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*NATIONAL CENTER FOR GEOGRAPHIC INFORMATION
AND ANALYSIS*

ANNUAL REPORT

Year 7
(January 1, 1995 - December 31, 1995)

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

30 March 1996

NATIONAL CENTER FOR GEOGRAPHIC INFORMATION AND ANALYSIS

ANNUAL REPORT

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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 seventh full year of operation. Three research initiatives were closed: Formalizing Cartographic Knowledge (I8, begun in October, 1993); Institutions Sharing Geographic Information (I9, begun in February 1992); GIS and Spatial Analysis (I14, begun in February 1992). Two major new research initiatives were begun, on Multiple Roles for GIS in US Global Change Research (I15), and on Collaborative Spatial Decision-Making (I17), and a third was in the advanced stages of planning for its specialist meeting (I19, GIS and Society: The Social Implications of How People, Space, and Environment are Represented in GIS, the first NCGIA research initiative to be planned mostly outside the center's three institutions). Education programs continued to be directed to K-12, GIS in the community colleges, and the development of new curriculum materials in GIS and remote sensing. Two collaborative projects were initiated under the Collaborative Grants program, and the Visiting Scholars program continued to support the work of visiting researchers at NCGIA sites. The program of collaboration with the European Science Foundation's GISDATA program continued, and the first joint Summer Institute for Young Scholars was held in Maine.

Active collaboration continued between NCGIA and the Alexandria Digital Library project, and the semiannual meeting of the NSF/ARPA/NASA Digital Library Initiative was held in Santa Barbara in November. NCGIA also participated in the establishment of the National Center for Ecological Analysis and Synthesis at Santa Barbara.

The University Consortium for Geographic Information Science was founded. All three members of the NCGIA consortium were among the roughly 30 founding institutions to join the consortium in 1995.

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 seventh year's operation began officially on January 1, 1995. 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, and are available through the Center's main web site (http://www.ncgia.ucsb.edu).

In November, 1995, a new proposal to NSF entitled "Advancing Geographic Information Science" was submitted to NSF on behalf of NCGIA. It requests funding for three years beginning in January 1997.

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.

NCGIA (1992) *A Research Agenda for Geographic Information and Analysis*. Technical Report 92-7. Santa Barbara, CA: National Center for Geographic Information and Analysis.

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 the establishment of a Steering Committee including the initiative leaders, and others prominent in the field from outside the three Center institutions. The committee plans a specialist meeting, to be attended by professionals from outside the Center, selected by invitation following an open call, 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 Year 7 two new initiatives were begun, and three were completed, leaving a total of four active initiatives at the end of year 7:

10. *Spatio-Temporal Reasoning in GIS*. Co-Leaders: Reginald G. Golledge (Santa Barbara), Max Egenhofer (Maine). Specialist Meeting: Lake Arrowhead, CA, May 1993.

15. *Multiple Roles for GIS in US Global Change Research*. Co-Leaders: Michael Goodchild, Jack Estes (Santa Barbara), Kate Beard (Maine), Tim Foresman (University of Maryland, Baltimore County). Specialist Meeting: Santa Barbara, CA, March 1995.

16. *Law, Public Policy, and Spatial Databases*. Co-Leaders: Harlan Onsrud (Maine), Robert Reis (Buffalo). Specialist Meeting: Tempe, AZ, October 1994.

17. *Collaborative Spatial Decision-Making*. Co-Leaders: Paul Densham (University College, London), Marc Armstrong (University of Iowa), Karen Kemp (Santa Barbara). Specialist Meeting: Santa Barbara, CA, September 1995.

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 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.

A Workshop on Progress in Map Generalization was held in Barcelona Spain 1-3 September 1995. The workshop was jointly sponsored by NCGIA, European Science Foundation (ES), Institut Geographique National (IGN-Paris), Institut Cartographic de Catalunya (ICC), and the Canadian Centre for Remote Sensing (CCRS). Workshop Steering Committee Members include Robert Weibel, Univ. Zurich, Jean-Phillipe Lagrange, IGN-Paris, Josep Luis Colomer, ICC, Bob McMaster, Univ. Minnesota, Diane Richardson (CCRS) and Barbara Buttenfield, NCGIA-Buffalo. Thirty researchers and practitioners (spanning eleven countries) participated in the workshop. The three main topics at the workshop were 1) quality assessment of design alternatives, 2) formalizing various types of knowledge in the generalization process, and 3) conflict detection and resolution for cartographic features. The meeting concluded by identifying several key research tasks. A report comprising the position statements, discussions and

research agenda from the three day meeting will be published as an NCGIA technical report.

Publications resulting from Initiative 8 include the research volume *GIS and Generalization: Methodology an d Practice*, published by Taylor and Francis. The book forms part of the GISDATA series. Editors include I8 steering Committee Members Jean-Claude Muller and Rob Weibel. Authors whose chapters extend to work presented at the I8 Specialist Meeting include (alphabetically) Barbara Buttenfield, Chris Jones (U. Glamorgan), Bob McMaster (U. Minnesota), Jean-Claude Muller (U. Bochum), Tiina Kilpalainen and Tapani Sarjakoski (Finnish Geodetic Institute), and Rob Weibel (U. Zurich). A special issue of *Cartography and GIS* (Editor, Bob McMaster; Associate Editor, Barbara Buttenfield) will be guest edited by Robert Weibel, on I8 topics. The issue is expected to be in print by year's end.

In Buffalo, efforts relate to various aspects of knowledge elicitation for the Alexandria Digital Library Project, and to data delivery over distributed networks. Doctoral student Brandon Plewe continued his implementation of Mosaic-based map indexing tools, expanding upon his earlier GEOWEB project. Another doctoral student, Ming Tsou, helped postdoctoral researcher Chris Weber to build an Access database for Alexandria user evaluation. In March Geoff Dutton spent two weeks in Buffalo as a consultant to the Alexandria Project. He developed a hypertext browser for the FGDC's Metadata Content Standard. Much of activity on the Alexandria Digital Libraries Initiative during the first part of 1995 was devoted to creation of a CD-ROM version of the Library and to creation of an online tutorial and questionnaire to be distributed with the CD-ROM. Pre-testing was carried out to guide refinement of the questionnaire, and versions of the tutorial were created for both the UNIX and Windows versions of the Library. September 6-8, 1995, the First Alexandria Design Review Workshop held in Leesburg, Virginia; the workshop was coordinated by Barbara Buttenfield, NCGIA-Buffalo.

In Zurich, Rob Weibel's research team continues to formalize knowledge elicitation through interactive logging and machine learning. Current focus relates to the use of graphical interface tools for selection of algorithms and of tolerance parameters. Projects on knowledge elicitation were presented at the International Cartographic Association meetings in Spain in August. Rob is also editing the *CAGIS* special issue.

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.

Initiative 9 was brought to closure in 1995. Its closing report will be submitted to the Board of Directors during Spring 1996.

The Initiative had several findings in 1995. Most significant was the result of a study to evaluate criteria for identifying high priority framework data sets for the National Spatial Data Infrastructure. As input to the process of formulating framework data sets there was a need to identify which sets of geographic and land data are being used and who is using them. There was also a need to discover if these data sets meet the expectations of those who are using them. NCGIA researchers and a focus group conducted a mail survey to pursue these questions. The following findings are out of context and the full report should be consulted prior to drawing any inferences from them.

Of those respondents that used GIS or products generated from GIS, transportation feature data was

used or needed by 91.9% of the respondents while 85.3% used or needed water feature data, 83.3% used or needed other well-defined cultural feature data, 70.6% used or needed elevation data, 80.9% used or needed land parcel data, and 94.3% used or needed jurisdictional boundary data. In each of the data categories, people responded that they needed better data by a three to one margin.

Many current GIS users appear to be using GIS across more than one disciplinary application area. An average number of almost ten applications were cited per user. Differences in user requirements appear to vary with the application, and are documented in the reports of the study, which include a paper in press in the *Journal of the Urban and Regional Information Systems Association*.

Work by Steven Frank at the University of Maine in investigating cataloging paradigms for spatial metadata was completed. "Cataloging Digital Geographic Data in the Information Infrastructure: A Literature and Technology Review" was published in *Information Processing & Management* and "The National Spatial Data Infrastructure: Designing Navigational Strategies" in the *URISA Journal*. Steven's PhD "Cataloging Paradigms for Spatial Metadata" is available by ftp at the Maine site.

Wrap-up findings of the various research efforts undertaken in affiliation with Initiative 9 were reported in two sessions on Institutions Sharing Geographic Information at the 1995 annual URISA conference in July. The first session included presentations on the survey of user requirements for framework GIS data, a review of GIS organizational and implementation research, approaches for sharing geographic data among scientists, and developments in sharing geographic data for transportation purposes. The second session focused on a range of social science studies that have addressed implementation, organizational, and institutional impediments and incentives to the sharing of geographic information. Presentations on I9 research were made by Harlan Onsrud (Maine), Steven Frank (New Mexico State University), Michael Goodchild (Santa Barbara), Gerard Rushton (University of Iowa), Rick Weatherbe (Buffalo), Jeff Pinto (Penn State Erie), Zorica Budic (University of Illinois), and Bijan Azad (GIS/Trans Ltd). The book *Sharing Spatial Data* edited by Harlan Onsrud and Gerard Rushton and containing papers developed from the I9 specialist meeting appeared.

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.

During 1995, Initiative 10 continued its progress on a number of dimensions. We held several national and international meetings to promote the issues of spatio-temporal reasoning and to disseminate the findings of our research. On the research side, work focused on the development and testing of cognitively plausible models for natural-language terms; the development of formal models to assess consistency and derive change; and models for reasoning about spatial relations. We received complementary funding to extend some of this work beyond the initial scope of the initiative. A web page was developed for I10 (http://www.spatial.maine.edu/~max/i10.html), including an html version of the Specialist Meeting Report.

Initiative 10 was very prominent at the 1995 AAG meeting; the Fourth International Symposium on Large Spatial Databases, SSD '95; and the Conference on Spatial Information Theory, COSIT '95. At the 1995 AAG Meeting in Chicago, Dan Montello (UC Santa Barbara) and Scott Freundschuh (University

of Minnesota-Duluth) organized an interdisciplinary session entitled: "The Nature and Nurture of Map Skills: Culture, Innateness, and Development" (Environmental Perception and Behavioral and Cartography Specialty Groups). Papers from the 1994 AAG session have been collected and were published in a special issue of *Geographical Systems*, edited by Dan Montello (UCSB) and Scott Freundschuh (University of Minnesota - Duluth). Scott Freundschuh also organized a well attended AAG session on "Concepts of Geographic Space" with papers by Couclelis, Peuquet, and Freundschuh and Egenhofer; Mark was a discussant.

For the Fourth International Symposium on Large Spatial Databases, SSD '95, Egenhofer served as General Chair. From among 60 submissions of full papers, the international program committee selected 23 papers. A full session included papers on Reasoning about Spatial Relations, including a paper by Sharma and Flewelling, graduate research assistants at Maine. Proceedings were published in Springer-Verlag's *Lecture Notes in Computer Science* series. The program also included a tutorial on Spatio-Temporal Information Systems (by Mike Worboys, participant at the I10 Specialist Meeting).

For the Conference on Spatial Information Theory, COSIT '95, Mark served as co-chair (with Frank and Kuhn, Vienna). Out of the 70 full papers submitted, 27 were selected for inclusion in the program. It included several sessions on Spatial Reasoning and Temporal Reasoning with papers by Egenhofer, Golledge, Mark, Montello, B. Smith, and Papadias on results of I10 research, as well as Bruegger and Yuang who are former NCGIA graduate assistants, as well as I10 participants Cohn, Freksa, Hirtle, and Worboys. Proceedings were published in Springer-Verlag's *Lecture Notes in Computer Science* series. Egenhofer and Mark also participated in the *SpaceNet* meeting, which is a network of European Space-Time researchers, led by Tony Cohn (University of Leeds) and Christian Freksa (University of Hamburg). Egenhofer gave an invited talk on Qualitative Details for the Definition of Natural-Language Spatial Relations between Lines and Regions.

Another meeting with I10 participation was the *International ACM Workshop on Advances in GIS*, held in Baltimore, MD, in December 1995. Nectaria Tryfona, post-doctoral research associate at Maine, presented Geographic Applications Development: Models and Tools for the Conceptual Level, and Dimitris Papadias presented Collaborative Spatial Decision Making with Qualitative Constraints, co-authored with Karacapilidis and Egenhofer. This paper showed the link between collaborative decision making (Initiative 17) and formal methods for spatial inferencing (Initiative 10).

The collaboration with Gould, Comas, and Nunez (all Spain), with additional funding from a NATO grant, on "Cross-Cultural Differences in Spatial Concepts: Application to Spatial Information System Use" continued with a meeting in Spain in Spring '95 (Mark and Freundschuh visiting) and a mini-symposium at Maine in June '95 (Gould, Comas, and Nunez visiting). 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, and complements other research in this area. The result from the first meeting was a comprehensive research plan and a refereed paper that was presented at COSIT '95. During the Fall semester, David Mark was on sabbatical, visiting several universities and research organizations in Europe and continuing his research on spatial relations. Mark spent a week with Mike Gould (University of Extremadura), collecting human-subjects data on prototypes for prepositions and also for verbs of motion. He also spent a week at the Technical University of Vienna working on the same project, and three days with the Cognitive Anthropology Group at the Max Planck Institute for Psycholinguistics in Nijmegen, Netherlands, where he discussed cross-cultural work on spatial cognition and language.

Significant results of our research into fundamental properties of space include:

- We found that natural-language spatial relations between geographic objects conceptualized as a line and a region can be grouped into the main categories of inside, outside, through, goes to, enters, and along.

- Through the combination of direction- and topological reasoning we found a new method to derive spatial information that is impossible to be inferred from pure topological relation-reasoning, or from combinations of cardinal directions alone.

- We developed a comprehensive formal model to assess the consistency of the spatial relations with objects that change their structure through aggregation from parts to a composite object. It shows that about half of all possible cases can be decided from the mere knowledge of the relations with the parts, while the other half of the situations require additional, at times detailed, knowledge in order to infer uniquely the relation with the composite object.

- We found a small set of operators that are sufficient to describe the transition between two topological relations. These change operations serve as a foundation to formalize similarity.

Dr. Bob Rugg (Virginia Commonwealth University) participated in the Visiting Scientists program and spend 2 months at Maine. He worked with Egenhofer and Shariff (graduate research assistant) on "Operational Definitions of Feature Types". Rugg extended Kuhn's earlier work on the formalization of a geographic feature type such as a dam and demonstrated how algebraic specifications can capture the behavior of feature types. An implementation was done with MacGopher, a functional specification language. A paper is under review with a refereed journal.

At UCSB Mei-Po Kwan and Reginald Golledge presented a paper at the Annual Meetings of the Transportation Research Board in Washington DC entitled "Integration of GIS with Activity-based Model in ATIS". Scott Bell completed a Masters thesis titled "Cartographic Presentation as an Aid to Spatial Knowledge Acquisition in Unknown Environments" and read a paper at the annual meetings of the AAG titled "Strip Maps and Spatial Knowledge Acquisition in Unknown Environments". At the end of Winter Quarter, Mr. Rob Kitchin of the University of Swansea visited both SUNY Buffalo and Santa Barbara campuses on I10 related topics and will be applying for funding to visit the Santa Barbara campus for a more extensive visit during 1995-96 academic year. Reginald Golledge, Valerie Dougherty, and Scott Bell had a paper published in the May 1995 *Annals of the Association of American Geographers* titled "Survey versus Route Based Knowledge". Also at Santa Barbara, Danette Coughlan began work on the design of a system for determining instantaneous water depth based on hydographic and tidal data, and the appropriate data models.

A book with papers developed from the I10 Specialist Meeting, and edited by Golledge and Egenhofer, is expected to be published by Oxford University Press in 1996.

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.

The first specialist meeting for I15 was held on March 9-11, 1995, at the Upham Hotel in Santa Barbara, California. It was attended by fifty participants from several domains of the global change research community. Participants consisted of invitees as well as participants selected from an open call. The open call was intended to target young researchers, researchers with interest in linkages between human and physical systems, researchers with international links, and researchers who could provide specific examples of the strengths and weaknesses of GIS in global change research.

The structure of the meeting was organized by the Steering Committee. Members of the committee include:

Frances Bretherton, University of Wisconsin
Bob Corell, NSF
Jeff Dozier, UC Santa Barbara
Jerry Garegnani, NASA
Catherine Gautier, UC Santa Barbara
Dave Kirtland, USGS
Barrien Moore, University of New Hampshire
Roberta Miller, Director of CIESIN
John Townshend, University of Maryland
Peter Thacher, World Resources Institute
Cort Willmott, University of Delaware

The Steering Committee identified eight topics which were felt to be significant in clarifying areas where research is needed to improve the ability of GIS/GIA to contribute to the US global change research program. These topics included:

Atmosphere, climate
Oceans, Ocean-atmosphere coupling, coasts
Biogeochemistry
Hydrology, water
Ecology, biodiversity
Demography, population, migration
Production, consumption
Policy, decision-making

Participants for the meeting were selected to cover these eight topical areas. Each participant submitted a two page position paper on the advantages and impediments of current GIS/GIA for global change. Key topics which emerged from the participant position papers included:

- access, libraries, metadata
- institutions, cultural, social
- scales, hierarchies
- interoperability, standards
- data models
- system requirements
- data resources
- time
- education
- georeferencing, tesselations
- science data policy
- visualization

During the meeting small groups were formed to discuss three main topics: 1) data access, 2) representation/analysis and 3) communication/integration. Each of the three groups were tasked with identifying impediments to the use of GIS for global change and a set of researchable topics to address these impediments. Some of the key research topics identified included:

- Integrating GIS with user-based or user-defined models;
- Inclusion of temporal analysis and links to spatial statistics.
- Uncertainty representation
- Research on describing change
- Reconciling different descriptions of space.
- User interface issues and the interoperability of analysis functions among systems.
- Research on aggregation and generalization of data.
- Development of distributed systems in which both data and analysis tools will be distributed.
- Integration of data from different sources and scales.

Substantial intellectual progress was made as an outcome of the specialist meeting. Many of the pertinent research topics were predicted prior to the meeting but the meeting served to clarify these issues and refocus priorities. In particular issues of interoperability appeared as major impediments for representatives from all disciplines. Issues of interoperability were broadly identified as including those: (a) among disciplinary domains; (b) among GIS analysis tools and models; (c) between scales (time and space); (d) between data structures (for example between raster and vector data structures); (e) among distributed systems; (f) among user communities (scientist, policy makers, public); and (g) across space - time referencing systems. Representation of uncertainty and error propagation was identified as a cross cutting theme in which the focus would be on uncertainty or errors associated with interoperability (e.g. the loss of information in the transformation between data structures or the potential loss of information in reconciling concepts from different domains. As change is the operative word in global change research, it was interesting to note the dearth of methods for robustly modeling, quantifying, and predicting change and this was identified as a key area for collaborative research.

