Several changes occurred in the membership of the Board of Directors in Year 6. The Board welcomed Ron Abler (Association of American Geographers), Prue Adler (Association of Research Libraries), Lawrie Jordan III (ERDAS), Malvin Kalos (Cornell University), Annette Krygiel (Central Imagery Office), and Peter Thacher (World Resources Institute). Meetings were held in Santa Barbara (December 1993, December 1994) and Maine (June 1994) and at the end of December 1994 the members of the Board were:

Ronald Abler (Association of American Geographers), Chair
Prue Adler (Association of Research Libraries)
Lawrence F. Ayers (Intergraph Corporation)
Jack Dangermond (ESRI)
Susan Hanson (Clark University)
Lawrie Jordan III (ERDAS)
Malvin H. Kalos (Cornell University)
Annette Krygiel (Central Imagery Office)
Eric Sheppard (University of Minnesota)
John Sprague (Washington University)
Peter Thacher (World Resources Institute)
Giovanni Wiederhold (Stanford University)
Cort Willmott (University of Delaware)

Executive Committee. The Executive Committee is made up of the Director and Associate Directors, and the Chair of the Scientific Policy Committee. The Director is responsible for overall management of the Center, and the Associate Directors for management of operations at each site. On December 31, 1994 the members were Michael F. Goodchild (Director); Helen Couclelis (Associate Director, Santa Barbara); Michael Batty (Associate Director, Buffalo); Max Egenhofer (Associate Director, Maine); and Harlan Onsrud (Chair, SPC).

Scientific Policy Committee. During the period from December 1, 1993 to December 31, 1994, the Scientific Policy Committee (SPC) held formal meetings in Santa Barbara in December 1993 and December 1994, and in Maine in June 1994. Other informal meetings of committee members also occurred when opportunities arose. Harlan Onsrud (Maine) served as Chair of the SPC throughout the period. In addition to the Executive Committee members, the SPC on December 31 1994 included Terence Smith (Santa Barbara); Waldo Tobler (Santa Barbara; NCGIA Senior Scientist); John Estes (Santa Barbara); David Mark (Buffalo); Hugh Calkins (Buffalo); and Kate Beard (Maine). SPC meetings are also attended by selected members of the Board of Directors.

Personnel changes. Paul Densham left Buffalo in December, 1993 to assume a position at University College London. He will remain affiliated with the Buffalo site of NCGIA through his involvement in Initiative 17, and has received an appointment as an Adjunct Assistant Professor in the Department of Geography of SUNY Buffalo. Ronald Rozensky joined the Department of Geography/NCGIA on January 3 as GIS and Workstation Support Specialist in the Geographic Information and Analysis Laboratory. Jim Smith, his predecessor, had left the Department in September 1993. Martin Helander, Department of Industrial Engineering, resigned his membership in the Buffalo Center in the Spring of 1994. He will be leaving the university to take up the position as Professor of Mechanical Engineering at Linkoping Institute of Technology in Sweden. Stewart Fotheringham left the University at Buffalo in June to assume a position in the Department of Geography, University of Newcastle. Jennifer Robinson joined the Center at Buffalo as a Research Fellow, on a one-year appointment, beginning July 1, 1994. Dr. Robinson had been a Senior Research Scientist at the Environmental Research Center of Leipzig-Halle, Applied Landscape Ecology Section, Leipzig Germany. Barbara Battenfield returned to Buffalo in the Summer of 1994 following her sabbatical at the US Geological Survey,

National Mapping Division. Peter Rogerson stepped down as Chair of the Department of Geography in August 1994. Dr. James McConnell, Professor of Geography and Director, Canada-US Trade Center, SUNY Buffalo was appointed to fill the vacancy. Dr. Michael Woldenberg, Professor of Geography at SUNY Buffalo accepted membership in the Buffalo center. Dr. Woldenberg's research areas include comparing the form, growth and dynamics of flows in rivers, blood vessels, lungs, brain cells and other tree-like networks. He is also interested in developing his interests in epidemiology. Dr. Woldenberg is also serving as the Department of Geography's Director of Graduate Studies. Dr. Christopher Weber was employed as Post Doctoral Researcher for the Alexandria Project. Chris received his PhD from SUNY Buffalo for empirical research in hypermedia evaluation of cartographic user interfaces.

Dr. Max Egenhofer was appointed Associate Director of the NCGIA at the University of Maine, effective December 1, 1993. Dr. Harlan Onsrud took his sabbatical at the College of Law, Arizona State University, Tempe, AZ, from January-May 1994. He has also been appointed as Chair of the Department of Surveying Engineering. Mr. Roberto Ferrari, Assistant Professor, Department of Computer Science, Federal University of Sao Carlos, Brazil, joined the NCGIA as a visiting research associate for a one year term, and will work with Harlan Onsrud contributing to research on organizational issues and how they relate to geographic information systems. Mr. Vincent Schenkelaars, Faculty of Economics, Dept. of Computer Science, Erasmus University, The Netherlands, was a visiting research associate with the NCGIA and worked with Max Egenhofer contributing to research on user interfaces for geographic information systems, September 26-December 15. Dr. Michael Worboys, Senior Lecturer, Department of Computer Science, University of Keele, was a visiting professor with the NCGIA and worked with Max Egenhofer conducting research on spatio-temporal reasoning, November 13-December 5. Several Maine post-docs and research faculty moved on to tenure-track appointments at various academic institutions: William Mackaness, Department of Geography, University of Edinburgh; Scott Freundsuh, Department of Geography, University of Minnesota-Duluth; Steven Frank, Department of Surveying Engineering, New Mexico State University; and Michael Collins, Department of Geomatics Engineering, University of Calgary.

At Santa Barbara, Karen Kemp returned from Europe to take a position as Assistant Director, with responsibility for development. LaNell Lucius joined the staff as Office Manager in March, and Terry Figel was appointed as Systems Manager. Dr. Ole Joergen-Haugholt, Telemark College, Norway spent eight months at NCGIA beginning in September 1994. Dr. Zbigniew Zwolinski, Adam Mickiewicz University, Poland visited to work with Leal Mertes on mutual interests in geomorphology and modeling with GIS. Dr. Helena Mitasova, CERL and University of Illinois, Champaign visited for one month and gave a 3-Day Miniseries: "Surface Modeling, Analysis and Visualization with Applications to Environmental Modeling".

Space. At Maine, the Department of Surveying Engineering has obtained further laboratory space through a computer laboratory shared with the College of Engineering. GIS software has been installed on Pentium pc's in this lab and a Hewlett Packard Design Jet 650C color plotter is available.

3. EXTRAMURAL SUPPORT

A. Grants and Contracts Awarded as of 12/31/94

ERIE COUNTY WATER AUTHORITY: "AML Programming for Erie County Water Authority"; \$33,015 (29 weeks). Principal Investigator: Hugh Calkins. June 20, 1994-December 31, 1994.

NATIONAL SCIENCE FOUNDATION: "Dissertation Enhancement Grant: Responses of Motorists and the Neighborhoods they Drive through to the January 1994 Los Angeles Earthquake"; \$7,011 (1 year). Principal Investigator: D. Mark (for Ann Deakin, PhD Student, Geography). April 1, 1994-March 30, 1995.

NATIONAL SCIENCE FOUNDATION, "Dissertation Enhancement Grant (Supplement): Responses of Motorists and the Neighborhoods they Drive through to the January 1994 Los Angeles Earthquake" Supplement of \$2,964. Principal Investigator: D. Mark (for Ann Deakin, PhD Student, Geography). April 1, 1994-March 30, 1995.

NATIONAL SCIENCE FOUNDATION: "Geographical and Sociological Models of Intergenerational Relations"; \$65,860 (1 year). Principal Investigators: Peter Rogerson, Jeffrey Burr and Jan Mutchler (Dept. of Sociology, SUNY Buffalo). Sept. 1, 1994-August 31, 1995.

UNIVERSITY OF CALIFORNIA-SANTA BARBARA: "The Alexandria Project: Towards a Distributed Digital Library with Comprehensive Services for Images and Spatially Referenced Information" \$636,140 (4 years) (Buffalo subcontract). Principal Investigator (Buffalo): Barbara Bittenfield. Sept. 1, 1994-August 1, 1998.

ARPA: "International Workshop on Cognitive Aspects of User Interfaces for GIS; \$14,300. Max Egenhofer, PI; March 1994 - December 1995.

ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE, INC.: "Direct-Manipulation User Interface Design Tools for GISs"; \$15,000. Max Egenhofer, PI; December 1993 - June 1994.

INTERGRAPH CORPORATION: "Spatial Relations"; \$158,000. Max Egenhofer and Andrew Frank, Co-PI's; July 1992 - June 1995.

MAINE MATHEMATICS AND SCIENCE ALLIANCE: "Geographic Information Systems of Local Education Agencies in the State of Maine"; \$3,581. Max Egenhofer and Kathleen Hornsby, Co-PI's; May - August 1994.

NATIONAL SCIENCE FOUNDATION: "Spatial Relations in GIS"; \$97,000. Max Egenhofer, PI; September 1993 - August 1996.

NATIONAL SCIENCE FOUNDATION: "Topographic Framework for the National Spatial Data Infrastructure"; \$34,154. Harlan Onsrud, PI; October 1993 - September 1994.

NATO INTERNATIONAL SCIENTIFIC EXCHANGE PROGRAMMES: "Cross-cultural Differences in Spatial Concepts: Application to Spatial Information System Use"; 140,000 Belgian Francs. Michael Gould, Scott Freundschuh, Joan Nunes, Max Egenhofer, and David Mark, Co-PI's; May 1994 - December 1995.

LOCKHEED MISSILE AND SPACE COMPANY: "Access to Large Image Archives: User Requirements Study and Interface Design"; \$34,929. PI: Michael Goodchild. 12/01/94-11/30/95.

IBM CORP: "A Spatial Analysis and Decision Support for Conservation of Biological Diversity"; \$300,000. PI: Frank Davis; Co-PI: Michael Goodchild. 1/01/93-12/31/96.

NATIONAL SCIENCE FOUNDATION: "Board of Directors San Diego Retreat"; \$15,353. PI: Michael Goodchild. 7/21/94-12/31/94.

HITACHI AMERICA LTD: "Cooperative Research Program Between Hitachi America Ltd and NCGIA, Year 3"; \$133,000. PI: Michael Goodchild; Co-PIs: Richard Church, Helen Couclelis. 4/01/94-3/31/95.

