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Future Directions in Spatial Demography, Final Report

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Publication Date

2012-03-01

Future Directions in Spatial Demography

Specialist Meeting

Final Report

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Upham Hotel
Santa Barbara, California

December 12–13, 2011

This specialist meeting was convened 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; Dr. Stephen A. Matthews, Principal Investigator)

Executive Summary

Spatial demography is concerned with the spatial analysis of demographic processes and outcomes. While interest in spatial demography is evident throughout the history of the core discipline of demography, the degree to which spatial thinking and different forms of spatial analysis in the field has varied widely (Weeks, 2004; Voss, 2007).

Demographic research requires the study of complex patterns of interrelated social, behavioral, economic, and environmental phenomena; increasingly it is argued that spatial thinking and spatial analytical perspectives have important roles to play. In recent years, the revival in macro-demography has been supplemented by the integration of micro- and macro-demography and the linking of data on people to data on places (Entwisle, 2007). This integration has piqued the interest of many in the harnessing of geospatial technologies to collect, manage, and analyze new forms of geospatial data that can help address research and policy questions. Demographic research in the United States and overseas increasingly depends on the collection and analysis of individual- and contextual-level data across a wide range of spatial and temporal scales. Indeed, this is evident in demographic research on such issues as racial/ethnic segregation and other forms of social stratification and inequality; health behaviors, morbidity and mortality; fertility; family structure/transitions and aging; and population-environment interactions (Entwisle, 2007, see also several position papers from the specialist meeting, available at: <http://ncgia.ucsb.edu/projects/spatial-demography/participants.php>).

Challenges for spatial demography

Although the research environment for spatial demography is changing rapidly and in exciting ways, the field faces important challenges. The specific objective of the specialist meeting was to identify these challenges and define gaps in current knowledge regarding innovations in geospatial data and spatial statistical methods, including the integration of data and models. An overarching goal was to prioritize a research agenda to enhance the science of spatial demography in population and health research. Specific questions addressed during the meetings included:

- How are demographers measuring place and the interrelationships among places?
- How can demographers harness emerging developments in the generation of geospatial data (e.g., volunteered geographic information and crowd-sourced data)?
- How can new measures be validated for use in neighborhood and contextual research?
- What visualization and spatial analytical methods make up the current tool kit of the spatial demographer?
- What new methodological developments in spatial analysis are possible in the next five years and how might these be integrated into mainstream demographic research?
- What are the training challenges to the enhancement of future research in spatial demography?
- What research priorities will best advance the applicability of spatial demography to address issues in reproductive health, population health, and other areas of societal need?

Structure of the specialist meeting

The “Future Directions of Spatial Demography” specialist meeting brought together 41 specialists from multiple disciplines to discuss the future of spatial demography. Whereas the majority of attendees were geographers and sociologists, many other disciplines were represented, including anthropology, economics, epidemiology, health economics, and political science. Most participants were interested in demographic research questions. Full details about the specialist meeting, including a participant list, short position papers from participants, copies of presentations made during the meeting, and additional materials (including this report) can be found at <http://ncgia.ucsb.edu/projects/spatial-demography/>. Materials of likely value to researchers in spatial demography are listed in the Appendix.

In addition to the materials posted on the website, this report outlines the primary outcomes of the meeting, including recommendations about training-related activities and cross-site collaborations, activities that promote spatial demography within the wider academy, and information about upcoming conferences, workshops, and new journals.

This report follows the structure of the specialist meeting, held over two days—December 12–13, 2011. Day 1 of the meetings included four plenary sessions. In each session, two invited experts provided 20-minute presentations, each followed by open discussion. The four sessions focused on:

1. The state of the science in spatial demography
2. Emergent geospatial data and measurement issues
3. Spatial statistical methods
4. A synthesis of challenges

Day 1 ended with a group discussion about the breakout sessions that would provide the structure for deliberations on Day 2.

For Day 2, participants were divided into three breakout groups and each group was provided with the same set of questions for discussion. These questions, along with others raised by the group, reflected on the core conceptual, data-related, and methodological issues that arose during the four plenary sessions. After a working lunch, participants re-assembled to hear the summary presentations from each group.

The summaries reported below, are just that; they do not account for everything said during the meetings but rather summarize the main points raised by presenters or in the discussion sessions. The website includes the PowerPoint of all plenary presentations and summaries of group deliberations. Interested readers are encouraged to consult those resources at <http://ncgia.ucsb.edu/projects/spatial-demography/>.

Day One: Invited Presentations

Day 1 was organized around four sessions. Each session included two 20-minute invited presentations followed by approximately 40 minutes of open discussion based on the salient issues arising from the presentations.

Session 1: State of the Science in Spatial Demography

John Logan (Brown University)

Interpreting Spatial Dependence as a Theoretical Problem

John Logan is a distinguished sociologist and demographer. Throughout his career it is clear that spatial thinking has informed his research, how he addresses problems, what data he collects, and how he analyses data (see Logan, forthcoming). Logan's presentation on interpreting spatial dependence started with a useful general comment "The more we know, the better we understand how much we don't know." His goal was to illustrate this point, drawing on two current projects where spatial dependence is "a central phenomenon": a study of residential clustering and a study of hurricane damage.

A fundamental issue for Logan was "*What is a neighborhood?*" followed by questioning "*How do we study neighborhoods?*" In the study of residential clustering he discussed the use of Moran's I and LISA statistics to identify and visualize spatial clustering based on census tract boundaries. The question arising here was "*When we see spatial dependence, does this mean we are mis-estimating our boundaries?*" Logan then transitioned into a study drawing on individual-level historical census data (1880) with resources from the Minnesota Population Center (<http://www.nappdata.org/napp/>). Using individual-level data, the primary question Logan and his colleagues asked is "How can we use the social composition of areas at different scales to identify neighborhoods and determine what defines them?" That is, using an ecocentric perspective (where every individual has a neighborhood) they explored how segregation (by socioeconomic indicators or race/ethnicity) can vary by spatial scale. The flexibility that individual-level data affords is the opportunity to study intergroup relations from a spatial perspective unconstrained by administrative boundaries or by scale. This highly innovative work is forthcoming in the *Annals of the Association of American Geographers* (Spielman and Logan, forthcoming).

The second example, asked "How far do the effects of a hurricane extend and what kinds of effects are these?" The empirical example is based on county-level data of hurricane damage, population displacement, and employment change. Hurricane damage has a high degree of spatial dependence and, again, this dependence raised the question "What is the neighborhood?" (which in this instance is several counties) as well as what the issues are that can be associated with the construction or operationalization of a spatial weights matrix. Logan implied that the observed spatial dependence defines the neighborhood. He briefly drew a parallel with the well-known work by Sampson *et al.* (1999) on collective efficacy for children to raise the issue of whether there is spatial lag dependence or whether there are "larger zones." As he concluded, "*it all depends on how we choose to think about spatial dependence.*"

Marcia Castro (Harvard University)
State of the Science in Spatial Demography: Methods and Training

Marcia Castro recapped on why there has been a resurgence of interest in spatial demography, including (but not limited to) geospatially referenced and other new forms of data; developments in computation, mapping and spatial analysis; the importance of spatially targeted policies; the growth of interest in social contexts (i.e., community and neighborhood effects); and greater interest in spatial thinking across the social sciences. But, as her title suggests, there are both opportunities and challenges associated with the future development of spatial demography that relate methodology and training.

For Castro, spatial methods and spatio-temporal models can be used to identify or confirm regional patterns (distribution, clustering, spatial inequalities), inform predictive models, and enhance targeted interventions. Their application has helped generate demand for data, models, and statistical software by researchers in the field. She suggested that the applications in spatial demography (broadly defined) tend to be published in geography, public health, criminology, and statistical journals, and are not always visible in demography's core journals. Three exceptions are the special issues in *Proceedings of the National Academy of Science* (2006) edited by Ken Wachter, *Population Research and Policy Review* (2007) edited by Paul Voss, and *Demographic Research* (2012) edited by Stephen Matthews. Castro also drew attention to the new e-journal being launched in 2012 by Frank Howell and Jeremy Porter, titled *Spatial Demography*.