The report for this first specialist meeting has been completed and is being distributed as NCGIA Technical Report 95-10. It includes summaries of the discussion and conclusions, and the position papers prepared by the participants. It identifies the major foci of center research during the active phase of the initiative as: data models, particularly the harmonization of spatiotemporal data models from the GIS and modeling communities; interoperability, interpreted at multiple levels from systems to data; the global population database and its associated methodologies; global spatial data policy; digital library research and access mechanisms to spatial data, particularly models of metadata formulation and use; and education linkages. In addition an annotated bibliography on GIS and Global Change has been developed by Ashton Shortridge at UCSB and is available as a technical report.

Several research activities are under way at all three sites on topics identified in the specialist meeting. In the area of spatial metadata, we have determined that the 1:1 mapping between information object and record that exists in traditional catalogs must be generalized to allow for 1) radically different concepts of information granularity inherent in geographic seamlessness and the formal data model descriptions required for interoperability; 2) the need to treat metadata as an attribute both of data custodian and of data user. In November 1995 a one-day intensive workshop on metadata in association with the semiannual meeting of the Digital Libraries Initiative was held in Santa Barbara. Thirty participants were drawn from the geospatial data, cataloging, and metadata standards communities. A wide range of issues was discussed, and the results will be assembled in a report.

In the area of global spatial data policy, we have developed a taxonomy of data types to use as a framework for discussions of such case studies as the international exchange of meteorological data. At Santa Barbara, Jack Estes continues his involvement in international policy development with respect to global topographic and thematic mapping. Also, John Felkner has been focusing on the scientific data transfer issue. Specifically, he is examining international proposals to charge money for meteorological and other scientific data. John interviewed many individuals in the federal and international geospatial data communities in Washington in September, and has developed a first draft of his study on global spatial data policy, using the WMO as a case study. Ashton Shortridge is studying data pricing issues as well – in particular, spatial data, including remotely sensed imagery. Price is related to value, which is a function of area, resolution, data quality, processing, and time. This relationship must be straightforward and transparent to the purchaser in the interface used to identify and download the data. Mike Goodchild in October held discussions with several European groups with a view to developing joint projects demonstrating interoperability of geospatial data catalogs.

A visiting researcher at Santa Barbara, Harumi Yanagimachi, is investigating how GIS can be used to study interannual snow depth fluctuation in Japan, and whether the technology can help clarify the difference between years of varying snowfall. Another visiting researcher, Cort Willmott, has been working with Robert Raskin to develop a conceptual design for a general purpose toolkit for spatial interpolation on the sphere. The design is being implemented by a team that includes Terry Figel, system manager, and Chris Funk.

At Maine, as part of the BASIN project, a local digital spatial library, the archive is being expanded to include research data sets generated by members of the Quaternary Institute involved in global change research. One of the research issues here is to develop a metadata model that in particular supports assessment of the varying quality of the data sets. Some of the climate records are based on anecdotal evidence as well as actual observations. The metadata should allow for assessment of these differences preferably before retrieval. Bheshem Ramlal, a Ph.D. student at Maine, is working on a data quality model for soils called a mixed variation model. It develops a compromise solution between the object/map unit model in which soils are modeled as classes and the continuous field model in which individual soil properties are modeled as smoothly continuous fields. The mixed variation model departs from the discrete soil class model but recognizes that many soil properties can exhibit sharp discontinuities which are not well modeled by standard geostatistical methods.

Work on the Alexandria Project for development of a Digital Spatial Library continues to make progress on data access issues, including user interface development to expedite spatial search for data, database development for data and metadata, compression of image data for browsing, and fast retrieval for large data sets.

After attending the first I15 workshop, Jenny Robinson returned to the task of working up an informal needs assessment relating to geographical information analysis and management in global change research. This is planned to result in a review paper based on literature review and discussion with key individuals. Robinson and Zubrow collaborated on setting up an environment for exploration of methodological issues relating to the integration of polygon-based social accounting data with gridded and point data from the physical, environmental, and biological sciences. This will expand upon work previously done by Waldo Tobler and associates. Using Interactive Data Language, Robinson wrote a

series of routines to 1) generate rasterized renditions of continuous synthetic surfaces; 2) generate rectangular and irregular (Delaunay) polygon meshes; 3) overlay polygons on the synthetic surfaces and compute polygon averages and geographical centers; 4) interpolate among/between polygon centers using ordinary kriging, and linear and quintic polynomial interpolations; and 5) do statistical comparisons of surfaces reconstructed using interpolation to the original (synthetic) surface. Some of the results of this research were presented in November 1995 in Leicester, England at an EU sponsored meeting on the use of GIS in environmental reconstruction and in Durham, England at a meeting of the GLOBUS project. Robinson and Zubrow are writing up the material presented for a pair of edited volumes, and writing up the experiment in general for a journal article on polygon interpolation.

The Buffalo site has received the generous donation from L. Jordan III of several ERDAS IMAGINE 8.1/8.2 licenses. In the Spring of 1995, Robinson, with the assistance of Ron Rozensky and David Howes, worked on integrating the use of the software into the teaching of remote sensing at SUNY Buffalo. Ling Bian will continue to use the software in teaching and research in the coming year.

In Fall, 1995 Buffalo PhD student Aleksey Naumov assisted Ling Bian with preparing data for a hydrological modeling project for the Republican River Basin in Kansas. The project investigates the effect of scale on the outcome from a hydrological model. Kelly Pew, a graduate student at Buffalo worked with Dept. of Geography Asst. Prof. Chris Larsen on a project analyzing the spatial distribution of wildfires on Vancouver Island. The purpose of the study is to propose more effective management strategies to combat the negative economic and environmental impact of forest fires.

The data modeling issues raised during the first specialist meeting will be the topic of the second specialist meeting to be held in Santa Fe, New Mexico in January 1996. The first meeting identified geographic data modeling as a key theme underlying many of the issues impeding the use of geographic information technologies in global change research. Approximately 20 people are being invited to this second meeting to address a series of specific questions arising from the first in this general area. The invited participants to the second I15 meeting include GIS specialists, particularly in the areas of data modeling; global change researchers with particular interest in data models; and GIS vendors.

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.

The major activities in 1995 have been steady progress on research and preparation of two major publications arising from the specialist meeting. An overall web page for this initiative has been established at http://www.spatial.maine.edu/I-16/I-16_home.html. In addition to the proceedings, this site provides access to papers prepared by I16 researchers, a legal and information policy bibliography, and links to related legal index sites.

The first publication is the issue of *Jurimetrics: The Journal of Law, Science, and Technology* of the American Bar Association. The volume begins with an introduction article by Harlan Onsrud and Robert Reis reviewing the range of legal issues confronting the GIS community. This is followed by articles on (1) copyright of electronic maps by Dennis S. Karjala, College of Law, Arizona State University, (2) experiences in private sector provision of access to government data in the legal and medical communities by Anne Wells Branscomb, Program on Information Resources Policy, Harvard University, (3) legal and economic arguments against governments selling GIS data by Henry Perritt, Villanova University School of Law and (4) the research agenda developed from comments and working group sessions at the specialist meeting.

The second publication is the "Proceedings of the Conference on Law and Information Policy for

Spatial Databases". This bound volume incorporates most of the papers and talks presented at the specialist meeting. The papers in this compilation were reviewed on a more informal basis and revised prior to incorporation. The bound volume of the proceedings was published by NCGIA at the University of Maine in October ($35 U.S. including mailing, add $10 for overseas shipping) and most of the articles also have been made available on the web server at Maine - http://www.spatial.maine.edu/tempe/temp94.html.

A brief, one page questionnaire survey of 211 local governments in the U.S. provided responses from approximately 90 local government GIS agencies. Results indicate that more than 70% of the GIS agencies responding were either charging for data or restricting secondary uses of data, while only slightly more than 20% of agencies were disseminating data at marginal costs with no restrictions. As a follow-up to this work, Judy Winiecki used the previously prepared questionnaire with some additional questions to do a more concentrated survey of government GIS agencies and users in Minnesota. Judy is head of the Survey Division of the Minnesota Department of Natural Resources and has financed her work for the past 9 months with NCGIA at the University of Maine through a Bush Fellowship grant. The results of her state-level survey are being combined and contrasted with the national-level sample and will be reported in an upcoming *URISA Journal* article. Through the case study and survey work to date by Onsrud, Johnson, and Winiecki, we have confirmed a strong movement towards implementation of "cost recovery" and "revenue generation" policies by local and state government agencies in the U.S. in developing their geographic information system databases. Yet the same case study and survey research indicates that few if any agency GIS operations are generating or can expect to generate more than a very small amount of revenue in proportion to expenditures from the sale of spatial data collected for government purposes (exceptions were found in a few cases involving payments to local governments by ratepayer-supported public utilities). The primary benefit for local government agencies in selling technical data appears to be in the bargaining leverage that a revenue generation approach provides in arranging data sharing arrangements with other government and quasi-government agencies. If alternative means of addressing inter-governmental "free rider" issues could be developed, this NCGIA research suggests that the trend by local governments towards increased restrictions on technical and scientific data might be stemmed.

Jeff Johnson's master's thesis research yields several interesting conclusions regarding information policy adoption, implementation, and results in local government GIS agencies. Among the three open access and three cost recovery case studies, there is a strong correlation between mandates and information policy. Of the three open access cases, two agencies have mandates that emphasize improving government efficiency *and* serving the public. Conversely, the three cost recovery case studies all have mandates that solely focus on governmental efficiency, with no mention of the public. GIS agencies that consider the public to be a stakeholder in the GIS appear to be more likely to adopt an open access policy, while agencies with emphases on government efficiency alone appear more likely to adopt cost recovery policy. A second interesting observation is of the results of cost recovery policy in the three cost recovery case studies. Two of the three cases are recovering virtually no funds, while the third cost recovery site is recovering significant funds. Based on this small selected sample, adoption and implementation of a cost recovery policy does not appear guaranteed, or even likely, to recover the expected level of funds. Thirdly, one of the strongest expressed reasons for following a government agency policy of restricting access to GIS data was the advantage that a revenue generation policy gave in negotiating data or cost sharing partnerships. One open access county GIS agency is currently unable to share data with the largest city in that county because the city GIS has a cost recovery policy. The city is demanding $80,000 per year or a $700,000 purchase of the data, rather than agreeing to accept updates and improved data in return for that data. Such differences in policy may be constraining data sharing among many local and regional government GIS agencies in the U.S. In this specific instance, the county is now considering adoption of a cost recovery policy as a defensive means to place them in a better negotiation relationship with the city. Local government GIS agencies across the U.S. may be adopting cost recovery primarily to improve negotiating position for data or cost sharing partnerships with other public agencies or with private firms. In addition to these and other results, Jeff Johnson's research identifies several areas of important future work. The most important issue may be partnerships: how can data and cost sharing be encouraged among public agencies while providing an atmosphere of free public access to government's spatial data? Surveys of a broader sample of GIS agencies should be undertaken. Finally, mechanisms for improving the efficiency of providing public access should be researched and developed. Potential considerations for

providing efficient access would obviously include the internet and digital libraries.

Xavier Lopez, PhD candidate at Maine, 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. His focus is primarily on the policies of national mapping agencies and the effects of those policies. In furtherance of his research plan he has interviewed over 50 personnel at numerous mapping agencies in Canada, the U.S. and Europe. His proposal was one of two recently selected as Best Proposed Research by the International Geographic Information Foundation and he received an NSF Dissertation grant to help cover the travel and survey expenses related to the grant. He has also received a Ford Fellowship in support of his work.

Harlan Onsrud presented a talk on "Copyright Protection for Multi-Media Products" at the Maine Multi-Media Conference on February 14 and presented another talk on "Unanswered Questions in Copyrighting Spatial Databases" at the ACSM/ASPRS Convention in Charlotte N.C. on February 28. Harlan Onsrud, Jeff Johnson, and Xavier Lopez presented a session on May 22 to College of the Atlantic faculty and students on legal and economic issues surrounding the protection and sharing of geographic data in Bar Harbor, Maine. Harlan Onsrud, Jeffrey Johnson, and Xavier Lopez received the ESRI first place award for best scientific paper in geographic information systems at the ASPRS 1995 annual convention for their paper "Protecting Personal Privacy Using Geographic Information Systems", *Photogrammetric Engineering and Remote Sensing* 60(9):1083-1095, September 1994.

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 focusing on an international study and spent several short periods at the University of Maine to interact with personnel working on similar topics. Ms. Cote also presented a lecture on the legal and policy issues related to geographic information systems at the SUNY Buffalo Law School, and prepared the paper "Legal and Information Policy Issues for Spatial Databases". The abstract of the paper was included in the proceedings of the AfricaGIS'95 Conference, Abidjan, Ivory Coast, 6-10 March 1995.

Paul Schroeder, with current graduate degrees in Political Science and Library Science, entered the PhD program at Maine in September 1995. He is working on Initiatives 16 and 19 research with Harlan Onsrud. His research focuses on effective end-user access to electronic data sources and his approach serves as a counter-approach to studies of network deployment and the development of centralized information services. The role of GIS is pivotal in this work, both as a tool to evaluate the distribution of information services and as an example of the advanced information systems to which the general public will increasingly expect access. In May 1995, the Maine Public utilities Commission initiated a process that may result in a data network serving all school facilities and public libraries in the State of Maine. Paul's extensive efforts throughout the PUC hearing process were critical in designating $4 million per year for the next five years to establish this network. His dissertation work on end-user access models will utilize the ongoing experiences in increasing access to GIS technology, datasets and other information resources in Maine's libraries and schools. Paul also is currently coordinating a workshop for state legislators on telecommunications and information policy, in conjunction with the Margaret Chase Smith Center for Public Policy, University of Maine. He coordinated panels on public access for the Maine Government Technology Conference in September and continues to represent Maine state libraries in the development of a state-wide schools and libraries data network.

Initiative 17: Collaborative Spatial Decision Making (begun September 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.

The Specialist Meeting was held in Santa Barbara September 16-19, 1995. The organizers sought to bring together a wide range of researchers from academia as well as from the public and private sectors. In particular, the organizers encouraged the participation of researchers with interests in linkages between GIS and group-based decision-making, researchers with international links, and researchers who could provide specific examples of the strengths and weaknesses of GIS in CSDM research.

Fifteen of the external participants were affiliated with universities in 5 countries (US, Canada, UK, Germany and Switzerland). Two of the participants work for US private corporations (one of these has recently moved to an academic position, but retains a part-time relationship with his prior employer). Three participants work for US public sector agencies. Two additional international participants (David Grimshaw, UK, and Paul Hendriks, the Netherlands) were not able to attend at the last minute, but as their position papers were included in the set reviewed by others they are included in the specialist meeting report (Technical Report 94-14).

During the course of the specialist meeting, participants developed a research agenda for CSDM which centers around two major themes: tool development, and tool use. Research questions that relate to tool development can be grouped into those concerned with assessing and defining the tool requirements of individuals and groups, those that seek to exploit developments in cognate fields, and those that focus on the peculiarly spatial aspects of CSDM. In the case of tool use, research questions can be grouped into those that examine representation, those that seek to assess the effectiveness of CSDM software, and those that are concerned with the roles of users and mediators during CSDM and how they relate to different forms of CSDM software.

One of the outcomes of the specialist meeting is that a cadre of researchers have discussed the impediments to the widespread adoption of CSDM and have developed a common understanding of the magnitude and relative importance of these impediments. This shared understanding provides a starting point for research under the aegis of the Initiative. Many of the participants were working on parts of this agenda before the specialist meeting, others have indicated that they will adopt elements of it in their own research. A WWW server is planned to help these researchers coordinate their work and to be informed of what others are doing.

It is important to note that the formal termination of the initiative (currently planned for the summer of 1997) will not signal the end of research on CSDM. Rather, the research carried out during the life-span of the initiative will further refine the research agenda and make it accessible to a wider research community.

At UCSB, a small working group has been formed to continue work on topics related to this research initiative. This working group has defined six major research areas in Collaborative Spatial Decision Making resulting from discussions at this meeting. Most of these research areas are not unique to the spatial domain, but their solutions in the spatial domain require modification of existing models and development of new models and model interfaces. To address some of these research themes, the following research is planned at UCSB:

1. Identify and formalize the geographic conceptions of problems inherent in the interests of participants in multiparticipant decision situations. This may use a variety of methodologies including experimental techniques, ethnographic techniques and other methods for analyzing text or discourse. Initially, research will focus on land use debates because they pose the biggest problem in terms of divergence in the conceptions of the problem. Content analysis techniques will be used on records of a land use debate to identify the geographic concepts that are important in this debate. Analysis of experimentally derived protocols may provide additional data.

2. Analyze common representations of spatial information that are used in SDSS to determine their

efficacy in addressing the interests of participants in debates. This will require formalizing the types of information that are explicit or implicit in representations of spatial information. These formalizations will be compared to the concepts identified in the analysis of the land use debate (this will use a knowledge representation language such as Conceptual Graphs) and tested for their ability to represent the participants' interests. These analyses should lead to the identification of needed extensions to common representations.

3.   Develop a prototype for generating spatial alternatives in a spatial decision support system. The major objective will be to develop and test a method for generating alternatives, a graphical user interface to present alternatives, and a method to spatially direct searches for feasible alternatives. Such a tool can be used in collaborative situations to provide comparison and examination of similar solutions.

Several research directions are being developed at Buffalo. First, collaborative spatial decision-making environments in which group members individually and collectively pursue solutions to ill-structured problems have a unique set of cartographic visualization requirements. Group members normally have varying levels of education, disciplinary backgrounds, and familiarity with computing, as well as different stakes in, and degrees of familiarity with, ill-structured problems. Consequently, we can expect that group members will articulate different types of questions and will have considerably different perspectives on the way that these questions should be addressed. The purpose of our work is to develop a cartographic framework that supports the design, construction and use of maps in CSDM. The central principle in this framework is that each map created by an individual as part of a solution to a problem can be decomposed into a collection of atomic objects - a path through a network can be decomposed into a series of nodes and links, for example. These objects are then placed into an accounting framework that supports summary operations on the objects and enables group members to determine the level of agreement among geographically-distributed components of alternative solutions.

Second, the range of tasks and types of applications that need to be supported in CSDM environments is characterized by great diversity, since they are often constructed from a number of different software modules. This interoperability problem in CSDM is a difficult one to treat, however, because great differences exist among the user interfaces of software modules and each module typically has unique data flow requirements. Software agents represent one attempt to circumvent such interoperability problems. Agents also may actively assist users who may be unfamiliar with the operation of software. The purpose of this work is to articulate a vision of how agents can be used to support decision-makers and to develop a conceptual framework for the roles of agent-based computing in CSDM environments.