NATIONAL SCIENCE FOUNDATION: "Topographic Framework for the NSDI"; \$50,000. PI: Michael Goodchild.

NATIONAL SCIENCE FOUNDATION: "The Alexandria Project: Towards a Distributed Digital Library with Comprehensive Services for Images and Spatially-Referenced Information"; \$4,000,000. PI: Terence Smith; Co-PIs: Michael Goodchild, Oscar Ibarra, Sanjit Mitra, Jeff Dozier. 9/1/94-8/31/98.

NATIONAL SCIENCE FOUNDATION: "National Center for Geographic Information and Analysis"; \$1,200,000. PI: Michael Goodchild; Co-PIs: Helen Couclelis, Reg Golledge, Terence Smith, John Estes. 1/1/94-12/31/94.

NATIONAL SCIENCE FOUNDATION: "Dissertation Research: The Achievement of Comprehensive Planning Goals: An Empirical Study of Public Service Accessibility"; \$10,000. PI: Helen Couclelis. 6/1/93-3/31/95.

NASA: "Graduate Student Fellowship: Exploring the Potential of Space Shuttle Earth Observations Photography as Metadata to Access and Manage Earth System Data"; \$22,000. PI: Helen Couclelis. 9/1/94-8/31/95.

UC TRANSPORTATION CENTER: "Object-Oriented Dynamic GIS for Transportation Planning"; \$102,784. PI: Reg Golledge. 8/1/94-7/31/95.

NATIONAL SCIENCE FOUNDATION: "Spatial Competence: The Contribution of Socio-Cultural and Gender Factors in Measures of Sex-Related Differences"; \$74,892. PI: Reg Golledge. 4/1/94-3/31/96.

CALIFORNIA PATH: "Investigating the Mass Transit Needs of a Non-Driving Disabled Population: A Pilot Study"; \$24,515. PI: Reg Golledge. 7/1/94-6/30/95.

UC BERKELEY: "A GIS Data Model for Transportation Modeling and Planning"; \$6,809. PI: Reg Golledge. 8/1/92-7/31/96.

UC BERKELEY: "A GIS Computational Process Model of Travel Destinations in Activity Scheduling"; \$45,056. PI: Reg Golledge. 8/1/92-7/31/96.

NASA: "Remote Sensing Information Science Research"; \$462,300. PI: John Estes. 10/1/94-9/30/95.

B. Equipment and Software Acquisitions

Maine

- 2 Pentium computer systems, with 24MB RAM and gigabyte hard drive
- 2 Intergraph InterPro 6000 workstations

ARC/INFO for Alpha 3000/300 OSF/1 workstation
 Digital Equipment Corporation Fortran Compiler
 Appletalk remote access software
 Citizen notebook printer II
 TCP/IP connect software
 MacLinkPlus/PC Connect 7.5
 MacHandwriter
 MapInfo 2.0
 Director 4.0
 Filemaker Pro 2.1
 Interleaf 6 University Kit
 Norton Utilities 3.0
 Powerpoint
 Retrospect Remote 2.1
 Systat
 System 7.5
 Virex 5.05
 Word 6.0

Buffalo

During this period, an external hard drive for the Sun Computers (2.1 Gigabyte hard disk) was purchased and then two more 2.1 gigabyte Expansion disks were also added. The Sun Server was upgraded to SPARCserver 10; and an additional Sun seat was installed. Other hardware acquisitions include a Macintosh Powerbook Duo and a Macintosh 6115 for the use of faculty members, and four Apple 7100 computers were installed in the GIAL. Two Netport II print servers and a La Cie Pocket Drive were also purchased.

Software acquisitions include SimCity 2000 for Mac, Intellimation library for Macintosh, several copies of MapInfo for Windows, MapInfo 3.0 and Motif (5 licenses of each) for Suns, Deltagraph Pro 3, Map Basic, additional copies of Microsoft Excel for MacIntosh, WordPerfect Presentations for Windows, IDRISI V. 4.1, ERDAS Imagine, Deltagraph Pro 3, Macromedia Director 4.0 upgrade.

Santa Barbara

The process of recovering from the burglary of November 1993 continued into 1994. By April, all affected workstations had been replaced by new RS/6000s. Staff workstations were also replaced in early 1994, and extensive upgrades were made to the NCGIA network. In addition to these major purchases, the following hardware and software acquisitions occurred:

540c Mac color powerbook
 165 Mac B&W powerbook
 15 Category 5 10bt cable for networking
 2 8 port 10bt ethernet hub
 3 16' AUI Cable (Hitachi funds)
 4 port AUI fanout (Hitachi funds)
 PCNFS Network software (Hitachi funds)
 PCNFS Network software
 Powerbook 520 - 4MB Ram /160MB HD
 PowerPort Merc Global Village 19.2bps fax/modem
 Apple Ext. Keyboard II
 Apple Desktop Bus ADB Mouse II
 Apple 17" Monitor

20 Sony 8mm tapes
 4 8mm Cleaning kit
 4 One Step Screen Cleaner
 5 Mouse Pads H58561
 5 Wrist supports
 Mac 16 meg upgrade
 DLT tape Drive with Centronix IO, Cables and terminator 5 tapes
 8mm 8505-XL tape drive w hardware
 Scsi2 to Centronics 3 ft cable
 4 Centronics to Centronics
 4 10BT 45' Cat 5
 2 IBM Xstation 150 with ethernet Connection 8 megs simms
 64 meg upgrade for IBM RS6000 370
 3 Power PC 6100/60 8 Megs
 3 Hitachi 15" monitor
 3 Apple design keyboard
 6 8MB 72pin CHP102
 3 Friendly Net 10BaseT
 Magnum 144 Modem
 540 Meg IDE western Digital hard drive
 350 Meg Colorado Tracer 350 Tape backup 5 tapes
 2 4-roll 3-color ink sheet for color printer
 Gator Box CS (RSRU Funds)
 HP Laserjet 4MV (RSRU Funds)
 Softwindows for Power Mac
 Ethernet card SI
 Ethernet card Mac II
 Ethernet 8 port Hub
 Cat. 5 RJ45 pkg 10
 Cat 5 Stranded Cable 500'

APPENDIX 1 - PUBLICATIONS

A. Articles published or formally accepted in refereed journals

- Al-Taha, K.H., R.T. Snodgrass, and M.D. Soo (1994) Bibliography on spatiotemporal databases. *International Journal of Geographical Information Systems* 8(1): 95-103.
- Anas, A. (in press) Capitalization of urban travel improvements into residential and commercial real estate: simulations with a unified model of housing, travel mode and shopping choices. *Journal of Regional Science*.
- Anas, A. and Richard Arnott (1994) The Chicago Prototype Housing Market Model with tenure choice and its policy applications. *Journal of Housing Research* 5(3).
- Batty, M. (1994) The world wide web. *Environment and Planning B* 21(6): 651-652.
- Batty, M. (1994) A chronicle of scientific planning: the Anglo-American modeling experience. *Journal of the American Planning Association* 59: 7-16.
- Batty, M. (1994) The job market for PhD's. *Environment and Planning B* 21: 257-258.
- Batty, M. (1994) On building ideas. *Environment and Planning B* 21: s3-s4.
- Batty, M. (1994) Urban models 25 years on. *Environment and Planning B* 21: 515-516.
- Batty, M. and B. Barr (1994) The electronic frontier: exploring and mapping cyberspace. *Futures* 26: 699-712.
- Batty, M. and Y. Xie (1994) From cells to cities. *Environment and Planning B* 21: s31-s48.
- Batty, M. and Y. Xie (1994) Modeling inside GIS: Part 1: Model structures, exploratory spatial data analysis, and aggregation. *International Journal of Geographical Information Systems* 8: 291-307.
- Batty, M. and Y. Xie (1994) Modeling inside GIS: Part 2: Selecting and calibrating urban models using ARC/INFO. *International Journal of Geographical Information Systems* 8: 451-470.
- Batty, M., V. Mesev, P. Longley and Y. Xie (in press) Morphology from imagery: detecting and measuring the density of urban land use. *Environment and Planning A*.
- Beard, K., and W. Mackaness (1993) Visual access to data quality in geographic information systems. *Cartographica* 30(2&3): 37-45.
- Butenfield, B.P. (1994) Representing spatial data quality. *Cartographica* 30(2/3): 1-7.
- Butenfield, B.P. and C.R. Weber (1994) Proactive graphics for exploratory visualization of biogeographical data. *Cartographic Perspectives* 19(3): 8-18.
- Chithambaram, R., M.K. Beard, and R. Barrera (in press) Reversible polygon skeletonization using an object-oriented approach. *International Journal of Geographical Information Systems*.

- Church, R.L., and R. Gerrard (in press) A general construct for the zonally constrained p-median problem. *Environment and Planning B*.
- Church, R.L., and R. Gerrard (in press) The generalized approach to modeling the hierarchical maximal covering location problem with referral. *Papers in Regional Science*.
- Church, R.L., and A. Murray (in press) Heuristic approaches to operational forest planning problems. *OR Spektrum*.
- Church, R.L., and A. Murray (in press) Constructing and selecting adjacency constraints. *INFOR*.
- Clementini, E., J. Sharma, and M.J. Egenhofer (1994) Modeling topological spatial relations: strategies for query processing. *Computers and Graphics* 18(6): 815-822.
- Couclelis, H. (1994) An aesthetic sense of order. *Environment and Planning B* 21: s1-s2.
- Couclelis, H. (1994) Spatial technologies. *Environment and Planning B* 21(2): 142-143.
- Couclelis, H. and M. Monmonier (in press) Using SUSS to resolve NIMBY: how spatial understanding support systems can help with the 'Not in My Back Yard' syndrome. *Geographical Systems*.
- Davis, F.W., P.A. Stine, D.M. Stoms, M.I. Borchert, and A.D. Hollander (in press) Gap analysis of the actual vegetation of California I. The Southwestern Region. *Madrono*.
- Davis, F.W., P.A. Stine, and D.M. Stoms (1994) Distribution and conservation status of coastal sage scrub in Southwestern California. *Journal of Vegetation Science* 5(5): 743-756.
- Davis, F.W. (in press) Improving biodiversity data and information flows among scientists, policy makers and managers. *Bioscience*.
- Densham, P.J. (1994) Integrating GIS and spatial modeling: Visual interactive modeling and location selection. *Geographical Systems* 1(3): 203-219.
- DePinto, J., H. Calkins, P. Densham, J. Atkinson, W. Guan, H. Lin and P. Rodgers (1994). An approach for integrating GIS and watershed analysis models. *Microcomputers in Civil Engineering* 9: 251-262.
- Ding, Y., A. Baveja and R. Batta (1994) Implementing Larson and Sadiq's location model in a geographic information system. *Computers and Operations Research* 21(4): 447-454.
- Ding, Y. and P.J. Densham (1994) A loosely synchronous, parallel algorithm for hill shading of digital elevation models. *Cartography and GIS* 21(1): 5-14.
- Eagles, M. (in press) Introduction: spatial and contextual models of political behaviour. *Political Geography*.
- Egenhofer, M.J. (1994) Spatial SQL: a query and presentation language. *IEEE Transactions on Knowledge and Data Engineering* 6(1): 86-95
- Egenhofer, M.J. (1993) A model for detailed binary topological relationships. *Geomatica* 47(3&4): 261-273.
- Egenhofer, M.J. (1994) Deriving the composition of binary topological relations. *Journal of Visual Languages and Computing* 5: 133-149.

