REPORT ON THE CENTER FOR SPATIAL STUDIES

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I. Introduction

The Center for Spatial Studies (spatial@ucsb) was founded in July 2007 through an initiative by Professor Michael Goodchild. Upon his retirement in July 2012, Professor Mary Hegarty (Department of Psychological and Brain Sciences) assumed the directorship. Beginning November 2013, Werner Kuhn will be the director of the center and Hegarty will be the co-director.

The founding vision of the center was to develop spatial thinking as an approach to scholarship, supporting its use across the entire range of disciplines at UCSB for research and education. With the transfer of leadership of the center from Goodchild (July 2007–June 2012) to Hegarty (July 2012–October 2013) and the senior appointment of Werner Kuhn to fill the Jack and Laura Dangermond Chair in Geography, this report lays the groundwork for renewing and expanding the center's mission to be at the forefront in the development of educational and research initiatives and to engage researchers in spatially enabled linked science through open access to research data referenced by location and topic

This report documents the activities of the center since March 2010 (the date of the last report to the Executive Vice Chancellor), highlighting its role as a catalyst for interdisciplinary communication, teaching, and research. It reviews the center's initiatives in educational program development and its research activities as documented in the lists of external funding sources (Appendix 1), publications, and presentations (Appendix 3). The report (in section VI) also addresses the evolving mission of the center and its vision for transformative impact on interdisciplinary research and education at UCSB.

II. Services to the Campus and Community

The center provides a number of services to the academic community at UCSB. These include the development of laboratories and work spaces for access to cutting-edge hardware, data, and software tools; the creation of a consulting service and seminar series; community outreach; housing for visitors; international summer workshops; and a conference series. All of these have helped to enrich the resources at UCSB for spatially enabled research and have contributed to the development of a strong interdisciplinary thread of spatial studies.

Facilities

Phelps 3510/12, redeveloped in 2007 to serve as the administrative hub for the center, provides space for program directors and the coordinator, and workstations for graduate students and

visitors. As the former UCSB site of the National Center for Geographic Information and Analysis, spatial@ucsb also fulfills activities related to a memorandum of understanding with NCGIA partners at the University of Maine and SUNY Buffalo.

Ellison 2616 and **Ellison 3625**. Ellison 2616 is a 16-seat computing lab with high-end workstations, designated for daily use by graduate students and faculty and for the international workshops that the center offers each summer. It also houses the center's help-desk activities. All of the workstations in this lab were updated in 2012. Ellison 3625 (the GeoTrans Lab) is a workspace for graduate students in transportation-related research (e.g., the recently completed L.A. ports project (funded by the U.S. Department of Transportation), as well as research projects directed by Professor Kostas Goulias.

All of these facilities benefit from the UCSB **site license for Esri software**, for which the campus receives a significant discounted rate. The cost of the site license has been shared for many years among various user groups on campus. In addition, strong links have been established with the Map and Imagery Laboratory, a major repository of spatial data, and with other groups on campus that manage substantial data resources, including the Marine Science Institute (MSI), Facilities Management, and Cheadle Center for Biodiversity and Ecological Restoration (CCBER). The center has chosen this approach of building partnerships as a better alternative to developing its own data-center functions.

Inter-disciplinary Campus Engagement

The spatial center actively pursues opportunities to interact across disciplinary boundaries and to contribute to programs sponsored by other organizations on campus. Some examples follow.

In academic year 2010–2011, Goodchild and Janelle served as consultants, advising the Interdisciplinary Humanities Center (IHC) on speakers and program options for its year-long series on the "*Geographies of Place*." The theme emerged from a proposal submitted several years earlier for a humanities cluster hire in "spatial studies." As part of an extensive program of speakers and exhibits, spatial@ucsb organized and presented a three-hour workshop on ***Tools for Map Making: A Geographies of Place Workshop*** (15 Oct. 2010) and developed a complementary web resource to assist researchers and students on campus. In addition, with IHC, the center co-sponsored a two-day conference on ***Mapping Place: GIS and the Spatial Humanities*** (Feb. 25–26, 2011). This conference examined the intersection between GIS and the spatial turn in the humanities.

On a regular basis, spatial@ucsb assists in publicizing other spatially relevant events on campus, including programs sponsored by IHC, the Center for Information Technology & Society, the Carsey-Wolf Center (especially its 2012–2013 series of events on sea-level rise), the Cognitive Science program, and talks presented in the departments/programs of Computer Science, Comparative Literature, History of Art and Architecture, Media Arts and Technology, and Medieval Studies, among others.

Seminar Series

The center has made special efforts to bring together campus-wide faculty and student researchers to exchange ideas and methodologies about spatial thinking and spatial analysis. These include the ***ThinkSpatial Brown-bag Forum*** and the ***Graduate Student Forums***. Appendix 2, Service Activities, provides detailed listings of all of the events in these series over the past three years.

In the academic year of 2010–2011, Janelle organized 14 presentations in the ***ThinkSpatial*** series, with 12 presentations in 2011–2012 and 14 in 2012–2013. This series is well attended by academics campus-wide, and involves speakers from both on and off campus. Sessions average more than 20 attendees; some sessions attract as many as 40. In this period, speakers have come from local industries that engage in spatial technologies and services, from UCSB (Art, Art History, the Broom Center for Demography, Computer Science, Davidson Library, Film and Media Studies, Geography, Linguistics, Media Arts and Technology, Psychological and Brain Sciences, and Statistics and Applied Probability), as well as visiting scholars from several other universities and from national research laboratories.

The ***Graduate Student Forums*** features student-organized events, drawing on participants from diverse disciplines across campus. Currently organized by Kitty Currier (a graduate student associate of the center), these sessions have included *Spatial Technology Lunch Discussions* and *Spatial Lightning Talks*. The latter feature several 3-minute talks on spatial topics over a lunch period. In 2012–2013 Currier has hosted four lunch discussions and one Spatial Lightning event with 14 speakers. All of these sessions were filled to capacity. Details are contained in Appendix 2 and are available on line at http://www.spatial.ucsb.edu/events/student-forums.php.

Consulting Service

The center has offered a consulting service (Help Desk) since its inception, offering consultation and advice to the campus community on the uses of spatial data and tools. This has evolved into a weekly event with a broad base of interested users, including faculty, graduate students, undergraduates, and campus personnel in Facilities Management. It is staffed by graduate research assistants (currently by Song Gao, graduate student, Department of Geography). Many of the topics concern standard GIS client software, but there is increasing interest in Web programming and server software, and in tools such as Google Earth. Support requests range from simple cartographic design to complex, multistep spatial information modeling (examples are listed in Appendix 2).

Community Outreach

While the primary orientation of the center is toward the campus, several activities have continued to focus on outreach and relations with the local community. Each year it sponsors a spatial@ucsb.local event, which is publicized widely to the campus and the local community, and includes plenary speakers and poster displays. Posters feature the work of UCSB students and faculty, as well as non-campus projects in the local community. These events give UCSB undergraduates, in particular, an excellent opportunity to communicate their work. This event is co-sponsored with the Channel Islands GIS group, a professional collaboration among GIS users in Santa Barbara and Ventura Counties.

The sessions for each year attract between 200 and 300 participants and as many as 50 posters are exhibited. Participants at these events have opportunities to tour campus facilities such as the AlloSphere, the MSI, and the Center for Spatial Studies.

The thematic foci for the most recent years include:

- June 1, 2010 **GIS for Disaster Planning and Response**
- June 2, 2011 **Marine GIS**
- June 6, 2012 **Educating the Spatial Thinker**

- June 6, 2013 **Visualization of Spatial Data**

Appendix 2 offers more information about these events. Slide presentations and student poster displays for previous years are accessible at http://www.spatial.ucsb.edu/events/local-gis.php.

III. Services to Science and Scholarship

Visitors

The center has hosted productive visits by 14 international scholars over the past three years (2010–2013). The full list of visitors is given in Appendix 2. Visitors have given presentations in the ThinkSpatial Brown-bag series, have interacted with UCSB faculty and students in research and education activities, and have participated in center-sponsored workshops and specialist meetings.

International Workshops and Institutes

UCSB is recognized as a home for workshops on a variety of spatial topics, offered to senior graduate students and junior faculty during the summer months. The tradition began with NCGIA in the late 1980s and continued with the Varenius Project in the 1990s and the CSISS and SPACE projects (2000–2007)—all NSF-funded programs. The following workshops and institutes have been offered 2010–2013:

National Institute of Child Health and Human Development (NICHD) Training Programs for GIS and Spatial Analysis

In 2005 the center teamed up with the Population Research Institute at Pennsylvania State University to host an NICHD training program for GIS in the population sciences. An additional award in 2008 extended this program for five years (June 2008–May 2013) on the theme of **Advanced Spatial Analysis**. These workshops, aimed at the current cohort of young demographers and population scientists, have traditionally been substantially oversubscribed, and have been unusually successful at attracting graduate students and junior faculty from minority-serving institutions. In 2010 UCSB hosted two workshops, one focused on geographically weighted regression and the other on spatial pattern analysis. The latest workshop, in 2011, focused on multi-level modeling. Participants come from a broad range of disciplines, including demography, epidemiology, the social sciences, and the health sciences. A limited number of positions in the workshops have been filled by participants from UCSB, most recently from the departments of Communications, Economics, Geography, Marine Science, Sociology, and the Bren School. The workshops have also provided instructional experiences for Geography graduate students, who work as teaching assistants.