Third, the lack of structure inherent in many complex spatial problems makes it difficult for individuals to understand the relationships among different components of a problem. Consequently, individuals require tools that help them to explore and understand problems as well as resolve them. In many settings, human-computer interaction is enhanced if each user can articulate their ideas by interacting directly with graphical representations of their problem. When faced with a decision about where to locate a school, for example, users could drag the symbol for the school to different locations on a map and watch the system enumerate and display in real time the concomitant changes in enrollment, age structure, gender and ethnic ratios, and distances traveled; an alternative approach is to specify some criteria for selecting a location and invoke an optimizing spatial search procedure. In such a context, a visual interactive modeling environment provides analytical capabilities that are invoked using map windows and linked tabular views that help groups of decision-makers to understand and reconcile depictions of spatial pattern with statistical reports about locational configurations. The purpose of the work proposed under this heading is to take a fresh look at the design, representation and implementation of spatial models. More specifically, we intend to extend earlier work on the design and implementation of modelbase management systems (MBMSs) into the domain of CSDM to meet the challenge of providing flexible modeling tools for group use. We will build substantially upon research carried out under I6 (Spatial Decision Support Systems) and that described above on the cartography of collaboration and the role of intelligent agents.

Marc Armstrong and Paul Densham worked in Buffalo during June and July 1995, both to prepare for the Specialist Meeting and to work on initiative research. Research by Densham and Armstrong has

focused on conceptual frameworks for the design of CSDM tools. In particular, they investigated the requirements for collaborative locational decision-making in terms of overall system design, visualization, and the design of user interfaces. Work is now underway to investigate how these principles can be implemented in various computing environments.

Densham is investigating the use of a parallel coordination language, Linda, to implement location selection tools on a network of PCs. Such tools can be used by a single user to exploit the inherent parallel processing capabilities of a network or by a group of users to facilitate collaboration. Currently, both traditional heuristics and a genetic algorithm are being implemented; the use of a Microsoft Windows interface is being investigated.

Armstrong is also investigating the use of parallel computing to support the computational needs of multiple users who need simultaneous near-real-time response to computationally complex problems. He has obtained funding, in the form of computer time, from the Cornell Theory Center (NSF-supported) to pursue use of the IBM SP-2 distributed parallel supercomputer.

Armstrong and Densham are also investigating several issues relating to the design and construction of group-based maps, expanding on work initially reported at Auto-Carto 12 in February. A collection of new map types are being developed that are designed to communicate the degree to which geographically-based agreement exists among collaborators in a CSDM setting. The approach is based on a decomposition of maps into an organized set of atomic cartographic elements that are manipulated using map operators. In addition to this visual depiction of the degree of similarity among alternatives, statistical measures are also calculated and presented to users. A paper that describes this work is in preparation for submission to a journal.

Armstrong and Densham have written a paper that attempts to bring CSDM into the arena of the "GIS critique" literature. This paper was presented at GIS/LIS '95 and appears in the proceedings of that meeting. This critique is especially relevant to work in a collaborative setting since the socio-political elements of group-based decision-making must be explicitly acknowledged and treated in a viable system. This theme also emerged as an important thread during the initiative meeting.

A special session on I17 has been organized for the GIS and Envvironmental Modeling Conference, Santa Fe, NM, January 1996.

Initiative 19: GIS and Society: The Social Implications of How People, Space, and Environment are Represented in GIS (to begin February 1996). The initiative focuses attention on the social contexts of GIS production and use and addresses a series of conceptual issues:

- In what ways have particular logic and visualization techniques, value systems, forms of reasoning, and ways of understanding the world been incorporated into existing GIS techniques, and in what ways have alternative forms of representation been filtered out?

- How has the proliferation and dissemination of databases associated with GIS, as well as differentiatial access to spatial databases, influenced the ability of different social groups to utilize information for their own empowerment?

- How can the knowledge, needs, desires, and hopes of marginalized social groups be adequately represented in GIS-based decision-making processes?

- What possibilities and limitations are associated with using GIS as a participatory tool for more democratic resolution of social and environmental conflicts?

- What ethical and regulatory issues are raised in the context of GIS and Society research and debate?

The Initiative received final formal approval in mid-April 1995. Since then, details for leadership and management of the Initiative have been discussed. Since this is the first NCGIA Research Initiative with the majority of the leadership and expected activities outside the three NCGIA sites, there are many new questions to address.

The co-leaders of the initiative are Dan Weiner and Trevor Harris of West Virginia University, and the core planning group also includes Helen Couclelis (UCSB), Michael Curry (UCLA), Robert McMaster (Minnesota), David Mark (SUNY Buffalo), Harlan Onsrud (U. Maine), and Eric Sheppard (Minnesota). The Steering Committee held its first organizational meeting August 25-27 in Morgantown, WV. The Initiative 19 Specialist meeting is scheduled for March 3-5, 1996 near Minneapolis, MN. Approximately 35 persons are expected to attend.

Initiative 20: Interoperating GISs. This new initiative was approved in principle at the June, 1995 meeting of the Board. A full proposal for approval in detail will be submitted to the June, 1996 meeting. Its intent is to study the fundamental theoretical and conceptual problems underlying the concept of GIS interoperation, and thus to provide the necessary scientific underpinnings to current efforts to establish GIS interoperability through efforts such as the Open Geodata Interoperability Specification (OGIS).

Initiative 21: Formal Models of Common-Sense Geographic Worlds. This initiative was approved in principle in June, 1995, and was submitted for approval in detail in December, 1995. It will be led by Mark and Egenhofer, and will focus on 1) identifying the basic elements of common-sense conceptualizations of geographic space, entities, and processes, and on developing an integrating framework; 2) investigating GIS users' reactions to intuitive geographic inferences, and comparing these inferences with the results obtained with current GIS technology. We anticipate a specialist meeting late in 1996.

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 project focusing on GIS in the Community Colleges. Year Seven also included the first ESF/NSF Summer Institute for Young Scholars (see below).

2. NCGIA Core Curriculum

Although its content is increasingly dated, demand continues for the 1990 edition of the NCGIA Core Curriculum in GIS. From October 15 to November 22, 1995, Marius Theriault was at Santa Barbara continuing his work on a French translation and adaptation. Both the English and Hungarian versions are now available on the World Wide Web.

During 1995 preliminary plans were made for a new Core Curriculum II. The proposed framework of the curriculum is based on a simple principle - that the characteristic distinguishing GIS and geographic information technologies in general from all other fields is a focus on geographic concepts. These are defined as the primitive elements, features, and relationships used to analyze, model, reason, and make decisions in a geographic context. They range from concepts about the form of the Earth and the measurement of position on its surface, to concepts of direction, adjacency, and connectivity, to the more advanced concepts that underlie our understanding of the processes that operate on the Earth's surface. Geographic knowledge is constructed from geographic concepts, and these concepts form the basis for people's conceptual understanding of the world around them. Geographic concepts range from the simplest primitives of geographic cognition learned in early childhood to the far more advanced structures used in the modeling of environmental and social processes.

The proposed structure for the curriculum is tree-like, with geographic concepts at the bottom or root node. Above this are three major branches: the branch that deals with the concepts themselves, enumerates them, and describes their role in human cognition; the branch that discusses the implementation and handling of geographic concepts in digital computers; and the branch that examines the management of these technologies, their implications for society, and the social context in which they are being used. The three branches are entitled "Fundamental Geographic Concepts for GIS"; "Implementing Geographic Concepts in GIS"; and "Geographic Information Technology in Society". By using a tree structure, the curriculum avoids linearity, and allows complexity to be added. The number of levels in the tree is not defined; new units can be added above existing ones, to add greater detail, but must be appropriately linked to the parent.

The entire curriculum will be built using the World Wide Web, and linked with other related projects. An Editorial Board is being formed to take a general oversight role, and an Editorial Committee which will oversee the construction of each unit. The bulk of the construction work on the new curriculum is scheduled for the summer of 1996, with testing and revision during the following winter.

3. Sessions at GIS/LIS

Two paper sessions and one panel session on GIS and K-12 education were held at GIS/LIS in Nashville Tennessee, in November, 1995. The sessions provided a forum for K-12 teachers in the Nashville area to attend the GIS/LIS convention and hear reports on curricular materials developed in the mapping sciences. Representatives from NSF, TERC, and National Geographic presented ideas on directions in mapping sciences education at a third panel session. Specifically, the goals of the program were to offer insights to teachers and students about applications in the mapping sciences; to demonstrate existing curricular products and materials under development; to sensitize the mapping science community to issues challenging K-12 education; to provide a forum for prioritizing efforts to improve K-12 education in GIS and the mapping sciences; and to provide access to the conference Exhibit Hall for students and their teachers.

In addition to these sessions, NCGIA organized or helped to sponsor sessions on Teaching GIS, on the proposed new Core Curriculum, and on Education Curriculum for GIS.

4. GIS in the Community Colleges

Steve Palladino, NCGIA Education Projects Manager, continues to maintain an NCGIA-centered information network in support of GIS in the community colleges. During 1995 sessions were organized on this theme at the NCGE conference in San Antonio in October, and at the Association of American Geographers conference in Chicago in March. A proposal to support this activity and an associated Core Curriculum for community colleges has been developed. Palladino helps to organize an AAG task force on this topic.

5. Secondary Education Project

The SEP functions as a nexus for information, activities, and materials for using GIS in the pre-collegiate classroom. Since it is likely that the SEP has the most comprehensive knowledge of GIS activities in the pre-collegiate realm (at least outside of the software vendors), SEP representatives have continued to communicate this knowledge through sessions at national meetings including the National Council for Geographic Education and the Association of American Geographers. NCGIA researchers Barbara Buttenfield and Paul Rooney at Buffalo have organized a K-12 GIS day for the GIS/LIS conference in November, 1995. The SEP is continuing to develop example instructional materials and GIS modules for use in the schools. Current development activities include a set of ArcView 2.0-based learning modules which seek to show how the power of GIS can be used to teach geographic concepts. The modules also are designed to draw the student into using the GIS tools available in ArcView. Color Your World was the first of this set of resources. This particular game was conceived, designed, and written by Paul Sutton, Paul Van Zuyle, and Steve Palladino at the NCGIA, Santa Barbara. Presently under development by the same team are two modules, Know Your Neighborhood and Light up Your Nation. Know Your Neighborhood uses the First St. census and demographic data from WESSEX as a basis of student exploration of Washington, D.C. and their own home town. Light up Your Nation uses ArcView's USA data and DMSP imagery to explore patterns of nighttime light emittance and human activity in the United States. This module development effort has been primarily supported through generous gifts from ESRI, the developers of ArcView.

NCGIA sites are engaging in various forms of GIS outreach with schools. For example, at Santa Barbara, the NCGIA continues to provide a GIS day for K-12 teachers attending the Southern California Geographic Alliance Summer Geography Institutes at UC Santa Barbara each summer.

6. Remote Sensing Core Curriculum

Work continued during 1995 on the NCGIA Remote Sensing Core Curriculum, a coordinated effort involving several individuals and institutions, and funded by NASA through a grant to Dr. Tim Foresman at the University of Maryland, Baltimore County. Steering Committee meetings were held in November in Nashville, and in August in Washington DC.

C. Outreach

1. General

Harlan Onsrud, Jeffrey Johnson, and Xavier Lopez received the ESRI first place award for best scientific paper in geographic information systems at the ASPRS 1995 annual convention for their paper "Protecting Personal Privacy Using Geographic Information Systems", *Photogrammetric Engineering and Remote Sensing*, 60(9):1083-1095, September 1994.

Khaled Hassen was the sole student member of a computer design team that earned the top award of best software design using ArcView II, at the ESRI International User Conference held in May in Palm Springs, CA.

At the GIS/LIS '95 Conference in Nashville, Thomas Cova, a graduate student at Santa Barbara, was the recipient of the International Geographic Information Foundation's (IGIF) Best Student Paper Award ($1000) for his paper/presentation entitled "A Spatial Search for Neighborhoods that may be Difficult to Evacuate" written in collaboration with Richard L. Church (Cova, T.J. and R.L. Church (1995) A spatial search for neighborhoods that may be difficult to evacuate. *Proceedings GIS/LIS '95, Nashville, TN* 1:203-212).

Richard P. Appelbaum became the Founder and Co-Editor of *Competition and Change: The Journal of Global Political Economy*, an international, multidisciplinary journal that examines the changing nature of business organization in a highly competitive global economy. The journal draws on recent scholarship in business economics, political economy, organizational sociology, economic geography, international relations and developmental studies to explore the interplay of economic, political, and social forces contributing to global integration and regional fragmentation. The first issue is expected in Spring 1996.

Karen K. Kemp was elected member of the UCGIS Board of Directors for a one-year term beginning November 1995. Kemp is also a Steering Committee member for the International Symposium on GIS in Higher Education, and the 1996 meeting is scheduled in Miami.

At the URISA annual meetings in July, Gary Hunter and Michael Goodchild were awarded the Horwood Critique Prize for their paper describing their research on uncertainty in spatial data.

NCGIA has provided modest financial support to a project being undertaken by the University of Wisconsin and Ohio State University under the direction of Ben Niemann and Earl Epstein, to study the effects of land records modernization and the diffusion of land information systems, primarily in Wisconsin. Reports of this work were given at the 1995 ESRI User Conference, URISA '95, and GIS/LIS '95. A paper has also been published in the *URISA Journal*.

2. Conferences

Human Capital Conference. NCGIA Buffalo organized a three-day conference "Geographic Information Analysis and Human Capital Research", held in Boulder, CO, July 9-12. This workshop was co-sponsored by the National Science Foundation and the U.S. Department of Housing and Urban Development. Support and assistance were also received from ESRI-Boulder. Munroe Eagles served as Project Director and Hugh Calkins as Co-Investigator on the project award. Approximately 35-40 participants from the university, government and private sectors attended.

The conference was designed to introduce researchers in the Human Capital community to the capabilities of GIS tools and their potential applications to areas of Human Capital research. The workshop was organized around three substantive themes, which were selected to allow representation of human capital issues across the full range of geographic analysis methods [disaggregated event data (points), spatially linked events or phenomenon (networks), and aggregated statistics (zones or areas)]. The three groups were: Geography, Crime and Human Capital (led by John Sprague, Washington University, St.

Louis and Carol Kohfeld, University of Missouri, St. Louis); Neighborhoods, Social Networks and Human Capital (led by Robert Huckfeldt, SUNY at Stony Brook), and Migration, Demographic Change and Human Capital (led by Peter Rogerson, SUNY Buffalo and Richard Morrill, University of Washington).

Buffalo PhD students CJ Cote and Martin Camacho assisted with data conversion, presentation preparation and technical support. PhD student Tom Whitehouse also assisted with data preparation and Pat Randall (secretary) provided hourly assistance to the project. In Fall, 1995 graduate student Darlene Gawron (Political Science) assisted with library research on Human Capital issues.

The Workshop on Progress in Automated Map Generalization. The workshop on Progress in Automated Map Generalization, the closing meting for European activities on Initiative 8, was held in Barcelona, Spain in early September. Thirty researchers and practitioners (spanning eleven countries) with proven track records in generalization theory and practice presented research. This is the fourth in a series of international meetings on generalization research held during the life of Research Initiative 8 and funded in whole or in part by NCGIA. The goal of this meeting was to provide a forum to advance the state of knowledge on cartographic automation, to report demonstrated progress in areas of map generalization and design, and to introduce junior researchers from Europe and North America.

3. Visiting Fellows

June 7-8: Robert Huckfeldt, SUNY Stony Brook, worked with Hugh Calkins , Munroe Eagles and PhD assistants CJ Cote and Martin Camacho at Buffalo on research and data concerning the Human Capital project.

June 14-17: Carol Kohfeld, University of Missouri, St. Louis, worked with Hugh Calkins, Munroe Eagles, and PhD assistants CJ Cote and Martin Camacho at Buffalo on research and data concerning the Human Capital project.

June 18-July 8: Marc Armstrong, University of Iowa, visited the Buffalo site to work on research and organizational matters related to Initiative 17. He worked with initiative co-leader Paul Densham, who was visiting Buffalo at the same time.

July 16-28, 1995: Donald Myers, University of Arizona, visited the Buffalo site to work with Peter Rogerson on issues related to Initiative 14.

Dr. Bob Rugg (Virginia Commonwealth University) spent two months at Maine. He worked with Egenhofer and Shariff (graduate research assistant) on "Operational Definitions of Feature Types". Rugg extended Kuhn's earlier work on the formalization of a geographic feature type such as a dam and demonstrated how algebraic specifications can capture the behavior of feature types. An implementation was done with MacGopher, a functional specification language. A paper has been written and will be submitted to a refereed journal.

June 25-July 16: Rahul Simha, Department of Computer Science, College of William and Mary, Williamsburg, VA, conducted research at Maine under the NCGIA Visiting Scholars Program.

Carolyn Hunsaker, Oak Ridge National Laboratory, was in residence at NCGIA-Santa Barbara for the first six months of 1995, working with Michael Goodchild, Frank Davis, and Chuck Ehlschlaeger on the modeling of uncertainty and generalization in vegetation cover maps, and its impact on modeling in landscape ecology.

August 1995: Cort Willmott, University of Delaware, began a five month residence at NCGIA to work on "smart" methods of interpolation of fields over the global surface, under I15.

August 1995: Rob Raskin began an extended period at Santa Barbara as a visiting scholar from UC Santa Cruz. He worked with Cort Willmott on developing new methods of spatial analysis on the sphere, and with Chris Funk and Cort Willmott on the functional specification of a package

"Spherekit" for implementing the methods using standard data structures.

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 provided continuing support in FY95 at $30,000.

During 1995 a further three specialist meetings were held, in addition to the six held previously; and another three are planned in 1996. Details of the three meetings held in 1995, with US participation, follow:

Remote Sensing and Urban Change (Strasbourg, France, 8-10 June, 1995)

The meeting considered the application of airborne and satellite remote sensing technology to the study of urban areas and urban change. It was divided into four main sessions: 1) cartographic feature extraction and map updating; 2) delimiting urban agglomerations; 3) characterizing urban structure, setllement, and distribution; and 4) urban modelling. The US participants sponsored by NSF were Mike Batty (NCGIA, Buffalo) and C.P. Lo (University of Georgia). A book will be edited by Jean-Paul Donnay and Mike Barnsley, and published by Taylor and Francis.

Spatial Models and GIS (Friiberghs Herrgard, Sweden, 14-18 June 1995)

Spatial models have become an important branch of scientific endeavor. In the environmental sciences they include models of climate, weather forecasting, air dispersion, chemical reaction, rainfall-runoff, groundwater, soil erosion, biological ecosystems, energy systems, and noise propagation. In the social sciences they include models of regional economic development, land and housing markets, plant and facility location, spatial diffusion, migration, transport, and urban land use. Geographic

information systems have opened the way to much more sophisticated representation of space in these models. Participants from the US were John Wilson (Montana State University) and John Landis (UC Berkeley), with interests in physical and social models respectively. A book will be edited by Stewart Fotheringham and Michael Wegener, and published by Taylor and Francis.