Castro identified a number of key methodological issues and challenges. Her listing began with the well-known issue that empirical results are scale dependent (the Modifiable Areal Unit Problem). Further, she noted that the data demographers use are not always appropriate for spatial analysis due to the sampling frame and/or spatial coverage. Similarly, she identified the new problems that can be introduced when combining data from different sources (and also at different spatial and temporal scales) and the occasional lack of a sound conceptual framework about scales and processes. Issues of endogeneity and our ability to assess causality are major concerns. Overall, Castro identified a general lack of support for macro-demography relative to micro-demography, although the growing need to integrate the two is important for the discipline.

The methodological challenges allow Castro to discuss perhaps the most fundamental issue the field faces—the issue of training in spatial thinking and spatial analysis. As others have noted (see Matthews, Janelle, and Goodchild, 2007 at <http://csiss.org/GISPopSci/about/proposal.php> and several position statements, e.g., Voss), many universities that host a population center do not host a geography department. Although some universities have classes in software (e.g., ArcGIS), very few specifically teach spatial thinking and spatial analytical methods. This is a problem. Not only is the lack of training a challenge for the field, but the fact that very few “demographers” receive any training at all in spatial methods prior to entering graduate school compounds it. The implication is that we need to think about how we “seed and populate” the network to train the next generation of trainers. Castro also laments the lack of a core curriculum. This in fact raises bigger issues associated with what is “spatial demography” and how it can be or should be taught.

Open Discussion: State of the Science in Spatial Demography

The discussion focused almost entirely on training, drawing on participants' experiences in offering "spatial demography" courses. For example, it was noted that, even at universities with geography programs and/or a GIS capacity, spatial training—especially training in advanced spatial analysis methods—may not be associated with geography and GIS programs.

It was noted that there are many challenges in trying to design a one-semester/quarter "spatial demography" course; inevitably a lot gets left out, and what is included can depend on the prerequisite courses that are required and on what other courses are offered as part of the wider curriculum at an institution. There is also concern over how much depth an instructor can provide regarding micro-macro demography or specific spatial statistical methods. With regard to the former, since the spatial component is not easily aligned with either of the frameworks this can be a challenge. For the latter, there is diversity in what methods are covered and how they are taught, even within existing courses and within allied fields such as statistics. There is no one ideal teaching model.

The diversity of the student body seeking out spatial demography courses is also a challenge. While there is high demand for such courses, often the diversity of the students' background and experience (in geospatial data handling, cartography, quantitative methods) and their substantive interests creates other challenges associated with how to pitch and introduce spatial analytical methods. It was mentioned that Population Geography courses would offer a possible solution, which in turn raised the general question of what the difference was between Population Geography and Spatial Demography. But, again, Population Geography is taught in many different ways, and most courses and textbooks do not discuss spatial analysis in depth.

Another key challenge regarding course design and content is that many people do not know what to do with the spatial methods that might be taught. This may be due to the general lack of "spatial questions" in substantive courses. Some participants implied this was also a function of a general lack of interest in modeling and statistics. It should be noted that demography and demography-related graduate programs tend to be highly quantitative in orientation compared to the programs in many other social sciences. One outcome of this discussion was the suggestion that, perhaps, there ought to be efforts to promote a network of graduate students that use spatial methods in demography. This could draw on the existing Advanced Spatial Analysis Training Program in Population Science that has hosted 8 workshops attended by more than 200 participants since 2008—see <http://www.csiss.org/GISPopSci/>.

(Note: Training is an issue that arises in almost every plenary and breakout session and represents a continuing dialogue throughout the meeting.)

Session 2: Emergent Geospatial Data and Measurement

Michael F. Goodchild (University of California, Santa Barbara) Emergent Geospatial Data and Measurement Issues

Michael Goodchild provided a wide-ranging overview of the new forms of data that are already available to demographers and hinted at the kinds of data we will increasingly encounter. The presentation focused on the considerable opportunities as well as the inevitable methodological challenges of using these new data sources. For example, his first main slide on volunteered geographical information (VGI) nicely summarized both the opportunities and challenges. Opportunity-wise, VGI are free, increasingly abundant, timely, and multidimensional (in this instance referring to the fact that almost any type of information can be collected and mapped). However, the challenges with VGI relate to inevitable concerns with metadata and documentation and to a host of issues regarding data quality (e.g., complete coverage) and how data are used (e.g., privacy and confidentiality). Goodchild provided several examples of innovative use of VGI (e.g., Direct Relief International’s Earthquake Aid Mapping in Haiti, and Crandall *et al.*, 2009—see Appendix A). He offered three perspectives on meeting the challenges for using, validating, and trusting VGI source data: “crowd solution,” the “social solution,” and the “geographic solution.” Emerging from this is the need for geographic rules and consistency with fundamental geographic knowledge (e.g., Tobler’s First Law).

The second half of Goodchild’s talk focused on challenges related to the more traditional data sources for demographers, especially the U.S. Decennial Census and the American Community Survey (ACS). The latter raised several new challenges (also covered in Barbara Entwisle’s talk in Session 2 and in Paul Voss’s presentation in Session 3, below). The ACS is unquestionably a valuable resource that facilitates analysis of specific types of questions at specific geographic levels; however, it has sacrificed spatial detail for temporal data. Other data sets discussed (often contrasting a U.S. approach to other countries) included the use of administrative data and challenges of coordination across agencies and levels of government. It could be that the era of taxpayer-based high-quality data (government data) could possibly be coming to an end. What will replace these data? The emergence of the private sector as a source of data is key, which raises many challenges for academic researchers (e.g., private-sector data often being out of reach). Access to data and issues of privacy and confidentiality were briefly discussed, including possible solutions based on the Census Data Center and virtual Census Data Center models. Goodchild also discussed analytical challenges, such as the need to aggregate individual-level data, the associated problems that emerge because of changes in the boundaries of administrative units (reporting zones) over time, and the importance of understanding methods of areal interpolation.

Goodchild concluded with a review of the main issues for possible discussion: (a) the diversity of data sources generated by new technologies, (b) the emergence of data collection by the private sector and the decline in taxpayer-financed data, (c) the implications of both (a) and (b) for data access and data quality and how these changes may simultaneously close off and open up certain kinds of demographic and social science research.

Barbara Entwisle (University of North Carolina at Chapel Hill)
Spatial Demography: Opportunities and Challenges

Barbara Entwisle's opening comments stressed that demography has always been spatial. As illustration, she discussed the geography of the U.S. Census, noting that spatial demography in the U.S. has largely been tied to the standard census units (e.g., counties, census tracts, and census blockgroups). Echoing John Logan's earlier presentation, a key question today is the relevance of some of these units and whether they provide good representations of neighborhoods. The standard geographical boundaries have come to define the subject matter of demographers. In the case of migration research, Entwisle briefly discussed how, historically, migration was seen as the movement across nations (i.e., immigration) and between states and counties (i.e., internal migration and residential mobility). Entwisle suggested that there have been two main "game-changers": the gradual adoption of GIS technologies by demographers and the torrent of geospatial data.

In terms of GIS, demographers have begun to use mapping to explore spatial patterns in research, using locational references to integrate data sources and measurements and to derive new variables (e.g., distance, adjacency, density) and using remote sensing to explore new approaches to human-environment interactions. The technology allows us to put people in place (Entwisle, 2007; Glass and McAtee, 2006) and, increasingly, across the social sciences, we are beginning to look at the dynamic conceptualizations of place to link micro and macro processes (see Castro session 1). The fully dynamic conceptualization and thus recognition of the reciprocal relations between people and places is critical—we need to know more about human behavior in certain places and why those places are chosen.