- Egenhofer, M.J. (1994) Pre-processing queries with spatial constraints. *Photogrammetric Engineering and Remote Sensing* 60(6): 783-790.
- Egenhofer, M.J. and R. Franzosa (in press) On the equivalence of topological relations. *International Journal of Geographical Information Systems*.
- Egenhofer, M.J., E. Clementini, and P. Di Felice (1994) Topological relations between regions With holes. *International Journal of Geographical Information Systems* 8(2): 129-142.
- Egenhofer, M.J., and D.M. Mark (in press) Modeling conceptual neighborhoods of topological relations. *International Journal of Geographical Information Systems*.
- Fotheringham, A.S. (1994) What does 'doing a PhD in GIS' mean? Commentary. *Environment and Planning A* 26: 6-8.
- Fotheringham, A.S. (1994) Review of Jones, J.P. III and E. Casetti (eds), "Applications of the Expansion Method". *Annals of the Association of American Geographers* 84(1): 170-171.
- Fotheringham, A.S., P.J. Densham and A. Curtis (in press) The zone definition problem in location-allocation modelling. *Geographical Analysis* 27(1).
- Frank, S. (1994) The National Spatial Data Infrastructure: designing navigational strategies. *Journal of the Urban and Regional Information Systems Association* 6(1): 37-55.
- Frank, S. (1994) Cataloging digital geographic data in the information infrastructure: a literature and technology review. *Information Processing and Management* 30(5): 587-606.
- Friedl, M.A., and F.W. Davis (1994) Sources of variation in radiometric surface temperature over a tallgrass prairie. *Remote Sensing of Environment* 48: 1-17.
- Friedl, M.A., J. Michaelsen, H. Walker and F.W. Davis (1994) Estimating grassland biomass and leaf area index using ground and satellite data. *International Journal of Remote Sensing* 15(7): 1401-1420.
- Gautier, C. and D. Schweizer (1994) Mini-Rio summit: an innovative method for teaching the policy relevance of Earth-system science. *Bulletin of the American Meteorological Society* 11: 2171-2174.
- Gerrard, R.A., and R.L. Church (1994) Analyzing tradeoffs between zonal constraints and accessibility in facility location. *Computers and Operations Research* 21(1): 79-99.
- Goodchild, M.F. (1994) Integrating GIS and remote sensing for vegetation analysis and modeling: methodological issues. *Journal of Vegetation Science* 5(5): 615-626.
- Goodchild, M.F., and S.D. Palladino (in press) GIS as a tool in science and technology education. *Speculations in Science and Technology*.
- Hunter, G.J., and M.F. Goodchild (1994) Managing uncertainty in spatial databases: putting theory into practice. *Journal of the Urban and Regional Information Systems Association* 5(2): 55-63.
- Hunter, G.J., and M.F. Goodchild (in press) Dealing with error in spatial databases: a simple case study. *Photogrammetric Engineering and Remote Sensing*.

- Jamil, M., R. Batta, and D.M. Malon (1994) The Traveling Repairperson Home Base Location Problem. *Transportation Science* 28(2): 150-161.
- Jin, H., R. Batta, and M.H. Karwan (in press) On the analysis of two new models for transporting hazardous materials. *Operations Research*.
- Kottman, C. and B.P. Buttenfield (in press) Standards for spatial data use: similes improve understanding. *Cartography and GIS*.
- Lanter, D.P. (in press) A lineage metadata approach to removing redundancy and propagating updates in a GIS database. *Cartography and Geographic Information Systems*.
- Lin, G. and P. Rogerson (in press) Elderly parents and the geographic availability of their adult children. *Research on Aging*.
- Lopez, X. (1993) Database copyright issues in the European GIS community. *Government Information Quarterly* 10(3): 305-318.
- Lopez, X. (1994) Balancing information privacy with efficiency and open access: a concern of government and industry. *Government Information Quarterly* 11(3): 255-260.
- Mark, D.M., and M.J. Egenhofer (in press) Modeling spatial relations between lines and regions: combining formal mathematical models and human subjects testing. *Cartography and Geographic Information Systems*.
- Michaelsen, J., D.S. Schimel, M.A. Friedl, F.W. Davis, and R.C. Dubayah (1994) Regression tree analysis of satellite and terrain data to guide vegetation sampling and surveys. *Journal of Vegetation Science* 5(5): 673-686.
- Montello, D. R., C.N. Sullivan, and H.L. Pick (in press) Recall memory for topographic maps and natural terrain: effects of experience and task performance. *Cartographica*.
- O'Loughlin, J., C. Flint, and L. Anselin (1994) The geography of the Nazi vote: context, confession, and class in the Reichstag election of 1930. *Annals of the Association of American Geographers* 84(3): 351-380.
- Odland, J., and M. Shumway (1994) Interdependencies in the timing of migration and mobility events. *Papers in Regional Science* 72(3): 221-238.
- Onsrud, H.J., J.P. Johnson, and X.R. Lopez (1994) Protecting personal privacy in using geographic information systems. *Photogrammetric Engineering and Remote Sensing* 60(9): 1083-1095.
- Paradis J. and M.K. Beard (in press) Data quality filter: a user's tool for data quality assessment. *Journal of the Urban and Regional Information Systems Association*.
- Presson, C.C., and D.R. Montello (in press) Updating after rotational and translational body movements: coordinate structure of perspective space. *Perception*.
- Rogerson, P. (in press) Inconsistencies in league standings. *Journal of Recreational Mathematics*.
- Rogerson, P. (1994) On the relationship between handedness and season of birth for men. *Perceptual and Motor Skills* 79: 499-506.

- Rogerson, P. (in press) Review of Rogers, A. (ed) "Elderly Migration and Population Redistribution" (London: Belhaven Press). *Annals of the Association of American Geographers*.
- Rogerson, P. and A.S. Fotheringham (1994) Spatial analysis and GIS: an introduction. *Geographical Systems* 1: 175-77.
- Sivakumar, R.A. and R. Batta (1994) The Variance-Constrained Shortest Path Problem. *Transportation Science* 28(4): 309-316.
- Tobler, W. (1994) Bidimensional regression. *Geographical Analysis* 26: 186-212.
- Tobler, W. (in press) The resel based GIS. *International Journal of Geographical Information Systems*.
- Waliser, D., B. Blanke, J.D. Neelin, and C. Gautier (1994) Shortwave feedbacks and ENSO: forced ocean and coupled ocean-atmosphere model experiments. *Journal of Geophysical Research: Oceans* 99(NC12): 25109-25125.
- Walsh, S.J., and F.W. Davis (1994) Applications of remote sensing and geographic information systems in vegetation science. *Journal of Vegetation Science* 5(5): 610-613.
- Wang, Y., E.S. Kaschiske, J.M. Melack, F.W. Davis, and N.L. Christensen (1994) The effects of Loblolly pine biomass and soil moisture backscatter on ERS-1 SAR backscatter. *Remote Sensing of Environment* 49: 25-31.
- Wortman, K. and B.P. Buttenfield (in press) A note on standards. *Cartography and GIS*.
- Wright, D.J., R.M. Haymon, and D.J. Fornari (in press) Crustal fissuring and its relationship to magmatic and hydrothermal processes on the East Pacific Rise (9°12'-54'N). *Journal of Geophysical Research*.
- Wu, C.V. and B.P. Buttenfield (1994) Spatial data quality and its evaluation. *Computers, Environment and Urban Systems* 18(3): 153-165.

B. Books

- Batty, M. and P. Longley (1994) *Fractal Cities: A Geometry of Form and Function*. London: Academic Press.
- Batty, M., J. Brotchie, P. Hall, P. Newton, and E. Blakely, editors (1994) *Cities in Competition: The Emergence of Productive and Sustainable Cities for the 21st Century*. London and New York: Longman.
- Fotheringham, A.S. and P. Rogerson, editors (1994) *GIS and Spatial Analysis*. London: Taylor and Francis.
- Maschner, H. and M. Aldenderfer, editors (in press) *Anthropology Through Geographic Information and Analysis*. Oxford University Press: New York.
- Nyerges, T., D.M. Mark, M.J. Egenhofer, and R. Laurini, editors (in press) *Cognitive Aspects for Human Computer Interaction for GIS*. Dordrecht: Kluwer Academic Press.

Obermeyer, N.J. and J.K. Pinto (1994) *Managing Geographic Information Systems*. New York: Guilford Publications, Inc.

Plane, D. and P.A. Rogerson (1994) *The Geographical Analysis of Population: With Applications to Planning and Business*. New York: John Wiley & Sons, Inc.

Renfrew, C. and E. Zubrow, editors (1994) *The Ancient Mind: Elements of Cognitive Archaeology*. The New Directions in Archaeology Series. Cambridge: Cambridge University Press.

C. Articles in Refereed Conference Proceedings

Armstrong, M.P. and P.J. Densham (1994) Toward the development of a conceptual framework for GIS-based collaborative spatial decision-making. *Proceedings, 2nd ACM Workshop on Advances in Geographic Information Systems*.

Armstrong, M.P. and P.J. Densham (1995) Cartographic support for collaborative spatial decision-making. *Proceedings, Twelfth International Symposium on Computer-Assisted Cartography (Auto Carto 12)*.

Beard, K. (1994) Accommodating uncertainty in query response. *Proceedings, Sixth International Symposium on Spatial Data Handling, September 5-9, 1994, Edinburgh, Scotland*, Vol. 1, pp. 240-253.