Data Quality (Lisbon, Portugal, 5-9 July 1995)

The main objective of this meeting was to discuss the concept of quality in geographic information, recognizing the need to define the qualitative aspects and components of geoinformation quality, and the different approaches to this issue from different fields. Four broad areas were covered: concepts; mathematics; quality control; and applications. The US participants funded by NSF were Joel Morrison (Bureau of the Census) and Hong Jiang (IDRISI Project, Clark University).

Michael Goodchild represents the U.S. on the GISDATA Steering Committee. He participated in the meeting held in December in Zurich. Ian Masser (University of Sheffield), coordinator of the GISDATA program, is a member of the NCGIA Science Policy Committee.

The GISDATA program includes two joint NSF/ESF Summer Institutes for Young Scholars. The 1995 Institute took place July 26 to August 2 at the Wolfe's Neck Center of the University of Southern Maine, near Freeport, ME. A full report of the meeting follows. The second Summer Institute is planned for Berlin in 1996.

1995 International Young Scholars Summer Institute in Geographic Information

The first of two NSF/ESF-sponsored Summer Institutes in Geographic Information took place from July 26 to August 2 at the Wolfe's Neck Conference Center near Freeport, Maine. Fifty-two early-career and senior scientists in the area of geographic information participated in the intensive residential Institute program, about half from the US and half from Europe. The 15 US and 16 European early-career scientists were selected following a national and international, respectively, competition based on the submission of an extended paper abstract. The Institute was organized by the NCGIA on the US side and the GISDATA program on the European side. Drs. Cora Marrett from the NSF and Guido Martinotti from the ESF opened the week-long program.

The themes of the Summer Institute, based on selected NCGIA Research Initiatives for the US, and on the topics of the first six GISDATA workshops for Europe, were as follows: For the US: (a) Representing spatial data quality; (b) Formalizing cartographic knowledge; (c) Human and organizational factors in GIS implementation; (d) Collaborative spatial decision support; (e) Cognitive perspectives on spatio-temporal reasoning; (f) National spatial data infrastructure. For Europe: (a) GIS and multimedia; (b) Generalization; (c) GIS diffusion in Europe; (d) GIS and spatial analysis; (e) Spatial conceptual models for geographic objects with undefined boundaries; (f) European data availability. Papers on these themes were presented by both the early-career and senior scientists. Two special workshops were also presented, one on international funding opportunities and the second on publishing in the refereed literature. In addition, both the junior and senior scientists participated in one of six project teams that developed research pre-proposals within the following cross-cutting themes: GIS and ethnic conflict; GIS in the integration of global change research (2 teams); Technical impediments to international geographic information sharing; Social, cultural and political impediments to international geographic information sharing; Impact of social and cultural divisions on GIS. The six submissions were evaluated by a panel and the best proposal received an award. Finally, a day devoted to field trips took about half the participants to the Boston/Cambridge area and a morning of demonstrations at MIT, and the other half to the NCGIA site at Orono and Acadia National Park.

The Summer Institute was organized around three concurrent goals: promotion of basic research in geographic information; human resource development; and the development of international cooperations between US and European scientists. Judging from the written evaluations collected from the participants,

these goals were met. The paper presentations were on the whole of very high caliber. Participants especially appreciated the breadth of the perspectives presented and the opportunity to be exposed to work outside their own narrow area of specialization. An aspect strongly stressed in the evaluations of most junior participants was the presence and continuous availability of several widely respected senior scientists from both continents. The special workshops and hands-on proposal development were deemed very valuable professionally and for allowing preliminary international collaborations to emerge. An electronic discussion list has been set up to encourage the strengthening of that international network that first took shape in Wolfe's Neck. Lastly, the wider geographic information community will also benefit from the forthcoming publication of the Summer Institute proceedings by Taylor & Francis, one of the best-known publishers in the field.

Undoubtedly, the idyllic setting of the Wolfe's Neck Conference house in a park-like landscape between two bays contributed to the enthusiastic evaluations. Still, the international program committee felt that the structure of the Institute was successful enough to be repeated virtually identically at next year's Summer Institute, which will take place in Berlin, Germany, July 24-31, 1996.

5. Collaborative Grants Program

In the 1993 renewal of the NCGIA Cooperative Agreement, funds were set aside to support collaborative projects with other institutions outside the NCGIA consortium. The program requires non-NSF matching by the collaborating institution. Proposals are reviewed by NSF as supplemental awards. In 1995 the first two such projects began.

Predator-Prey Modeling of Fish Populations in 3-Dimensional GIS: NCGIA Buffalo and the Great Lakes Center at Buffalo State College.

The emphasis of this project is on developing 3-D spatial models of fish population growth using GIS. Recently, 2-D models have been developed to predict growth rate potential with temperature being a key variable. These models have traditionally been based on hydroacoustic data taken along cross-lake transects (an x, z sampling scheme) from which fish size and densities can be determined. Analysis and visualization have been performed using IDL. In an attempt to develop more realistic models, this project is geared toward constructing a three dimensional representation of the water volume. As a first step, data has been collected in Lake Ontario during July and October of 1995 in a 1 km^2 grid pattern allowing for x, y, and z values within the data set. At the same time, temperature, chlorophyll a, and zooplankton data were collected. This sampling scheme should be conducive to modeling multiple trophic level interactions, growth rate potential, and interactions between cells. Since these data were collected continuously over a 24-hour period (4-6 passes) and replicated in October, temporal changes can be analyzed. Questions of spatial scale will also be addressed.

The data have been collected and the processing of the data is nearing completion. We are currently working on developing the appropriate data structure for multiple sets of 3-Dimensional; data. Intergraph corporation has generously offered to loan the project a TDZ-40 computer and a copy of its Voxel Analyst software. It is expected that Intergraph will have the 3-D modeling and visualization capabilities necessary to analyze the growth rate potentials and trophic level interactions of interest.

Integration of Remote Sensing and GIS, Assessment of Land Cover Change and Regrowth in a Northern California Forested Ecosystem. NCGIA Santa Barbara and the University of Washington

This collaborative research project was initiated with Dr. Alan Gillespie of the University of Washington (UW). The UW group is currently studying the use of remotely sensed time-series data for mapping vegetation and monitoring change in the Bluff Creek watershed, a mixed evergreen forested region of northern California. As a part of that project collaborators at UW have assembled an extensive satellite-based data set consisting of over 23 years of Landsat MSS, over 10 years of Landsat TM and one full-season data set of MSS starting in August of 1987. These data have been co-registered, intercalibrated and atmospherically corrected. In addition, considerable supporting geographical information including

digital elevation data, soils maps, seral stage maps and vegetation associations were assembled by the U.S. Forest Service. The resulting data set represents one of the most complete temporal records of land use for the Pacific Northwest.

Our objective is to merge UCSB expertise in GIS into the UW research effort to provide an integrated multitemporal study of changes in land cover and regrowth. Our primary goal is to assess the success of conifer regeneration using remote sensing and to evaluatae the environmental, biotic, and anthropogenic factors that may have influenced regrowth success using GIS. This effort provides an opportunity to explore multitemporal applications while strengthening the methodological basis of the UW study. Methods employed will combine remotely sensed analysis and geographical analysis using ARC/INFO. The remotely sensed analysis is focusing on two approaches. In the first approach change and regeneration are being assessed through multitemporal image classification and the establishment of temporal profiles for regrowth. Our classification approach is based on the use of spectral mixture models that will be used to develop temporal maps showing transitions in land cover. Regeneration success will be evaluated by comparing regrowth across the study area to a temporal profile of regrowth under optimal conditions. The temporal profile will be generated using existing seral stage maps and spectral mixture analysis to describe canopy attributes (architecturally derived shadows, green leaf fraction and non-photosynthetic vegetation fraction). In the second approach, foreground/background analysis will be used to evaluate changes in forest cover which will be related to regeneration success. Once regeneration success has been established environmental, biotic, and anthropogenic factors will be evaluated with respect to regrowth success through GIS. The work at Santa Barbara is being conducted by Dar Roberts and graduate student Charles Kayman. At UW, Nick Chrisman is also assisting the work.

6. University Consortium for Geographic Information Science

Since 1992, NCGIA and its Board of Directors have been instrumental in instigating the formation of a national consortium of universities committed to research in GIS and geographic information analysis. A founding meeting was held in December 1994, and in 1995 an organization known as the University Consortium for Geographic Information Science (UCGIS) came into being. By its first annual meeting in Nashville in November, close to 30 institutions had made the necessary initial commitment to become full members, including the three NCGIA institutions. Karen Kemp serves as a member of the Board of Directors. The first research meeting of the consortium will be held in Columbus, OH in June 1996. Further information can be obtained at http://www.ucgis.org.

7. Technical Papers published

95-1: Framework Data Sets for the NSDI, by Steven M. Frank, Harlan Onsrud, Jeffrey Pinto, U. Maine; and Michael Goodchild, UCSB, reports on the results of a survey conducted in 1994 to help identify and priorize framework data sets to be included in the NSDI.

95-2: Two Papers on Triangulated Surface Modeling, by Carlos Felgueiras, Instituto Nacional de Pesquisas Espaciais(INPE), and Michael Goodchild, UCSB, examines three TIN surface modeling methods and associated algorithms for fitting surfaces: linear, quintic and stochastic, through the use of both qualitative and quantitative criteria.

95-3: Multiple Roles for GIS in US Global Change Research: An Annotated Bibliography, compiled by Ashton Shortridge, UCSB, in conjunction with Initiative 15, presents a collection of articles concerned with the application of GIS in global change research.

95-4: A Comparison of Strategies for Data Storage Reduction in Location-Allocation Problems, by Paul A. Sorensen and Richard L. Church, UCSB, describes a set of comparative tests evaluating the effects on solution quality of imposing different distance string definitions and sizes. Two new methods for the selection of nodes to be included within distance string data structures are outlined.

95-5: Color Your World, An Exploration With ArcView 2.0, compiled by Paul Sutton, Paul Van Zuyle, and Steve Palladino, UCSB (with disk, also available via ftp), an interactive GIS based computer

game designed for secondary school students to expose them to fundamental and essential geographic information necessary for understanding not only geography but politics, economics, demography, and other disciplines. The game produces thematic maps which show patterns and distributions of important phenomena. Required software: ArcView 2.0.

95-6: The Global Demography Project, by Waldo Tobler, Uwe Deichmann, Jon Gottsegen, and Kelly Maloy, UCSB (with disk, also available via ftp), a three part report which explores demographic data using populations extrapolated to 1994 and converted to a piecewise continuous population surface, gridded by latitude/longitude quadrangles. Part I gives the motivation and several possible approaches, Part II provides the results to date, and Part III describes needed extensions, as well as the appendices containing detailed information on the results with maps and data sources; includes PC disk with data and BASIC programs.

95-7: Formalizing Behavior of Geographic Feature Types, by Robert D. Rugg, Max J. Egenhofer, U. Maine, and Werner Kuhn, Tech. Univ. Vienna, addresses the problem of formalizing the natural language definitions of spatial features. An approach using functional algebra is developed.

95-8: Naive Geography, by Max J. Egenhofer, U. Maine, and David M. Mark, SUNY-Buffalo, defines the notion and concepts of Naive Geography, the field of study that is concerned with formal models of the common-sense geographic world.

95-9: Direction Relations and Two-Dimensional Range Queries: Optimization Techniques, by Theodoridis Yannis, Emmanuel Stefanakis, & Timos Sellis, Technical National University of Athens; and Dimitris Papadias, U. Maine, defines direction relations (east, southeast, etc.) between two-dimensional objects at different levels of qualitative resolution and shows how these relations can be efficiently retrieved in existing DBMSs using B-, KDB- and R-tree-based data structures.

95-10: Research Initiative 15: Multiple Roles for GIS in US Global Change Research, Report of the First Specialist Meeting, Santa Barbara, compiled and edited by Michael Goodchild and John E. Estes, UCSB; Kate Beard, U. Maine; Tim Foresman, U.Maryland Baltimore County, and Jenny Robinson, SUNY-Buffalo, summarizes the Specialist Meeting discussions and provides a synthesis of emerging research topics and activities.

95-11: Geographic Information/GIS Institutionalization in the 50 States: Users and Coordinators, by Lisa Warnecke, GeoManagement Associates, Syracuse, New York, analyzes recent information about the use and institutionalization of geographic information and related technologies in the US state governments.

95-12: On Information Modeling to Support Interoperable Spatial Databases, by Nectaria Tryfona and Jayant Sharma, U. Maine, deals with the special semantics of spatial data in an information systems context and describes a geographic model to encapsulate the distinguishing properties of space.

95-13: Understanding Guidance on GIS Implementation: A Comprehensive Literature Review, by Roberto Ferrari and Harlan J. Onsrud, U. Maine, documents a comprehensive review of the literature on GIS implementation and analyzes it in terms of issues addressed, theoretical consistency, and theoretical diversity.

95-14: Collaborative Spatial Decision-Making: Scientific Report for the Initiative 17 Specialist Meeting, by Paul J. Densham, U. College London; Marc P. Armstrong, U.Iowa; and Karen K. Kemp, UCSB, summarizes the meeting discussions and outlines some critical areas for research.

95-15: NCGIA Research Initiative 8 Formalizing Cartographic Knowledge: Scientific Report for the Specialist Meeting, by Barbara P. Buttenfield, U.Colorado, and Catherine Dibble, UCSB, summarizes the meeting discussions and lays out an international research agenda.

Other NCGIA publications added January - December 1995:
Closing Report for Initiative 12
Closing Report for Initiative 14
Annual Report Year 6 (December 1, 1993 - December 31, 1994)

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 7. The Board welcomed Kija Kim, President, Harvard Design Mapping; T.R. Lakshmanan, Director, Bureau of Transportation Statistics; and Henry H.Perritt, Jr., Villanova Law School. Meetings were held in Buffalo (June 1995) and Santa Barbara (December 1995), and at the end of December 1995 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)
> Kija Kim (Harvard Design Mapping)
> Annette Krygiel (Central Imagery Office)
> T.R. Lakshmanan (Bureau of Transportation Statistics)
> Joel Morrison (Bureau of the Census)
> Henry H. Perritt, Jr. (Villanova Law School)
> 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, 1995 the members were Michael F. Goodchild (Director); Helen Couclelis (Associate Director, Santa Barbara); David Mark (Associate Director, Buffalo); Max Egenhofer (Associate Director, Maine); and Harlan Onsrud (Chair, SPC).

Scientific Policy Committee. During the period from January 1, 1995 to December 31, 1995, the Scientific Policy Committee (SPC) held formal meetings in Buffalo in June 1995, and in Santa Barbara in December 1995. 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 1995 included Waldo Tobler (Santa Barbara; NCGIA Senior Scientist); John Estes (Santa Barbara); Munroe Eagles (Buffalo); Hugh Calkins (Buffalo); and Kate Beard (Maine). SPC meetings are also attended by selected members of the Board of Directors.

Personnel changes. At Buffalo, Mike Batty resigned his position as Associate Director effective July 1, and as of August 24 resigned his position as Professor of Geography of SUNY Buffalo, to take up a chair at University College London. David Mark was named Associate Director. Rajan Batta, Professor and Chair of Industrial Engineering and Munroe Eagles, Assistant Professor of Political Science were named as co-Principal Investigators of the SUNY Buffalo site, and were nominated as Key Personnel in the NCGIA Cooperative Agreement with NSF. In August, Munroe Eagles was promoted to the rank of Associate Professor of Political Science with tenure. Ronald Rozensky, GIS and Workstation Support Specialist in the Geographic Information and Analysis Laboratory resigned his position in August to join his wife in Florida. Ling Bian joined the faculty of the Department of Geography as Assistant Professor, and became a member of NCGIA-Buffalo. In September, Ms. Diane Holfelner joined the Center's office staff. She is employed as a project assistant by Hugh Calkins' project: "Planning and Implementing a GIS for Local Governments". Sharmistha Bagchi-Sen and Meghan Cope, Assistant Professors of Geography, joined the Center as members. From September through November 17 David Mark spent a sabbatical leave in Western Europe, and participated in a number of activities which have been included in this report. In

November Martin Camacho was hired at GIS and Workstation Support Specialist in the Geographic Information and Analysis Laboratory in November

Barbara Buttenfield resigned her position as Associate Professor of Geography, SUNY Buffalo at the end of the Fall 1995 semester to accept a position as Associate Professor of Geography at the University of Colorado, Boulder. Effective December 31, 1995 she was removed as co-principal investigator and key personnel member of NCGIA. Jennifer Robinson, Research Scientist, accepted a position as Lecturer at the School of Biological and Environmental Sciences, Murdoch University, Western Australia.   Her resignation from Buffalo was effective December 31, 1995.

At Maine, Douglas Flewelling was appointed Research Associate with the NCGIA, effective March 1, 1995. Nectaria Tryfona was appointed Post-Doctoral Research Associate effective April 9, 1995. Dimitris Papadias was appointed Research Assistant Professor with the Department of Spatial Information Science and Engineering and the NCGIA, effective June 5, 1995. Peggy Agouris was appointed Assistant Professor with the Department of Spatial Information Science and Engineering and the NCGIA, effective September 1, 1995. Kathleen Hornsby resigned her position of Administrative Officer with the NCGIA and is now a Ph.D. student in the UMaine Department of Spatial Information Science and Engineering and the NCGIA, effective September 1, 1995. Ubirajara Moura de Freitas, researcher at the National Space Research Institute - INPE, Sao Jose, Brazil, has joined the NCGIA as a research scholar for a one year term effective September 22, 1995. He works with Max Egenhofer conducting research on geographic information systems with a particular focus on large spatial databases.

Roberto Ferrari, Assistant Professor, Department of Computer Science, Federal University of Sao Carlos, Brazil, completed his visiting research associate appointment with the NCGIA, December 11, 1995. Virginia Ragoni de Moraes Correia, researcher at the National Space Research Institute - INPE, Sao Jose, Brazil, has joined the NCGIA as a research scholar for a one year term effective December 17, 1995. She works with Kate Beard on the development of GIS for global change.

At Santa Barbara, John E. Estes returned September 1995 from a 3-year partial leave as Senior Visiting Scientist, U.S. Geological Survey, National Mapping Division, where he acted as liaison between USGS and NASA for the Mission to Planet Earth Program's Earth Observing System Data and Information Systems (EOSDIS). Two additions to the faculty of the Department of Geography were made: Dr. Oliver Chadwick was appointed to a joint position with the Department of Environmental Studies, specializing in soils and remote sensing; and Dr. Thomas Dickey, an oceanographer, was appointed following the retirement of Dr. Ray Smith. In June 1995, Daniel R. Montello was awarded affiliated faculty status in the Department of Psychology, University of California, Santa Barbara.