UCSB Workshop on Developing Spatial Literacy Benchmarks

In March 2011, as part of an NSF project, Janelle and Karl Grossner (then a post-doctoral associate with the center) convened a two-day specialist workshop for leading researchers and educators who share an interest in spatial learning for STEM education. Its participants reflected a diversity of perspectives from the science education, mathematics, cognitive psychology, and spatial science disciplines. Workshop activities included (a) a review of the National Science Education Standards (NSES 1996) for grades 9–12 to

assess their explicit or implicit contribution to student spatial reasoning skills and to identify essential spatial principles and skills that are not embedded either explicitly or implicitly within 9–12 NSES and Math and Science standards; (b) expert assessment about desired spatial learning objectives and their appropriateness for achieving spatially literate/informed high school graduates; and (c) an assessment of what university undergraduate instructors in STEM disciplines can rely on as foundation knowledge for spatial reasoning by incoming first-year undergraduate students.

International Spatial Cognition Summer Institute

In summer 2013 the center will host the International Spatial Cognition Summer Institute (ICSCI). ISCSI 2013 will present two consecutive week-long sessions consisting of intensive lectures, tutorials, and student presentations on spatial cognition, the study of spatial perception, thinking, reasoning, and communication by humans, nonhuman animals, and computational entities such as robots. Spatial cognition includes research approaches from several disciplines and sub-disciplines of the social and behavioral sciences, life sciences, and information and computer sciences. Like its predecessor, held in Germany in 2003, the 2013 Institute is primarily aimed at graduate students, postdoctoral students, and early-career researchers and academics with a strong interdisciplinary interest in spatial cognition research. Nineteen instructors and approximately 50 students from the disciplines of psychology, geography, computer and information science, architecture, and education will participate. Mary Hegarty and Daniel Montello are the lead UCSB organizers of this important new initiative by spatial@ucsb.

Conference Series

Another longstanding spatial tradition at UCSB has been an annual **Specialist Meeting.** These meetings convene 30–40 researchers from around the world to discuss a cutting-edge topic, and to formulate a community research agenda. Fifty such meetings have been held since 1988, with support from a variety of funding sources, including NSF, National Institute of Health (NIH), and Esri. Final reports on meetings over the past three years are available at http://www.spatial.ucsb.edu/events/. Summary of these events follow:

December 2010

Spatio-Temporal Constraints on Social Networks—Forty researchers from multiple disciplines identified and prioritized a research agenda and began the development of an international community of collaborating scholars seeking to understand the spatio-temporal constraints on social networks. Discussions focused on (a) incorporating the constraining effects of space, time, the Internet, and mass media in theories of social network interaction; (b) the development of metrics and models for assessing critical nodes, groups, and trails in and through networks; (c) methods for visualizing the operation of spatio-temporal constraints and their effects on the flow of ideas and information through meta-networks; and (d) the detection of spatio-temporal and network constraints in crowd-sourced data and appropriate metrics of uncertainty.

December 2011

***Future Directions in Spatial Demography*—**Specialists from a range of population and health sciences reviewed challenges and new directions for spatial demography, identifying gaps in current knowledge regarding innovations in geospatial data, spatial statistical methods, and the integration of data and models to enhance the science of spatial demography in population and health research. Program officers from the NIH participated in the discussions. Expenses for this meeting were mostly offset through the NICHD Advanced Spatial Analysis Training program, which is offered jointly by UCSB and Penn State University.

December 2012

***Spatial Thinking Across the College Curriculum*—**This two-day specialist meeting included invited plenary presentations by experts on challenges of spatial thinking in different disciplines, cognitive analyses of spatial thinking processes, and current best practices in educating spatial thinking. In smaller breakout sessions, disciplinary experts, cognitive scientists, and college administrators worked together to identify the current state of our understanding of spatial thinking, identify gaps in our knowledge, and set priorities for both research and practice in educating spatial thinkers at the college level. The NSF-funded Spatial Intelligence and Learning Center (SILC, based at Temple University) and Esri cooperated with spatial@ucsb to co-sponsor and fund the meeting.

December 2013 or early 2014

The Smart Campus—preliminary plans are under discussion for a specialist meeting that addresses the practices and potentials for implementing campus resources to integrate geo-spatial and other information sources for access via mobile technologies to students, researchers, staff, and the general public. Moving beyond the role of technology in promoting efficiencies in energy use and the management of physical resources, a data-driven smart campus could be the foundation for expanded levels of cross-disciplinary collaboration for innovative teaching and research.

Although this section is labeled “services to science and scholarship,” the center’s sponsorship of workshops, institutes, and specialist research meetings, and its hosting of visitors, bring significant attention to the important role that UCSB plays in advancing spatial understanding in science and society. These events also accommodate participation by UCSB students and researchers, thereby facilitating access to opportunities for building collaborative networks nationally and globally.

IV. Curriculum Development

One of the center’s goals is to increase student access to courses and instructional materials that build spatial intelligence. Efforts since the establishment of the center have focused on: the UCSB undergraduate curriculum, building interdisciplinary strength at the graduate level, outreach to the K–12 curriculum, and creating extensive online resources.

Undergraduate Curriculum—Minor in Spatial Studies

A proposal for a Minor in Spatial Studies was submitted to the College of Letters and Science in March 2010 and approved by the Academic Senate Undergraduate Council in November 2010

for implementation beginning in January 2011. The minor is managed through the Department of Geography, with Janelle and Karen Doehner (the center's administrative coordinator) serving as student advisors. An advisory board includes Richard Church and Helen Couclelis (Geography), Kim Yasuda (Art), Mary Hegarty (Psychological and Brain Science), and Volker Welter (History of Art and Architecture).

Spatial Studies is an interdisciplinary minor that complements a student's academic major with concepts and tools for spatial thinking, spatial analysis, and spatial representation. For the minor, students select one of three foci that allies most clearly with their areas of disciplinary and/or career interest: (a) **Spatial Thinking**, (b) **Space and Place**, and (c) **Spatial Science**. The curricula for these areas of study include a breadth of courses that reflect the pervasive nature of spatial reasoning across diverse fields of knowledge. **Spatial Thinking** emphasizes spatial cognition and reasoning associated with problem solving and representation, and applications of both elementary and complex reasoning processes in different domains of human activity and knowledge development; **Space and Place** builds on courses that apply spatial reasoning and visualization in the arts and humanities; and **Spatial Science** emphasizes the analysis and visualization of information, featuring courses that build methodological and technological competencies for documenting space–time patterns and processes about phenomena in the physical world as well as about behavior and its consequences in the human world.

Geography 12 (Maps and Spatial Reasoning, developed by Professor Keith Clarke) is the required common course for the minor. It treats the fundamental science of mapping, including the underlying mathematics for spatial transformations and projections, exposure to computerized graphics and mapping systems, and the use of maps as research tools to document and communicate information as well as to solve problems.

To date, 42 students have completed the minor; two more students have submitted their documents for graduation in September 2013, and one for December 2013, bringing the total to 45. Since there is no formal "declaration" for undergraduate minors at UCSB, many students simply present their materials at the end of their studies, having completed the minor, so it is possible that these numbers will increase by the end of the summer quarter. There has definitely been a growth in the number of students who visit the center to discuss the possibility of working toward the minor. Graduates have come from the departments of Biology/EEMB, Chemistry, Chicano Studies, Communication, Environmental Studies, Geography, Geology, Mathematics, Psychology, and Sociology. Interest from students in Applied Statistics and Probability, Art History, and Film and Media Studies has increased in the past year. We anticipate that interest in the minor will continue to grow.

Freshman Seminar: *Thinking Spatially in the Arts and Sciences*

Through the initiatives of Hegarty, Montello, and Janelle, the spatial center offered a Freshmen Seminar in fall quarter 2012. *Thinking Spatially in the Arts and Sciences* (INT 94PN) aimed to expose students to applications of spatial reasoning by instructors from several departments. In addition to the organizers, these included Kim Yasuda (Art), Matthew Turk (Computer Science), Michael Goodchild and Richard Church (Geography), and Volker Welter (History of Art and Architecture). Students learned how statistics, graphs, maps, and virtual reality aid learning, analysis, data visualization, discovery of solutions to socio-environmental problems, and space/place interpretations in the arts and humanities. Sixteen students completed the course and three of these indicated an interest in pursuing the minor in spatial studies. This course will be

modified based on our experience and student feedback, and will be offered again in fall quarter 2013.

Graduate Curriculum

Even students at the graduate level lack the kinds of critical spatial thinking skills that are needed to make effective use of today's spatial tools, and to conduct research in areas that make extensive use of data and models that are embedded in space and time. Correspondingly, in recent years, both Goodchild and Hegarty have encouraged graduate students from multiple disciplines to enroll in their graduate-level courses related to spatial cognition and geographic information science. Students from computer science, the Bren School, environmental science, the social sciences, and engineering have taken advantage of these courses, but a more formal approach may be needed and is under consideration by the center to make critical spatial thinking skills more widely available to graduate students across the campus. GK-12 and IGERT proposals, submitted to NSF in 2009–2010, were highly rated by reviewers. Although not funded, those efforts provide excellent grounding for renewed development and submission in the near future.

K–12 Initiatives

The center is interested in establishing long-term linkages with K-12 educators to help embed spatial intelligence across the entire educational spectrum. This goal is inspired by a successful project, concluded in 2010. With support from the U.S. Fish and Wildlife Service, Josh Bader (a graduate student associate of the center) worked with middle schools in Guadalupe and Ventura to introduce spatial concepts into the Grade 6 earth science curriculum, developing teaching materials using GPS to identify and map plant species in relation to topographic elevation.

Another project, funded by an NSF grant to Janelle (PI) and Grossner, engaged a small group of researchers and educators to assess the spatial content of the K-12 National Science Education Standards (NSES 1996)—150 standards grouped into three science domains (physical, life, and earth/space) for the purpose of developing a set of spatial literacy benchmarks—the spatial concepts and principles one should expect new college freshmen to understand , as well as the spatial reasoning skills in which they should be proficient. Together, these prior initiatives represent a basis for pursuing further spatial literacy initiatives in K-12 education.