Entwisle's second game-changer is the torrent of data being produced and now available (European Union, 2010; US Department of Commerce, 2009; McKinsey Global Institute, 2011). A sampling of her list mirrored those mentioned by Michael Goodchild, including census, registration, and administrative data through to transactional data, internet searches, and tweets. She also referred to the census geographical hierarchy diagram to illustrate the nested and non-nested structure and other spatial boundaries that are available beyond the census block, blockgroup, tract, and county frames. The challenges she identified include those connected to the integration of diverse data sources, data documentation/quality, privacy and confidentiality, and data management.

In her wrap-up, Entwisle asked "When did demography become statistical rather than mathematical?" (This was asked in reference to the definition of demography that appears on the front cover of the journal *Demography*). She identified a difference in the "demography toolkit" of the twentieth and twenty-first centuries. At a basic level, it is a shift from statistical to spatial science and from survey methodology to data science. She also envisioned that, as we acquire more fine-tuned spatial scales and data, the importance of a topic such as migration will increase (as compared to the importance of fertility and mortality). As part of this argument, she stated that many changes are migration-related and identifies several new areas for exploration, including: life-course transitions and spatial mobility, social and spatial mobility, neighborhoods and migration, social networks and migration, tourism and ecological impacts, and the distributional and mobility implications of climate change.

Open Discussion Emergent Geospatial Data and Measurement Issues

Building upon the two presentations, the discussion then centered primarily on data quality and data access. Other key areas concerned the data needs of demographers and the research methods used by demographers. Discussion also returned to a theme featured in Session 1—the definition of place.

Private-sector data invoked concerns about quality issues, such as whether the data are representative. To some, this was a non-issue in that as data grow and become richer, issues of selection effects and representativeness will become less of a concern. It was pointed out that demographers (and social scientists) use and develop surveys as a way to get around “volunteered” data and issues of representativeness. But it was also noted that many demography research surveys are not representative, that we must consider survey information (in addition to volunteered information), and we must think creatively about how to combine different sources of data. The attraction of new types of data must be balanced by validation as well as consideration of whether these new data are appropriate for the research demographers are doing.

It was mentioned that demographers must explain why they select the data they choose to gather and address transformations in data availability tied to cost. It was suggested that, as we enter an era of “Big Data,” we may be exiting the era of free data. This perhaps counters the fundamental ideas of VGI and open source materials. That said, a concern was expressed regarding the implications of data sharing when the data may become privatized. Licensed data typically cannot be shared. It is not always clear that one can or should aggregate licensed data and, if one does so to derive new variables, it is not clear that these new measures can be shared. There was no resolution to these issues but it is apparent that as data become privatized there could be important implications for researchers across all fields. Certainly, the collection and use of geospatial data will have implications for some of the questions addressed by spatial demographers.

Data and measurement issues also arise in the new research area on the demography of cyberspace. This is potentially a very important and dynamic topic; yet, we do not know how proximity is measured in cyberspace and, more specifically, we have little understanding of how cyberspace communities influence individual decision-making (e.g., residential choice).

Regarding the measurement of place, there was a call for demographers to think about data that looks at exposure to place as a function of time rather than just as an outcome or presence/absence exposure. It is possible to be more sophisticated. It was pointed out that several meeting participants were engaged in built-environment research and that in some fields (e.g., nutrition and physical activity research) the conceptualization of exposure to places was often focused on people (i.e., egocentric zones or buffers) rather than on administrative boundaries such as census tracts (with data aggregated at such levels). In such cases, researchers are moving away from “area” data toward point data (e.g., locations of food stores, fast food restaurants) and developing more continuous views of place.

It was noted that very few participants defined “demography” in their position statements and that the emphasis was on the spatial and not necessarily the demographic. Demography has an

interdisciplinary focus but it is evident that sociologists/demographers and geographers view things differently. Moreover, although there are established literatures in GIS, spatial analysis, place/space, and activity spaces, these literatures are not widely read in sociology/demography. This criticism was not meant to imply that limited cross-reading is one-directional. Indeed, it was noted that, while demography has its own theories, it has traditionally looked outward to embrace theories and methods from other disciplines. However, there are the usual obvious challenges of academic positions—irrespective of discipline—that require disciplinary focus and specialization. It was observed that this may run counter to the research funding environment that rewards innovation and increasingly requires collaboration in substantive and methodological areas. In this environment, familiarity with other fields (cross-reading) can provide a comparative advantage as applications must be written for, and will be reviewed by, panels composed of a diverse group of scientists.

Session 3: Spatial Statistical Methods

Sergio Rey (Arizona State University)

Recent Advances in Software for Space-Time Data Analysis

Sergio Rey provided an overview of the evolution of space-time analysis software, introduced PySAL software to look at spatial dynamics, and offered some challenges for the future.

Rey noted that the Center for Spatial Integrated Social Science (CSISS) hosted a specialist meeting on Spatial Data Analysis Software Tools in 2002 (see <http://csiss.ncgia.ucsb.edu/events/meetings/spatial-tools/index.htm>). At this meeting, space-time was identified as a future theme with a specific emphasis given to three topics: the dynamics of spatial clustering, the clustering of co-temporal movements, and a recognition that no specialized software package existed at that time.

Rey then introduced programs he has developed: Space-Time Analysis of Regional Systems (STARS) and the Python Spatial Analysis Library (PySAL). He provided an overview of the functionality of STARS including tasks such as brushing and linking data across space-time paths before describing and demonstrating PySAL (for further details on the latest release of PySAL [v.1.3] see <http://geodacenter.asu.edu/pysal> or <http://pysal.org> and the book chapter by Rey and Anselin, 2010). PySAL provides an extensive range of analytical functions and is supported by an equally extensive documentation. Rey's substantive focus lay in issues of spatial inequality and regional decomposition (illustrated later by an example in crime) while the methodological focus was on exploratory spatial data analysis (ESDA) methods as well as Directional LISA (local indicators of spatial association) (Rey, Murray, and Anselin, 2011), Bivariate LISA, and LISA Markov (Rey and Janikas, 2006) methods.

Rey identified several challenges, beginning with the complexity of the modifiable areal unit problem (MAUP) in space-time, a complexity in part created because of the changing administrative boundaries researchers use due to annexations, splitting, and creation of new administrative entities. Some solutions to this issue may lie in the common use of areal interpolation to time-constant and exogenous boundaries or perhaps to a future based on endogenous boundaries (where space is no longer an exogenous container). A second challenge is software. Rey briefly discussed the challenges and potential of cyberinfrastructure, high-performance computing, and parallelization as well as the research community's need for extensive and flexible tools (as well as a continuing need for new methods). As a player in this arena himself, Rey identifies the increasing role of the scientist as the producer rather than the consumer of these new methods. Rey invited spatial demographers to tell him (and other software developers) what analytical tools or features they would like to see.

Paul Voss (University of North Carolina at Chapel Hill)
Spatial Statistical Methods

Paul Voss reminded the audience of the breadth and depth of spatial statistics and specifically how many different spatial statistical methods there are. He simply recounted how researchers may say things like “I’ve tried them all” but in fact they probably haven’t. This dovetails with decisions about what materials do you teach, and how, within a spatial demography course.

The focus of Voss’s talk was on the “small topic” of small-area population estimates. He argued that applied demographers can learn a lot from their statistical colleagues and from recent developments in the statistics field (i.e., mixed-effects models and Bayesian hierarchical models). Applied demographers are using tried and tested approaches; however, these are quite dated (30–50 years old). Voss suggested several reasons for the lack of attention to new methods: a lack of interest in statistics, most estimates are straightforward, the consumer wants an estimate and is less concerned with issues such as uncertainty in the estimate, and that the old methods actually generate reasonable information. Despite this there are reasons to be concerned.