3. EXTRAMURAL SUPPORT

A. Grants and Contracts Awarded as of 12/31/95

DEPARTMENT OF PARKS AND RECREATION, STATE OF CALIFORNIA, $15,455, "Development of a GIS-Based Inventory of Historic Properties", 4/1/1995, PI: M. Aldenderfer.

DEPARTMENT OF PARKS AND RECREATION, STATE OF CALIFORNIA, $16,900, "Development of a Distributed Digitial System for Historic Resources", 12/1/95, PI: M. Aldenderfer.

NASA, $22,000, "Graduate Student Fellowship: Exploring the Potential of Space Shuttle Earth Observations Photography as Metadata to Access and Manage Earth System Data", 9/01/95-08/31/96, PI: Couclelis.

THE NATURE CONSERVANCY, "Bioenvironmental Analysis for the Columbia River Basin", 5/1/95-9/30/95, PI: Davis.

NASA, $659,987, "Remote Sensing Information Sciences Research Group (NAGW-1743)", 10/1/95-9/30/96, PIs: Estes, J.E., Robert C. Frohn, and Joseph Scepan.

OFFICE OF INSTRUCTIONAL DEVELOPMENT, UC SANTA BARBARA, $11,568, "Practical Learning in Geographic Information Systems", 7/1/95-6/30/96, PIs: Goodchild, Kemp, Palladino.

NATIONAL SCIENCE FOUNDATION, $60,000, "Integration of Remote Sensing and GIS, Assessment of Land Cover Change and Regrowth in a Northern California Forested Ecosystem", 4/1/95-3/31/97, PIs: Roberts, Goodchild.

US GEOLOGICAL SURVEY, $14,748, "Multiple Roles for GIS in US Global Change Research", 1/1/95-2/28/96, PIs: Goodchild, Estes.

UC ENERGY INSTITUTE, $21,000, "Remote Sensing Study of Historical Changes in Natural Oil Slick Volumes in Santa Barbara Channel", 7/1/95-6/30/96, PI: Estes.

NASA (subcontracted through University of Maryland, Baltimore County), $13,222, "Remote Sensing Core Curriculum", 5/1/95-4/30/97, PI: Estes.

UC TRANSPORTATION CENTER, $102,784, "Object-Oriented Dynamic GIS for Transportation Planning", 8/1/94-3/31/96, PI: Golledge.

NATIONAL SCIENCE FOUNDATION, $30,000 (second year), "Participation of US Scientists in the European Science Foundation's GISDATA Program", 9/1/95-2/28/98, PI: Goodchild.

CALIFORNIA DEPARTMENT OF TRANSPORTATION, $160,000, "System Integration Issues of Distributed Navigable Map Databases", 7/1/94-6/30/96, PIs: Goodchild, Church.

US GEOLOGICAL SURVEY, $9,450, "Third International Conference/Workshop on Integrating GIS and Environmental Modeling", 5/1/95-3/31/96, PI: Goodchild.

US ARMY CORPS OF ENGINEERS, $70,000, "Data Quality Dimensions for the Open Geodata Interoperability Specification", 7/1/95-12/31/95, PI: Goodchild.

ADVANCED RESEARCH AND DEVELOPMENT COMMITTEE OF THE COMMUNITY MANAGEMENT STAFF, $207,453, "Heterogeneous Geographic Databases", 3/1/95-2/28/96, PIs: Egenhofer, Beard.

ARPA, $15,000, "Cognitive Aspects of User Interface Design for Geographic Information Systems",

3/1/94-12/31/95, PI: Egenhofer.

ENVIRONMENTAL SYSTEMS RESEARCH INSTITUTE, $5,000, "Large Spatial Databases", PI: Egenhofer.

INTERGRAPH CORPORATION, $158,000, "Spatial Relations", 7/1/92-6/30/95, PI: Egenhofer.

LOCKHEED MARTIN, $5,000, "Large Spatial Databases", PI: Egenhofer.

NATIONAL SCIENCE FOUNDATION, $9,975, "The Impact of Law and Information Policy on the Dissemination of Scientific and Technical Databases: A North American-European Community Comparative Study", 1/1/95-12/31/95, PIs: Onsrud, Lopez.

NATIONAL SCIENCE FOUNDATION, $97,000, "RIA: Formalization, Inference, and Query Processing of Spatial Relations in Geographic Databases", 9/1/93-8/31/96, PI: Egenhofer.

NORTH ATLANTIC TREATY ORGANIZATION, SCIENTIFIC AND ENVIRONMENTAL AFFAIRS DIVISION, $7,000, "Cross-Cultural Differences in Spatial Concepts: Application to Spatial Information System Use", $7,000, PIs: M. Gould, Egenhofer.

ROME LABORATORIES, $199,934, "Spatial-Query-by-Sketch", 9/1/95-8/31/97, PI: Egenhofer.

SPACE IMAGING INC, $68,697, "Access to Image Archives", PI: Egenhofer.

US DEPARTMENT OF EDUCATION, $115,000, "GIS Literature Database", 1/1/95-12/31/95, PIs: Marilyn Lutz, Onsrud.

UNIVERSITY OF MAINE, ACADEMIC COMPUTING ADVISORY COMMITTEE, $80,000, "BASIN - A Browsable HyperArchive of Spatial Information on the Net", PI: Beard.

SPACE IMAGING INC, $33,000, "Access to Large Image Archives", 3/1/95-10/30/95, PI: Goodchild.

SPACE IMAGING INC, $33,300, "Access to Large Image Archives: User Requirements Study and User Interface Design", 12/1/94-11/20/95, PI: Buttenfield.

ERIE COUNTY WATER AUTHORITY, $35,781, "AML Programming", 5/1/95-12/31/95, PI: Calkins.

NATIONAL SCIENCE FOUNDATION, $60,989, "Geographic Information Analysis and Human Capital Research", 4/1/95-11/30/95, PIs: Batty, Calkins.

NATIONAL SCIENCE FOUNDATION, $73,539, "Predator-Prey Modeling of Fish Populations in Three-Dimensional GIS", 1/15/95-6/15/96, PIs: Calkins, Batty, DePinto.

ADMINSTRATION ON AGING, $270,087, "Minority Aging in a Diverse Society", 1/1/96-12/31/97, PIs: Rogerson, Burr, Mutchler.

ERIE COUNTY WATER AUTHORITY, $224,000, "Planning and Implementing a GIS for Local Governments", 5/1/95-6/30/96, PI: Calkins.

CANADIAN EMBASSY, $4,000, "The Political Ecology of Representation in Canada: MPs and Their Constituencies", 12/95-12/96, PI: Eagles.

SUNY BUFFALO RESEARCH DEVELOPMENT FUND, $4,000, "Evaluation of Effects of Watershed Discretization on Hydrologic Parameters Estimation and Prediction", 1995-1996, PI: Bian.

DESERT RESEARCH INSTITUTE, UNIVERSITY OF NEVADA RENO, $6,561, "Pre-SOLA

Planning Workshop", 9/1/95-8/31/96, PI: Calkins.

B. Equipment and Software Acquisitions

Maine

Epson Stylus Color Inkjet printer
Macintosh Performa 6115 8/350/CD
DOS Compatibility card
HP LaserJet 4M Plus printer
Macintosh Powerbook 540C
Excel 5.0
Pagemaker 5.0
Visual C++ for Windows
Windows NT 3.5
Map'n'Go for Windows
Microsoft Windows NT, Version 3.5 SVR
Maclink Plus 8.0
Adobe PageMill
Oracle Power Objects

Buffalo

During Year 7 Buffalo received an award from Intergraph Corporation of "An Intergraph Center of Excellence Laboratory in the Mapping Sciences". Software grants in the first phase amount to $138,000, and a further $102,000 of software will be awarded in the second phase. The Co-Investigators for the Intergraph award are Barbara Buttenfield, C. Brunskill, and J. Bis.

Buffalo has also received five licenses for Imagine 8.1/8.2 from ERDAS Corporation, Atlanta. The licenses are valued at $100,000.

Other hardware and software acquisitions: Macintosh external hard drive for the GIAL; Dell 590 computer; Memory Upgrades for Rogerson's and Eagles' office computers; 4.2 GB Hard Drive for the UNIX platform; Two Sun Sparc5 workstations for GIAL; Dell 7100 computer for GIAL; MAC X software, WordPerfect for Windows, QuatroPro 6.0, IDRISI for windows (v. 4.1 update), Atlas GIS for Macintosh, Atlas Pro for Macintosh, Gauss Software 3.2, Upgrades of MapBasic and MapInfo, Freehand, Pagemaker, Canvas; Solaris software operating system for UNIX platform.

Santa Barbara

The greatest effort for 1995 went into upgrading the network, hooking the department and NCGIA together onto the new campus network, rebuilding old PC's and networking various offices to provide graduate students access to NCGIA computing power from their offices outside of the main NCGIA office.

Major hardware and software acquisitions: Pentium 90 17"; extra 16 MEG SIMM for printer; HP1600CM Color Printer; Mac 540c 12/500; 10BT to AAUI tranceivers; 2 Port Micro Repeater; 32 Meg Simm For Plotter; 4.2 gig external fast scsi drive; CDROM with PCNFS Pro; Ethernet 16 port Hub; Mac OS Site license; 4.2 gig externalfast scsi drive.

APPENDIX 1 - PUBLICATIONS

A. Articles published or formally accepted in refereed journals

Armstrong, M.P (1995) Is there a role for high performance computing in GIS? *Journal of the Urban and Regional Information Systems Association* 7(1):7-10.

Armstrong, M.P. and R. Marciano (in press) Local interpolation using a distributed parallel supercomputer. *International Journal of Geographical Information Systems* 10(5).

Armstrong, M.P. and R. Marciano (1995) Massively parallel processing of spatial statistics. *International Journal of Geographical Information Systems* 9(2):169-189.

Batty, M. (1995) Comment on Delafons. *Town Planning Review* 66(1):95-97.

Batty, M. (1995) Editorial introduction: urban planning and planning support systems. *Regional Development Dialogue* 16(1):v-xiii.

Batty, M. (1995) Planning support systems and the new logic of computation. *Regional Development Dialogue* 16(1):1-17.

Batty, M. (1994) The World Wide Web. *Environment and Planning B* 21:651-652.

Beard, M.K. (1995) Digital spatial libraries: a context for engineering and library collaboration. *Information Technology and Libraries* 14(2):79-86.

Benedetti, R. and D. Palma (1994) Markov random field-based image subsampling method. *Journal of Applied Statistics* 21(5):495-509.

Benedetti, R. and D. Palma (1995) Optimal sampling designs for dependent spatial units. *Environmetrics* 6:101-114.

Bian, L. and E. West (in press) Modeling elk calving habitat in a prairie environment. *Photogrammetric Engineering and Remote Sensing*.

Breininger, D.R., V.L. Larson, B.W. Duncan, R.B. Smith, D.M. Oddy, and M.F. Goodchild (1995) Landscape patterns of Florida Scrub Jay habitat use and demographic success. *Conservation Biology* 9:1442-1453.

Chakraborty, J. and M.P. Armstrong (1995) Using geographic plume analysis to assess community vulnerability to hazardous material accidents. *Computers, Environment and Urban Systems* 19(5).

Christerson, B., and R.P. Appelbaum (1995) Global and local subcontracting: space, ethnicity, and the organization of apparel production. *World Development* 23(8):1363-1374.

Church, R.L., D.M. Stoms, and F.W. Davis (in press) Reserve selection as a maximal covering location problem. *Biological Conservation.*

Church, R.L. and A. Murray (1995) Measuring the efficacy of adjacency constraint structure in forest planning models. *Canadian Journal of Forest Research* 25(9):1416-1424.

Couclelis, H. (in press) From cellular automata to urban models: new principles for model development and implementation. *Environment and Planning B: Planning and Design*.

Couclelis, H. and M. Monmonier (1995) Using SUSS to resolve NIMBY: how spatial understanding

support systems can help with the "Not In My Back Yard" syndrome. *Geographical Systems* 2:83-   101.

Dale, V.H, H.Offerman, R.C. Frohn, and R. Gardner (in press) Landscape characterization and biodiversity research. *Proceedings of the International Union of Forestry and Research Organizations Symposium on Measuring and Monitoring Biodiversity in Tropical and Temperate Forests, August 28-September 2, 1994, Chiang Mai, Thailand.*

Davis, F.W., P.A. Stine, D.M. Stoms, M.I. Borchert and A.D. Hollander (1995) Gap analysis of the actual vegetation of California. 1. The Southwestern Region. *Madrono* 42:40-78.

Davis, F.W. (1995) Information systems for conservation research, policy and planning. *Bioscience (Supplement on Science and Biodiversity Policy*) pp. S36-S42.

DeCola, L. and B.P. Buttenfield (1995) Multiscale mapping for the NSDI: data modeling and representation. *International Journal for Geomatics* 9(3):6-9.

Densham, P.J. (1995) Invited comment on V.K. Tewari, "Planning support systems: an application to service development in Mysore District, India". *Regional Development Dialogue* 16(1):69-72.

Densham, P.J. and G. Rushton (in press) Providing spatial decision support for rural service facilities that require a minimum workload. *Environment and Planning B*.

Dell, R.F., R. Batta, and M.H. Karwan (in press) The multiple vehicle TSP with time windows and equity constraints over a multiple day horizon. *Transportation Science*.

Ding, Y. and P.J. Densham (in press) Spatial strategies for parallel spatial modeling. *International Journal of Geographical Information Systems*.

Eagles, D.M. (1995) Spatial and contextual models and political behavior. *Political Geography* 14(6-7):499-502.

Egenhofer, M.J. and R.D. Franzosa (1995) On the equivalence of topological relations. *International Journal of Geographical Information Systems* 9(2):133-152.

Egenhofer, M.J. and D.M. Mark (1995) Modelling conceptual neighbourhoods of topological line-region relations. *International Journal of Geographical Information Systems* 9(5):555-565.

Frank, S.M., M.F. Goodchild, H.J. Onsrud, and J.K. Pinto (in press) User requirements for framework geospatial data. *Journal of the Urban and Regional Information Systems Association*.

Freundschuh, S.M. and M. Sharma (in press) Spatial image schemata, locative terms, and geographic spaces in children's narrative: fostering spatial skills in children. *Cartographica*.

Friedl, M.A., F.W. Davis, J. Michaelsen, and M. Moritz (in press) Scaling and uncertainty in the relationship between LAI and NDVI: an analysis using a scene simulation model and data from FIFE. *Remote Sensing of Environment*.

Gerrard, R.A. and R.L. Church (1995) A general construct for the zonally constrained p-median problem. *Environment and Planning B* 22(2):213-226.

Golledge, R.G., V. Dougherty, and S. Bell (1995) Acquiring spatial knowledge: survey versus route-based knowledge in unfamiliar environments. *Annals of the Association of American Geographers* 85(1):134-158.

Goodchild, M.F. (1995) Future directions for geographic information science. *Geographic Information*

Sciences 1:1-7.

Goodchild, M.F. and G.J. Hunter (in press) A simple positional accuracy measure for linear features. *International Journal of Geographical Information Systems*.

Goodchild, M.F. and S.D. Palladino (1995) Geographic information systems as a tool in science and technology education. *Speculations in Science and Technology* 18(4):278-286.

Hudak, P.F., H.A. Loaiciga, and M.A. Marino (1995) Regional-scale ground water quality monitoring via integer programming. *Journal of Hydrology* 164:153-170.

Hunter, G.J., M. Caetano, and M.F. Goodchild (1995) A methodology for reporting uncertainty in spatial database products. *Journal of the Urban and Regional Information Systems Association* 7(2):11-21.

Hunter, G.J. and M.F. Goodchild (1995) Dealing with error in spatial databases - a simple case study. *Photogrammetric Engineering and Remote Sensing* 61(5):529-537.

Hunter, G.J. and M.F. Goodchild (in press) A new model for handling vector data uncertainty in geographic information systems. *Journal of the Urban and Regional Information Systems Association*.

Hunter, G.J. and M.F. Goodchild (in press) Communicating uncertainty in spatial databases. *Transactions in GIS*.

Jegat, H., J. Alvarado, and H.A. Loaiciga (1995) Over-exploitation and deterioration of aquifers in Venezuela. *Ground Water Monitoring and Remediation* 15(3):119-123.

Kottman, C. and B.P. Buttenfield (1994) Standards for spatial data use: similes improve understanding. *Cartography and GIS* 21(3): 140-144.

Leitner, M. and B.P. Buttenfield (1995) Multi-scale knowledge acquisition: inventory of European topographic maps. *Cartography and GIS* 22(3).

Loaiciga, H.A. and T.H. Robinson (1995) Sampling of agrochemicals for environmental assessment in rice paddies: dry tropical wetlands, Costa Rica. *Ground Water Monitoring and Remediation* 15(3):107-118.

Loaiciga, H.A., J.B. Valdes, R. Vogel, J. Garvey, and H. Schwarz (1995) Global warming and the hydrologic cycle. *Journal of Hydrology* 174(1-2):83-127.

Loaiciga, H.A. and R.B. Leipnik (in press) A stochastic renewal model of low flows. *Stochastic Hydrology and Hydraulics*.

Loaiciga, H.A., R.B. Leipnik, P.F. Hudak, and M.A. Marino (in press) 1-, 2-, 3-dimensional effective conductivity of aquifers. *Mathematical Geology*.

Mackaness, W.A. (1994) An algorithm for conflict identification and feature displacement in automated map generalization. *Cartography and Geographic Information Systems* 21(4):219-232.

Mark, D.M. and M.J. Egenhofer (1994) Modeling spatial relations between lines and regions: combining formal mathematical models and human subjects testing. *Cartography and Geographic Information Systems* 21(4):195-212.

Mark, D.M. and A.U. Frank (in press) Experiential and formal models of geographic space. *Environment and Planning B*.

Murray, A.T. and R.L. Church (1995) Solid waste disposal site location. *Journal of Urban Planning and Development (ASCE)* 121(3):109-114.

Onsrud, H.J. (1995) Identifying unethical conduct in the use of GIS. *Cartography and Geographic Information Systems* 22(1):90-97.

Onsrud, H.J. and R.I. Reis (1995) Law and information policy for spatial databases: a research agenda. *Jurimetrics Journal of Law, Science and Technology* 35(4):377-393.

Onsrud, H.J., J. Johnson, and J. Winnecki (in press) GIS dissemination policy: two surveys and a suggested approach. *Journal of the Urban and Regional Information Systems Association*.

Papadias, D. and Y. Theodoridis (in press) Spatial relations, minimum bounding rectangles, and spatial data structures. *International Journal of Geographical Information Systems*.

Paradis, J. and K. Beard (1994) Visualization of spatial data quality for the decision-maker: a data-quality filter. *Journal of the Urban and Regional Information Systems Association* 6(2):25-34.