Online Resources

One of the center's significant contributions has been the development of extensive online resources. The main **spatial.ucsb.edu** site, maintained by a part-time webmaster, provides a wealth of information on the center and its programs, draws attention to events, allows users to see PowerPoint and video recordings of presentations, and includes extensive educational resources. In addition, the center has developed **teachspatial.org** as a substantial collection of materials relating to fundamental spatial concepts in different disciplines. The initial work on this site was by Grossner. Upon completion of his Ph.D., he worked with Janelle (PI) to enhance and expand these resources as a pathways collection within the National Science Digital Library.

The TeachSpatial collection of concepts and related teaching materials allows users to approach the resource from a range of perspectives. Beyond simple alphabetical indexing, the site identifies part-whole relationships, cases of semantic similarity where the same or similar concepts have different names in different disciplines, groupings based on loosely defined categories, and links to national curriculum standards. Owing to http://teachspatial.org, users can

now search the body of more than 140,000 NSDL instructional materials from a broad range of STEM disciplines based on their relevance to spatial concepts. In the future, it may be possible to consider whether and how spatial concepts can be used to create new, more intuitive, and more coherent user interfaces to spatial technology.

Currently, Janelle and graduate student Daniel Ervin are working with researchers at Penn State University (Stephen Matthews and his team at the Population Research Institute) to build a new website based on workshops from the NICHD-supported training program in Advanced Spatial Analysis for the Population Sciences. Guylene Gadal, Bryan Karaffa, and Karen Doehner at UCSB have assisted in this effort with technical and editorial support. The site http://gispopsci.org will be launched for public access in May 2013.

V. Research and Funding

Table 1 in Appendix 1 presents a summary of center funding from all sources in the period since March 2010.

Goodchild Project Funding:

Endowed Chair

The center has worked closely with UCSB development staff since its inception. Esri, the leading developer of Esri software, has had close relationships with UCSB for the past 30 years and has provided substantial funding for research, conferences and workshops, and student support. In 2010 the owners, Jack and Laura Dangermond, funded an endowed chair. Michael Goodchild was the first holder of the chair; with his retirement in 2012, the Dangermond Chair is scheduled to be assigned to Werner Kuhn, who replaces Goodchild in the Department of Geography in November 2013.

U.S. DOT Ports Project

Funded by the U.S. Department of Transportation's Research and Innovative Technology Administration, this project was concerned with improving the efficiency of the trucking operation to and from the Ports of Los Angeles and Long Beach. It was led by Goodchild with Richard Church as co-PI, and with Val Noronha as project manager. Approximately 200 trucks were tracked in and out of the port on a 5-second sampling interval using GPS, and the results provided a real-time database of the movement of a large sample of the roughly 8,000 trucks that move shipping containers in the LA Basin. Work by Church and the project's subcontractors focused on improving the efficiency of the operation and reducing its air pollution by optimizing truck routing, minimizing queuing time at the port, and optimizing the handling of containers in the port. The project employed two graduate students at UCSB through its conclusion in June 2010.

National Geospatial-Intelligence Agency (NGA)

The NGA's Academic Research Program has funded two projects at the center. The first, with PI Goodchild and co-PI Phaedon Kyriakidis, examined the application of geostatistical techniques to spatio-temporal data. It developed new methods of interpolation that use both spatial and temporal evidence, and that defined confidence limits on the detection of change in temporal sequences of imagery. The project continued as a no-cost extension through 2011, employing Guofeng Cao, a graduate student who finished his Ph.D. in 2010.

The second project was initially funded in 2009 for two years, but additional funding will carry this project through early 2014, with Goodchild as PI and Martin Raubal as co-PI. It focuses on conflation, or the merging of geospatial data sets from disparate sources. The conflation problem is especially current in GIScience because of the rapid proliferation of data sources on the Web. Two graduate students were employed on the project: Linna Li (Geography) and Ben Adams (Computer Science). They have each completed the Ph.D. Dr. Li is continuing as a specialist on the project.

NSF and Army Research Office: Volunteered Geographic Information (VGI)

The topic of volunteered geographic information was the focus of two awards from the NSF Geography and Spatial Sciences program and from the Army Research Office. Both awards were made in 2009 for three years with Goodchild as PI. VGI is the geospatial form of user-generated content, and raises numerous research questions: who contributes? about what? and what assurances lead to confidence in the results? The NSF project was collaborative with colleagues at the University of Washington and Ohio State University. In Santa Barbara, the four recent fire emergencies provided an excellent case study of the creation and use of VGI in time-critical situations. Three undergraduates were employed on the research in summer 2009, and graduate student Darren Hardy (Bren) investigated the geospatial content of Wikipedia.

Minerals Management Service (MMS)

In 2009 the center was awarded a small grant from the Camarillo office of the MMS to develop their geospatial data resources for the Federal portion of the coastal zone. The project involved the creation of metadata, cleaning of existing data, and identification of new data sources. The center collaborated with the Marine Science Institute and employed graduate student Gargi Chaudhuri (Geography) on the project.

UC Multicampus Research Programs and Initiatives (MRPI)

In 2009 the center participated in two submissions to the MRPI program, one jointly with UCLA and UC Merced on community sensing and mapping, and the other jointly with UC Riverside on the development of a spatially disaggregated model of the economy, transportation, and land use in the L.A. Basin. The latter was successful and funded for five years beginning in January 2010. The UCR PI is Richard Arnott, an economist, and Goodchild is the UCSB PI. UCSB's part of the project concerns the construction of a GIS database and the development of Web services that allow access to the model's forecasts. A full-time Specialist (Wenwen Li) worked on the project at UCSB for two years but has since taken a tenure-track appointment at Arizona State University. She was replaced by Linna Li, who will continue working on the project through its completion in late 2014.

NSF: SEEK

This project to study the spatial skills of Alzheimer's patients was originally proposed by Reginald Golledge before his death. Direction of the project was carried out by Goodchild and Daniel Montello. The funds supported a post-doc for Andrea Nuernberger through 2011.

Hegarty Project Funding:

National Science Foundation: Visualization of Uncertainty

Funded by NSF, this is the first large-scale effort to consider the visualization of uncertainty in a systematic, end-to-end manner, with the goal of developing a generalizable set of techniques and procedures for accurately and effectively conveying the appropriate level of uncertainties in a wide range of decision-making processes of national importance. The approach combines a principled mathematical treatment of uncertainty in simulations, a comprehensive analysis of how this information can be transformed into a visual form, and a careful study and evaluation of human perception and cognition of spatial and multidimensional uncertainty, all informed by the needs of real-world applications. This project is collaborative with the University of Utah and Clemson University. It is led at UCSB by Hegarty PI and Goodchild, co-PI, and two graduate students, Grant McKenzie (Geography) and Trevor Barrett (Psychology).

National Science Foundation: Representation Translation with Concrete and Virtual Models in Chemistry

Funded by NSF, this project examines how students use concrete and virtual molecular models to understand the spatial structure of molecules, reason about spatial transformations in the domain of organic chemistry, and develop competence in using the various spatial representations of the domains, including models and diagrams. The approach combines laboratory studies of student learning and classroom interventions. This project is a collaborative with the University of Illinois, Chicago and the University of Maryland. At UCSB it is led by Hegarty and has employed two postdoctoral scholars (Andrew Stull and Shamin Padalkar) and two graduate students (Trevor Barrett and Heather Burte) in the Department of Psychological and Brain Sciences.

Institute for Collaborative Biotechnologies, UCSB: Investigating the Neural Basis of Individual Differences in Navigational Abilities

Funded by a grant to the Institute for Collaborative Biotechnologies from the Army Research Institute, the goal of this project is to study the neural basis of individual differences in navigational abilities. Specifically, it studies both structural and functional differences in the brains of people with good and poor sense of direction using Diffusion Spectrum Imaging (DSI) and functional magnetic resonance imaging (fMRI). This project is directed by Hegarty and will provide funding for graduate student Heather Burte (Ph.D. student in the Department of Psychological and Brain Sciences).

Janelle Project Funding:

NICHD Advanced Spatial Analysis Training Program *(subcontract with Pennsylvania State University's Population Research Institute)*

This Penn State-UCSB collaboration has been in place since 2005 and more than 300 demographers and population scientists (mostly Ph.D. candidates, post-docs, and early-career professors from institutions across the United States) have benefited from intensive one- and two-week-long residential workshops taught by internationally recognized methodologists in GIS and spatial econometrics. In 2010 UCSB hosted two workshops, one focused on geographically weighted regression and the other on spatial pattern analysis. The 2011 workshop addressed multi-level modeling. Participants in these workshops come primarily

from demography, epidemiology, the social sciences, and the health sciences. A limited number of positions in the workshops are filled by participants from UCSB, most recently from the departments of Communications, Economics, Geography, Marine Science, Sociology, and the Bren School. The workshops also provide instructional experiences for Geography graduate students, who work as teaching assistants.

The current grant from NIH expires on 31 May 2013. A proposed five-year renewal is currently under review by NIH. If successful, ISBER (Stuart Sweeney as PI) will manage the UCSB subcontract, with both the Broom Center for Demography and the Center for Spatial Studies as primary partners.

NSF National Science Digital Library (a DUE NSDL Pathways project):

TeachSpatial—A Portal to Instructional Resources on Spatial Concepts for STEM Education

TeachSpatial provides a "spatial lens" on the National Science Digital Library (NSDL). NSDL catalogs more than 140,000 high-quality digital teaching resources from around the U.S. and the world, available on the Web. Those resources can be browsed and searched at http://nsdl.org/ and through the websites of many discipline-specific "Pathway" projects, for example ComPADRE (physics), BEN (biological sciences) and DLESE (earth sciences). The TeachSpatial site (http://teachspatial.org) now provides directed access to resources for all STEM subjects that are particularly useful for the teaching and learning of spatial concepts, principles, and skills. Grossner, now at Stanford University, worked with Janelle (PI) and Goochild in implementing this project. Funding from NSF (September 2010 –December 2011) enabled the "resources" section of the TeachSpatial website to be managed as an NSDL Collection. The TeachSpatial collection was accessioned to NSDL in February, 2012.