Much of Voss’s presentation concerned the American Community Survey (see <http://www.census.gov/acs/www/>). Acknowledging the “high price of admission” Voss suggested that most of us complain about the uncertainty in the estimates rather than investing time to better understand the methodology or to extract information from the estimates. He pointed the audience to the NSF Census Research Node at the University of Missouri at Columbia on “Improving the Interpretability and Usability of the American Community Survey through Hierarchical Multiscale Spatio—Temporal Statistical Models” (see <http://www.census.gov/NCRN/>). Voss next provided an illustration of small-area estimates based on the ACS looking at child poverty in married-couple families in North Carolina cities. He compared single-year estimates and their confidence intervals (ACS 2009) to those from multiple single-year ACS files (2005, 2006, 2007, 2008, and 2009). In summary, there is considerable “noise.” Some single-year estimates are based on small samples, which can generate large margins of error. For some measures (e.g., income) the estimates are derived from overlapping time periods. Specifically, a single-year income estimate is generated from 12 monthly estimates all asking about reported income in the past 12 months, which means that the responses represent a 23-month period. The temporal complexity thus introduces other methodological problems (see also Schmertmann, 2010). Voss closed with a brief discussion of ramifications of these problems, such as the need to apply estimates to multidimensional time series (e.g., child poverty and unemployment) and the challenges that this introduces.

Open Discussion: Spatial Statistical Methods

Continuing with Voss's point of "trying them all" it was implied that, if one can find more data, the added value of methodological sophistication (e.g., Bayesian methods) was minimal for many tasks, including small-area estimation. Voss suggested that although more complex models do not necessarily produce better point estimates, they can soften the variance. This led to a discussion of how we educate users about the importance of uncertainty. Related to this issue, it was noted that finding more data is not easy in international demographic research settings, and, thus, the need for use of sophisticated methods will vary.

Several small-area estimation challenges were identified, such as the difficulty in isolating the variables and ancillary data sets to use (and the general confluence of choosing models, variables, and datasets). As regards the ACS, it was noted that there are challenges associated with having to constantly retrofit estimates based on the newest data release (for the 1-year but also, now that ACS is in full swing, for the 3-year and 5-year releases).

This discussion led one to focus on identifying places that matter and, by extension, the need to develop tools that allow the researcher to flexibly aggregate data across scales and units when based on a single data source (e.g., the combination of multiple census tracts into another unit to help reduce the standard errors).

Another topic focused on how to weight data and the art of specifying spatial weights (W) matrices. Several participants commented on the challenges of theoretically justifying a specific W matrix. A fundamental question is whether W is truly exogenous or endogenous. If W is endogenous then there are difficulties of interpretation. Rey reinforced the need for a tighter integration of confirmatory and exploratory methods and the need to expand a spatially explicit theory for specifying W matrices. This could be tied to Tobler's Law, but the group clearly identified the need for more theory regarding spatial processes. It was noted that spatial processes are more than just diffusion processes, that adjacency does not always matter (hierarchical diffusion processes), and that there is complexity in other forms of proximity (social and peer networks). These are all relevant to demographers (and other social scientists). The discussion ended with a series of brief comments on how other methods can be informative (e.g., spatial filtering, multilevel modeling). For example, multilevel data structures (and models) are not always hierarchical or based on a neat nesting of different sets of places. It was suggested that the field needs more discussion of the differences between specific well-known approaches, such as spatial econometrics and multilevel modeling.

Session 4: Synthesis of Challenges and Opportunities

Deborah Balk (CUNY)

Emergent Geospatial Data and Measurement Issues

Deborah Balk suggested that in just a relatively short time “demographers have gone from a rather tabular view of the world to a spatial one.” Further, she pointed out that studying and thinking about a spatial world doesn’t always translate to a study of place, and that in many ways spatial demography remains distinct from population geography.

Balk identified an abundance of geospatial data, and throughout her presentation she provided examples that draw on international demographic data sets. It is important to remind ourselves of the most salient demographic topics of the day (the twenty-first century) and our data needs. Among the topics she identified were migration, urbanization, aging, vulnerable populations, and inequality. This led to a discussion of emergent and underutilized data.

Cell phone technologies and a host of wirelessly integrated devices for collecting data in real-time (with geographic position data) and different forms of ecologic momentary assessment data are already (or will be) a part of future research. There are many challenges, ranging from the analytical, computational, and practical issues associated with handling new forms of data to concerns for data privacy.

Other new methods focusing on data integration include the use of remote sensing (e.g., night-time lights databases for looking at urban spatial change and measles [see Bharti *et al.*, 2011]). Demographers in the field of population and environment have already looked to remote sensing to enhance their work, however, remote sensing is slow to emerge in other sub-fields.

Balk discussed the integration of survey and census data, as a means to generate better spatial aggregates (e.g., of poverty and age-specific rates), but she also acknowledged the complex issue of uncertainty. Uncertainty is problematic when we start to integrate very different data sets, and the difficulties facing researchers are compounded by the lack of metadata and good data codebooks for geospatial data.

Balk has worked on several data-access and data-confidentiality issues, providing a brief discussion of the need for access to micro-data and for permitting flexibility in how these data can be aggregated to new sets of geographies or places (e.g., flood zones). There are technical solutions to data access and there is a need for common protocols to be developed and implemented across different statistical agencies (and across countries’ statistical agencies). Balk asked “Do we need to rethink our study designs and sampling frames?” Remote sensing and other geographic data can help detect hidden populations (e.g., slums) and areas of rapid change (e.g., urban growth, refugee camps).

Balk asked that we “do more with what we have” but also that we embrace new data and new methods, noting that we still need to invest in education so that users will know how to use geospatial data. She closed with a plea for demographers to be engaged in interdisciplinary work.

Daniel Sui (The Ohio State University)

Synthesis of Challenges and Opportunities

Daniel Sui introduced Holling's (1998) two cultures of ecology—analytical and integrative (synthesis)—applying these to his discussion of GIScience. While integration and synthesis were an important part of GIS and spatial analysis, Sui claimed that the growth of VGI and social media in the age of Web 2.0 has revitalized the goal of synthesis; he described parallels in other related technical fields—spatial statistics on data assimilation; remote sensing on data fusion; cartography/photogrammetry on data conflation; and geocomputation on CyberGIS). For Sui, synthesis provides new opportunities especially with the availability of more diverse data and more real-time data (see slide 9 of presentation on Google Maps = Google in Maps based on the integration of photos, video, text, social media data, and much more; and also “We Feel Fine” at <http://wefeelfine.org/>). Other examples included Supramap (<http://supramap.osu.edu>), a web application for integrating genetic, evolutionary, geospatial, and temporal data on topics such as Avian Flu, and Photosynth (<http://photosynth.net/>), a suite of tools for capturing and viewing photographs and images of the world in 3D. In sum, there are many different types of data and tools for integrating them that bring us closer to a “Digital earth.”

Sui next discussed multiple methods for gathering data, including the developments in qualitative GIS (Cope and Elwood, 2008). He introduced an example of interpretation of problems from different perspectives (Margery Wolf's 1992 book, *Thrice Told Tale*) and provided many examples of integrating data sources.

Sui discussed the challenges regarding the synthesis of space and place (Tuan, 1977; Casey, 1997), followed by comments on the need for a new synthesis of space and time, a synthesis based on different problem domains, and the synthesis of known and unknown information (including encrypted or confidential data). Finally, Sui cited Gardner (2007) to introduce the educational challenges and strategies for developing a synthesizing mind.

Open Discussion: Synthesis of Challenges and Opportunities

The group discussion began with comments about remote sensing data and their use by demographers. Major barriers to such use are that the data do not always have the same temporal footprint as demographic processes and there may be inadequate or missing ground-truth for the data. It was noted that these issues are known and this does not preclude the use or value of remotely sensed data in addressing specific demographic questions in specific places/times.

The main discussion quickly turned to institutional review board (IRB)-related issues. Geospatial data are information identifiers and this falls under HIPPA standards (i.e., the *Health Insurance Portability and Accountability Act of 1996*). It was noted that there are few studies that look at the risk of identification (confidentiality breaches) and that we must have a formal mechanism for creating a “body of knowledge” for identification and measurement of risk, and whether certain types of studies are able to take on higher risks (e.g., cancer research). Participants were also reminded of the many different kinds of risks. For example, not only is there a need to better understand the risks associated with the practice of the data collector but also there is a need for oversight regarding different risks associated with users of the same data (often at multiple institutions). It also was noted that IRB’s at institutions appreciate help and guidance from a community of interested scholars in areas such as geospatial data and privacy.