Buttenfield, B.P. (1995) Evaluating user requirements for a digital library testbed. *Proceedings, AUTO-CARTO 12, Charlotte, North Carolina, 27 February - 1 March*.

Densham, P.J., and M.P. Armstrong (1994) A heterogeneous processing approach to spatial decision support systems. In T.C. Waugh and R.G. Healy (eds), *Advances in GIS Research, Proceedings of the 6th International Spatial Data Handling Symposium*, Vol. 1, pp. 29-45.

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APPENDIX 2 - PRESENTATIONS BY NCGIA PERSONNEL

December 2-5: Michael Goodchild, Waldo Tobler, Helen Couclelis, Jack Estes, Sandi Glendinning, and Angela Mills were hosts for the NCGIA Board of Directors and Science Policy Committee meetings, held in Santa Barbara.

December 15-19: Babs Buttenfield participated in the European Science Foundation Conference on Generalization, Compiègne, France.

January 6: Ezra Zubrow delivered a paper entitled "Folk Ecology" at the Man and the Biosphere Human Systems Symposium, Miami, FL.

January 27-29: William Mackaness attended the first national conference on the Educational Applications of Geographic Information Systems (EDGIS), Washington, DC. Steve Palladino presented a report on NCGIA educational activities for the K-12 Schools. Barbara Buttenfield and Michael Goodchild gave keynote presentations and closing comments.

February 7-9: Mike Batty visited Dr. George Freidman, Louisiana State University, Baton Rouge, LA to discuss a potential Collaborative Research effort between NCGIA-Buffalo and the Center for Geopolitical Studies at Louisiana State University on commodity chains and GIS.

February 23: Ezra Zubrow gave an invited paper "Archaeometry - an International Discipline?" at the 5th International Archaeometry Workshop, AARG, Buffalo, NY.

February 23-27: Waldo Tobler attended the Western Regional Science meeting in Tuscon.

February 25-27: Michael Goodchild attended the Advanced Research Workshop on Socioeconomic Factors and Biodiversity, Semiamoo, WA, as a participant.

March 10-12: David Mark and PhD Student Ann Deakin visited Los Angeles to conduct field research for a study on "Responses of Motorists and the Neighborhoods they Drive through to the January 1994 Los Angeles Earthquake". The results of this study will be incorporated in Ann's PhD dissertation.

March 13: Michael Goodchild gave a presentation on GIS and NCGIA at the University of St Andrews.

March 21-25: David Mark and Paul Densham were invited participants in the NATO Advanced Research Workshop: *Cognitive Aspects of Human-Computer Interaction for Geographic Information Systems*, (T. Nyerges, Director, D. Mark, co-Director, Palma de Mallorca, Spain.) Mark's position paper was entitled "Spatial Concepts and Cognitive Models for Geographic Information Use". Densham contributed two papers to the conference, both co-authored with Marc Armstrong: "HCI Considerations for Visual-Interactive Locational Analysis" and "A Conceptual Framework for Improving HCI in Locational Decision-Making".

March 22-29: Mike Batty visited the Geography Department at the University of Bristol.

March 28 to April 4: Stewart Fotheringham and Hugh Calkins attended the Asia GIS/LIS AM/FM and Spatial Analysis Conference, Chinese University of Hong Kong, Hong Kong. Hugh was invited to participate in the Workshop on GIS Planning and Implementation.

March 28: Uwe Deichmann visited the Club du Sahel (part of the Organisation for Economic Cooperation and Development, OECD) in Paris.

March 29-April 1: PhD student C.J. Cote attended EGIS '94, Paris, France.

March 29-April 2: Kate Beard, Max Egenhofer, Scott Freundsuh, and Kathleen Hornsby attended the Association of American Geographers annual meeting, San Francisco, CA. Egenhofer (with Reg Golledge, UCSB) organized and chaired a session on "NCGIA: Spatial and Temporal Reasoning". Freundsuh participated in the following sessions: organized (with Daniel Montello, UCSB) a session on "Cartography and Environmental Perception and Behavioral Specialty Groups: Sources of Spatial Knowledge and Resulting Cognitive Representations: Part I" and presented "Spatial Knowledge Acquisition from Maps Versus Narrative"; organized (with Daniel Montello, UCSB) and chaired the session on "Cartography and Environmental Perception and Behavioral Specialty Groups: Sources of Spatial Knowledge and Resulting Cognitive Representations: Part II"; and organized and chaired the session on "Cartography Specialty Group: Cognitive Cartography".

Several Center members attended the conference from Buffalo. Mike Batty presented a paper he had co-authored with Yichun Xie: "Cellular Automata Models of Suburban Residential Development." Stewart Fotheringham chaired the session "MMQM and GIS Specialty Groups: Innovations in Spatial Analysis" and presented the paper "Empirical Evidence from Spatial Choice Supporting Hierarchical Information Processing", co-authored by Andrew Curtis and Timothy Pitts. David Mark presented a paper entitled "The Value of Human Subjects' Testing in Spatial Relations Research." Pete Rogerson presented the paper "Geographic Perspectives on Elderly Population Growth During the late 1980's". PhD student May Yuan won the student paper competition sponsored by the GIS Specialty Group at the AAG. The title of her paper was "Knowledge Acquisition for Building Wildfire Representation in GIS." PhD student Andrew Curtis presented his paper "Variations in Spatial Cluster and Hierarchy Formations". PhD student Ge Lin presented the work he had done in cooperation with Thomas C. Rosenthal and Mary Horwitz of the New York Rural Health Center, SUNY at Buffalo. The paper was entitled: "Young Physicians' Practice Location Choices: A Survey of New York State Residence-Trained Family Physicians". PhD student Frank Xia delivered his paper, co-authored with Hugh Calkins: "The Design of a 3-D GIS for Water Quality Modeling". PhD Student Yichun Xie presented a paper he had co-authored with Stewart Fotheringham. He also presented a paper co-authored with Pete Rogerson, entitled "Factors Influencing Chinese Fertility: A Regional Approach". PhD student Feibing Zhan presented "Simulation of periodic Marketing Systems", a paper he had co-authored with David Mark.

From Santa Barbara, Helen Couclelis participated in an I10 special session (paper on Aristotelian spatial dynamics). Waldo Tobler presented an invited paper. Daniel R. Montello presented "Modeling spatial knowledge and reasoning in environmental space: Testing qualitative metric models" and an invited paper at a special session, "NCGIA: Spatial and Temporal Reasoning." He also co-organized and chaired the special sessions, "Sources of Spatial Knowledge and Resulting Cognitive Representations: Parts I & II". Steve Palladino took part in a special session on community college geography as a representative of the NCGIA. He was appointed to co-lead a task force on GIS in the Community Colleges.

April: Rajan Batta delivered two papers at the TIMS/ORSA Conference, Boston: "Maximizing Expected Coverage for a N-Server Emergency Service System Through Dispatch Order Assignments" (L.L. Chaitin, R. Batta and S.Y. Prasad, authors); and "Modeling Uncertainty in Hazardous Materials Transportation" (R. Batta and H. Jin, authors).

April 1: Ezra Zubrow delivered the paper "The Human Implications of Everglade Restoration" at the Rosentiel School of Marine and Atmospheric Sciences, Miami, FL.

April 6: Stewart Fotheringham delivered a talk on spatial interaction models to NYNEX.

April 7: Ezra Zubrow gave a talk entitled "Sugar Alligators, and Restoration of the Everglades" at the University of Miami.

April 11-13: Paul Densham presented the paper “Scenario Management for Spatial Decision Support Systems” (Densham, P.J., H.W. Calkins and F. Xia, authors) at GIS Research U.K. 1994 (GISRUK '94), Leicester, U.K. Densham also chaired two sessions at the conference: “Spatial Decision Making” and “Spatial Analysis”.

April 14-21: Stewart Fotheringham was invited to conduct an evaluation of the Department of Geography, University of the United Arab Emirates, El-Ain, U.A.E.

April 14: Uwe Deichmann visited the World Resources Institute in Washington, DC, to discuss collaboration in the development and analysis of spatial socioeconomic databases for West Africa.

April 19: Michael Goodchild made presentations on GIS and NCGIA at Stanford University.

April 20: Hugh Calkins presented a paper on GIS Planning and Implementation at the WNY Regional Conference of the American Water Works Association (AWWA), Buffalo, New York.

April 24: Ezra Zubrow’s paper “Association, Spatial Variation, Spatial Taxonomy, and GIS in Archaeology” was invited for inclusion at the meeting of the Society of American Archaeology, Anaheim, CA.

April 27-29: Waldo Tobler attended a CIESIN meeting in Saginaw, MI and presented a research plan for his global population database project.

April 28: Ezra Zubrow gave a lecture entitled “Pursuing Agriculture” to the Department of Geography at Ohio State University.

April 28-30: David Mark visited traveled to UCSB to serve as a consultant on a Environmental Protection Agency grant (Dennis White and John Kimerling [Oregon State University], Principal Investigators). The project involved examining global tessellations and sampling schemes for global environmental data. Other consultants attending the meeting included Waldo Tobler, Mike Goodchild and Frank Davis (UCSB), and Geoff Dutton.

May 2: Kathleen Hornsby, Richard Ozog, and Tony Sleezer attended the Problem Solving in Science and Mathematics (PRISM) conference, Rockport, ME. They gave a workshop on GIS using the NCGIA Africa Data Viewer, to high school science and math teachers.

May 2-5: Max Egenhofer attended the International Intergraph Graphics Users Group annual conference, Huntsville, AL, and presented “Assessing Inconsistencies in Multiple-Representation GISs”.

May 9: Paul Densham gave the talk “Visual Interactive Locational Analysis” at the Department of Geography Seminar Series, University of Sheffield, Sheffield, U.K.

May 10: Dawn Wright presented to the MIT Department of Earth, Atmospheric, and Planetary Sciences Lecture Series, Cambridge, MA, “GIS and Oceanographic Research: A Match Made in Heaven?”