VI. Future Directions for spatial@ucsb

The center has made very significant contributions over the past six years, building awareness of the role of spatial perspectives in research, initiating educational programs, and nurturing cross-disciplinary collaboration. Going forward, spatial@ucsb seeks to broaden its missions in the areas of research, infrastructure development, education, and service. The articulation of an expanded mission is summarized below, drawing on the legacy of Goodchild's and Janelle's contributions in establishing the center, building on the research foundations in spatial cognition by Hegarty, and linking these within the overarching vision advanced by Werner Kuhn.

The Vision

Kuhn's proposed vision for spatial@ucsb, presented to the Executive Vice Chancellor on 8 April 2013, draws on the concepts of ***linked science*** and ***smart campus***. The idea of linked science is to combine open access to research results (data, models, publications) with topical and spatio-temporal links across disciplinary silos. This vision would draw on a backbone of cyber-infrastructure and computational expertise to position UCSB as a spatially integrated smart campus. The realization that location is a basis for (a) linking diverse data resources, (b) enabling spatio-temporal search and discovery of research materials, and (c) visualizing and analyzing processes in spatio-temporal context offers researchers, educators, and students a near seamless approach to knowledge development and transfer.

The enabling of spatial reference and search is a core component of this vision, one that aligns with opportunities for diverse academic units and services to take part in the creation of a smart campus. One possibility is to build working relationships between the library and the spatial center to collaborate in establishing a service for sharing and integrating data and information resources. The pioneering efforts of the Alexandria Digital Library project, the resources of the Map and Imagery Laboratory, and the UCSB Library's linkage to the broader UC Digital Library represent a core of resources and talent to establish and demonstrate the synergy of linked-science to enhance teaching and research. The Center for Spatial Studies is prepared to open discussions on this prospect and help implement the expanded technical services and conceptualization that such an initiative entails.

Service

Aside from the primary benefits of linked science for providing a platform for trans-disciplinary research, teaching, and project-based learning and problem investigation, there are other tangible benefits in promoting the vision of a smart campus. Examples that will steadily grow a spatially enabled service infrastructure for research and teaching include:

- help for domain scientists to discover and investigate questions and data spatially;
- web services, such as the current student-produced and constantly evolving *Interactive Campus Map* (ICM), a smart map for UCSB patrons and visitors (http://map.geog.ucsb.edu/);
- location-based apps for visitors and campus employees that enhance the efficiency and ease of use and care of the campus and its facilities; and
- expansion of the spatial@ucsb help desk beyond its current half-day per week (using the resources from the library and expertise of Geography graduate students).

Education

Spatial@ucsb is committed to enhancing the quality of its current initiatives, such as the Minor in Spatial Studies and the Freshman Seminar on *Thinking Spatially in the Arts and Sciences*. The center will also take the lead in evaluating the potential for and creating campus-wide general education courses in (a) **spatial computing** with novel, project-based teaching elements online, and (b) **spatial cognition** with a focus on evidenced-based learning for applications in everyday life and in professional/disciplinary practice. Such courses represent potential candidates for designation as core requirements for the Minor in Spatial Studies.

The center's existing http://teachspatial.org website already provides interactive online demonstrations of core spatial concepts (location, neighborhood, networks, and so forth). These can be used as elements for a general course, but they also can be used as **micro-insertions of spatial content into existing science and humanities courses**. The application-driven nature of spatial concepts and their uses suggests a novel idea of two-way micro-insertions, where domain courses benefit from hands-on spatial perspectives, while spatial computing courses are grounded in realistic application projects.

We argue that ***spatially enabled interdisciplinarity*** has the potential to unite multiple social,

scientific, and technical perspectives on key issues like climate, energy, transportation, health, poverty, or financial systems. This kind of interdisciplinary teaching innovates at the undergraduate level, reinforces graduate programs, and—if systematically evaluated—supports academic program development.

Using the examples of fundamental spatial concepts and spatially enabled interdisciplinarity, spatial@ucsb will seek to involve high school students and teachers in the Santa Barbara area in spatial thinking and computing projects and to document the results of these initiatives with learning assessments.

Research

Research directions will be guided by the primary interests of Kuhn, Goodchild, Hegarty, and Janelle, as documented elsewhere in this report, and by scholarship from those who affiliate with the center.

The use of **data visualization technologies** is a theme that cuts across the academy and has been and will remain central to the research by Kuhn, Goodchild, Hegarty, and their students.

Hegarty's interest in collaborating with disciplinary specialists to document **spatial cognition** within specific disciplines (such as medical surgery, chemistry, and mechanics), emerges as a platform for refining our understanding of how spatial reasoning and spatial methodologies intersect across disciplines. It is also supportive of Kuhn's interest in research collaboration that extends into the arts, humanities, social sciences, humanities, and across the sciences—especially in terms of their interest in **spatio-temporal perspectives**. All of the personnel affiliated with the center share research interests in the use of **spatial concepts for reasoning** processes in problem solving and education.

The planned research is clearly fundable, as inter- and transdisciplinary research remains high on the agenda of funding agencies and "spatial" keeps proving its worth by connecting disciplines and world-views in a data-driven way, supporting rational and transparent arguments for governance and resource allocations.

Outreach

Spatial@ucsb is already considered a leader worldwide in its sponsorship of specialist research meetings and a leader nationally in training workshops for the next generation of spatially enabled scholarship. It is well known locally for engagement in K-12 education to promote spatial literacy and for research and conference initiatives that help integrate UCSB academic activities with the interests of private industry and government agencies. Going forward, these efforts will be maintained. However, spatial@ucsb has identified a set of new initiatives that warrant consideration.

The first is to establish **UCSB as the hub for spatial knowledge and learning**. An existing role of the center that warrants strengthening and further promotion is the attraction of faculty and advanced graduate students to spend time in residence at UCSB as contributing visitors, interacting with each other and with local researchers. Hosting sabbatical visitors, possibly with a thematic focus at certain times, offers huge potential at almost no cost. UCSB is ideally situated in terms of its academic talent pool, facilities, and local environment to be recognized as

a destination of choice for the world's leading researchers in spatial thinking and geographic information science**.**

Building complementary roles for spatial@ucsb and the Vespucci Initiative would provide an expanded global perspective for the center. The Vespucci Initiative (co-founded by Goodchild, Kuhn, and others) sponsors international institutes for scholars to integrate and synthesize ideas in different research fields germane to the analysis of location and to assume leadership in the advancement of geographic information science and its relevance to society. While most of these institutes have met in Italy, the Initiative has branched out geographically in recent years and held an April 2013 week-long institute on Catalina Island. Spatial@ucsb's existing alliances with NCEAS, NCGIA, and UCGIS, and its presence within the UC system, position it as a central contributor to the Vespucci Initiative and improves UCSB's access to an expanding global network of spatial centers and information on research and funding programs.

An **online publication series** may be a useful carrier of the message that spatial is everywhere and the center would garner wide recognition by making the core literature of the spatial information sciences available online.

Personnel and Operational Support

In January 2014, Kuhn will assume the role as Director and Hegarty as co-Director of the center, and the prospect of engaging a post-doctoral student in the center is under consideration. The current staff component for the center includes a half-time Program Director (Janelle), full-time Administrative Coordinator/Student Advisor (Doehner), part-time specialists in computer systems support and web development, and two graduate student researchers to manage the campus help desk and engage graduate students in interdisciplinary research activities.

Operational funds allow for special initiatives, such as (a) an annual local conference to bring GIS professionals from the private and government sectors together with UCSB academic personnel and students, (b) an annual specialist research meeting to focus on cutting-edge topics in geographic information science, and (c) maintaining the center's infrastructure. Outside funding is a priority of special significance for maintaining the research profile of the center and in advancing its academic objectives.

APPENDIX 1
FUNDING
2010–2013

Table 1. Funding in Support of Research and Training Programs (covering period April 2010–April 2013) Listing organized by principal investigator

Funding Agency	Title	Start / End	Award
Michael Goodchild, principal investigator			
U.S. Department of Transportation	MeTrIS: Metropolitan transportation information system applying space-based technologies for freight congestion mitigation	8/7/07 to 6/30/10	$1,995,329
National Geospatial-Intelligence Agency	A geospatial framework for data analysis and modeling across multiple spatial and temporal scales	8/7/07 to 8/6/10	$450,000
Minerals Management Service	GIS research	9/24/09 to 8/15/10	$60,000
National Geospatial-Intelligence Agency	Geospatial feature conflation: conceptual, statistical, and optimization approaches, with no-cost extension into 2012, followed by additional funding	10/16/09 to 10/15/11 10/16/12 to early 2014	$288,548 $134,000
National Science Foundation	Development and assessment of self-assessed scales for everyday environmental knowledge (SEEK)	9/1/09 to 2/29/12	$200,000
Army Research Office	User-generated terrain information	6/15/09 to 6/14/12	$237,392
National Science Foundation	Collaborative research: a GIScience approach for assessing the quality, potential applications, and impacts of volunteered geographic information	6/1/09 to 11/30/12	$149,454
UC Office of the President	Virtual co-laboratory for policy analysis in Greater LA (subaward from UC Riverside)	1/1/10 to 12/31/14	$630,730 to UCSB
Mary Hegarty, principal investigator			
National Science Foundation	Representation Translation with Concrete and Virtual Models in Chemistry (PI: Mary He-	8/15/2010 to 7/31/2013	$667,559

	garty).		
National Science Foundation	Modeling, Display and Understanding Uncertainty in simulations for Policy Decision Making (PIs: Mary Hegarty and Michael Goodchild)	10/1/2012 to 9/30/2016	$599,797
Center for Collaborative Biotechnologies	Investigating the Neural Basis of Individual Differences in Navigational Abilities	12/1/2012 to 11/30/2013	$100,000
Donald Janelle, principal investigator			
National Science Foundation	(NSDL DUE), TeachSpatial: A Portal to Instructional Resources on Spatial Concepts for STEM Education. See**:** **http://teachspatial.org** (with Karl Grossner)	9/1/10 to 12/31/11	$149,859
National Institutes of Health (NICHD R25) sub-contract with Pennsylvania State University	Advanced Spatial Analysis Training for Population Scientists, Stephen Matthews (PSU, PI) Donald Janelle (UCSB PI), and Michael Goodchild (UCSB PI).	6/1/2008 to 5/31/2013	$519,595 to UCSB