Discussions also focused on education and training, specifically, “What do we teach in spatial demography courses?” with a specific interest on the topic of migration, noting that some institutions were more likely to have demography courses on fertility and mortality than on migration. The variability in substantive training in demography across institutions was in evidence, with the general acknowledgement that spatial demography was rarely taught and was seldom incorporated into demography courses. Reasons for the absence of courses on a core topic such as migration include: the lack of migration data in, or removal of migration data from, large-scale surveys; the difficulty of compiling birth (fertility) or death (mortality) data; and the scant demand for such courses. Nonetheless, the group expects to see more migration data available in the future because of new technologies (cell phones) and the ubiquity of social media and web-based tools. The availability of these kinds of data may also facilitate closer integration between demography and other social science disciplines (e.g., political science). Moreover, new sources of data (real-time and social network) may provide new insights to a fundamental question “Why do we move?” At least one challenge was discussed regarding new forms of migration data and the tracking of movement—the confidentiality issue (multiple data points making disclosure risk higher). Information about the level of comfort that researchers and the academy have regarding risks associated with data integration and synthesis is not available. It was agreed that more work is necessary on many of these topics: new forms of migration data, confidentiality, etc.

Defining Breakout Groups and the Parameters for Discussion

Moderator: Stephen Matthews

A session at the end of the first full day introduced the concept of Breakout Groups and reviewed the topics for discussion. The plan included three parallel groups, each provided with the same questions, although each was free to identify topics of interest that they judged as salient opportunities and challenges to the future direction of spatial demography.

Several potential end-products from the breakout sessions and for the meeting as a whole were discussed, the most concrete being this Report from the Specialist Meeting. Breakout-group reports will be made available (online) and are summarized in the next section of this report. Longer-term products may include papers and collaborations for developing research and training programs, and the identification of priority areas for the future of spatial demography in the United States.

A summary of the comments presented by each Breakout Group follows.

Day Two: Breakout Sessions and Group Reports

Discussion Group 1:

Moderator: Stephen Matthews

Members: Susana Adamo, David Berrigan, Andrew Beveridge, Christopher Browning, Marcia Castro, Frank Davenport, Barbara Entwisle, Frank Howell, Nicholas Nagle, Sergio Rey, Narayan Sastry, Stuart Sweeney, and Brian Wood

Phase 1: Brian Wood Recorder, Narayan Sastry Reporter

This group discussed several emerging issues relevant to the field of spatial demography; they organized part of their presentation around issues of measurement, data, analysis, and cross-cutting themes.

The issue of measurement resonated across much of this group's earlier discussion. Two areas were singled out as warranting attention. The first related to the general area of migration (in all its facets from residential to international, from studies of mobility and an interest in motivations and the effects of migration). A critical issue was the need for more data, better measurement, and validation of the measures. A second general topic was that of neighborhoods and the multiple dimensions and measures that are available. Demographers have a long-standing tradition of looking at administrative units, however, this group saw much change on the horizon and the need for closer attention to the relationship between places and behavior (i.e., activity spaces), to diverse sets of places (e.g., rural and non-traditionally studied places), and to the multiple measures of place/neighborhood. The group also envisioned the continued emphasis on the study of effects of place on outcomes (especially social behaviors, health outcomes), and a recognition that we also would need better data on neighborhood change (and past contexts).

Regarding data, this group acknowledged the need for better measurement and innovation in data collection. At the other end of the research process, the group also focused on the need for better stewardship of data and the need to invest in archiving. Members of this group identified the possibility of the emergence of "social observatories." The emerging analytical issues focused on modeling, need for new software, and concerns regarding casual modeling.

The main cross-cutting research area where spatial demography and related perspectives would appear to have most traction was studies of health. It was noted that "health" was possibly the most common word used in the applications of spatial demography in the specialist meeting participant position statements. Inequality, climate change, and research on population and environment were other areas in which spatial demography could make potentially important contributions.

This group suggested several action items, as follows:

- The need for more resources for training and instruction, with a special emphasis on textbooks on GIS, spatial demography, and spatial thinking for demographers. As noted

by Castro and Matthews (two members of this Breakout Group) and by Voss in their position papers, training in spatial demography remains underdeveloped and under-supported across institutions.

- The need to provide outreach to the field, with suggestions including special issues of journals, letters to editors, and short commentaries.
- The need for migration questions and measures in large-scale surveys and for the development of standards for measuring migration and movement.

Phase 2: Frank Davenport Recorder, Frank Howell Reporter

Continuing one of the main themes from Phase 1, Phase 2 discussed training, VGI, measurement of place, and data validation.

The group was concerned with the growing disparity in spatial demography training at graduate and undergraduate levels. The demand for skills in this area is not evident until late in a graduate career, which may imply the need for an introduction of materials at earlier stages of the curriculum (undergraduate), possibly via chapters in textbooks. There is a need to promote analytical courses, such as spatial analysis, as early as possible although these do not necessarily need to be integrated within courses on demographic techniques. At the graduate level, the emphasis is less on curricula needs and more on the development and sharing of materials across institutions. One model suggested was the CSISS body-of-knowledge approach. There was a concern that no single course could or should be developed. Instructors and learners should be able to pick from a broad library of shared resources. For example, Matthews noted that the American Sociology Association's curriculum collections do not exist for the field of demography, although some spatial demography course outlines are online at http://csiss.ncgia.ucsb.edu/learning_resources/content/syllabi/ (under CSISS-Learning Resources-Course Syllabi). There were suggestions to collect more syllabi and existing lecture materials, to provide guidance to graduates on what to learn and master, as well as to inform them that they might benefit from a repository of core demographic data sets (similar in form to the R program vignettes seen in the *Journal of Statistical Software*). The new journal, *Spatial Demography*, intends to provide regular reviews of data, code, and software. Other models discussed included the use of web-based instruction, a strategy that is partially adopted by units such as the GeoDa Center (<http://geodacenter.asu.edu>), and that is much more common to some other statistical software. The Advanced Spatial Analysis training program has audio and video recordings from several of the workshops (2008–2011) and end-products that splice in PowerPoint materials and/or labs from these will be available by fall 2012. Additional concerns about training related to how spatial training is defined and marketed. There was clearly a focus on method rather than application. Another concern that was discussed was that the adjective “spatial” could be a deterrent, however, not all agreed on this point.

The discussion of VGI recognized the opportunity these forms of data present but also the concerns with non-representative samples. VGI data appear valuable for exploratory analysis and the generation of new questions, and VGI warrants further attention from demographers (a process that is already happening). A valuable resource might be a guide to the usefulness of

VGI focused on ease of use and key references covering the range of data sources (e.g., from cell phones, twitter, and geo-reference tags).

This group also discussed the measurement of place and the emerging disconnect between administrative definitions and social definitions (derived from activity spaces). As the interest in measuring place-based exposure increases (as is happening in several related fields) more doubts will arise on the salience of census units such as the census tract. However, given the lack of easily implemented alternatives, as a definition of place/neighborhood, the census tract is likely here to stay. That said, there also was discussion about the future of the census tract and its usefulness in specific contexts, e.g., rural areas. The dependence on the ACS for long-form questions does raise many interesting challenges, including nontrivial reservations about the census tract. To be sure, census tracts and other administrative units certainly have value, but their overall usefulness may be waning. Given this, the group agreed that there must be more education and training about limitations associated with the different possible definitions of place. At present there is little critical thought given to the definition of neighborhoods and their relevance to daily life.