May 13-14: William Mackaness (organizer), and graduate students Barbara Bicking, Tom Bruns, Jeff Johnson, Xavier Lopez, and Bheshem Ramlal attended the Atlantic Research Institute Symposium, University of New Brunswick, Fredericton, Canada. This annual event is an opportunity for graduate students and post-doctoral researchers from Laval University, the University of New Brunswick, and the University of Maine to meet and share their ideas and to present their research. The following presentations were made at the meeting: “The Importance of Topology in Map Design” - William Mackaness; “Toward an Automated Attribute Accuracy Checker for Digital Cartographic Data Sets” - Barbara Bicking; “The Impact of Government Information Policy on Access to Spatial Datasets: A Comparative North American European Community Study” - Xavier Lopez; “Direct Manipulation User Interfaces for GIS Map Algebra” - Tom Bruns; “Law, Information Policy

and Spatial Databases: Cost Recovery Policies in Local and Regional Government GIS” - Jeff Johnson; and “Using Survey Observations in a Soil Information System” - Bheshem Ramlal.

May: Rajan Batta presented the paper, co-authored with H. Jin, “Modeling Uncertainty in Hazardous Materials Transportation” at the IE Research Conference, Atlanta, GA.

May 16-20: Michael Goodchild gave a presentation on visualization research to the International Conference on Spatial Accuracy of Natural Resource Databases, Williamsburg, VA.

May 18-19: Mike Batty attended the SUNY Congress on Economic Development in Albany, NY and gave a presentation on “Collaborative Projects with The National Center for Geographic Information and Analysis, the Canada/US Trade Center and the Center for Regional Studies at SUNY Buffalo”.

May 19-22: Alex Anas presented the paper “Advances in Urban Economic Theory” at Tel-Aviv University, Department of Economics, Tel-Aviv, Israel.

May 19-26: Dan Montello travelled to the Technical University of Vienna as an invited lecturer and collaborated with Andrew Frank on research related to I10.

May 23-26: Max Egenhofer met with agencies for potential funding opportunities in Washington, DC.

May 23-27: Hugh Calkins, Ronald Rozensky, David Mark, and students May Yuan, C. J. Cote, and Jill Gorsky attended the 14th Annual ESRI Users Conference in Palm Springs, CA. Hugh Calkins presented a paper entitled “3-D Segmentation for Water Quality Modeling with ARC/INFO”. David Mark presented a paper entitled “Determining Spatial relations Between Lines and Regions in ARC/INFO”. May Yuan presented the paper “Eliciting Experts' Knowledge for Wildfire Data Modeling in GIS.” Ron Rozensky presented a paper he co-authored with Andrew Curtis, titled: “Developing a Cognitive Spatial Clustering Algorithm Using Arc/Info”. C.J. Cote and Jill Gorsky served as student assistants at the conference. From Santa Barbara, David Lanter presented “The Contribution of ARC/INFO's Log File to Metadata Analysis of GIS Data Processing”. Steve Palladino made a presentation on NCGIA educational activities for the K-12 schools. Michael Goodchild attended the conference as well.

May 24-29: Stewart Fotheringham gave the keynote presentation, the “Regional Research Laboratories Lecture”, at the Northern Ireland Conference on GIS, Public Policy and Spatial Analysis at the Geographical Information Systems and Public Policy Conference, Ulster Business School, Port Ballantrae, Northern Ireland.

May 25-29: David Zubin visited the “Forschungsschwerpunkt Allgemeine Sprachwissenschaft”, a new government-sponsored institute in Berlin, Germany, and gave a paper on categorization processes in nominal classification systems.

May-June: Rajan Batta presented the paper, co-authored with A. Bansal, “Aggregation Error Characterization in One- and Two-Dimensional Minisum and Minimax Location Problems” at the Canadian Operations Research Society Conference, Montreal, Quebec.

May 31-June 2: Max Egenhofer met with agencies for potential funding opportunities, Washington, DC.

June 1-2: Michael Goodchild and Barbara Buttenfield met with the Mapping Science Committee, National Research Council in Washington, DC.

June 7-8: Richard Church presented “Integrating Normative Location Models into GIS: Problems and Prospects with the p-median Model”, at a GIS and Spatial Modeling Workshop, Rodney Lodge, University of Bristol.

June 7-10: Helen Couclelis presented at the ESF GISDATA workshop on “Conceptual models of geographic objects with undefined boundaries” in Baden, Austria.

June 7-8: Paul Densham presented his paper “Visual Interactive Locational Analysis” and Mike Batty presented his paper: “Global Economic Modeling and GIS” at Spatial Modeling and GIS, School of Advanced Urban Studies, University of Bristol, Bristol, U.K. This conference was co-organized by Mike Batty.

June 8: Babs Buttenfield presented the paper “Cartography and Visualization: Lessons Learned” at the National Conference on Environmental Data, Crystal City, Virginia.

June 9-11: Michael Goodchild served as a panelist for the National Science Foundation, Network Infrastructure for Education program.

June 12-15: Harlan Onsrud attended the National Science Foundation and National Aeronautics Space Administration site visit for the Digital Libraries proposal, Santa Barbara, CA.

June 15-16: Babs Buttenfield participated in the Defense Mapping Agency's First Annual Academic Forum on GIS, DMA Headquarters, Bethesda, MD.

June 17: Mike Batty presented the paper “Digital Data Sources for Land Use Analysis” at the conference Land Use and Information, sponsored by ESRC, held at Birkbeck College, University of London.

June 21-22: Max Egenhofer met with program officers at the National Science Foundation, Washington, DC.

June 27: Paul Densham spoke on “GIS and Monitoring Change” at the Sustainable Development: Towards 2000, Geography Teachers' Conference, Department of Geography, University College London, London, U.K.

June 27-28: Marcus Wieshofer, PhD student at Buffalo, attended the Wiener Symposium in Vienna, Austria and presented his paper entitled “Kartographic and Hypermedia”.

June 22: Michael Goodchild presented on “Geographic Information Science: the research and education needs of the NSDI” and “Spatial Information in Contemporary Social Science” at the National Science Foundation in Washington, DC.

June 23-July 8: Steve Palladino co-directed the 2-week Southern California Geographic Alliance Summer Institute which included a full day of GIS activities presented by Michael Goodchild and Palladino.

June 30: Michael Goodchild met with a consortium of TRW, Foothill College, Stanford University, and UC Santa Cruz to discuss collaborative projects, at Foothill College.

July 1994: Frank Davis presented “Applying Gap Analysis: the California Experience”, at the 5th annual Gap Analysis Principal Investigators Meeting, Silverdale, Washington.

July 1994: Steve Palladino made GIS Presentations to two groups of high school students participating in UCSB special summer programs (QUEST and Summer Science Project).

July 4-10: Mike Batty visited CENID-COMEF in Mexico City and presented a series of lectures on The Use of Models in GIS.

July 6-8: PhD student Michael Leitner attended the International Symposium for Applied Geographic Information Technology (AGIT) in Salzburg, Austria. He presented two papers, both co-authored with B.

Buttenfield: "Acquisition of Prototype rules for Automated Map Generalization" and "Visualization of Data Quality in Cartographic Displays".

July 6-22: David Mark and Scott Freunds Schuh taught a course "Geographical Organization of Space" in the First International Summer School of Cognitive Science at SUNY Buffalo. The course was attended by about 20 people from six countries. David Mark and Max Egenhofer (NCGIA-Maine) also participated in two Workshops within the FIS meeting: "Topological Foundations of Cognitive Science" (July 9-10) and "Ontology of Space" (July 26-27).

July 8-11, Max Egenhofer and Scott Freunds Schuh attended the First International Summer Institute in Cognitive Science: Multidisciplinary Foundations of Cognitive Science, SUNY-Buffalo, NY. David Mark (SUNY-Buffalo) and Freunds Schuh gave a course on Geographic Organization of Space.

July 1994: David Zubin attended and taught at the "First International Institute in Cognitive Science", SUNY Buffalo, July 1994.

July 16: Michael Goodchild attended the 15th International Congress of Soil Science, Acapulco, and presented a paper on "GIS Error Models and Visualization Techniques for Spatial Variability in Soils".

July 18: Michael Goodchild participated in a GIS workshop at Arizona State University, and advised the ASU administration on development of a GIS program.

July 19: Michael Goodchild attended a meeting at NSF in Alexandria, VA, to negotiate the cooperative agreement for the Alexandria project.

August 1994: Frank Davis presented "Improving biodiversity data and information flows among scientists, policy makers and managers", at the 1994 American Institute of Biological Sciences (AIBS) Plenary Session, "Science and Policy: What We Know and What We Need to Know", Knoxville.

August 1: Michael Goodchild attended a GIS conference at Columbia College in Sonora, CA, and made a keynote presentation.

August 1994: CJ Cote was invited as a scientist to participate in the Citizen Ambassador Program Environmental Technology Conference, Moscow by the National Mapping Division of USGS and the CAP.

August 1994: Paul Densham visited NYNEX Science and Technology in White Plains, NY, to discuss developments in computer supported collaborative work and collaborative spatial decision-making environments and their relevance to the optimization of telecommunications networks.

August 1994: The paper "Gender Differences in Map Reading Abilities: What Do We Know? What Can We Do?", co-authored by M. Kumler and B. Buttenfield was presented at the First Annual Conference on Research Issues in Map Design, Ottawa, Canada.

August 2: Paul Densham gave an invited talk on Computer Supported Cooperative Work and Collaborative Spatial Decision-Making at NYNEX Science and Technology, White Plains, NY.

August 3-5: Michael Goodchild participated as an instructor in the "Advanced Topics in GIS" workshop, Breckenridge, CO, organized by GIS World Inc.

August 6-7: Michael Goodchild met with Steve Frank in Las Cruces, NM, to discuss progress on the FGDC NSDI Framework study.

August 7-9: William Mackaness attended the Canadian Institute of Geomatics Symposium on Map Design and Research, Ottawa, Ontario, Canada. He presented "Automated Cartography and the Human Paradigm".

August 8-12: Michael Collins attended the International Geoscience and Remote Sensing Symposium, Pasadena, CA. He presented 2 papers.

August 9-13: William Mackaness attended the Canadian Cartographic Association and the North American Cartographic Information Society conferences, Ottawa, Ontario, Canada. He presented "The Use of Displacement in Automated Cartography".

August 10-16: Max Egenhofer attended the NCGIA Summer Institute on Advanced Topics in Geographic Information Science, Santa Barbara, CA. He was one of three seminar leaders and led a seminar on "Knowledge Representation for Spatial Data".

August 10-16: Steve Palladino coordinated the First Annual NCGIA Summer Institute held in Santa Barbara; Max Egenhofer, Paul Densham, and Michael Goodchild participated as instructors.

August 17: Michael Goodchild met with Al Watkins, USGS National Mapping Division, to discuss prospects for collaboration.