APPENDIX 2
SERVICE ACTIVITIES
2010–2013

Specialist Meetings

December 2010
Spatio-Temporal Constraints on Social Networks
http://ncgia.ucsb.edu/projects/spatio-temporal/ for presentations and final report

December 2011
Future Directions in Spatial Demography
http://ncgia.ucsb.edu/projects/spatial-demography/ for presentations and final report

December 2012
Spatial Thinking Across the College Curriculum
http://www.spatial.ucsb.edu/events/STATCC/ for presentations and final report

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Advanced Spatial Analysis Training Program Workshops

Organized by Don Janelle (UCSB) and Stephen Matthews (Penn State)
In conjunction with Penn State University's Population Research Institute, spatial@ucsb has, since 2005, organized and hosted week-long residential training workshops for researchers in the population sciences. This program is funded by the Eunice Kennedy Shriver National Institute of Child Health and Human Development (NICHD) to help expose population scientists to ways of integrating spatial data and spatial analytic methods in demographic inquiry. Participants, approximately 30 per workshop, come from major research universities across the United States—they include mostly junior faculty, post-doctoral scholars, and Ph.D. students from disciplines such as demography, epidemiology, public health, sociology, economics, and geography. Visiting instructors are recognized leaders in applications of spatial econometrics and geographic information technologies. The most recent of these workshops are listed below and more details and related resources for all workshops are available at http://www.csiss.org/GISPopSci/workshops/index.php. The website in support of the program is maintained by the spatial webmaster.

2010

Geographically Weighted Regression
Instructors: A. Stewart Fotheringham (National University of Ireland, Maynooth), Chris Brunsdon (University of Leicester), and Martin Charlton (National University of Ireland, Maynooth)
Host Institution: Center for Spatial Studies, UCSB (July 12–16)

Spatial Pattern Analysis
Instructors: Arthur Getis (San Diego State University), John Weeks San Diego State University), Jared Aldstadt (University at Buffalo), and Stephen Matthews (Penn State University)
Host Institution: Center for Spatial Studies, UCSB, (July 19–23)

2011

Spatial Regression Modeling
Instructors: Paul R. Voss (University of North Carolina at Chapel Hill) and Katherine Curtis, University of Wisconsin-Madison
Host Institution: The Population Research Institute, Penn State (June 19–24)

Multilevel Modeling
Instructors: Kelvyn Jones (University of Bristol), and S. V. Subramanian (Harvard University)
Host Institution: Center for Spatial Studies, UCSB (July 10–14)

The UCSB ThinkSpatial Brown-bag Forum sponsors noon-time sessions that feature theories, concepts, tools, and applications of spatial thinking. Speakers are drawn primarily from UCSB, but also from industry and academic visitors to the campus. ThinkSpatial was initiated in 2007. The ThinkSpatial presentation archive features abstracts and slide presentations of more than 70 talks that help document the interest in spatial perspectives by researchers at UCSB. The program is organized by Donald Janelle.

ThinkSpatial 2010–2011

4 October	**Danielle Forsyth**, Thetus Corporation, Portland, Oregon ***Using Savanna to Model and Analyze Complex Human Ecosystems***
5 October	**Arnold Bregt**, Geo-information Science, Wageningen University, The Netherlands ***Discovering Spatial Thinking***
15 October	**Michael Worboys**, Spatial Information Science and Engineering, University of Maine ***The Foundations of Spatial Change***
26 October	**Petrutza Caragea**, Statistics, Iowa State University ***Analysis of Areal Data: Should a Model with (Spatial) Dependence be Considered?***
2 November	**Waldo Tobler**, Geography, UCSB ***Visualization of Some Spatial Concepts***
9 November	**George Legrady**, Media Arts & Technology/Art, UCSB ***Representing Space—Representation in Space***
30 November	**Lisa Parks**, Film and Media Studies, UCSB ***Zeroing In: Infrastructure Ruins and Datalands in Afghanistan and Iraq***
18 January	**Michael Goodchild**, Geography, UCSB *and* **Donald Janelle**, spatial@ucsb ***Introducing the New UCSB Undergraduate Minor in Spatial Studies***
1 February	**Jon Jablonski**, Map and Imagery Library, UCSB ***A Geographic Approach to Information Seeking Behavior***
15 February	**Marko Peljhan**, UC Institute for Research in the Arts ***Unmanned Poles—Human Landscapes***
24 February	**Ruth Mostern**, History, UC Merced ***Spatial Literacy in the History Classroom Teaching the Silk Road with Google Earth***
8 March	**Mark Kram**, Groundswell Technologies, Inc., Santa Barbara ***Sensor and GIS Integration for Automated Web-Based Environmental Monitoring***
19 April	**Steve Conner and Dennis Whelan**, Campus Planning and Design, UCSB ***Campus Long Range Development Planning with a 3D GIS Model***
3 May	**Volker Welter**, History of Art and Architecture, UCSB ***Umwelt: Seeing the World from the Inside Out***

ThinkSpatial 2011–2012

4 October	**Michael Goodchild**, Geography, UCSB ***Geographical Intelligence***
25 October	**Kostas Goulias**, Geography, UCSB ***Simulator of Activities, Greenhouse Emissions, Networks, and Travel (SimAGENT) in Southern California***
15 November	**Karl Grossner**, spatial@ucsb ***Finding the Spatial In Order to Teach It***
6 December	**Katherine Kaford Papineau**, History of Art and Architecture, UCSB ***Finding Domestic Space in a Glass House***
17 January	**Donald Janelle**, spatial@ucsb ***An Open Forum on the UCSB Undergraduate Minor in Spatial Studies***
20 January	**David Uttal**, Northwestern University ***Spatial Abilities and STEM Education: When, Why, and How*** Presentation in (co-sponsored by UCSB Psychological & Brain Sciences; Cognition, Perception and Cognitive Neuroscience Group)
24 January	**Swati Chattopadhyay**, History of Art and Architecture, UCSB ***Unlearning the City***
14 February	**Andrew Stull**, Psychological & Brain Sciences, UCSB ***Orienting Objects in 3D Virtual Reality***
06 March	**Bernard Comrie**, Linguistics, UCSB; Max Planck Institute for Evolutionary Anthropology, Leipzig ***Mapping the world's linguistic diversity: The World Atlas of Language Structures***
09 March	**Teenie Matlock**, Cognitive and Information Sciences, UC Merced ***The Semantics of Space, Politics, and Car Accidents*** Presentation in (co-sponsored by UCSB Psychological & Brain Sciences; Cognition, Perception and Cognitive Neuroscience Group)
13 March	**Richard Church**, Geography, UCSB ***What Makes a Location Problem Difficult to Solve?***
8 May	**Jon Jablonski**, Davidson Library, UCSB ***Measuring Place: Evaluating the Importance of Libraries through Sketch Maps***

ThinkSpatial 2012–2013

30 October	**Rick Wood**, CHK America ***The Psychology of Wayfinding***
2 November	**Timothy Hawthorne**, Georgia State University **Hamil Pearsall**, Temple University and **Daniel Block**, Chicago State University ***Engaging Communities to Increase Spatial Knowledge Production in Geographic Research***
6 November	**David Weaver**, School of Tourism, Leisure, Hotel and Sport Management, Griffith University (Australia) ***Assisting Endangered Spaces: Protected Area Visitor Willingness to Participate in Site Enhancement Activities***
13 November	**Janet Walker**, Film and Media Studies, UCSB ***Site Seeing: Documentary Film and (other) Technologies of Visualization***
27 November	**Krzysztof Janowicz**, Geography, UCSB ***The Role of Space and Time for Identity Resolution on the Web***
4 December	**Matthew Turk**, Computer Science, UCSB ***Gesture Interaction***
29 January	**Rich Mayer**, Psychological & Brain Sciences, UCSB ***Using Graphics to Enhance Learning***
5 March	**Wendy Meiring**, Statistics and Applied Probability, UCSB ***Nonstationary Spatial Correlation Modeling and Estimation***
19 March	**Keith Clarke**, Geography, UCSB ***What is the World's Oldest Map?***
16 April	**Scott Grafton**, Psychological & Brain Sciences, UCSB ***Spatial Reference Frames for Real and Virtual Movements***
30 April	**Donald Janelle**, spatial@ucsb ***Rivers, Bridges, Stagecoaches, and the Early Nineteenth-Century Space-time Structure of Maine's Settlement System***
14 May	**Dieter Lukas**, Zoology, University of Cambridge, ***Where are all the Females? The Effect of Resource Distribution on Mammalian Mating Strategies***

21 May	**Jianhong Xia**, Geography, Curtin University, ***Why Don't Commuters Choose the Nearest Train Station?***
28 May	**Jeff Howarth, Geography**, Middlebury College, ***What are Students Thinking When You Teach GIS?***
3 June	**Phaedon Kyriakidis**, Geography, UCSB, ***Multivariate Gaussian Distributions, Points on Hyper-Ellipsoids, and Efficient Simulation of Lognormal Random Fields for Hydrogeological Applications***

Graduate Student Forums

Since 2008, spatial@ucsb has provided opportunities for graduate students from several academic departments to gather on a regular basis at the center to share information and to cooperate on innovative projects relating to tools and techniques for online mapping. They take the form of **Spatial Technology Lunches**, **Lightning Talks**, and **Coding Sessions**. Since the 2009 fires in Santa Barbara and the January 2010 earthquake in Haiti, the coding group has emphasized disaster relief infrastructure by bolstering the OpenStreetMap dataset for UCSB and Isla Vista and by creating and testing kite and balloon aerial photography rigs and associated GIS workflows. Because of their general interest, the forums have expanded to include faculty, staff, undergraduates, and technologists from the local Santa Barbara community.