Pinto, J.K. and B. Azad (1994) The role of organizational politics in GIS implementation. *Journal of the Urban and Regional Information Systems Association* 6(2):35-61.

Presson, C.C., and D.R. Montello (1994) Updating after rotational and translational body movements: coordinate structure of perspective space. *Perception* 23:1447-1455.

Richards, J.R. and M.J. Egenhofer (1995) A comparison of two direct-manipulation GIS user interfaces for map overlay. *Geographical Systems* 2(4):267-290.

Rodriguez-Estrada, H. and H.A. Loaiciga (1995) Planning urban growth in ground water recharge areas, Central Valley, Costa Rica. *Ground Water Monitoring and Remediation* 15(3):119-123.

Rogerson, P. (in press) Elderly population growth in the United States during the late 1980s. *Growth and Change*.

Rogerson, P. (in press) A generalization of Hewitt's test for seasonality. *International Journal of Epidemiology*.

Rogerson, P. (1995) A question of balance. *International Regional Science Review* 18:219-222.

Rogerson, P. and G. Lin (1995) Elderly parents and the geographic availability of their adult children. *Research on Aging* 17:303-331.

Rokos, D. and M.P. Armstrong (1996) Using Linda to compute spatial autocorrelation in parallel. *Computers and Geosciences* 22(5).

Springer, D.S., and H.A. Loaiciga (in press) Air permeability of porous materials under controlled laboratory conditions. *Water Resources Research*.

Takeyama, M. and H. Couclelis (in press) Map dynamics: integrating cellular automata and GIS through Geo-Algebra. *International Journal of Geographical Information Systems*.

Tobler, W.R. (in press) Migration: Ravenstein, Thornthwaite, and beyond. *Urban Geography*.

Tobler, W.R. (in press) A graphical introduction to survey adjustment. *Cartographica*.

Wang, Y., F.W. Davis, J.M. Melack, E.S. Kasischke, and N.L. Christensen, Jr. (1995) The effects of

changes in forest biomass on radar backscatter from tree canopies. *International Journal of Remote Sensing* 16:503-513.

Wortman, K. and B.P. Buttenfield (1994) Standards. *Cartography and GIS*, Preface to Special Issue on Spatial Data Standards 21(3):131.

Zhan, F. and B.P. Buttenfield (1995) Knowledge-based selection of map design symbols. *International Journal of Geographical Information Systems* 9(3):293-315.

Zhan, F. and B.P. Buttenfield (in press) Multi-scale representations of digital cartographic lines. *Cartography and GIS*.

B. Books

Aldenderfer, M. and H. Maschner, editors, (in press) *Anthropology, Space, and Geographic Information Systems*. New York: Oxford University Press.

Eagles, D.M., editor (1995) *Spatial and Contextual Models in Political Research*. London: Taylor and Francis.

Egenhofer, M.J. and J.R. Herring, editors (1995) *Advances in Spatial Databases, Proceedings of the Fourth International Symposium on Large Spatial Databases*, Lecture Notes in Computer Science, Vol. 951. New York: Springer-Verlag.

Estes, J.E., J. Lawless, and D.W. Mooneyhan, editors (1995) *Proceedings, International Symposium on Core Data Needs for Environmental Assessment and Sustainable Development Strategies, Bangkok, Thailand, November 15-18, 1994* (2 volumes).

Goodchild, M.F., L.T. Steyaert, B.O. Parks, C.A. Johnston, D.R. Maidment, M.P. Crane, and S. Glendinning, editors (1996) *GIS and Environmental Modeling: Progress and Research Issues*. Fort Collins, CO: GIS World Books.

Longley, P. and M. Batty, editors (in press) *Spatial Analysis: Modelling in a GIS Environment*. Cambridge: GeoInformation International.

McDonnell, R., and K. Kemp (1995) *International GIS Dictionary*. Cambridge, UK: GeoInformation International.

Nyerges, T.L., D.M. Mark, R. Laurini, and M.J. Egenhofer, editors (1995) *Cognitive Aspects of Human-Computer Interaction for Geographic Information Systems*. Dordrecht: Kluwer Academic Publishers.

Onsrud, H.J. and G. Rushton, editors (1995) *Sharing Geographic Information*. Piscataway, NJ: CUPR-Rutgers.

C. Articles in Refereed Conference Proceedings

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)*, pp. 49-58.

Bicking, B. and K. Beard (1995) Toward implementing a formal approach to automate thematic accuracy checking for digital cartographic datasets. *Proceedings, Auto-Carto 12, March 1-3, 1995, Charlotte, NC*, 4:355-362.

Buttenfield, B.P. (1995) Evaluating user requirements for a digital library testbed. *Proceedings, Twelfth International Symposium on Computer-Assisted Cartography (Auto Carto 12)*, pp. 207-214.

Egenhofer, M.J. and H.T. Bruns (1995) Visual map algebra: a direct-manipulation user interface for GIS. In S. Spaccapietra and R. Jain, editors, *Visual Database Systems 3, Visual Information Management, Proceedings of the Third IFIP 2.6 Working Conference on Visual Database Systems, March 27-29, 1995, Lausanne, Switzerland*, pp. 235-253.

Egenhofer, M.J. and D.M. Mark (1995) Naive geography. In A. Frank and W. Kuhn, editors, *Spatial Information Theory—A Theoretical Basis for GIS, International Conference COSIT '95, Semmering, Austria*. Lecture Notes in Computer Science 988, pp. 1-15. Berlin: Springer-Verlag.

Golledge, R. (1995) Path selection and route preference in human navigation: a progress report. In A.U. Frank and W. Kuhn, editors, *Spatial Information Theory—A Theoretical Basis for GIS, International Conference COSIT '95, Semmering, Austria*. Lecture Notes in Computer Science 988. Berlin: Springer-Verlag.

Hong, J.-H., M.J. Egenhofer, and A.U. Frank (1995) On the robustness of qualitative distance- and direction-reasoning. *Proceedings, Auto-Carto 12, March 1-3, 1995, Charlotte, NC* 4:301-310.

Karacapilidis, N., D. Papadias, and M. Egenhofer (1995) Collaborative spatial decision making with qualitative constraints. *Proceedings, ACM-GIS '95, December 1-2, 1995, Baltimore, MD*, pp. 53-59.

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Mark, D.M. and M.J. Egenhofer (1995) Topology of prototypical spatial relations between lines and regions in English and Spanish. *Proceedings, Auto-Carto 12, March 1-3, 1995, Charlotte, NC* 4:245-254.

Montello, D.R. (1995) How significant are cultural differences in spatial cognition? In A.U. Frank and W. Kuhn, editors, *Spatial Information Theory—A Theoretical Basis for GIS, International Conference COSIT '95, Semmering, Austria*. Lecture Notes in Computer Science 988. Berlin: Springer-Verlag.

Papadias, D., Y. Theodoridis, T. Sellis, and M.J. Egenhofer (1995) Topological relations in the world of minimumbounding rectangles: a study with R-trees. *Proceedings, 1995 ACM SIGMOD International Conference on Management of Data, May 23-25, 1995, San Jose, CA* 24(2):92-103.

Sharma, J. and D.M. Flewelling (1995) Inferences from combined knowledge about topology and directions. In M.J. Egenhofer and J.R. Herring, editors, *Advances in Spatial Databases, Proceedings of the 4th International Symposium on Large Spatial Databases, August 6-9, 1995, Portland, ME*, pp. 279-291.

Smith, B. (1995) On drawing lines on a map. In A.U. Frank and W. Kuhn, editors, *Spatial Information Theory: A Theoretical Basis for GIS*. Lecture Notes in Computer Science 988. Berlin: Springer-Verlag.

Theodoridis, Y. and D. Papadias (1995) Range queries involving spatial relations: a performance analysis. In A. Frank and W. Kuhn, editors, *Spatial Information Theory—A Theoretical Basis for GIS, International Conference COSIT '95, Semmering, Austria*. Lecture Notes in Computer Science

988, pp. 537-551. Berlin: Springer-Verlag.

Tryfona, N. and T. Hadzilacos (1995) Geographic applications development: models and tools for the conceptual level. *Proceedings, ACM-GIS '95, December 1-2, 1995, Baltimore, MD*, pp. 19-28.

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Weber, C.R., B.P. Buttenfield, and D.L. Jelinski (1995) A case study for hypermedia cartography: radial growth in Trembling Aspen at Waterton Lakes National Park. *Proceedings, Twelfth International Symposium on Computer-Assisted Cartography (Auto Carto 12)*, pp. 32-40.

D. Articles in other outlets

Agouris, P. and A. Stefanidis (in press) Automated extraction of man-made objects from digital imagery. *Proceedings, 1996 ASPRS/ACSM Annual Convention*.

Aldenderfer, M. (in press) Introduction: quantitative anthropology, space, and geographic information systems. In M. Aldenderfer and H. Maschner, editors, *Anthropology, Space, and Geographic Information Systems*. New York: Oxford University Press.

Aldenderfer, M. (1995) Archaeology and GIS. *McGraw-Hill Encyclopedia of Science and Technology: 1995*, pp. 32-34. New York: McGraw-Hill.

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Appelbaum, R.P. (1996) Multiculturalism: some new directions in global capitalism. In A. Gordon and C. Newfield, editors, *Multiculturalism: The Second Wave*. Minneapolis: University of Minnesota Press.

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Armstrong, M.P. (in press) Requirements for the development of GIS based group decision support systems. In R. Klosterman, editor, *From Geographic Information Systems to Planning Support Systems*. New Brunswick, NJ: Center for Urban Policy Research Press. (Reprint of an article originally appearing in *Journal of the American Society for Information Science*, 1994, 45).

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Batty, M. (1995) Geographic information systems in the social and policy sciences. In D.M. Eagles, editor, Spatial and Contextual Models of Political Research, pp. 14-40. London: Taylor and Francis.

Blodgett, C.F., S.L. Egbert, H. Sun, and L. Bian (1995) Developing graphic links between Arc/Info, Visual Basic, and SWAT. *Proceedings, GIS/LIS '95*, pp. 62-69.

Buttenfield, B.P. (in press) Issues of size and scalability. In L.C. Smith, editor, *GIS and Libraries.* Champaign-Urbana: University of Illinois Press.

Buttenfield, B.P. (1995) Object-oriented map generalization: modeling and cartographic considerations. In J.C. Muller, J.P. Lagrange, and R. Weibel, editors, *GIS and Generalization: Methodology and Practice*, pp. 91-105. London: Taylor and Francis.

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Dale, V.H., H. Offerman, R. Frohn, and R. Gardner (1995) Landscape characterization and biodiversity research. In T.J.B. Boyle and B. Boontawee, editors, *Measuring and Monitoring Biodiversity in Tropical and Temperate Forests*, pp. 67-87.

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APPENDIX 2 - PRESENTATIONS BY NCGIA PERSONNEL

December 1-2, 1994: Marc Armstrong presented the paper he co-authored with Paul Densham "Toward the development of a conceptual framework for GIS-based collaborative spatial decision-making" at the 2nd ACM Workshop on Advances in Geographic Information Systems, held at the National Institute of Standards and Technology, Gaithersburg, MD.

January 12: Paul Densham presented his paper "Group Spatial Decision Support for Locational Problems" at Environmental Systems Research Institute Forum, Redlands, CA

January 13: Paul Densham gave a presentation on "Visual Interactive Modeling, High Performance Computing & Location Problem-Solving" to the Software Development Group at Environmental Systems Research Institute, Redlands, CA

January 17: Karen Kemp organized and attended the EOSDIS User Model, Libraries chapter meeting, University of California, Santa Barbara.

January 20: Michael Goodchild gave a presentation entitled "Digital Spatial Data Libraries", University of Southern California.

February 1-2: Michael Goodchild attended a meeting of the Mapping Science Committee, National Research Council, Washington, DC.

February: Marc Armstrong presented his paper "Visualization and Collaboration in Spatial Decision Support Systems" at the Iowa Planners Association Conference, Cedar Falls, IA.

February 5-6: Max Egenhofer met with David Hall, Martin Marietta, Philadelphia, PA.

February 6-10: Uwe Deichmann participated in the Rockefeller Foundation Team Residency on African Farming Systems in Bellagio, Italy.

February 11-15: Mike Woldenberg and Karen Kemp attended the International Symposium on Computer Mapping in Epidemology and Environmental Health, Tampa, FL, as representatives of NCGIA. Michael Goodchild presented "GIS, Spatial Representation, and Statistical Mapping".

February 14: Harlan Onsrud presented "Who owns what? Legal Issues in Multimedia Development", at the University of Maine Multi Media Summit for Education, Orono, ME.

February 19-22: Mike Batty attended the FHWA Travel Model Improvement Program's Land Use Models Conference, Dallas, TX. Batty presented a paper entitled "Data Requirements for Land Use Modeling" (co-authored with David Howes, Xiaohua Zheng, C J Cote and P. Pellegrini).

February 18-21: David Mark was an invited participant in the NATO scientific collaboration workshop, "Cross-cultural aspects of spatial cognitioning and GIS use, Part 1", Caceres, Spain.

February 20: David Mark gave an invited lecture to the Faculty of Arts and Letters, University of Extremadura, Caceres, Spain.

February 21-22: Max Egenhofer, Michael Goodchild, and Barbara Buttenfield attended a contract initiation meeting with Lockheed Space Imaging, Sunnyvale, CA.

February 25-27: Max Egenhofer, Michael Goodchild, David Mark, Karen Kemp, and Harlan Onsrud traveled to Washington DC, to attend an NCGIA Executive Committee meeting.

February 27-March 1: The following representatives of NCGIA-Buffalo attended the Twelfth International

Symposium on Computer Assisted Cartography (Auto Carto 12), Charlotte, NC.   Barbara Buttenfield presented the paper "Challenges of Distributing Spatial Data on the Internet".   Marc Armstrong presented the paper he co-authored with Paul Densham "Cartographic support for collaborative spatial decision making".   PhD student Brandon Plewe presented the paper "The Tiger Mapping Service: Integrating Census Data into the World Wide Web".   From NCGIA-Maine, Max Egenhofer presented "Difference in Natural-Language Spatial Relations in English and Spanish" and "Robust Inferences of Distance- and Direction Reasoning."   Karen Kemp attended from Santa Barbara.

February 27-March 2: Harlan Onsrud attended the ACSM/ASPRS '95 annual convention, Charlotte, NC, and presented "Unanswered Questions in Copyrighting Spatial Databases".

March 1: Karen Kemp organized and attended the UCGIS planning meeting, Charlotte.

March 3-4: Uwe Deichmann co-organized a workshop/training session for USAID staff from Mali, Ghana, Cote d'Ivoire and Madagascar on GIS in development planning at USAID/REDSO/WCA (Regional Economic Development Services Office for West and Central Africa) in Abidjan.

March 4:   John Cloud presented a workshop on space shuttle photography applications and theoretical issues and social implications of GIS at the University of Oregon Law School LAW (Land, Air, and Water) Conference, in Eugene, OR.

March 5-6: Michael Goodchild participated on a Blue Ribbon Panel on Natural Resource Information Planning and Management, Natural Resource Conservation Service, U.S. Department of Agriculture, Denver.

March 6-10: Uwe Deichmann participated in AFRICA GIS '95, Abidjan, Cote d'Ivoire, and co-organized a session on "Socio-economic and bio-physical data integration in GIS".

March 8-16: Jennifer Robinson attended the Initiative-15 Specialist Meeting in Santa Barbara, CA.

March 13-19: Several representatives of the Buffalo Site attended the AAG meetings in Chicago. David Mark presented the paper "Cognitive Categories and Geographic Entity Types in the Spatial Data Transfer Standard (STDS)", served as a discussant in "Representing Space", and chaired a panel on "Variations in the Perception of Geographic/Environmental Space." Barbara Buttenfield presented the papers "Evaluating and Interface Design with Multimedia Tools", "User Evaluation of the Alexandria Digital Libraries Project", and "Teaching Map Animation and Hypermedia Programming".   Peter Rogerson presented the paper he co-authored with Jeffrey Burr and Ge Lin "Changes in the Geographic Proximity Between Parents and Their Adult Children".   Marc Armstrong presented the paper (co-authors D. Rokos and F. Weirich) "Distributed Parameter Surface Runoff Model Designed for a Parallel Processing Environment".   PhD students attending the conference with NCGIA support were: Patricia Baumgarten: "Examining U.S. Interregional Migration Flows: A Gendered Topography"; Randy Bertolas: "Hydroelectricity: Cross-Cultural Attitudes Toward a 'Clean' Energy Resource"; Martin Camacho: "A Spatial Analysis of Gentrification"; Reginald Carroll: Hazardous Waste Sites in the Urban Environment"; Andrew Curtis: "The Identification of Clusters in Geographic Spatial Knowledge Recalls"; Ann Deakin: "The Fallen Santa Monica Freeway: Impact on Los Angeles Motorists"; Michael Letiner: Data Quality Visualization and Its Impact on Decision Making"; Ge Lin: "The Geographic Distribution of Nurse Practitioners in the United States"; Melissa Neave: "Interrill Erosion on the Ranger Uranium Mine Waste Rock Dump"; Pasquale Pellegrini: "Spatial Choice Models of U.S. Migration, 1985-1990 (co-authored with Stewart Fotheringham).   From the Maine site, Max Egenhofer was discussant in a session on Standards, and chaired another session on Spatial Reasoning.   From Santa Barbara, Karen Kemp attended; Paul Sutton presented a paper for himself, Paul Vanzuyle, and Steve Palladino on the NCGIA Secondary Education Project Color Your World ArcView 2 educational module.   Steve Palladino served as an organizer/panelist for a session titled "The Role of GIS Education in the Schools, Colleges, and Universities" and was also the chair/panelist for a session titled "GIS in the Community Colleges: Directions for the Community College Special Interest Group GIS Task Force".   Daniel R. Montello was a discussant in a paper session "Variations in the Perceptions of Geographic/Environmental Space", and also co-organized, chaired, and

moderated a Panel Discussion for the session "The Nature and Nurture of Map Skills: Culture, Innateness, and Development". Helen Couclelis presented the paper "Proximal Space". Reginald G. Golledge presented a paper with Helen Couclelis entitled "Spatial Analysis in the 2020s: A Midway View". Michael Goodchild gave a presentation entitled "The Context of Alexandria: Library and Extracomputational Issues".

March 17: Kate Beard and Khaled Hassen attended the State of Maine Leadership Technology Day in Augusta, ME. They presented a demonstration on GIS and on current NCGIA research at the University of Maine. The purpose of this one day meeting was to explore areas for technology development in Maine.

March 19: David Mark and Barbara Buttenfield represented the University at Buffalo at a meeting to approve the draft bylaws of the University Consortium for Geographic Information Science. Harlan Onsrud represented the University of Maine. Karen Kemp organized and attended the meeting, and represented UC Santa Barbara with Michael Goodchild.