August 18-19: Michael Goodchild participated in a workshop on future research sponsored by the NSF Signal Processing program, Alexandria, VA.

August 18-21: Alex Anas presented the paper he co-authored with Ikki Kim, "A General Equilibrium Model of Polycentric Urban Land Use with Endogenous Traffic Congestion and Job Agglomeration", in the Bilateral Conference on Recent Advances in Transportation/Land Use Modeling, Stockholm Sweden.

August 25-26: Michael Goodchild visited ESRI in Redlands, CA, to discuss ESRI participation in the Alexandria project.

September 1994: Frank Davis presented "Information Management", a lecture for the National Park Service Training Workshop in Inventory and Monitoring, Ventura.

September 5-9: David Mark served as chair of the session "Algorithms" at the International Symposium on Spatial Data Handling (SDH '94), Edinburgh, Scotland. Paul Densham chaired a session entitled Spatial Analysis II, and presented two papers. He had also served as a member of the Conference Editorial Committee. The papers he presented were: "A Heterogeneous Processing Approach to Spatial Decision Support Systems" (co-authored with Marc Armstrong); and "A Dynamic and Recursive Parallel Algorithm for Constructing Delaunay Triangulations" (co-authored with Yuemin Ding).

September 6-9: Richard Church, Alan Murray, and Klaus Barber presented "Designing a Hierarchical Planning Model for USDA Forest Service Planning", at the Sixth Symposium on Systems Analysis and Management Decisions in Forestry, Asilomar Conference Center, Pacific Grove, CA.

September 9-13: Troy Jordan attended the Networld and Interop conference, Atlanta, GA.

September 12-16: Richard Church, Alan Murray, M. Figueroa, A. Ager, and R. McQuaghey presented "Artificial Landscape Visualization of Ecosystem Management Plans", at Decision Support 2001, Toronto.

September 12-13: Michael Goodchild participated in a workshop on Sampling Designs for Aquatic Networks Across Scales, Mt Hood, OR.

September 20: Michael Goodchild gave a presentation to the Department of Human Geography, University of Stockholm, on "GIS Research and NCGIA".

September 20-25: Harlan Onsrud and Michael Goodchild attended an ESF planning meeting, Aalborg, Denmark.

Sept 23-24: David Mark was an invited participant in the workshop "The Management of Spatial Data and InterSite Data Access in the Ecological Sciences", Long Term Ecological Research (LTER) Network Office, Seattle, Washington.

September 22-23: Paul Densham was a presenter at "Spatial Decision Support Systems", a two-day course taught as an element of a six-month course on GIS sponsored by the European Union at FORMEZ (Centro Formazione e Studi per il Mezzogiorno - Napoli), Naples, Italy.

September 26: Michael Goodchild and Jack Estes participated in an I15 Steering Committee meeting, Reston, VA.

September 26: Michael Goodchild met with Joel Morrison, USGS, to discuss NCGIA Board of Directors issues.

September 27: Michael Goodchild met with Ron Abler, Executive Director, AAG, to discuss the future of NCGIA.

September 28-29: Michael Goodchild participated in an Antarctic GIS Workshop, sponsored by NSF at USGS, Reston, VA, and gave a tutorial on GIS.

October 1-4: Michael Goodchild attended the conference of the International Association for Mathematical Geology, Mt Tremblant, Que, gave a workshop on "Accuracy of Spatial Databases", and made a presentation on "GIS and Mathematical Geology: Status and Prospects".

October 5-7: Harlan Onsrud and Helen Couclelis attended an ESF/NSF organizational meeting at the National Science Foundation, Washington, DC, for the Wolfes Neck summer institute to be held July 1995 in Freeport, ME.

October 12-13: Harlan Onsrud attended the FIG/Geomatics Atlantic '94 meeting, Fredericton, NB, Canada.

October 13-14: Michael Goodchild attended the Applied Geography Conference, Akron, OH, chaired two sessions, and made a presentation on "GIS Data Models for Map Databases".

October 23-26: Rajan Batta attended the ORSA/TIMS Joint National Meeting in Detroit, MI. He gave the talk "An Integer Programming Model of Dynamic Action in Mobile Trading".

October 23-27: At the GIS/LIS '94 Conference in Phoenix, Jonathan Gottsegen presented a paper entitled "A conceptual navigable database model for intelligent vehicle highway systems" (co-authored by M.F. Goodchild and R.L. Church). Paul Van Zuyle presented a paper, "GIS education with ArcView2," that detailed the purpose and methods of development of an introductory geography/GIS educational module entitled "Color Your World." Tom Cova presented a paper (co-authored by M.F. Goodchild) entitled "Spatially distributed navigable databases for intelligent vehicle highway systems." Charles R. Ehlschlaeger presented a paper (co-authored by M.F. Goodchild) entitled "Uncertainty in spatial data: defining, visualizing, and managing data errors." Michael Goodchild gave a workshop on GIS and Spatial Analysis and participated in a panel discussion on global tessellation schemes. LaNell Lucius was responsible for the NCGIA exhibit. Steve Palladino presented William Mackaness' paper "Curriculum Issues in GIS in K-12", participated in

demonstration of the ARCVIEW "Color Your World" education module, and organized and moderated "GIS in the 2-year community and technical colleges", a panel discussion.

October 25-26: Mike Batty and Hugh Calkins visited New York state Congressional Representatives and NSF program officers in Washington, DC.

October 22-27: David Mark and PhD student C.J. Cote attended GIS/LIS in Phoenix, AZ. David Mark chaired two conference sessions, and C.J. Cote worked as a Student Assistant.

October 24-28: Sam Cole attended the Third Biennial Meeting of the International Society for Ecological Economics, San Jose, Costa Rica. He chaired a session on Ecology and Economy in the Caribbean Basin and presented "Economic culture and ecology in a small Caribbean island: a short history of Aruba".

October 24-28: Ezra Zubrow attended the Third Biennial Meeting of the International Society for Ecological Economics, San Jose, Costa Rica. He presented "The everglades project: environmental economic sustainability".

October 25-27: Barbara Bicking attended GIS/LIS '94, Phoenix, AZ, and presented "A Formal Approach to Automate Thematic Accuracy Checking for Cartographic Data Sets", co-author, Kate Beard.

October 28-29: Harlan Onsrud, Kathleen Hornsby, Jeff Johnson, and Xavier Lopez attended the NCGIA Conference on Law and Information Policy for Spatial Databases, Tempe, AZ. Onsrud was the organizer of this NCGIA-Maine and Arizona State University College of Law sponsored conference. Onsrud moderated the session on "Protecting Privacy in Using Geographic Information Systems II. Johnson presented "Liability for GIS Datasets as Applied to the Commercial, Non-Profit and Other Private Sectors", Bishop Dansby, GIS Law and Policy Institute, Harrisonburg, VA, and Jeff Johnson, authors. Lopez presented "Protecting Personal Privacy in Using Geographic Information Systems", Harlan Onsrud, Jeff Johnson, and Xavier Lopez, authors.

Oct 31-Nov 4: Jennifer Robinson attended the NCAR Workshop "The Use and Misuse of El Nino Information in North America" and presented the paper "Fire and ENSO".

November 2-5: Mike Batty gave a talk entitled "Possible Urban Automata", at the International Conference on "Artificial Worlds" in the Institute of Architecture at the University of Venice.

November 2-4: Hugh Calkins visited the Desert Research Institute to discuss long term ecological research with Jordan Hastings and Robert Wharton, University of Nevada, Reno. A research proposal to NSF's Office of Polar Programs was developed after this visit.

November 2-5: Helen Couclelis participated in the international conference on "Artificial Worlds," Venice, Italy.

November 2-5: In Lexington, Kentucky, at the NCGE annual meeting, Steve Palladino gave two 90-minute "Intro to GIS" workshops for K-12. He also organized and participated in a half-day IDRISI workshop.

November 4-5: Harlan Onsrud, Barbara Bicking, and graduate students John Florence, Jeff Johnson, and Xavier Lopez, attended an interdisciplinary northeast regional conference on "NSDI - National Spatial Database Infrastructures: The Challenges to State and Local Government", Worcester, MA. Onsrud presented "An American Institutional Model: Considerations for Plan of Action", co-author, Jeff Johnson.

November 6-8: Sam Cole attended the workshop on Transportation and Regional Economic Development at George Mason University Institute of Public Policy.

November 7-10: Michael Goodchild gave a presentation on "Spatial Databases for Global Environmental Issues" at the 8th Toyota Conference, Mikkabi, Japan.

November 9-11: Max Egenhofer attended the International Workshop on Spatial and Temporal Interaction, Singapore, and presented "Commonsense Reasoning about Geographic Space and Time".

November 15-16: Hugh Calkins and Munroe Eagles met with NSF program officers and elected representatives from New York State in Washington, DC.

November 16: Steve Palladino made a GIS Presentation at San Marcos High School for GAW (with Paul van Zuyle).

November 17: Steve Palladino made a GIS Presentation to a cultural geography class at Santa Barbara City College.

November 17-19: Mike Batty, Ronald Rozensky and PhD students and others from the Buffalo center took part in the North American Regional Science Association Annual Meetings held in Niagara Falls, Ontario.

November 22-24: Michael Goodchild gave a keynote presentation, "The Bottom Line of Spatial Accuracy", at the 22nd AURISA Conference, Sydney, and presented a workshop on Data Quality with Gary Hunter, University of Melbourne.

November 30: Mike Batty visited Lee DeCola at USGS in Washington DC to discuss joint work on urban growth in the Bay Area and in the Baltimore-Washington corridor.

November 30: Mike Batty visited Fred Ducca and Ed Weiner at the FHWA, DOT, Washington DC on to discuss developments in Land Use Modeling in the light of the Clean Air Act and ISTEA legislation.

November 30-December 3: Max Egenhofer attended the Second Workshop on Advances in Geographic Information Systems, for which he served as program chair, Gaithersburg, MD. Michael Goodchild gave an overview presentation "GIS research: where does Computer Science fit in?"

December 1: Mike Batty gave two talks at the Department of Geography at the University of North Carolina at Charlotte entitled "Modeling Using GIS" and "New Ideas Concerning Urban Growth"

December 3-7: Max Egenhofer and Harlan Onsrud attended the University Consortium for Geographic Information Science meeting, Denver, CO. David Mark served as the SUNY Buffalo representative.

December 13: Mike Batty visited Len Gaydos and William Acevedo at USGS, Ames Research Center, Moffat Field, CA to discuss their work on the animation of growth in the San Francisco Bay Area.