Spatial Technology Lunches, 2012–2013

Organized by Kitty Currier

April 29, 2013
Marko Peljhan, Professor, Department of Art and the Media Arts and Technology program, reviewed his experiences in the use of unmanned aerial imaging systems for orthophotographic mapping and surveying in the Antarctic and Arctic.

January 25, 2013
Scott Prindle, a Senior Support Analyst on the Server Usage team at Esri, presented on cloud-based GIS and collecting volunteered geographic information (VGI).

October 25, 2012
Kevin Wengler, **Steve Miley**, and **Kitty Currier** shared their enthusiasm for grassroots aerial imagery and mapping. Also featured were hands-on equipment displays and a post-lunch quadcopter demonstration.

November 29, 2012
Paul Wilson of General Electric Digital Energy discussed trends and advances in hardware and software spanning nearly four decades of mobile mapping applications.

Spatial Lightning Talks

As part of the spatial technology lunch series, Alan Glennon and Kitty Currier have organized Spatial Lightning Talks—a series of delicious, rapid-fire talks on geographically-flavored topics—intended as an inspirational session. Each presenter is allotted three minutes and ten slides to develop a topic, auto-progressing the slides every 18 seconds.

Videos of talks can be found by searching http://www.youtube.com for **spatial@ucsb**.

2013

Organized by Kitty Currier. Speakers included:

Tommy Dickey, Great Pyrenees Mountain Dogs and Mesoscale Ocean Eddy Trackers: How do they do their Jobs?

Mary Hegarty, How I Became a Spatial Thinker

Song Gao, Spatio-Temporal Patterns from Mobile Phone Data

Jim Caesar, Emergency Preparedness

Donald Janelle, Convergent Places—Warped Spaces

Rodrigo Bombardi, Relationships between Precipitation over Eastern South America and the South Atlantic Sea Surface Temperature

Skona Brittain, Where in the World is Hunter San Cazador?

Chuck Champlin, Twinkle: A Geometry of Meaning

Grant McKenzie, Airports: The Good, the Bad and the WTF

Emily Ellis, Can we use Terrestrial Biogeography to Inform Placement of MPAs?

Jon Jablonski, New in MIL: The Fairchild Aerial Surveys Collection

William Yim, Airfield Design and Capacity

Yingjie Hu, Citation Map: Visualizing the Spread of Scientific Ideas through Space and Time

Kitty Currier, Shipshaping and Fiafia (or How I Became a Geographer)

2010

Organized by Alan Glennon Speakers included:

Richard Church, Marine transportation: OOPS

Helen Couclelis, Why sketching works (or, why GIS needs design)

Kitty Currier, Beyond street view: Documenting coral reefs with “immersive” video

Alan Glennon, How to map a cave

Rhonda Glennon, How to become a private pilot

Michael F. Goodchild, Spatiotemporal constraints on social networks

Daniel Montello, Baldknobbers of the Ozarks

Hugo Repolho, Optimum location of motorway interchanges: Concessionaires’ perspective

Waldo Tobler, Ravenstein revisited

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spatial@ucsb.local series

On an annual basis, spatial@ucsb sponsors a half-day conference that engages students and faculty from UCSB with the Santa Barbara community. Typically, 50 to 60 students from a range of disciplines display their research in a professional poster format and have an opportunity to explain their work to visitors. Since its inception in 2008, undergraduate and graduate students from the departments of Media Arts and Technology, Computer Science, Environmental Science, Geography, and Psychology) have taken part in these events. An archive of their posters is maintained at http://www.spatial.ucsb.edu/events/local-gis.php. In addition, various government

agencies and consultants in the private sector have displayed uses of spatial technologies to solve problems. The **Channel Islands Regional GIS (CIRGIS)** has used this event as an opportunity to convene its quarterly meeting of the Ventura/Santa Barbara EsriArcGIS Users Group at UCSB and then attend the plenary sessions. CIRGIS is a support group of GIS and planning professionals that meet regularly to share insights on geospatial solutions to local problems. This provides excellent opportunities for the university to showcase the relevance of its programs to the region, for students to interact with potential employers, and for the campus community to review interdisciplinary themes in research and education. Recent themes have included the visualization of spatial data (2013), educating spatial thinkers (2012), marine GIS (2011), and GIS for disaster planning and response (2010). Speakers for these events are listed below.

Poster Exhibit and Plenary Sessions

June 6, 2013

spatial@ucsb.local2013—*Visualization of Spatial Data*
Speakers:

- **JoAnn Kuchera-Morin** (Prof., Media Arts and Technology, UCSB)
- **Jason Dykes** (Prof., School of Informatics, City University London)
- **Ross Whitaker** (Prof., SCI Institute, University of Utah)

June 6, 2012

spatial@ucsb.local2012—*Educating the Spatial Thinker*
Speakers:

- **Kim Kastens** (Adjunct Prof., Earth & Environmental Sciences, Columbia) *Spatial Thinking in Earth Science Education*
- **David Bodenhamer** (Exec. Dir., Polis Center; Prof., Indiana University-Purdue University, Indianapolis) *Deep Maps, Deep Contingencies: The Promise of Spatial Humanities*
- **Krzysztof Janowicz** (Assoc. Prof., Geography, UCSB) *Big Geo-Data*
- **John Wilson** (Prof., Dir. Spatial Sciences Inst., Geography, USC) *How Can We Reshape GIS Education to Serve Future Needs?*

June 2, 2011

spatial@ucsb.local2011—*Marine GIS*
Speakers:

- **Patrick Halpin** (Duke University)
- **Carrie Kapell** (NCEAS, UCSB)
- **Will McClintock** (UCSB)

June 1, 2010

spatial@ucsb.local2010—*GIS for Disaster Planning and Response*
Speakers:

- **Michael Goodchild**, (spatial@ucsb) Welcome, Introductions
- **Andrew Schroeder**, (Direct Relief International) *The SB County SoVI Project*
- **Mike Harris**, (SB County Emergency Services) *GIS in Emergency Management in SB County*
- **Alan Glennon**, (spatial@ucsb) *Grass Roots Crisis Mapping*

Visitors

Spatial@ucsb provides work space for visiting scholars and collaborators, offering opportunities for them to take part in the activities of the Center and engage in joint research efforts.

Visitors in 2013:

- **Jeff Howarth** (Middlebury College), Hosted by Richard Mayer, April–June
- **Cecilia Xia** (Curtin University), Hosted by Kostas Goulias, Feb.–June
- **Alinda Friedman** (University of Alberta), Hosted by Daniel Montello and Mary Hegarty, Feb.

Visitors in 2012:

- **Gagandeep Makker** (Indian Institute of Technology, Bombay), Hosted by Michael Goodchild May–July
- **Kai Cao** (Nanjing University) April–May
- **Michela Teobaldi** (University of Siena), Hosted byMichael Goodchild, Jan.–March
- **Miguel Gómez** (Universidad Complutense de Madrid), Collaborated with Stuart Sweeney, Jan.–Dec.

Visitors in 2011:

- **Daniel Lewis** (London School of Economics), Hosted by Keith Clarke February–April
- **Yating Chen** (China Agricultural University), Hosted by Michael Goodchild, Sept. 2011–Aug. 2012

Visitors in 2010:

- **Jeganathan Chockalingam** (University of Southampton), Hosted by Keith Clarke, Nov.
- **Yan Li** (South China Normal University), Collaborated with Michael Goodchild, Oct.–Nov.
- **Arnold Bregt** (Wageningen University), Collaborated with Michael Goodchild, Aug.
- **Pete Atkinson** (University of Southampton), Collaborated with Michael Goodchild, Aug.
- **Alfred Stein** (University of Twente), Collaborated with Michael Goodchild, July

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Vertices

Vertices is the e-newsletter for spatial@ucsb. Edited by **Karen Doehner**, *Vertices* provides a reader-friendly introduction to applications of spatial thinking by researchers and instructors at UCSB. It is distributed broadly across campus and to hundreds of researchers around the world.

Issue 1: spatial@ucsbInaugurated

Issue 2: A University Minor in Spatial Thinking?

Issue 3: teachspatial.org.