March 20: Michael Goodchild presented the keynote address "An Update on GIS Research" to the ERDAS User Group Meeting, Atlanta.

March 22-25: Munroe Eagles presented the paper "The Electoral Geography of a Landslide: The 1993 Federal Election in Ontario", to the 20th annual conference of the British Association of Canadian Studies, University of Hull, Hull, UK.

March 25-April 14: Xavier Lopez conducted research on NCGIA Initiative 16 in The Netherlands, France, Denmark, and England.

March 27-29: Tom Bruns attended the Visual Database Systems-3 Conference, Lausanne, Switzerland, and presented "Visual Map Algebra: A Direct-Manipulation User Interface for GIS", co-authored with Max Egenhofer.

March 30: Xavier Lopez attended the 1995 Joint European Conference on Geographic Information Systems, The Hague, The Netherlands, and presented "The Impact of Scientific and Technical Information Policy on the Diffusion of Spatial Databases".

March 31: Michael Goodchild chaired a Technical Committee to examine ANCS-II, National Ocean Service, NOAA, Washington DC; Max Egenhofer was also a member of the committee.

April 1-4: Barbara Buttenfield presented the closing keynote address "Generalization and Scalability of Digital Libraries" at the 32nd Annual Clinic of Library Applications of Data Processing, Champaign-Urbana, Illinois. She discussed the application of allometric models to determine points in the growth of a digital archive where collections management operations should be modified.

April 5-7: Mike Batty presented the Keynote Address "Understanding Urban Dynamics: Exploring Spatial Evolution through Visualization and Animation" at the Third Annual Conference on Research into Geographic Information Systems: GISRUK'95, University of Newcastle upon Tyne, Newcastle, UK. This paper had been co-authored with David Howes.

April 10: Michael Goodchild made the presentation entitled "The Alexandria Project" to the Council for Networked Information Spring Conference, Washington, DC.

April 14: Michael Goodchild presented the keynote address at the New Mexico Geographic Information Council Annual Conference, Albuquerque.

April 20-23: Max Egenhofer met with National Science Foundation program officers, Arlington, VA. He then attended a program committee meeting for the SSD '95 conference, College Park, MD.

April 21: Michael Goodchild chaired a Technical Committee to examine ANCS-II, National Ocean

Service, NOAA, Washington DC; Max Egenhofer was also present as a member of the committee.

April 21-22:   Michael Goodchild participated on a Blue Ribbon Panel on Natural Resource Information Planning and Management, Natural Resource Conservation Service, U.S. Department of Agriculture, Washington, DC.

April 22-24: David Mark went to Washington, DC, and met with several NSF program officers.

April 22-26:   Rajan Batta and PhD student Peiwu Zhao attended the INFORMS Conference in Los Angeles. Peiwu presented their co-authored paper "Analysis of Aggregation Error for Location Problems", and Rajan presented their paper "On the Analysis of Aggregation Error in Euclidean Distance p-Median Problems".

April 24-25: Michael Goodchild and Barbara Buttenfield participated in the NSF/ARPA/NASA Digital Libraries Initiative joint meeting, Champaign/Urbana, IL.

April: Peter Rogerson presented the paper he co-authored with Ge Lin and Jeffrey Burr "The dynamics of intergenerational geographic proximity: recent evidence from the National Survey of Families and Households" at the annual meeting of the Population Association of America, San Francisco.

April: Marc Armstrong presented the paper "Parallel Spatial Data Analysis: Opportunities and Challenges" at the National Center for Supercomputing Applications Workshop, University of Illinois, Urbana, IL.

April: Barbara Buttenfield presented two overviews on the Alexandria Project at the University of Missouri-Columbia. One presentation to the Geography department highlighted the interactive logging scheme, and the other (an invited presentation as part of the campus-wide Information Technology Lecture Series) was an overview presentation of the entire Alexandria Project.

April 28:   Kate Beard presented "Digital Spatial Libraries" as a guest lecturer for the Department of Chemical Engineering, University of Maine, Orono.

May: Richard Appelbaum presented a workship entitled "Cheap Labor Strategies and Export-Oriented Industrialization: Some Lessons from the Los Angeles/East Asia Apparel Connection", a workshop on Dynamics of Industrial Transformation: East Central Europe and East Asian Comparisons, Budapest University of Economic Sciences.

May: Reginald G. Golledge presented a paper entitled "Defining Criteria Used in Path Selection" at the European Institute of Retailing and Services Studies (ERISS), Eindhoven, The Netherlands.

May 1: Michael Goodchild presented the keynote address "The Application of Advanced Information Technology in Assessing Environmental Impacts", 1995 Bouyoucos Conference, Riverside, CA.

May 7-10: Xavier Lopez attended the National GeoData Forum, Washington, DC. Michael Goodchild participated in a panel discussion. Karen Kemp also attended.

May 8: Michael Goodchild chaired a Technical Committee to examine ANCS-II, National Ocean Service, NOAA, Washington, DC; Max Egenhofer also participated.

May 8: Karen Kemp attended the Remote Sensing Core Curriculum Steering Committee meeting in Washington, DC.

May 9-11:   Uwe Deichmann presented "Capacity Building and Networking Needs for the Use of Geographical Information Systems in Agricultural Research" at the Second Workshop on UNEP and CGIAR Cooperation on Data, Arendal, Norway (organized by the United Nations Environment Programme, Division of Environment Assessment, GRID-Arendal).

May 10:   Barbara Buttenfield presented "Alexandria Digital Library Project" at the Annual Meetings, CHI'95, Denver, Colorado.

May 12-13: Michael Goodchild participated on a Blue Ribbon Panel on Natural Resource Information Planning and Management, Natural Resource Conservation Service, U.S. Department of Agriculture, Denver.

May 19:   Michael Goodchild chaired a Technical Committee to examine ANCS-II, National Ocean Service, NOAA, Washington DC; Max Egenhofer also participated.

May 20-24: Ronald Rozensky attended the "ESRI Users Conference" in Palm Springs, CA.   Michael Goodchild presented "The Alexandria Digital Library".   Waldo Tobler presented "The Global Demography Project".   Robert C. Frohn, John E. Estes, David N. Fogel, Karen D. Kline, Michael J. Lawless, R. Gavin McGhie, Kenneth C. McGwire, Joseph Scepan, William J. Starmer, and Paul Van Zuyle presented "Integrating Remote Sensing And Geographic Information Systems: Research Projects", and received a Poster Presentation Award for Best Integration.

May 22-25: Max Egenhofer attended SIGMOD '95 in San Jose, CA.

May 23: Kate Beard and Richard Ozog gave an Arcview 2 presentation on "Health Service Delivery and GIS", at the University of Maine School of Nursing's Health Informatics workshop.

May 26: Michael Goodchild presented the keynote address "Future Directions for Geographic Information Science", GeoInformatics '95, Hong Kong.

June 2: Mike Batty presented the paper "Predicting temporal pattern in urban development from remote imagery" (co-authored with David Howes) at the European Science Foundation GISDATA Seminar on Remote Sensing and Urban Change, Strasbourg, France.

June 3-6: David Mark visited Orono, Maine, to meet with three researchers from Spain (M. Gould, University of Extremadura; D. Comas, University of Gerona; and J. Nunes, Autonomous University of Barcelona) as well as Max Egenhofer and some University of Maine graduate students. The meeting, funded by NATO Scientific Affairs Division, was to discuss collaborative research on the meanings of spatial language.

June 4-6: Munroe Eagles presented the paper he coauthored with James Bickerton, Alain-G. Gagnon and Patrick J. Smith "Ecological Models of Party Support: Pan-Canadian, Regional, and Local Patterns in the 1988 and 1993 General Elections" at the Canadian Political Science Association annual meeting, University of Quebec at Montreal, Montreal, PQ.

June 5:   Michael Goodchild gave the keynote address "Computational Geography" at the ACM International Workshop on Computational Geometry, University of British Columbia, Vancouver.

June 8:   Michael Goodchild gave a keynote presentation at the Tenth Annual Towson State GIS Conference, Towson, MD.

June 9: Michael Goodchild chaired a Technical Committee to examine ANCS-II, National Ocean Service, NOAA, Washington DC; Max Egenhofer also participated.

June 13:   Hugh Calkins attended the Environmental Protection Agency's "Workshop on Modeling Support Systems", at the Large Lakes Research Station, Grosse Ile, Michigan.   He presented the GEOWAMS system, a three-dimensional water quality model designed for the Great Lakes program at SUNY Buffalo.

June 19-22: Karen Kemp participated in the EOSDIS Potenial Users Model meeting in Washington, DC.

Tom Albright, Michael Colee, Robert C. Frohn, Philip Handley, Karen D. Kline, Michael J. Lawless, R. Gavin McGhie, Stuart Phinn, Joseph Scepan, Ashton Shortridge, William Starmer, and Paul Van Zuyle attended as rapporteurs.

July 3: Steve Palladino conducted a series of GIS demonstrations and lab exercises for a group of K-12 teachers attending the Southern California Geographic Alliance, Summer Geography Institute at
     UCSB. Michael Goodchild also presented a session on GIS to the group.

July 4-6: Mike Batty gave the keynote paper "The Computable City" at the 4th International Conference on Computer in Urban Planning and Urban Management, Melbourne, Australia

July 9-12: Deirdre Mageean, Assistant Professor of Public Administration, UMaine, attended the Geographic Information Analysis and Human Capital Research Conference, Boulder, CO, organized by the Buffalo site. Buffalo participants included Hugh Calkins, Munroe Eagles, and several graduate students.

July 9-12: David Mark participated in a meeting of the UCGIS in Knoxville, Tennessee. The purpose of the meeting was to design an upcoming conference, scheduled for early 1996, at which the UCGIS research agenda would be established.

July 12-15: Max Egenhofer gave an invited talk "Object-oriented GIS: The Concepts", at the Simposio Geoprocessamento in Sao Paulo, Brazil. He also gave a talk at the Scientific Center of IBM Brazil in Rio de Janeiro: "Formal Models of Spatial Relations", and visited the Instituto Nacional de Pesquisas Espaciais (INPE) at Sao Jose dos Campos where he gave a talk "Cognitive and Formal Aspects of Spatial Reasoning". Karen K. Kemp was also an invited speaker.

July 15-20: Harlan Onsrud, Jeff Johnson, and Xavier Lopez attended the URISA Annual Conference, San Antonio, TX. Onsrud presented "Unanswered Questions in Copyrighting Databases". Michael Goodchild participated in a panel discussion on Open GIS, and presented a paper on "Technical Advances in Data Sharing".

July 17: Max Egenhofer and Michael Goodchild attended a meeting of the Marine Board of the National Research Council in Washington, DC.

July 26-August 3: David Mark attended the ESF/NSF Young Scholars Summer Institute in Wolfe's Neck, Maine.

August 6-9: Max Egenhofer, Nectaria Tryfona, Doug Flewelling, Kathleen Hornsby, Tom Bruns, John Florence, Khaled Hassen, Joao Paiva, Rashid Shariff, and Jayant Sharma attended the Fourth International Symposium on Large Spatial Databases (SSD '95), Portland, ME. Egenhofer was the general chair of the conference. Sharma presented "Inferences from Combined Knowledge About Topology and Directions", co-authored by Flewelling. Paiva gave a software demonstration of the Spring GIS.

August 14-16: Harlan Onsrud attended an AM/FM executive seminar, Lake Tahoe, NV.

August 16: Steve Palladino made a presentation on GIS to a group of K-12 teachers attending the special Ventura Country Summer Geography Institute sponsored by the Southern California Geographic
     Alliance.

August 23-29: Uwe Deichmann participated in the 2nd Rockefeller Foundation Team Residency on Pressures of Change in Sub-Saharan Farming Systems, in Bellagio, Italy. A book is to come out of this residency.

August 26-27: David Mark attended a steering committee meeting for NCGIA Initiative 19, held in Morgantown and Terra Alta, West Virginia.

August 30: As a member, Karen K. Kemp attended the Steering Committee meeting of the Remote

Sensing Core Curriculum Project in Washington, DC.

September: Hugo A. Loaiciga attended the Workshop on Ground Water Modeling, Department of Geographical Sciences, National University, Heredia, Costa Rica.

September 3-9: Xavier Lopez attended the 17th International Cartographic Conference, Barcelona, Spain. He presented "Information Privacy and the Use of Geographic Information Systems", co-authored with Harlan Onsrud.

September: Barbara Buttenfield and Michael Leitner participated in the workshop on Progress in Automated Map Generalization, Barcelona, Spain. This workshop was the closing meting for European activities on Initiative 8. NCGIA was a co-sponsor of the workshop.

September 15: Rajan Batta presented his paper "Hazmat Routing Viewed as a Probabilistic Experiment" at the Department of Management Science Seminar Series, University of Waterloo, Waterloo, Canada.

September 16-19: Dimitris Papadias attended the I17 Specialist Meeting, Santa Barbara, CA.

September 18: John E. Estes, as an Invited Speaker, spoke on "The Mythical Map" at the Graduate Student Seminar, Purdue University, West Lafayette, Indiana.

September 19: John E. Estes presented the keynote address "On the Importance of Maps" at the Indiana State GIS User Meeting in Indianapolis, Indiana.

September 19-21: Harlan Onsrud, Kate Beard, and Ph.D. students Doug Flewelling, Xavier Lopez, and Paul Schroeder attended the Maine "I.S." on the Move Government Technology Conference, Augusta, ME. Onsrud presented "Impact of Information Policy on the Development of a Spatial Data Infrastructure" at a plenary session on Partnerships, Coordination, and Cooperation. Beard gave a presentation on "Digital Spatial Libraries" in a workshop on Geographic Information Systems. Flewelling presented "The Value of GIS Research and Education to Maine's Economy" in a session on GIS Technology Trends. Lopez (along with Don Wismer and Lars Rydell, Office of the Secretary of State) presented "Cost Recovery/Sale of State Information" in a session on Public Access. Schroeder was the moderator for a session on Changing Policy Perspectives.

September 20-23: Dr. Barry Smith, Department of Philosophy, SUNY Buffalo attended COSIT '95 in Semmering, Austria. His paper presentation "On Drawing Lines on a Map" was awarded Best Presentation of the conference. David Mark co-led the pre-conference workshop "Experientialism", presented the paper "Naive Geography" (co-authored with Max Egenhofer), and was co-author on the conference paper "Evaluating and Refining Computational Models of Spatial Relations Through Cross-Linguistic Human-Subjects Testing". Max Egenhofer chaired a session on Qualitative Spatial Reasoning. Reginald G. Golledge presented a paper entitled "Path Selection and Route Preference in Human Navigation".

September 21: John E. Estes was an invited speaker and presented "The Mythical Map" to the Graduate Student Seminar, Cooperative Fish and Wildlife Unit, The University of Idaho, Moscow, Idaho.

September 24-29: David Mark was a visiting scholar with the Geoinformatics Department at the Technical University of Vienna, and presented a colloquium.

October: Hugo A. Loaiciga presented at the Workshop on Land-Ocean Interactions in the Coastal Zone, International Geosphere and Biosphere Program held in Texel, Holland.

October 2-3: Hugh Calkins attended the 11th Annual NY state GIS conference in Syracuse, NY.

October 2-3: Sam Cole presented the paper "A Calamity Preparedness Model for the United States" at the 11th Annual New York State Geographic Information Systems Conference, Syracuse, NY.

October 4-6: Nectaria Tryfona visited the Department of Computer Science at the George Washington University, Washington, DC, and gave an invited colloquium lecture on "Database design for spatial applications: extending tools and techniques to handle geographic needs".

October 16: Michael Goodchild attended a meeting of the Marine Board, National Research Council, in Washington, DC.

October 18-20: Michael Goodchild attended the First Conference on Spatial Multimedia and Virtual Reality, Lisbon, and gave a keynote address on "Spatial Data Libraries".

October 23-November 3: Michael Goodchild visited the Institut Geographique National in Paris as a visiting scholar, and gave presentations on Spatial Analysis and the Alexandria Digital Library.

October 25-28: At the National Council for Geographic Education Annual Meeting in San Antonio, Steve Palladino gave a presentation on GIS in the Schools and the NCGIA GIS educational efforts.

October 26-27: Hugh Calkins attended a meeting organized by Jordan Hastings of the Desert Research Institute, Reno NV.

October 27: Barbara Buttenfield presented the paper "Putting Cartography on the Internet: The Alexandria Digital Library Project" at the Annual Meetings of the North American Cartographic Information Society, Wilmington, North Carolina (with co-authors C.R. Weber, H.H. Tsou, P. Trawinski and V. Ricci).

October 30: Barbara Butenfield presented "User Evaluation for the Alexandria Digital Library Project" at the Thirty-Seventy Allerton Institute, University of Illinois, Urbana Champaign.

Oct 28-Nov 1: PhD student Peiwu Zhao attended the INFORMS conference in New Orleans and presented the paper he coauthored with Rajan Batta: "Aggregation Analysis for Network Location Problems". Reginald G. Golledge presented a paper entitled "Activity Schedules of Disabled People: Why They Don't Like to Use Mass Transit".

November 3-5: Harlan Onsrud attended a steering committee meeting for the International Conference on Cadastre and Land Administration Reform, Washington, DC.

November: Peter Rogerson presented the paper (coauthored with Ge Lin) "Changes in the Proximity of Adult Children to Their Parents" at the Annual Meeting of the Regional Science Association, Cincinnati, OH. Rogerson was one of the co-authors on a second paper presented at the conference, "Store Strategies on Agglomeration When Consumers Search Optimally". Reginald G. Golledge presented a paper entitled "An Object-Oriented GIS For Conflict Resolution in Advanced Traveler Information Systems (ATIS) with M. Kwan.

November 7: Rajan Batta and Peter Rogerson visited Calspan Corporation, Cheektowaga, NY to discuss potential collaboration between Calspan and NCGIA. Dr. Batta delivered the talk "Conflict Free Routing of Automated Guided Vehicles" at the monthly meeting of the Sigma Xi fraternity, which was hosted by Calspan.

November 13: As a member, Karen K. Kemp attended the Steering Committee meeting of the Remote Sensing Core Curriculum Project in Nashville.

Nov. 12-13: GIS/LIS '95, Nashville, TN. Steven Parkansky presented his paper "The Construction of a GIS to Monitor and Model White-tailed Deer Movement through a Suburban and Exurban Fragmented Landscape"; Barbara Buttenfield chaired the panel session "The K-12 Education Infrastructure"; David Mark presented the paper "Toward a Standard for Spatial Relations in SDTS and Geographic Information Systems", co-authored by M. Egenhofer and A. Sharif; Ling Bian presented her paper "An object-oriented database for integrating GIS and hydrologic model" and was a co-author on three other conference papers.