December 12: Michael Goodchild gave a keynote presentation "An Update on GIS Research" at the Fifth Annual Nevada State GIS Conference, Reno.

December 12-13: Mike Batty visited Betty Deakin at the Department of City and Regional Planning in the University of California at Berkeley to discuss federal requirements in land use modeling.

APPENDIX 3 - VISITORS TO NCGIA SITES

Alec Derra Abrams, Hewlett-Packard
 Mike Adam, CSIR, Division of Forest Science and Technology, South Africa
 Carl Amrhein, University of Toronto
 David Anderson, LSU, Shreveport, Louisiana
 Willy Anderson, Lockheed
 Larry Ayers, Intergraph Corp
 Kenji Baba, Hitachi
 Judith Bailey, University of Maine
 Dan Barstow, TERC
 Steve Beckwitt, ESRI
 Sandi Berk, University of Ljubljana
 Jan Terje Bjorke, Norway
 Roberto Bonifaz, University of Mexico, Coyoacan, Mexico
 Patrick Bourgeron, The Nature Conservancy, Boulder
 David Boyce, Hitachi
 Scott Bridges, Stennis Space Center/Naval Research Laboratory, Mississippi
 Frank Brown, University of Manchester
 Zorica Budic, Virginia Polytechnic Institute and State University
 Colene Byrne, New York State Department of Health
 John Calkins, ESRI
 Heather Campbell, University of Sheffield
 Chris Caren, Lockheed
 Roy Chung, University of Northern Iowa
 Rose Ciotta, Buffalo News
 Jim Connolly, CH2M Hill
 Pat Conroy, Caltrans
 Frank Crossman, Lockheed
 Michael Curry, UCLA
 Sean Curry, Choice Computing/Transcom Technologies
 George Dailey, ESRI
 Daniel Dorling, University of Newcastle-upon-Tyne
 David Edson, J.W. Sewall Co
 Rob Edwards, Cabrillo College
 Griffith Feeney, East-West Center, Honolulu, Hawaii
 Manfred Fischer, Vienna University of Economics and Administration
 Paul Fisk, New York State Division of Budget
 Charlie Fitzpatrick, ESRI
 Robin Flowerdew, University of Lancaster
 Scott Freundsuh, University of Minnesota
 Kenn Gardels, University of California, Berkeley
 Tony Gatrell, University of Lancaster
 Reza Ghezelbash, GIS Consultant, Berkeley
 Francois Golay, University of Lausanne
 David Googins, New York State Division of Budget
 Richard Green, California EPA
 Daniel Griffith, Syracuse University
 Qi Guowei, Gansu Provincial Environmental Monitoring Centre, China
 Andreas Hadjirattis, Cyprus
 Robert Haining, University of Sheffield

David Hall, Martin Marietta
 Susan Haller, SUNY Buffalo
 J.W. Harrington, NSF
 Michael Harris, Stennis Space Center/Naval Research Laboratory, Mississippi
 Amy Hart, Navigation Technologies
 Ole-Jorgen Haugholt, Norway
 Joergen Haukland, Gjoevik College, Norway
 Erik Heikkila, University of Southern California
 Norbert Henninger, World Resources Institute, Washington, DC
 John Herring, Intergraph Corp
 Steve Hirtle, University of Pittsburgh
 Gary Hunter, University of Melbourne
 Tadashi Ikeda, Hitachi
 Sun Jingmin, Hebei Provincial Environmental Protection Bureau, China
 Anne Johnstone, Washington University, St Louis
 Maria Kalcic, Stennis Space Center/Naval Research Laboratory, Mississippi
 Malvin Kalos, Cornell University
 Igor Karnicnik, University of Ljubljana
 Bob Kates, President, Association of American Geographers
 Richard Keeler, CA Office of Strategic Technology
 Brian Klinkenberg, University of British Columbia, Vancouver
 Zarko Komadina, University of Ljubljana
 Victor Konrad, Canada-U.S. Fulbright Program, Ottawa
 Jerome Kreuser, World Bank
 Michelle Lachiusa, New York State Division of Budget
 Vanessa Lawrence, Longman GeoInformation
 Zhao Lechen, Sichuan Provincial Environmental Protection Bureau, China
 Mark Leipnik, Bureau of Reclamation, Las Vegas
 Clayton Lewis, University of Colorado, Boulder
 Ernie Littauer, Lockheed
 George Lo, Lockheed
 Anne Lucas, University of Bergen, Norway
 Jingsheng Ma, University of Sheffield
 Wolfgang Maass, University of Saarland
 Farrell Malkis, New York State Department of Health
 Arthur McLaughlin, Alfred Tech
 Bill Michener, Joseph Jones Ecological Research Center
 Gunnar Misund, SINTEF Group, Norway
 Helena Mitasova, CERL/University of Illinois, Champaign
 David Mooney, University of Delaware
 Cathy Mueller, ESRI
 Peggy Nelson, SUNY Buffalo
 Jeff Newman, California Trade and Commerce Agency
 Susan Nolen, Intergraph Corp
 Val Noronha, Digital Geographics
 John Odland, University of Indiana
 Tony Olsen, EPA
 Micha Pazner, University of Western Ontario
 Tomaz Podobnikar, University of Ljubljana
 Jack Quinn, U.S. Congress
 Jose Alberto Quintanilha, EPUSP, Brazil
 Robert Raskin, University of California, Santa Cruz

Steve Reed, Intergraph Corp
 Jin Rei, NEPA, China
 John Ricci, New York State Division of Budget
 Merrill Ridd, University of Utah
 Jenny Robinson, Environmental Research Center of Leipzig-Halle
 Dave Ryan, Hewlett-Packard
 Jim Ryder, Lockheed
 Peter Sandon, Dartmouth College
 Joe Sarsenski, IBM
 Vittal Shettigara, Defence Science and Technology Organization, Australia
 Charles Slivinsky, University of Missouri, Columbia
 David M. Smith, University of London
 Ronald Smith, USGS/EROS Data Center, Sioux Falls, SD
 Mirjam Stedelmann, ESRI
 Barrie Stevens, OECD, Paris
 Damjana Tavcar, University of Ljubljana
 Paris Vachon, Canada Center for Remote Sensing, Ottawa
 Rory Van Tuyl, Hewlett-Packard
 Tish Vajta-Williams, Lockheed
 Howard Veregin, Kent State University
 Andreja Vidervol, University of Ljubljana
 David Waits, Oklahoma State University
 Dan Walters, Maine Office of GIS
 Minhua Wang, LGL Limited, British Columbia, Canada
 Zhang Wei, Environmental Information Centre in Liaoning Province, China
 Shang Weihong, NEPA, China
 Shi Wenzhong, ITC, Netherlands
 Cathleen Wharton, University of Colorado, Boulder
 Denis White, Jon Kimerling, Oregon State University
 Ray Whitney, Lockheed
 Steven Wise, University of Sheffield
 Miao Xiaobo, Fujian Provincial Environmental Protection Bureau, China
 Yichun Xie, Eastern Michigan University
 Guo Xinwang, Henan Provincial Environmental Protection Bureau, China
 Zhang Yan, Jilin Provincial Environmental Protection Bureau, China
 Yossi Yaron, Israel
 Liu Yuguo, Environmental Information Centre in Jiangshu Province, China
 Shi Ziping, NEPA, China

APPENDIX 4 - COURSES TAUGHT BY NCGIA FACULTY

1. Santa Barbara

Earth from Space, Winter 1994, Catherine Gautier
 Physical Geography, Winter 1994, Terry Smith
 Socioeconomic Geography, Winter 1994, Dan Montello
 Introduction to Spatial Decision Making and Behavior, Winter 1994, Reginald Golledge
 Introduction to Meteorology, Winter 1994, Joel Michaelsen
 Groundwater Hydrology, Winter 1994, Hugo Loaiciga
 Introduction to Cartography, Winter 1994, David Lanter
 Biogeography: The Study of Plant and Animal Distributions, Winter 1994, Frank Davis
 Introduction to Geographical Data Analysis, Winter 1994, Dan Montello
 Applications of GIS Technology, Winter 1994, Michael Goodchild
 Geography Planning and Policy Making, Winter 1994, Helen Couclelis
 Introduction to Optimization Models for Geographic Problems, Winter 1994, Richard Church
 Introduction to Geographic Research, Winter 1994, Helen Couclelis & Ray Smith
 Urban Problems, Winter 1994, Helen Couclelis
 Seminar in Cartography, Winter 1994, Waldo Tobler
 Advanced Groundwater Analysis, Winter 1994, Hugo Loaiciga
 Mathematical Models in Physical Geography, Winter 1994, Dar Roberts
 Advanced Topics in Location and Transportation Systems, Winter 1994, Richard Church
 Physical Geography, Spring 1994, Dar Roberts
 Socioeconomic Geography, Spring 1994, Richard Church
 Intermediate Geographic Remote Sensing Techniques, Spring 1994, Leal Mertes
 Production Cartography, Spring 1994, David Lanter
 Land Surface Transport Phenomena in Physical Geography, Spring 1994, Terry Smith
 Cartographic Transformations, Spring 1994, Waldo Tobler
 Earth System Science, Spring 1994, Catherine Gautier
 Water Pollution, Spring 1994, Hugo Loaiciga
 Advanced Geographical Data Analysis, Spring 1994, Joel Michaelsen
 Technical Issues in Geographic Information Systems, Spring 1994, Michael Goodchild
 Seminar in Geography, Spring 1994, Dar Roberts
 Digital Techniques in Remote Sensing, Spring 1994, Leal Mertes
 Seminar in Remote Sensing, Spring 1994, John E. Estes
 Behavioral Geography, Spring 1994, Dan Montello
 Cartographic Transformations, Spring 1994, Waldo Tobler
 Earth System Science, Spring 1994, Catherine Gautier
 Advanced Geographical Data Analysis, Spring 1994, Joel Michaelsen
 Seminar in Geographical Information Systems, Spring 1994, David Lanter
 Special Topics: Geography and the Disabled, Spring 1994, Reginald Golledge
 Socioeconomic Geography, Fall 1994, Dan Montello
 Computational Concepts, Fall 1994, Terry Figel
 Environmental Hydrology, Fall 1994, Hugo Loaiciga
 Introduction to Geographic Information Systems, Fall 1994, Karen K. Kemp
 Location Theory in Geography, Fall 1994, Richard Church
 Introduction to Geographic Research, Fall 1994, Joel Michaelsen
 Seminar in Geography, Fall 1994, Reginald Golledge
 Behavioral Geography, Fall 1994, Reginald Golledge
 Seminar in Geographical Information Systems, Fall 1994, David Lanter
 Advanced Remote Sensing, Fall 1994, Dar Roberts