Issue 4: Tools for Map Making

Issue 5: LA-Plan: A Virtual Co-laboratory for Policy Analysis of the Greater Los Angeles Basin

Issue 6: The End of an Era—And the Beginning of a New One

Spatial@ucsb Help Desk

As part of the center's effort to promote spatial thinking, techniques, and tools across campus, each Friday morning, **spatial@ucsb** offers "help desk" research consultations. The free service is staffed by center graduate students (Song Gao, Geography for 2012–2013) and is open to the entire campus community. The primary focus is on research design and implementation for faculty, staff, and graduate student projects. The help desk serves as a starting point to connect with spatial resources available around campus, such as expert personnel, instructional materials, and software. A sample of projects and departmental affiliations that have received technical support from the spatial@ucsb help desk since mid-2010 include:

- accessing data to create a map of publication quality—Anthropology
- inferring geographic location and environmental conditions from documentary screen shots—Film and Media Studies
- geomatching by longitude and latitude the complex lexical structures found in a language database with world regional pathogen concentrations—Communications
- integrating and sharing different physical spatial databases within one datacenter—UCSB Facilities Management
- finding a suitable topography base map for document historical patterns in the 1300s—History and Religious Studies
- deriving pixel values from remote sensing imagery for use in digital elevation models—Geography
- converting data from an XY sheet to a feature class—visiting economics professor from Spain
- developing a geoprocessing tool to handle multiple feature class files in different subfolders of satellite imagery and aerial photographs—Davidson Library, Map and Imagery Lab
- identifying spatial tools for the analysis of mental healthcare outpatients—visiting graduate student in public administration from Long island University

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Technical Support for the Center for Spatial Studies

The center relies on technical staff affiliated with the Department of Geography for supporting computing infrastructure in the center (3512 Phelps Hall and the Spatial Lab (Ellison Hall). These services are provided currently on a recharge basis by **Guylene Gadal** and **Bryan Karaffa**. Gadal, maintains web servers, performs system maintenance, supports Google Apps, and works on the design of websites and related web services associated with the Center's projects. Karaffa troubleshoots issues with hardware in the spatial center and spatial lab (computers, media wall, monitors, printers, etc.), handles software installations and general lab maintenance, provides technical assistance for instruction and presentations, and sets up workstations for visiting scholars.

APPENDIX 3
PUBLICATIONS AND PRESENTATIONS
2010–2013

Publications (Covering period April 2010–April 2013):

Publications by Michael Goodchild

2013 S.L. Cutter, J.A. Ahearn, B. Amadei, P. Crawford, E.A. Eide, G.E. Galloway, M.F. Goodchild, H.C. Kunreuther, M. Li-Vollmer, M. Schoch-Spana, S.C. Scrimshaw, E.M. Stanley, G. Whitney, and M.L. Zoback. Disaster resilience: a national imperative. *Environment: Science and Policy for Sustainable Development* 55(2): 25–29.

2013 W. Li, M.F. Goodchild, and R.L. Church. An efficient measure of compactness for two-dimensional shapes and its application in regionalization problems. *International Journal of Geographical Information Science* DOI: 10.1080/13658816.2012.752093.

2012 M.F. Goodchild. GIScience in the 21st century. In W. Shi, M.F. Goodchild, B. Lees, and Y. Leung, editors. *Advances in Geo-Spatial Information Science*, pp. 3–10. Leiden: CRC Press.

2012 W. Shi, M.F. Goodchild, B. Lees, and Y. Leung, editors. *Advances in Geo-Spatial Information Science*. Leiden: CRC Press.

2012 G. Cao, P.C. Kyriakidis, and M.F. Goodchild. Response to "Comments on 'Combining spatial transition probabilities for stochastic simulation of categorical fields' with communications on some issues related to Markov chain geostatistics." *International Journal of Geographical Information Science* 26(9–10): 1741–1750.

2012 M.F. Goodchild. NCGIA: Its origins and impacts. In B. Wellar, editor, *Foundations of Urban and Regional Information Systems and Geographic Information Systems and Science*, pp. 195–202. Washington, DC: URISA.

2012 N. Li, S. Ervin, M. Flaxman, M.F. Goodchild, and C. Steinitz. Design and application of an ontology for Geodesign. *Revue International de Géomatique* 22(2): 145–168.

2012 S. Roche and M.F. Goodchild. Introduction: Geodesign: Theory and practice. *Revue Internationale de Géomatique* 22(2): 141–143.

2012 M.F. Goodchild. Afterword. In F. Harvey, editor, *Are There Fundamental Principles in GIScience?* pp. 88–93. Seattle: CreateSpace.

2012 D.Z. Sui, S. Elwood, and M.F. Goodchild, editors. *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice.* New York: Springer.

2012 D.Z. Sui, M.F. Goodchild, and S. Elwood. Introduction: Volunteered geographic information, the exaflood, and the growing digital divide. In D.Z. Sui, S. Elwood, and M.F. Goodchild, editors, *Crowdsourcing Geographic Knowledge: Volunteered Geographic Information (VGI) in Theory and Practice*, pp. 1–14. New York: Springer.

2012 M.F. Goodchild. Foreword. In A. Mitchell, *The Esri Guide to GIS Analysis Volume 3: Modeling Suitability, Movement, and Interaction*. Redlands, CA: Esri Press.

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2010 M.F. Goodchild. Spatial analysis and modeling. In J.D. Bossler, editor, *Manual of Geospatial Science and Technology*, pp. 575–592. Boca Raton: CRC Press.

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Publications by Mary Hegarty

(since becoming Director of the center in July 2012):

in press

Davies, C., S. Fabrikant, and M. Hegarty. Towards empirically verified cartographic displays. In J. L. Szalma et al., editors, *Handbook of Applied Perception Research.* Cambridge, MA: Cambridge University Press.

Hegarty, M., M. Stieff, and B.L. Dixon. Cognitive change in mental models with experience in the domain of organic chemistry. *Journal of Cognitive Psychology* 25(2): 220–228.

Khooshabeh, P., M. Hegarty, and T.F. Shipley. Individual differences in mental rotation: Piecemeal vs. holistic processing. *Experimental Psychology.*

2013 Hegarty, M. Cognition, metacognition and the design of maps. *Current Directions in Psychological Science* 22: 3–9.

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2012 Cohen, C.A. and M. Hegarty. Inferring Cross Sections of 3D Objects: A New Spatial Thinking Test. *Learning and Individual Differences* 22: 868–874.

2012 Stieff, M., M. Ryu, B. Dixon, and M. Hegarty. The role of spatial ability & strategy preference during spatial problem solving in organic chemistry. *Journal of Chemical Education* 89: 854–859.

2012 Hegarty, M., H.S. Smallman, and A.T. Stull. Choosing and using geospatial displays: Effects of design on performance and metacognition. *Journal of Experimental Psychology: Applied* 18: 1–17.

2012 Hegarty. M. and A.T. Stull. Visuospatial thinking. In K. Holyoak and R. Morrison. *Oxford Handbook of Thinking and Reasoning,* pp. 606–630. New York, NY: Oxford University Press.

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(Before becoming director of the center, but in the last 3 years):

2011 Hegarty, M. The cognitive science of visual-spatial displays; Implications for design. *Topics in Cognitive Science* 3: 446–474.

2011 Stieff, M., M. Hegarty, and G. Deslongchamps. Identifying representational competence with multi-representational displays. *Cognition and Instruction* 29: 123–145.

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2010 Kooshabeh, P. and M. Hegarty. Inferring cross sections: When internal visualizations are more important than properties of external visualization. *Human Computer Interaction* 25: 119–147.

2010 Hegarty, M. Components of spatial intelligence. In B. H. Ross, editor, *The Psychology of Learning and Motivation*, pp. 265–297. San Diego: Academic Press.

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2010 Hegarty, M., M. Canham, and S.I. Fabrikant. Thinking about the weather: How display salience and knowledge affect performance in a graphic inference task. *Journal of Experimental Psychology: Learning, Memory and Cognition* 36: 37–53.

2010 Fabrikant, S.I., Rebich-Hespanha, S., and M. Hegarty. Cognitively inspired and perceptually salient graphic displays for efficient inference making. *Annals of the Association of American Geographers* 100: 13–29.

2010 Canham, M. and M. Hegarty. Effects of knowledge and display design on comprehension of complex graphics. *Learning and Instruction* 20: 155–166.

Publications by Donald Janelle

2013 Grossner, K. and D.G. Janelle. Educating the Spatial Thinker. In D. R. Montello, K. Grossner, and D.G. Janelle, editors, *Space in Mind: Concepts and Ontologies for Spatial Education*. Cambridge, MA: MIT Press, in press.

2013 Janelle, D.G. Critical Spatial Thinking and Time-space Convergence. In R.J. Stimson, editor, *Handbook in Spatially Integrated Social Science Research Methods*. Edward Elgar, in press.

2013 Goodchild, M.F., D.G. Janelle, and K.E. Grossner. Critical Spatial Thinking. In R.J. Stimson, editor, *Handbook in Spatially Integrated Social Science Research Methods*. Edward Elgar, in press.

2013 Hegarty, M., N. Newcombe, M.F. Goodchild, D.G. Janelle, T. Shipley, and D. Sinton. *Spatial Thinking Across the College Curriculum Specialist Meeting—Final Report*. 42 pages. Meeting sponsored by the UCSB Center for Spatial Studies and the Spatial Intelligence and Learning Center (Temple University). 10–11 December 2012, Santa Barbara CA. http://www.spatial.ucsb.edu/events/STATCC/docs/STATCC-Final-report.pdf.

2012 Janelle, D.G. Space-adjusting Technologies and the Social Ecologies of Place: Review and Research Agenda. International Journal of Geographic Information Sciences 26(12): 2239–2251. http://dx.doi.org/10.1080/13658816.2012.713958.

2012 Matthews, S.A., D.G. Janelle, and M.F. Goodchild. *Future Directions in Spatial Demography Specialist Meeting—Final Report*. 37 Pages. Meeting sponsored by the Center for Spatial Studies at the University of California, Santa Barbara, the Population Research Institute at The Pennsylvania State University, and the NIH Advanced Spatial Analysis Training Program (NICHD 5R-25 HD057002-04, 12-13 December 2011, Santa Barbara CA. http://ncgia.ucsb.edu/projects/spatial-demography/.

2011 Grossner, K., D.R. Montello, and D.G. Janelle. Finding the Spatial in Text Corpora , Position paper for *Workshop on Ontology of Spatial Thinking and Reasoning*, Conference on Spatial Information Theory, pp. 23–27 (Sept).

2011 Janelle, D.G. and M.F. Goodchild. Concepts, Principles, Tools, and Challenges in Spatially Integrated Social Science. In T.L. Nyerges, R. McMaster, and H. Couclelis, editors, *The SAGE Handbook of GIS and Society*. SAGE Publications, pp. 27–45.