The session closed with a discussion of data validation and suggestions for disseminating and promoting spatial demography to a wider audience. A fundamental goal is the need to publish more on data validation. It was suggested that the new journal, *Spatial Demography*, might offer a forum on measures and validation. Similarly, it was recognized that geospatial data are being used uncritically in many fields and that we might want to submit letters, commentaries, and short reports to leading journals in fields (such as public health and epidemiology) on the strengths and weaknesses of existing geospatial data, different conceptualizations of place/neighborhood, and the need for better promotion of fundamental spatial concepts and ways of thinking spatially across the health sciences (as well as other fields). As an example, see Matthews' forthcoming editorial and book review/commentary in the *American Journal of Preventive Medicine* (May, 2012).

Discussion Group 2:

Moderator: Donald Janelle

Members: Michael Bader, Kate Cagney, David Darmofal, Arthur Getis, Kathryn Grace, Lee Rivers Mobley, William Pan, Daniel Parker, Daniel Sui, Paul Voss, David Wong, and Scott Yabiku

Phase 1: Daniel Parker Recorder, David Wong Reporter

This Breakout Group presentation more closely followed the set of 5 specific questions that all groups were asked to consider.

Q1: What are the emerging issues in reproductive health and other areas of societal need that can be addressed through spatial demography? The main areas of demography that cannot be solved without locational information include studies of residential moves and migration. From this it follows that research that focuses on migration/mobility is relevant to the study of health outcomes and social issues, such as educational outcomes. Locational data are also essential for the study of accessibility to resources and the exposure to risks.

Q2: How can spatial demography best make the case for itself in these areas? It is imperative that new data, measures, and methods will be important. We need data on (daily and life-time) mobility and exposure, more flexible ways of defining and measuring contexts, and an emphasis on person-centered interactions with environments. Further, we need better migration data and measures for understanding life-time exposures to toxins and other environments risks. Data on daily commuting, mobility, and activities would enable a better understanding of diurnal patterns of behavior and daytime population estimates for improved measures of place.

Q3: What kinds of research infrastructure, funding, and training programs will best advance spatial demography in these areas? This group suggested the need for more emphasis on migration in the curriculum to help promote the value of a spatial framework in answering demographic questions. They wanted to see a more cross-disciplinary focus in population centers, perhaps through consortia or center grants that would build groups of institutions and resources that would be available to graduate students in a cafeteria-style curriculum with potentially broader coverage than would otherwise be possible at one site. This would require training in spatial software and methods for analysis.

Finally, the group envisioned a future in which constructs from genomics and microbiomics that characterize contexts and attributes in micro-dimensions will be closely integrated in demographic research. They also anticipated a focus on how multi-scale measures and data-mining methods (e.g., sequence alignment methods) might be used to enhance definitions and measures of neighborhoods that capture relevant constructs for solving societal problems.

Q4: What are the training challenges to the enhancement of future research in spatial demography? It was suggested that one should build ideal population research centers around spatial demography. Population centers often lack in-house GIS expertise and have no spatial methods training programs. Mechanisms (e.g., NICHD T32 training grants) may be used to promote spatial demography, but there ought to be more effort to leverage existing workshops, syllabi, and regularly offered courses across existing centers (including other types of NIH Centers), university departments in a variety of disciplines in other institutions, and relevant programs offered in countries.

Q5: What steps might this group take following the specialist meeting to advance spatial demography? Following the group's response to the previous question, a next step might be to develop a Center Grant proposal around specific questions that can be answered with spatial demography, developed as collaboration across several disciplines and core capabilities.

The group closed out Phase 1 with a discussion of topics not on the suggested list of questions. These included the need to “patialize” space; i.e., to add greater texture to our understanding of space. Examples include developing data collection and measures about the meaning and memory of space (the recall of space) and comparing such information to actual mobility (via GPS and/or cell phones). Another general comment concerned the need to collect data to answer important research questions that draw on genomic and environmental exposure data (as alluded to earlier).

Phase 2: Kathryn Grace Recorder, Lee Rivers Mobley Reporter

This group discussion focused on the myriad of ways we can measure neighborhood and how these ways are expanding via the collection and use of data from social media, with the emergence of virtual neighborhoods with unknown physical boundaries. The complexity of neighborhoods is evident in that they are defined in different ways for different purposes but, most fundamentally, they need to reflect the relevant context for the people we study. It is evident that the field must develop multi-scale measures, embrace tracking technologies (to measure activity spaces), adopt data-mining techniques (from genomics, e.g., sequence alignment methods), and develop new ways to measure network structures, including social and virtual networks.

As with the other breakout groups, the issue of defining the neighborhood garnered much attention. Although some data are only available for polygons (e.g., administrative units), a great deal of built-environment data are recorded as points and lines and these can be harnessed to generate new data on relevant neighborhood infrastructures (see developments of built-environment measures in both physical activity and food environment research). Use of different forms of geospatial data (data objects) suggests the need to develop tools and teaching methods relevant to the defining and measuring of neighborhood context.

Finally, this group discussed Agent Based Modeling (ABM) and the value it can have in facilitating conceptual model development and in identifying salient constructs, as well as examining micro-macro level interactions. ABM and related models still need further development but they should be on the radar screen of spatial demographers.

Discussion Group 3:

Moderator: Michael Goodchild

Members: Deborah Balk, Budhendra Bhaduri, Regina Bures, Tze Kiu Edwin Chow, Katherine Curtis, Dustin Duncan, Michael Kramer, John Logan, David Lopez-Carr, Fernando Roismena, Seth Sanders, John Weeks, and Tse-Chuan Yang

Phase 1: Michael Kramer Recorder, Katherine Curtis Reporter

An overarching theme in spatial demography is spatial inequality (Lobao *et al.*, 2007). Spatial inequality covers almost all of the research topics identified in the main presentations of Day 1 and in subsequent discussions, especially for topics such as migration and urbanization.

The group discussed the ecological fallacy, a dominant concern in macro demography, and how better macro theory and flexibly scaled data could allow the scale of analysis to better match the theoretical scale of human actions. This would remove the “fallacy,” which is fundamentally a problem of analytic-inference scale mismatch. Boundary issues were also seen as important, specifically their conceptual and analytical importance, and the issues that arise from permanent/porous and sharp/fuzzy boundaries. Other topics discussed included the order of spatial effect (first order: pre-condition; second order: interaction) and compositional aspects versus contextual (aggregate) aspects. Since spatial inequality can drive different processes for different groups, the ability to distinguish first-order and second-order effects in relation to compositional versus contextual determinants can be informative. For example: What causes the composition (e.g., neighborhood selection)? What effect does contexts have on those selected (possibly cross-level interactions)?

A topic of much discussion in this group concerned the space versus place debate (or as it was phrased, spatial demography vs. platial demography). It was suggested that perhaps GIScience was inherently hostile to the idea of place rather than conducive, although it was also acknowledged that this methodological framing can be malleable. That is, a spatial framework is a vehicle for organizing place and, thus, the two are complementary rather than in conflict.

With regard to spatial demography making a better case for itself, there were several themes discussed by this group. A possible answer or starting point is the development of explicitly spatial theory. This would aid spatial demography in organizing itself and demonstrating the “value added,” even to those less familiar with spatial thinking. The group provided examples from migration and urbanization. How can we better engage in migration study and shift from an overly place-based approach to one that is more spatial? It was argued that spatial demography has a lot to offer to migration research. Similarly, the group suggested that the study of urbanization should not just be place-based, but must be linked to the issues of spatial scale (particularly for contrasting the notion of urbanization in developing countries with developed nations) and the spatial arrangement of people, resources, and infrastructure. Thus, spatial demography has a great deal to offer for better understanding urbanization.

This group closed with a brief discussion of making the case for spatial demography to new audiences, reviewers, and funders. The suggested strategy was to emphasize what we know from individual analysis and then demonstrate the additional insight offered by a spatial/platial perspective. It also was suggested that the case can be made by returning to original population “theory.”