2. Maine

Geometry and Computer Graphics, Spring 1994, Max Egenhofer
 GIS Applications, Spring 1994, Kate Beard
 Capstone, Spring 1994, Kate Beard
 Image Processing in Remote Sensing, Spring 1994, Michael Collins
 E-911-Implementation in Small Municipalities, Spring 1994, Kate Beard
 GIS Applications - Habitat Models, Spring 1994, Kate Beard
 Spatial Concepts in Children's Literature, Spring 1994, Max Egenhofer and Scott Freunds Schuh
 GIS Theory/Implementation, Spring 1994, Kate Beard
 Engineering Databases, Fall 1994, Max Egenhofer
 Environmental Law, Fall 1994, Harlan Onsrud
 GIS Intro., graduate level, Fall 1994, Kate Beard
 Introduction to Geographic Information Systems, Fall 1994, Kate Beard
 Spatial Query Optimization, Fall 1994, Max Egenhofer
 Spatio-Temporal Reasoning, Fall 1994, Max Egenhofer

3. Buffalo

Census Data & Their Use, Spring 1994, Calkins
 Geography Seminar, Spring 1994, Cole
 GIS Algorithms and Data Structure, Spring 1994, Mark
 GIS Applications, Spring 1994, Calkins/Yuan
 GIS Design, Spring 1994, Calkins
 Maps & Mapping, Spring 1994, Mark
 Math Models in Social Sciences, Spring 1994, Cole
 Models in Urban Geography, Spring 1994, Fotheringham
 Multivariate Statistics in Geography, Spring 1994, Fotheringham
 Population Geography, Spring 1994, Rogerson
 Research Design, Spring 1994, Rogerson
 World Civilizations, Spring 1994, Batty
 Univariate Statistics in Geography, Fall 1994, Rogerson
 Geographical Information Systems, Fall 1994, Mark
 Regional Analysis, Fall 1994, Cole
 Computer Cartography, Fall 1994, Buttenfield
 Cognitive Geography, Fall 1994, Mark
 GIS Design, Fall 1994, Calkins
 Geographic Perspectives and World Issues, Fall 1994, Calkins
 Introduction to Physical Geography, Fall 1994, Woldenberg
 Maps and Mapping, Fall 1994, Mark
 Population Geography, Fall 1994, Rogerson
 Geographic Information Systems, Fall 1994, Batty

APPENDIX 5 - GRADUATE DEGREES GRANTED AT NCGIA SITES

1. Santa Barbara

WATERS, Kirk, Ph.D., Winter 1994, Monte Carlo Modeling of the Open Ocean Light Field (R. Smith, Siegel, Prezelin, Michaelsen, Dozier).

WANG, Tao, M.A., Winter 1994, Satellite-Derived Long Term Net Solar Radiation Over the Global Ocean Surface: Its Relationship to Low Frequency SST Variation and El Niño (Gautier, Michaelsen, Siegel).

BUYAN, Brett, M.A., Winter 1994, degree by examination (Davis, Michaelsen, Lanter).

VERNON, Gregory, M.A., Winter 1994, degree by examination (Goodchild, Michaelsen, Tobler).

HE, Gang, M.A., Winter 1994, Toward Understanding the Interactions Between the Atmospheric Radiation and Surface Bidirectional Reflectance: Snow Surface (Gautier, Michaelsen, R. Smith).

SORENSEN, Paul, M.A., Spring 1994, Analysis and Design of Heuristics for the P-Median Location-Allocation Problem (Church, Goodchild, T. Smith).

PETERSON, Peter, M.A., Spring 1994, degree by examination (R. Smith, Tobler, Couclelis).

van den BOSCH, Jeannette, M.A., Spring 1994, Atmospheric Corrections for Hyperspectral Airborne Imaging Spectrometer Data (Davis, Gautier, R. Smith).

VAN KIRK, John, M.A., Spring 1994, An Assessment and Analysis of Air Pollution in the Czech Republic (Loaiciga, Michaelsen, Gautier).

WHITE, Lionel, M.A., Spring 1994, A Non-relational Analysis of Buildings in the Environment and Rates of Suicide: San Diego County, California: 1990 (Golledge, Proctor, Phillip Hammond).

SCHULMAN, Joanna, M.A., Spring 1994, A Video Tour of Santa Juanita: How Viewing Angle and Perspective Affect the Salience Attributed to Landmarks (Golledge, Couclelis, Stuart Aitken).

REY, Sergio Joseph, Ph.D., Summer 1994, Integrated Multiregional Model for Systems of Small Regions (Anselin, Couclelis, Golledge, Moss Madden).

PALLADINO, Steve, M.A., Summer 1994, A Role for Geographic Information Systems in the Secondary Schools: An Assessment of the Current Status and Future Possibilities (Goodchild, Golledge, Proctor).

SVENSSON, Bjorn, M.A., Summer 1994. Cognitive Maps at Different Scales (Golledge, Montello, Lanter).

DOUGHERTY, Valerie, M.A., Fall 1994, Spatial Familiarity and Globalness of Spatial Reference Systems in Cognitive Maps of Large-Scale Environments (Golledge, Couclelis, Montello).

BYERS, Michael, M.A., Fall 1994, A Computation of Global Oceanic Net Primary Productivity from Satellite Derived Data (R. Smith, Gautier, Siegel).

GRAY, M. Violet, M.A., Fall 1994, A Digital Multipurpose Vegetation Map for the Colorado Desert of California (Davis, Goodchild, Michaelsen).

CAYOCCA, Kelly, M.A., Fall 1994, Map-assisted Spectral Characterization of a Community Ecotone for Long Term Monitoring (Estes, Davis, Proctor).

LENAY, Jeffrey, M.A., Fall 1994, A Preliminary Analysis of the Classification and Prediction of Regional Scale Vegetation Distribution Using Climatic and Edaphic Data in a Decision Tree Model (Estes, Michaelson, Roberts).

KWAN, Mei-Po, Ph.D., Fall 1994, GISICAS: A GIS-Interfaced Computational-Process Model for Activity Scheduling in Advanced Traveler Information Systems (Golledge, Church, Goodchild, McNally).

WRIGHT, Dawn, Ph.D., Fall 1994, From Pattern to Process on the Deep Ocean Floor: A Geographic Information System Approach (Interdisciplinary Program: Chair - R. Smith; Goodchild, Macdonald, Haymon, Krause).

2. Maine

BICKING, B., M.S., Geographic Information, August, 1994, A Formal Approach To Automate Thematic Accuracy Checking for Cartographic Data Sets.

BRUEGGER, B.P., Ph.D., Surveying Engineering, August 1994, A Spatial Theory for the Integration of Resolution Limited Space.

BRUNS, T., M.S., Geographic Information, August 1994, Direct Manipulation User Interfaces for GIS Map Algebra.

DOLBY, L.A., M.S., Geographic Information, May 1994, Mapping Subsurface Geology in Eastern Casco Bay Using Seismic Reflection Profiles and GIS.

FRANK, S., Ph.D., Surveying Engineering, May 1994, Cataloging Paradigms for Spatial Metadata.

HONG, J.-H., Ph.D., Surveying Engineering, August 1994, Qualitative Distance and Direction Reasoning in Geographic Space.

PARADIS, J., M.S., Surveying Engineering, December 1994, Visualization of Spatial Data Quality for the Decision Maker: A Data Quality Filter.

PULLAR, D., Ph.D., Surveying Engineering, May 1994, A Tractable Approach to Map Overlay.

SLEEZER, T., M.S., Surveying Engineering, December 1994, Direct Manipulation of Temporally Constrained Activities for Geographic Modeling.

3. Buffalo

DOWNEY, Michael Shawn, M.A., February 1994 (Calkins), A Geographic Information System Requirements Analysis for the Fish and Wildlife Service Lower Great Lakes Fishery Resources Office.

HERDENDORF, Margo, M.A., February 1994 (Mark), Design and Implementation of a Geographic Information System for Cultural Resources Management within the Soil Conservation Service.

AMITABH, Bansal, M.S., Industrial Engineering, June 1994 (Batta), Analysis of Error due to Aggregation of Demand in Location Problems.

COTE, Carmelle Jacqueline, M.A., September 1994 (Calkins), Institutional and Technological Issues for the Use of Geographic Information Systems in Environmental Management by Developing Countries.

WIESHOFER, Markus, M.A., September 1994 (Buttenfield), Temporal Issues for Geographic Information Systems.

GORSKI, Jill M., M.A., February 1995 (Calkins), An Erie County Geographic Information System Requirements Study.

MOULTON, Steven M., M.A., February 1995 (Calkins), City of Lockport Geographic Information System Requirements Analysis.

NAMWAMBA, Fulbert Leon, M.A., February 1995 (Mark), The National Museums of Kenya Geographic Information System Requirements Study.

PARKANSKY, Steven R., M.A., February 1995 (Buttenfield), The Creation of a Digital Data Base of Natural Gas Wells.

PLEWE, Brandon S., M.A., February 1995 (Buttenfield), The GeoWeb Project: Using WAIS and the World Wide Web to Distribute Spatial Data.

SZCZESNY, Antoinette A., M.A., February 1995 (Calkins), A Scheduling and Routing Application Proposal for the Erie County Water Authority.

SMITH, Betty, Ph.D., June 1994 (Fotheringham), Urban Morphology in South America.

XIE, Yichun Xie, Ph.D., September 1994 (Batty), Analytical Models and Algorithms for Cellular Urban Dynamics.

YUAN, May, Ph.D., September 1994 (Mark), Representation of Wildfire in Geographic Information Systems.

ZHAN, Feibing, Ph.D., September 1994 (Mark), Spatio-temporal Location Models of Mobile Trading and the Organization of Periodic Market Places.

PITTS, Timothy, Ph.D., September 1994 (Rogerson), Inter-port Competition and Cargo Tributary Areas for International Containerized Exports from the United States.

WENG, Richard, Ph.D., September 1994 (Rogerson), The Parent-Child Relationship in U.S. Society: An Integrated Socio-geographic Study.

CHATTIN, Linda L., Ph.D., September 1994 (Batta), Maximizing Expected Coverage Using State Sensitive Dispatch Assignments.