2010 Janelle, D.G. Varenius (1622–1650). In B. Warf, editor, *Encyclopedia of Geography*. Sage Publications, DOI: 10.4135/9781412939591

2010 Goodchild, M.F. and D.G. Janelle. Toward Critical Spatial Thinking in the Social Sciences and Humanities. *GeoJournal* 75(1): 3–13.

2010 Janelle, D.G. and M.F. Goodchild. Clickstream mapping of scientific activity—Opportunity and caution. *Footnotes* 38(1): 9. Invited article for the online American Sociological Association newsletter.

Presentations (Covering period April 2010–April 2013):

The following presentations have described the work of the center to audiences worldwide.

Presentations by Michael Goodchild

2013, March **Emerging Trends: Communities**. Keynote, EUROGI imaGIne Conference, Dublin.

2013, Feb. **Exploring Digital Earth**. Keynote, 47th Annual Alaska Surveying and Mapping Conference, Anchorage.

2013, Jan. **Visualizing Geospatial Uncertainty**. Distinguished Lecture, SCI Institute, University of Utah.

2012, Nov. **Integrating Space-Time Analysis**. Space-Time GIScience and Analysis Forum, Chinese Academy of Sciences, Beijing.

2012, Nov. **Integrating Space-Time Analysis**. Space-Time GIScience and Analysis Forum, Wuhan University.

2012, Oct. **Geographic Intelligence**. Keynote, SpaceTimeLab Launch Event, University College, London.

2012, Oct. **A Personal Perspective on Cave Navigation**.

Caves and Cognition: Exploring the Cave Experience from Multidisciplinary Perspectives. University of California, Merced.

2012, Oct. **Exploring Digital Earth**. Keynote, GIS-Pro 2012, Portland, OR.

2012 June **The Future of Digital Earth**. Keynote, GeoInformatics 2012, Chinese University of Hong Kong.

2012, May **Exploring Digital Earth**. Retirement Celebration, University of California, Santa Barbara.

2012, May **Reflections and Visions**. Keynote, Global Geospatial Conference, Québec.

2012, April **GISRUK at 20**. Keynote, GIS Research UK, Lancaster.

2012, April **Geographical Intelligence**. Esri Colloquium, Redlands.

2012, Feb. **GIScience and Spatio-Temporal Analysis: An Overview of Recent Advances**. Annual Meeting, Association of American Geographers, New York.

2012, Feb. **Communicating Spatial Uncertainty**. Annual Meeting, Association of American Geographers, New York.

2012, Jan. **The Quality of Big (Geo)Data**. Colloquium presentation, Department of Geography, University of California, Santa Barbara.

2011, Nov. **GeoDesign: The Way Forward**. Keynote, Saudi Planning and GeoDesign Conference, Riyadh, Saudi Arabia.

2011, Nov. **Where are We? The Spatial Sciences in 2011**. Keynote, Surveying and Spatial Sciences Conference, Wellington, NZ.

2011, Nov. **Discrete Global Grids: Retrospect and Prospect**. Keynote, Workshop on Global Spatial Grid 2011, Beijing.

2011, Oct. **Geographical Intelligence**. Keynote, GeoMundus Conference, Münster, Germany.

2011, Oct. **Critical Spatial Thinking**. Lunchtime speaker, 34th Applied Geography Conference, University of Redlands.

2011, Sep. **Realizing the Vision of CyberGIS**. Plenary Address, NSF CyberGIS Project All Hands Meeting, Oak Ridge, TN.

2011, Sept. **Spatial Thinking and the GIS User Interface**. Keynote, International Conference: Spatial Thinking and Geographic Information Sciences 2011. Tokyo.

2011, Sept. **GIS Today and Tomorrow: A US Perspective**. PASCO Corp, Tokyo.

2011, Sept. **Digital Earth: Inventory and Prospect**. Keynote, Hengstberger Symposium "Towards Digital Earth: 3D Spatial Infrastructures." University of Heidelberg.

2011, Sept. **Geographic Intelligence**. Keynote, European Colloquium on Quantitative and Theoretical Geography, Harokopio University, Athens.

2011, June **Geographic Intelligence**. Keynote, GeoInformatics 2011, Shanghai.

2011, April **The Changing Face of GIS**. University of Miami.

2011, March **Citizens as Sensors: The World of Volunteered Geography**. George Mason University.

2011, Feb. **It's about Time: The Temporal Dimension in VGI**. Keynote, Esri Redlands Week.

2011, Feb. **Challenges in GIS Research**. University of Redlands.

2011, Feb. **Perspectives from the GIScience Research Community**. NIH-Wide GIS Infrastructure Workshop, Rockville, MD.

2011, Jan. **Data Synthesis: A New Statistical Paradigm**. Department of Statistics, University of California, Los Angeles.

2010, Dec. **Challenges in Geographic Information Science**. Conference on Enhancing Latin American GIS&T Capacity for Innovation and Economic Development, Panama City.

2010, Nov. **From Community Mapping to Critical Spatial Thinking: The Changing Face of GIS**. Distinguished Lecture, Social, Behavioral, and Economic Sciences Directorate, National Science Foundation, Washington DC.

2010, Nov. **The Future of Geographic Information Science**. James Madison University.

2010, Oct. **Citizens as Sensors: The World of Volunteered Geography**. Mapping Science Committee, National Research Council, Washington DC.

2010, Oct. The Changing Face of GIS. 12th Japan-Korea International Symposium on GIS, Kyoto.

2010, Oct. The Changing Face of GIS. School of Geographic Sciences and Planning, Arizona State University.

2010, Sept. Twenty Years of Progress: GIScience in 2010. Schermerhorn Lecture, Opening Academic Programme, ITC 2010–2011,Enschede, Netherlands.

2010, Sept. Challenges in GIS Research. Master Class, ITC, Enschede, Netherlands.

2010, Sept. The Changing Face of GIS. Tenth Anniversary Inaugural Lecture, New University of Lisbon.

2010, Sept. **Optimizing Feature Matching in Conflation**. With Linna Li. GIScience 2010, Zurich.

Presentations by Mary Hegarty

2014, April **Broadening the study of spatial thinking in science: The case of organic chemistry.** Annual meeting of the American Educational Research Association, San Francisco, CA.

2013, April **Spatial thinking across the college curriculum: Report of an interdisciplinary specialist meeting**. Annual meeting of the Association of American Geographers, Los Angeles, CA.

2013, March **Spatial thinking**. Cognitive Science Program. University of California, Berkeley, CA.

2012, Aug. **Meta-representational competence as an aspect of spatial intelligence**. Cognitive Science Conference, Sapporo, Japan.

2012, May **Broadening the study of spatial intelligence**. Pittsburgh Science of Learning Center, Pittsburgh, PA.

2012, April **Spatial abilities and chemistry achievement: Contributions and limitations of correlational studies.** Annual meeting of the American Educational Research Association, Vancouver, Canada.

2011, Nov. **The cognitive science of visual displays: Implications for design**. Department of Geography, University of Zurich, Switzerland.

2011, Nov. **Wayfinding in the Seattle Public Library: Discussion**. Annual meeting of the Psychonomic Society, Seattle, WA.

2011, April **Broadening the study of spatial intelligence**. Cognitive Science program, University of Arizona, Tucson, AZ.

2010, Dec. **The role of spatial thinking in undergraduate science education**. National Research Council committee on the status, contributions, and future directions of discipline-based education research Irvine, CA.

2010, Oct. **Representations in the mind and in the world: How cognitive science can inform the design of visualizations**. Keynote address, IEEE Visweek, Salt Lake City, Utah.

2010, Sept. **Eye fixations and geospatial displays**. GIScience, Zurich.

2010, Aug. **Do all science disciplines rely on spatial abilities? Evidence from self-report questionnaires**. With R. Crookes, D. Dara-Abrams and T. F. Shipley. Spatial Cognition.

2010, May **Varieties of spatial intelligence and their relevance for STEM disciplines**. Spatial Learning Conference, Cambridge, MA.

Presentations by Donald Janelle

2012, Sept. **William Warntz and Theoretical Geography at Harvard in the 1960s**. GIS Colloquium, Center for Geographic Analysis, Harvard University, Cambridge, MA.

2012, Feb. **CSISS**. Panel on Contributions of Michael Goodchild, Association of American Geographers Annual Meeting, New York, NY.

2012, Feb. **Space-adjusting Technologies and the Social Ecologies of Place**. Association of American Geographers Annual Meeting, New York, NY.

2012, Feb. **Spatiotemporal Thinking, Computing and Applications, Transportation**. Association of American Geographers Annual Meeting, New York, NY.

2011, Dec. **Frontiers in Spatial Demography.** Specialist Meeting on Future Directions in Spatial Demography, Santa Barbara, CA.

2011, Sept. **Affinity among Disciplines and Perspectives on Spatial Thinking**. Workshop on Ontology of Spatial Thinking and Reasoning: Multi-disciplinary Reconciliation. COSIT (Conference on Spatial Information Theory), Belfast, ME.

2011, April **TeachSpatial: A Portal to Instructional Resources on Spatial Concepts**. Session on Educating a Workforce Literate in Cyberinfrastructure. Association of American Geographers Annual Meeting, Seattle, WA.

2010, Nov. **Spatial data visualization in the social science classroom**. ICPSR (Interuniversity Consortium for Political and Social Research). Virtual Social Science Data Fair (Webinar presentation). http://www.icpsr.umich.edu/files/ICPSR/datafair/DataFairAt-a-Glance.xls.

2010, Sept. **When can I get there from here? Early 19th Century Stagecoach Networks and Settlement Development in Maine.** Curtis Memorial Library, Brunswick, ME