Marc Armstrong chaired a panel on Group Decision Making and presented the paper he co-authored with Paul Densham "Collaborative Spatial Decision-Making: A Look at the Dark Side". Paul Rooney coordinated the K-12 Convention Program, chaired the session "K-12 Research Products" and presented the paper "Implementing National Geography Standards in Buffalo Public School 40". Karen Kemp attended the conference. Tom Cova, a graduate student at Santa Barbara, was the recipient of the International Geographic Information Foundation's (IGIF) Best Student Paper Award ($1000) for his paper/presentation entitled "A Spatial Search for Neighborhoods that May be Difficult to Evacuate" written in collaboration with Richard L. Church.

November 17: Karen K. Kemp organized and attended the UCGIS First Annual Business Meeting in Nashville. Michael Goodchild also attended as UC Santa Barbara representative.

November 18: Munroe Eagles presented the paper "Continuity in Electoral Change: Patterns in Support for Canadian Parties, 1988 & 1993" (co-authored by D.M. Eagles, J.P. Bickerton, A-G. Gagnon and P.J. Smith) at the Association of Canadian Studies in the US (ACSUS) biennial meeting, Seattle, WA.

November 29-December 1: Dimitris Papadias and Nectaria Tryfona attended the 1995 Conference on Information Knowledge and Management, Baltimore, MD.

December: Hugo A. Loaiciga attended the American Geophysical Union Meeting as a member of the Executive Committee, San Francisco, CA.

December 1: David Mark gave a talk "Representations of Geographic Space in Language, Culture, and Geographic Information Systems" at the Regional Research Institute and Department of Geography, West Virginia University, Morgantown, WV.

December 1-2: Dimitris Papadias and Nectaria Tryfona attended the 3rd ACM International Workshop on Advances in Geographic Information Systems, Baltimore, MD. Tryfona presented "Geographic Applications Development: Models and Tools and the Conceptual Levels".

December 3-4: David Mark attended an Initiative 19 Core Planning Group meeting in Nitro, WV.

December 12-13: Michael Goodchild participated in a meeting of the Steering Committee of the European Science Foundation GISDATA program in Zurich.

December 18: Michael Goodchild visited the University of Leicester, UK, to act as external examiner for the PhD thesis of Joseph Green.

December 20: Paul Sutton and Paul Van Zuyle (graduate students at Santa Barbara) and Steve Palladino visited personnel at Environmental Systems Research Institute to demonstrate the ArcView Educational Modules (developed through an ESRI gift).

APPENDIX 3 - VISITORS TO NCGIA SITES

Peggy Agouris, Swiss Federal Institute of Technology
A. Akeno, EROS Data Center, Sioux Falls
Joseph P. Allen IV, Space Industries International
Carl Amrhein, University of Toronto
Marc Armstrong, University of Iowa
Kay Axhausen, University of Innsbruck, Austria
Jerome Barancik, Brookhaven National Laboratory
Garry Barringer, US Air Force Rome Laboratory
Keith Bell, AUSLIG, Australia
Richard Bernecki, Lockport Savings Bank
Arne-Jorgen Berre, SINTEF Informatics, Norway
Allan Blatt, Calspan-UB Research Foundation
Jan Terje Bjorke, University of Trondheim, Norway
Peter Burrough, University of Utrecht, Netherlands
Yoon C. Choy, Yonsei University, Korea
Robert Cromley, University of Connecticut
James Cusack, US Air Force Rome Laboratory
Jack Dangermond, ESRI
W. Jackson Davis, Monterey Institute of International Studies
Stephen de Jong, University of Utrecht, Netherlands
Paul Densham, University College London
Mani Arun Dixit, Wildlife Institute of India
Michael Dobson, Rand McNally
Terry Done, Australian Institute of Marine Science, Queensland
Geoffrey Dutton, University of Zurich
Elikkos Elia, Nicosia, Cyprus
Stephen Ervin, Harvard University
State Senator Sean Faircloth, Augusta ME
Peter Fisher, University of Leicester, UK
Stewart Fotheringham, University of Newcastle-upon-Tyne
Hiromichi Fukui, STB Research Institute, Japan
Sandro Gizzi, ESRI, Rome
Christine Gobbi, Brazil
Darryl Greenwood, US Air Force Rome Laboratory
Trevor Harris, West Virginia University
Clem Hendrickson, ESRI
Paul Hendriks, University of Nijmegen, Netherlands
Jonathan Howard, City of Ventura
Carolyn Hunsaker, Oak Ridge National Laboratory
Lawrie Jordan, ERDAS
Anthony Karnvas, Hewlett Packard
Jim Keating, Kansas State University-Salina
Jong Dae Kim, Dong-A University, Korea
Robert Kitchen, University of Wales, Swansea
Harald Klempe, Telemark College, Norway
Brian Klinkenberg, University of British Columbia
Ken Knight, Santa Barbara City Administrator's Office
J.G. Krishnayya, Systems Research Institute, Pune, India
Daniel Kupiak, US Air Force Rome Laboratory
Cooper Lansing, Erie Community College, NY
Rich Lee, United Way of Buffalo and Erie County, NY
Mark Leipnik, US Bureau of Reclamation, Las Vegas, NV
John Lewis, McGill University

Mark Lloyd, Penfield and Smith, Ventura, CA
John Lordi, Calspan-UB Research Center
Gunther Menz, University of Bonn, Germany
Randall L. Moory, State of California
Stan Morain, University of New Mexico
Kam Movassaghi, University of Southwestern Louisiana
Cathy Mueller, ESRI
Michael Nilan, Syracuse University
Susan Nolen, Intergraph Corporation
Lennart Olsson, Lund University, Sweden
Micha Pazner, University of Western Ontario
Jonathan Raper, Birkbeck College, University of London
Rob Raskin, UC Santa Cruz
Mary Ellen Rogge, Washington University
Svenn Rognas, University of Trondheim, Norway
Robert Rugg, Virginia Commonwealth University, Richmond
Steven Schoyk, Lockheed-Martin
Paul Schreilechner, University of Salzburg, Austria
Pau Serra, University of Maryland
Rahul Simha, College of William and Mary, Williamsburg
Eli Skop, National Environmental Research Institute, Denmark
Carl Steinetz, Harvard University
Jason Steinetz, Erie Community College, NY
Mark Stevens, Erie Community College, NY
Michael Teitz, UC Berkeley
Marius Theriault, Laval University, Quebec
Ed Thomas, Lockheed-Martin
Carol Traynor, University of Massachusetts, Lowell
Gunnar Vatn, University of Trondheim, Norway
Allen Watkins, USGS
Tom Waugh, University of Edinburgh, UK
Michael Wegener, University of Dortmund, Germany
Lyna Wiggins, Rutgers University
Alexander Wiley, Harvard University
Victoria Wiley, Harvard University
Cort Willmott, University of Delaware
Randolph Wynne, University of Wisconsin, Madison
R.N. Yadava, Regional Research Laboratory, Bhopal, India
Harumi Yanagimachi, Shinshu University, Japan
CiXiang Zhang, ESRI
Zbigniew Zwolinshi, Adam Mickiewicz University, Poland

APPENDIX 4 - COURSES TAUGHT BY NCGIA FACULTY

1. Santa Barbara

Physical Geography, Winter 1995, Terry Smith
Environmental Optics in Physical Geography, Winter 1995, Dar Roberts
Introduction to Spatial Decision Making and Behavior, Winter 1995, Reginald Golledge
Introduction to Meteorology, Winter 1995, Joel Michaelsen
Remote Sensing Techniques, Winter 1995, Leal Mertes
Groundwater Hydrology, Winter 1995, Hugo Loaiciga
Rivers, Winter 1995, Leal Mertes
Behavioral Geography, Winter 1995, Dan Montello
Biogeography: The Study of Plant and Animal Distributions, Winter 1995, Frank Davis
Introduction to Geographical Data Analysis, Winter 1995, Joel Michaelsen
Application Issues in Geographic Information Systems, Winter 1995, Michael Goodchild
Planning Issues, Winter 1995, Helen Couclelis
Environmental Ethics, Winter 1995, James Proctor
Optimization Models for Geographic Problems, Winter 1995, Richard Church
Introduction to Geographic Research, Winter 1995, Joel Michaelsen and James Proctor
Seminar in Geography, Winter 1995, James Proctor
Remote Sensing and Environmental Optics, Winter 1995, Dar Roberts
Research Methods in Human Geography, Winter 1995, Dan Montello
Advanced Atmospheric Remote Sensing, Winter 1995, Catherine Gautier
Advanced Hydrologic Modeling, Winter 1995, Hugo Loaiciga
Introduction to Data Analysis, Winter 1995, Joel Michaelsen
Advanced Topics in Location and Transportation Systems, Winter 1995, Richard Church
Physical Geography, Spring 1995, Dar Roberts
Socioeconomic Geography, Spring 1995, James Proctor
Intermediate Geographic Remote Sensing Techniques, Spring 1995, Leal Mertes
Great Cities of the World, Spring 1995, Helen Couclelis
Water Pollution, Spring 1995, Hugo Loaiciga
Advanced Geographical Data Analysis, Spring 1995, Joel Michaelsen
Technical Issues in Geographic Information Systems, Spring 1995, Michael Goodchild
Issues in Planning, Spring 1995, Richard Church
Seminar in Geography, Spring 1995, Dar Roberts
Digital Techniques in Remote Sensing, Spring 1995, Leal Mertes
Seminar in Remote Sensing, Spring 1995, Dar Roberts
Scientific Reasonings, Spring 1995, Helen Couclelis
Environmental Perception and Cognition, Spring 1995, Dan Montello
Biophysical and Biochemical Processes, Spring 1995, Frank Davis
Advanced Geographical Data Analysis, Spring 1995, Joel Michaelsen
Urban Geography, Fall 1995, Helen Couclelis
Environmental Hydrology, Fall 1995, Hugo Loaiciga
Geographic Air Photo Interpretation, Fall 1995, John E. Estes
Environmental Perception and Cognition, Fall 1995, Dan Montello
Australia and New Zealand, Fall 1995, Reginald Golledge
Introduction to Geographic Research, Fall 1995, Joel Michaelsen
Seminar in Geography, Fall 1995, Reginald Golledge
Advanced Remote Sensing, Fall 1995, Dar Roberts
Seminar in Geographic Information Systems, Fall 1995, Michael Goodchild
Advanced Topics in Location and Transportation Systems, Fall 1995, Richard Church

2. Maine

Land Development Design, Spring 1995, Harlan Onsrud

Community Info. System Design, Spring 1995, Kate Beard
GIS Applications, Spring 1995, Kate Beard
Land Info. Systems in Developing Countries, Spring 1995, Harlan Onsrud
Research Methods, Spring 1995, Max Egenhofer
Graduate Seminar, Spring 1995, Harlan Onsrud
Spatial Relations, Spring 1995, Max Egenhofer
Graduate Thesis, Spring 1995, Harlan Onsrud
Error Models/Spatial Statistics, Spring 1995, Kate Beard
Database Quality Modeling, Spring 1995, Kate Beard
DEMs & Soil Survey Mapping, Spring 1995.
Engineering Databases, Fall 1995, Max Egenhofer
Query Languages and User Interfaces, Fall 1995, Max Egenhofer
Remote Sensing, Fall 1995, Peggy Agouris
Introduction to GIS, Fall 1995, Kate Beard
Computer Law, Fall 1995, Harlan Onsrud
Introduction to Surveying, Fall 1995, Harlan Onsrud
Graduate Seminar, Fall 1995, Harlan Onsrud
Spatial Analysis, Fall 1995, Kate Beard

3. Buffalo

Introduction to Physical Geography, Spring 1995, Woldenberg
Maps and Mapping, Spring 1995, Mark
Cartography, Spring 1995, Buttenfield
GIS Applications, Spring 1995, Calkins
Remote Sensing, Spring 1995, Robinson
Spatial Decision Support Systems, Spring 1995, Cole
GIS Algorithms and Data Structures, Spring 1995, Mark
Multivariate Statistics, Spring 1995, Rogerson
Population Geography, Spring 1995, Rogerson
Census Data and their Use, Spring 1995, Calkins
Mathematical Models, Spring 1995, Cole
The Geography of the Information Society, Spring 1995, Batty
Geography of Economic Systems, Fall 1995, Bagchi-Sen
Urban Geography, Fall 1995, Bagchi-Sen
Geographical Information Systems, Fall 1995, Bian
Computer Cartography, Fall 1995, Buttenfield
Geographic Information Design, Fall 1995, Buttenfield
Regional Analysis, Fall 1995, Cole
Urban-Social Geography, Fall 1995, Cope
Univariate Statistics in Geography, Fall 1995, Rogerson
Population Geography, Fall 1995, Rogerson
Landform Development, Fall 1995, Woldenberg
Introduction to Graduate Geography, Fall 1995, Woldenberg
Introduction to Political Science, Fall 1995, Eagles
Politics and Society, Fall 1995, Eagles
Stochastic Methods, Fall 1995, Batta

APPENDIX 5 - GRADUATE DEGREES GRANTED AT NCGIA SITES

1. Santa Barbara

AURAND, Michele, M.A., Spring 1995, An Intelligent Assistant for Processing GIS Data (Lanter, Couclelis, Goodchild).

BELL, Scott, M.A., Winter 1995, Cartographic Presentation as an Aid to Spatial Knowledge Acquisition in Unknown Environments (Golledge, Couclelis, Montello).

CAETANO, Mario, M.A., Winter 1995, Burned Vegetation Mapping in Mountainous Areas with Satellite Remote Sensing (Mertes, Davis, Goodchild, José Pereira).

CLOUD, John, M.A., Fall 1995, A Splendor Which is its Own: Realizing the Potential of Space Shuttle Earth Observations Photography (Couclelis, Dozier, Tobler).

COVA, Thomas, M.A., Fall 1995, A Spatial Search for Neighborhoods that may be Difficult to Evacuate (Church, Couclelis, Goodchild).

ELDER, Kevin, Ph.D., Summer 1995, Snow Distribution in Alpine Watersheds (Dozier, Michaelsen, Melack, Loaiciga, Lee Dexter).
GERRARD, Ross, Ph.D., Summer 1995, The Location of Service Facilities Using Models Sensitive to Response Distance, Facility Workload, and Demand Allocation (Church, Anselin, Goodchild, John Current).

GIORDANO, Alberto, M.A., Winter 1995, Understanding Cartographic Design: An Experientialist Approach (Tobler, Couclelis, Lanter).

HAWKSWORTH, John, M.A., Spring 1995, degree by examination (Loaiciga, Mertes, Ferren).

KATTELMANN, Richard, Ph.D., Summer 1995, Water Movement and Ripening Processes in Snowpacks of the Sierra Nevada (Dozier, Melack, Loaiciga, P. Marsh).

LEIPNIK, Mark, Ph.D., Winter 1995, A Spatial Decision Support System for Management of Subsurface Contamination: A Case Study of SDSS Development, Implementation and Evaluation at Vandenberg AFB, California (Loaiciga, Church, Goodchild, Glyn Pritchard).

LOSCH (HANSEN), Claudine, M.A., Fall 1995, Vegetation Change from 1973 to 1987 in the Rora Habab Plateau, Northern Eritrea, Based on Lnadsat MSS Imagery (Jones, Estes, Mertes).

MURRAY, Alan, Ph.D., Spring 1995, Modeling Adjacency Conditions in Spatial Optimization Problems (Church, Goodchild, Anselin, Jared Cohon).

NOSSE, Craig, M.A., Winter 1995, Variations of the Optical and Physical Structure of Rainwater Layers in the Western Equatorial Pacific Ocean (Washburn, Siegel, R. Smith).

ODION, Dennis, Ph.D., Fall 1995, Effects of Variation in Soil Heating During Fire on Patterns of Plant Establishment and Regrowth in Maritime Chaparral (Davis, Bruce Mahall, Michaelsen, Jones).

SALETA, Jose, M.A., Winter 1995, Stand Discrimination in a Western Coniferous Forest Using AIRSAR Data (Davis, Melack, Michaelsen).

STINE, Peter A., Ph.D., Spring 1995, A Multi-Scale Conservation Assessment of Plant Communities in Southern California (Davis, Goodchild, J. Franklin, Estes, M. Gilpin).

SUTTON, Paul, M.A., Spring 1995, Public Opinion of Population Issues (Golledge, Montello, Tobler).

TALEN, Emily, Ph.D., Fall 1995, The Achievement of Planning Goals: A Methodology for Evaluating the Success of Plans (Couclelis, Golledge, Goodchild, Lewis Hopkins).

VAN ZUYLE, Paul, M.A., Spring 1995, Modeling Schistosomiasis: Using New Tools to Explore the Relationship between Human Behaior and Water-borne Disease (Couclelis, Golledge, Montello, Helmut Kloos).

WANG, Naxin, M.A., Winter 1995, Retrieving Temperature and Water Vapor Profiles of the Lower Part of the Atmosphere in Thermal Infrared (R. Smith, Dozier, Michaelsen, Wan Zhengming).

2. Maine

HASSEN, K., Ph.D., Spatial Information Science and Engineering, December 1995, Reference Grid: A Technique for Visualizing the Effects of GIS Positional Transformations.

JOHNSON, J.P., M.S., Spatial Information Science and Engineering, May 1995, Information Policy for Local Government Information Systems: Adoption, Implementation, and Results.

OZOG, R., M.S., Spatial Information Science and Engineering, December 1995.

SANBORN, J.A., M.S., Geographic Information, August 1995, The Relationship of GIS User Types and Their Preferences for Information Help Systems.

3. Buffalo

BERTOLIS, Randy, Ph.D., Geography, September 1995, Cross-Cultural Environmental Perception toward Wilderness and Development at James Bay, Quebec (Woldenberg, Mark, Ebert, Zubrow).

CONGILIO, Greg, M.A., Geography, September 1995, The Role of the University in the Development of Geographic Information Systems Within State Governments (Calkins, Mark).

COVINO, Eric, M.A., Geography, September 1995, The Export GIS Model (Batty, McConnell).

CURTIS, Andrew, Ph.D., Geography, September 1995, Surfaces of Macro Spatial Knowledge: Sources, Structures and Recall Methodologies (Fotheringham, Rogerson, Mark, Morton O'Kelly).

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

KICK, John Wilfred, M.A., Geography, September 1995, Alternative Methods for Mapping STATSGO and Defining Attribute Composition (Buttenfield, Mark).

KING, Nicholas, Ph.D., Geography, September 1995, Achieving Spatial Decision Support With GIS: A Case Study in Water Resources Management in South Africa (Calkins, Batty, Woldenberg, Densham).

KRACKER, Laura, M.A., Geography, September 1995, The Use of GIS in Wetlands and Soils Mapping for a Fish and Wildlife Management Plan (Buttenfield, Calkins).

KRUEGER, Christine, M.A., Geography, September 1995, Nonconsumptive Vessel Interaction with Killer Whales in Johnstone Strait, B.C. (Mark, Jelinski).

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

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

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

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

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

WEATHERBE, R., Ph.D., Geography, September 1995 (Calkins).

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