Phase 2: Dustin Duncan Recorder, Budhendra Bhaduri Reporter

This group discussed research infrastructure in relationship to training, particularly the need for available resources to develop research teams for exploring complex demographic questions. It was noted that the discipline—and increasingly the funding agencies—promote and reward interdisciplinary teams. Teams were seen as facilitating the diffusion of skills from one discipline to another. As spatial demography is quite broad, ranging from different forms of geospatial data, measurement, mapping, modeling, and statistical analysis, the discussion highlighted the value of teams comprising multiple skill sets even within spatial demography. Further, it is important that spatial analysts communicate with demographers. Since faculty performance is often based on discipline-specific models of assessment, there may be a need to establish special incentives for faculty to participate in multi-discipline research teams. Incentives must also be created to help junior and early-career scholars for whom interdisciplinary research can create confusion over attribution of credit. A change in academic culture is required, specifically one that supports and rewards interdisciplinary research. It was noted that teams should not be constrained to demographers and geographers. Engagement with non-traditional disciplines, including computer and computational scientists, electrical engineers, may be as valuable as team engagement with more traditional disciplines, such as public health/epidemiology, biostatistics, environmental science, and urban and transportation planning.

With respect to training, it was agreed that although the focus in spatial demography courses is often on methods, it is important to teach concepts and to have a solid foundation in spatial thinking. If we can convince researchers that space matters for specific types of demographic questions, they will be interested in enhancing their spatial analytical skill set. Several ideas to enhance the current training landscape were suggested, including the establishment of centers of excellence on Spatial Social Science (infrastructure investment in research, not just training), seed grants to stimulate multidisciplinary investigations, and “summer camps” for junior (and other) faculty on issues related to spatial methods and spatial demography (note current R25 awards).

This group raised the need to be flexible and imaginative in the collection and integration of useful data. This highlights the importance of fieldwork, mixed-method research, and data triangulation. Ideally, more data are always required (e.g., expanding the DHS coverage and more DHS data on fertility transitions). Similarly, as with certain large-scale surveys (e.g., LA FANS), we must collect data on the multiple spatial contexts (e.g., where an individual works, where one plays, where one’s child goes to school) and be more sensitive to the importance of context.

Both opportunities and risks were recognized in the use of cell phone tracking data in spatial demographic research. Concerns related to whether the private sector will share data and whether

confidentiality can be assured. One advantage of cell phones relates to the ability to engage in spatially informed ecologic momentary assessments (EMA). However, there was some consensus in this group that not many demographers would be interested in tracking people for 24 hours a day.

Other issues discussed included the potential for web-based censuses and/or surveys, the need for spatially representative samples, and the need for both spatio-temporal data and tools to model spatio-temporal processes (i.e., tools that go beyond visual analysis).

Extracts from Discussions from all three Breakout Groups

The major topic of discussion was training in spatial demography. Several models were proposed, ranging from specialization at specific centers to proposals that would move students between centers (although this model raises issues for researchers with families). A popular idea was for training a cohort that can move through a program together (an idea enacted in the current R25 on Advanced Spatial Analysis). Collaborative training programs in survey methods, such as the one between Michigan and Maryland—which, as an aside, appears to have been a useful training opportunity for federal staff—represent another useful model.

A major issue (as almost all groups noted) is the breadth of the field covering geospatial data and spatial analytical methods, as well as the challenge of assembling a curricula for a single course or sequence of courses. Moreover, it was noted that within the core field of demography there are very different training needs with regard to the multiple disciplines that are combined within demography, such that *spatial* demography may not be the highest priority—it competes for resources with other important components of a training curricula. Hence, some suggested that there was no need to duplicate resources at each center/institute but, rather, there was a need to support efforts that provide students easy access to spatial training methods (e.g., a webinar model will be explored by Matthews and Curtis). Further, it was suggested that “spatial” centers/institutions could be resources for early-career researchers who lack access to this type of training and/or mentorship at their local institutions. It was noted that, if one looked carefully and beyond one’s own field, spatial scientists can be found at every university—however, geographers or social scientists with spatial expertise may not be available at every university.

The Advanced Spatial Analysis (ASA) program is a collaboration between Penn State and UCSB (supported by an R25 grant from NICHD, <http://csiss.ncgia.ucsb.edu/GISPopSci/>). Over the years, it has offered workshops in advanced methods to more than 200 attendees. It has followed a model that is not necessarily tailored to the training needs of a single discipline, but instead draws participants from a mix of disciplines with interest in these methods and their application to demographic and health research. This has been beneficial at many levels since sociologists are working with researchers from public health, geography, archaeology, and anthropology. At each workshop, attendees reside together and are immersed in the experience, with ample opportunity to discuss their research, and listen and learn from each other. This is extremely beneficial. Several ASA participants were specialty meeting attendees and they were invited to speak about their experiences. One participant described how the workshops provided opportunities that were non-existent at their center. Another discussed how the ASA experience enabled new collaborations and a growing support network of spatial thinkers/analysts.

Guest Presentations

The meeting included several short presentations by participants. These included:

Arthur Getis described a new statistic by Ord and Getis (2012); *Hi* is designed to, among other things, find the consistency—or the degree of homogeneity—within neighborhoods. It is a variance statistic built on the same premises used for *G* and *I* spatial autocorrelation statistics. Boundaries of neighborhoods can be discerned from the application of *Hi* statistics.

Budhendra Bhaduri described a wide range of visualization tools developed at Oak Ridge National Laboratory that use different types of spatiotemporal data, including LandScan, facility level data, image/video, and demographic data. See Bhaduri's position paper on the specialist meeting website and at <http://www.ornl.gov/sci/landscan/>.

Andrew Beveridge discussed the **Social Explorer** website: <http://www.socialexplorer.com>.

Frank Howell briefly described the mission of the new journal, *Spatial Demography* (<http://www.spatialdemography.org>).

Stuart Sweeney and David Lopez-Carr made a short presentation about the recently established **Broom Center for Demography**. The Broom Center was established in fall 2011, directed by Peter Kuhn, Professor of Economics at UCSB, and in consultation with an advisory committee of UCSB faculty consisting of Kelly Bedard (Economics), Maria Charles (Sociology), Michael Gurven (Anthropology), Shelly Lundberg (Economics), David Lopez-Carr (Geography), and Stuart Sweeney (Geography), plus two ex-officio members: the director of ISBER and the Dean of Social Sciences. The Broom Center website is <http://www.broomcenter.ucsb.edu/>, where one can find details of its research foci. It is a small center but is expected to grow and involve graduate students from several disciplines. The closing reception for the meeting was sponsored by the Broom Center.

Synthesis Session

The meeting generated many ideas regarding potential priorities and strategies that could be pursued to help move the field of spatial demography forward, and how the field might better promote itself within demography and the broader social and health sciences.

Michael Goodchild provided a synthesis of the productive 2-day meeting.

Goodchild noted that while participants all think spatially, not everyone thinks spatially in the same way. This can force us to re-think what spatial thinkers are and what we need to do to facilitate spatial thinking in demographic research, specifically, and science, more generally. He suggested that the question of whether there is anything special about “spatial” should have been answered for the attendees of this meeting (at least a clearer picture should be generated). All the discussion at this meeting can be extended to the international context (most discussion of training and research focused on U.S. needs).

There were several recurring themes: What is the definition of neighborhood?; the distinction between space and place; the concept of spatial dependence (Tobler’s first law) and its relevance to spatial demography. It is also imperative to think about the meaning behind the “W” matrix and to make connections between theory and analysis.

The content of “spatial” occurs everywhere in academy, but demographers should attempt to capitalize on the concept of “spatial” more so than other disciplines. Goodchild noted that in a recent NSF (2011) report on *Rebuilding the Mosaic: Fostering research in the Social, Behavioral, and Economic Sciences at the National Science Foundation in the Next Decade* “spatial” is not always conjunct with “demography,” and spatial thinking may need to be more closely related to social and spatial observations.

It is clear that health issues have a strong relationship with place/space (a decade-long tradition in neighborhoods and health based on multi-level models), but that an individual’s perception of space/place and use of space/place must be further considered in health research. The funding agencies (NIH in particular) are paying more and more attention to establishing a research framework with a spatial perspective. New measures used in health-related research are crucial.

Specialist Meeting Agenda

Monday December 12, 2011

- 8.30 Welcome and introductions Michael Goodchild
- 8.40 Overview of Goals Donald Janelle
Stephen Matthews
- 9.00 Session 1:
State of the Science in Spatial Demography John Logan
Marcia Castro
Open Discussion **Moderator:** Stephen Matthews
- Break
- 10.30 Session 2:
Emergent Geospatial Data and Measurement Issues Michael Goodchild
Barbara Entwisle
Open Discussion **Moderator:** Donald Janelle
- Lunch
- 1.15 Session 3:
Spatial Statistical Methods Sergio Rey
Paul Voss
Open Discussion **Moderator:** Stuart Sweeney
- Break
- 2.45 Session 4:
Synthesis of Challenges and Opportunities Deborah Balk
Daniel Sui
Open Discussion **Moderator:** Michael Goodchild
- Break
- 4.15 Session 5:
Defining Breakout Groups and the Parameters for Discussion **Moderator:** Stephen Matthews

Tuesday December 13, 2011

9.00 Quick review of the day's objectives

9.10 Breakout Phase 1 (Three parallel groups)

Primary questions

- What are the emerging issues in reproductive health, and other areas of societal need that can be addressed through spatial demography?
- How can spatial demography best make the case for itself in these areas?
- What kinds of research infrastructure, funding, and training programs will best advance spatial demography in these areas?
- What are the training challenges to the enhancement of future research in spatial demography?
- What steps might this group take following the specialist meeting to advance spatial demography?

Break

11:00 Breakout Phase 2 (Three parallel groups)

Primary questions

- How are demographers measuring place and the interrelationships among places?
- How can demographers harness emerging developments in the generation of geospatial data (e.g., volunteered geographic information and crowd-sourced data)?
- How can new measures be validated for use in neighborhood and contextual research?
- What visualization and spatial analytical methods make up the current tool kit of the spatial demographer?
- What new methodological developments in spatial and spatiotemporal analysis are possible in the next five years and how might these be integrated into mainstream demographic research?

Working Lunch & preparation of presentations

1:00 Reports from Breakouts

| | Phase 1 | Phase 2 |
|---------|------------------|-------------------|
| Group 1 | Narayan Sastry | Frank Howell |
| Group 2 | David Wong | Lee Rivers Mobley |
| Group 3 | Katherine Curtis | Budhendra Bhaduri |

Break

2.30 Discussion

3.30 Next Steps and wrap up

5:00 Closing Reception Sponsored by the UCSB Broom Center for Demography
<http://www.broomcenter.ucsb.edu/>

Participant List

Conveners:

| | |
|-------------------|---|
| Michael Goodchild | University of California, Santa Barbara |
| Donald Janelle | University of California, Santa Barbara |
| Stephen Matthews | The Pennsylvania State University |

Attendees:

| | |
|----------------------|---|
| Susana Adamo | Columbia University |
| Michael Bader | American University |
| Deborah Balk | City University of New York |
| David Berrigan | National Cancer Institute |
| Andrew Beveridge | City University of New York |
| Christopher Browning | The Ohio State University |
| Budhendra Bhaduri | Oak Ridge National Laboratory |
| Regina Bures | National Institute for Child Health and Human Development |
| Kate Cagney | University of Chicago |
| Marcia Castro | Harvard University |
| Tze Kiu Edwin Chow | Texas State University, San Marcos |
| Katherine Curtis | University of Wisconsin, Madison |
| David Darmofal | University of South Carolina |
| Frank Davenport | University of California, Santa Barbara |
| Dustin Duncan | Harvard University |
| Barbara Entwisle | University of North Carolina at Chapel Hill |
| Arthur Getis | San Diego State University |
| Kathryn Grace | University of California, Santa Barbara |
| Frank Howell | Mississippi State University |
| Michael Kramer | Emory University |
| John Logan | Brown University |
| David Lopez-Carr | University of California, Santa Barbara |
| Lee Rivers Mobley | RTI International |
| Nicholas Nagle | University of Tennessee |
| William Pan | Duke University |
| Daniel Parker | The Pennsylvania State University |
| Sergio Rey | Arizona State University |
| Fernando Roismena | University of Colorado, Boulder |
| Seth Sanders | Duke University |
| Narayan Sastry | University of Michigan |
| Daniel Sui | The Ohio State University |
| Stuart Sweeney | University of California, Santa Barbara |
| Paul Voss | University of North Carolina at Chapel Hill |
| John Weeks | San Diego State University |
| David Wong | George Mason University |
| Brian Wood | Yale University |
| Scott Yabiku | Arizona State University |
| Tse-Chuan Yang | The Pennsylvania State University |

Acknowledgements

This workshop was sponsored by the University of California, Santa Barbara, the Pennsylvania State University, and the Advanced Spatial Analysis Training Program for Population Scientists NICHD: 5R25 HD057002-04 see <http://www.csiss.org/GISPopSci/>

Karen Doehner (Administrative Coordinator for UCSB’s Center for Spatial Studies) provided logistical support for the organizers and participants, and she assisted in the editing of the final report on the meeting.

Guylene Gadai (Web developer for UCSB’s Center for Spatial Studies) provided web support for the meeting.

Special thanks are extended to the **UCSB Broom Center for Demography** for sponsoring the meeting’s final reception.

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Appendix A: Websites & Resources

Session 1: Logan, Castro and discussion

Minnesota Population Center <http://www.nappdata.org/napp/>

Session 2: Goodchild, Entwisle and discussion

Examples of VGI

Direct Relief International: Earthquake Aid Mapping in Haiti
<http://www.directrelief.org/Flash/HaitiShipments/Index.html>

David Crandall, Lars Backstrom, Daniel Huttenlocher and Jon Kleinberg. 2009. Mapping the world's photos. <http://www.cs.cornell.edu/~crandall/papers/mapping09www.pdf>

National Historical GIS (NHGIS) (University of Minnesota)—<https://www.nhgis.org/>

The School Attendance Boundary Information System (SABINS)—<http://www.sabinsdata.org/>

Session 3: Rey, Voss and discussion

GeoDa Center—<http://geodacenter.asu.edu>

PySAL—<http://geodacenter.asu.edu/pysal>

PySAL—<http://pysal.org/>

CSISS Specialist Meeting on Spatial Data Analysis Software—
<http://csiss.ncgia.ucsb.edu/events/meetings/spatial-tools/index.htm>

American Community Survey—<http://www.census.gov/acs/www/>

NSF- Census Research Network—<http://www.census.gov/NCRN/>

Session 4: Balk, Sui and discussion

We Feel Fine—<http://wefeelfine.org/>

Supramap (integrating genetic, evolutionary, geospatial, and temporal data)—
<http://supramap.osu.edu>

Training Resources

GeoDa Center Arizona State University GeoDa Center for Geospatial Analysis and Computation—<http://geodacenter.asu.edu>

GISPopSci and Advanced Spatial Analysis Workshop Program—www.GISPopSci.org (under development—to be launched in October 2012. In the meantime, please see <http://www.csiss.org/GISPopSci>)

Journals

Spatial Demography www.spatialdemography.org—a new e-journal edited by Frank Howell and Jeremy Porter.

Special issues on Spatial Demography:

2005—*Proceedings of the National Academy of Science*. 102 (43)
(Edited by Ken Watcher)

2007-2008—*Population Research and Policy Review* 26 (5/6) and 27 (1)
(Edited by Paul Voss)

2012—*Demographic Research* www.demographic-research.org Special Collection 11
(Edited by Stephen Matthews)

See also:

<http://help.pop.psu.edu/gia-resources/listings/Spatial-Demography-Journals.pdf/view>

<http://teachspatial.org>: Resources on spatial concepts for multiple disciplines may be accessed from the National Science Digital Library through the teachspatial portal developed at the University of California, Santa Barbara.