Signature Program in Spatial Statistics

Proposal from: Department of Statistics, University of Missouri-Columbia, March 2005

OVERVIEW: Signature Program in Spatial Statistics

Global warming, variability in breast cancer survival rates, turkey hunting success rates in Missouri, El Niño prediction, the spread of invasive species, the likelihood of tornado occurrence–what do these seemingly disparate topics have in common? To begin with, the data for all of these problems are associated with a more-or-less precise spatial and temporal label. Since its inception as a discipline, Statistics has provided tools by which scientists can better understand the complex world. However, as scientists seek to answer ever more challenging questions concerning processes such as those that vary over space and time, the traditional methods that one might learn in introductory statistics courses are not sufficient to adequately account for this variability.

The later twentieth century and beginning of the twenty-first century has seen a tremendous growth in the development of spatial statistical methodology and its applications. This is primarily a function of the rapid progression of computational technology, hardware, software and algorithms, the increasing prevalence of spatially-referenced data sets, and the need to solve challenging scientific problems. Simultaneously, there has been an explosion in the use of so-called Bayesian statistical approaches. These methods allow one to express very complicated processes in terms of component probabilistic models, all linked together in a coherent framework. The key to the success of these methods are that they enable one to characterize his or her uncertainty concerning all phases of a scientific experiment or data set. *The faculty in the Department of Statistics at the University of Missouri have been instrumental in leading the development and implementation of Bayesian methodology in problems associated with spatial data.*

A core group of researchers in the Department of Statistics, C. He, A. Micheas, P. Speckman, D. Sun, and C. Wikle have been working on methodological issues related to Bayesian spatial analysis and have led or been involved with a wide variety of projects of fundamental importance to not only the world of science, but the world in general. These researchers have amassed a tremendous number (over 200) of peer-reviewed publications in this area over the last 10 years, as well as an impressive amount of extramural grant support (current department extramural grant funding level of $2.9 million with a department size of 11 tenure-track or tenured faculty). A distinguishing feature of the faculty's work in this signature area is that it is inherently cross-disciplinary, leading to

wide variety of lively and ever expanding collaborations with scientists both at MU and at institutions across the nation and the world.

The following outline summarizes the principal reasons why Spatial Statistics at MU should be designated a Signature Program.

- **Research Productivity in Spatial Statistics**
  - **Publishing Output:** Over the last 10 years, faculty in the department have published a combined total of over 200 peer-reviewed papers *directly related to spatial statistics and Bayesian methodology.*
  - **Grant Funding:** Along with the growing reputation of the faculty in spatial and Bayesian statistics, the department's extramural grant funding has increased dramatically over the last few years: $250,748 in 1997-1998, $596,354 in 2003-2004, and $876,354 in 2004-2005 (with current total available funding at $2,851,059). Note that the tenure or tenure-track faculty size averaged around 11 during this period. *A majority of this increase in extramural funding is due to projects related to spatial and Bayesian statistics.* It must be noted that this level of extramural funding is unprecedented for Statistics Departments, even those with much larger faculty numbers.
- **National and International Reputation in Spatial Statistics**
  - Faculty in the Department of Statistics have given at least 37 international and 180 national talks on spatial and Bayesian statistics over the past 10 years.
  - Faculty in the department have been on the organizing committees for numerous international and national conferences and workshops related to spatial and Bayesian statistics.
  - Faculty in the department who work in this signature area are Editors or Associate Editors of distinguished journals in the discipline.
  - Faculty in the department who work in this signature area have served on numerous national review panels, including those for NSF, NIH, and the National Academy of Sciences.
  - The department hosted a major NSF-supported national symposium integrally related to spatial statistics and wildlife in October 2004 (see below for details).
  - Faculty in the department are organizing a major NSF-supported international conference on objective Bayesian statistics to be held in Branson, MO from June 4-8, 2005 (see below for details).

- **Faculty Awards:**
  - *Elected Fellow, American Statistical Association:* N. Flournoy, D. Sun, C.K. Wikle, F.T. Wright
  - *Elected Fellow, Institute of Mathematical Statistics:* N. Flournoy, P.L. Speckman, F.T. Wright
  - *Elected Fellow, International Statistical Institute:* N. Flournoy, D. Sun, F.T. Wright
  - *Elected Fellow, American Association for the Advancement of Science:* N. Flournoy
  - *Elected Fellow, World Academy of Art and Science:* N. Flournoy
  - *Chancellors Award for Outstanding Research and Creative Activity in the Physical and Mathematical Sciences:* D. Sun
  - *Gold Chalk Award for Excellence in Graduate Education:* F.T. Wright
  - *Kemper Award for Outstanding Teaching:* J. Cavanaugh, L.D. Ries, F.T. Wright
  - *Distinguished Achievement Award, Environmental Section of the American Statistical Association:* C.K. Wikle
- **Comparison to Other Programs in Spatial Statistics:** The most well-known and prestigious program in spatial statistics is the program in Spatial Statistics and Environmental Sciences (SSES) at The Ohio State University. This program was established in 1999 in the Department of Statistics at Ohio State and has three primary investigators (Drs. Cressie, Berliner and Calder); it should be noted that Dr. Wikle in the MU Department of Statistics is also listed as an investigator in the SSES program. *In terms of publishing output, grant funding, participation in national and international meetings, and the number and variety of inter- and cross-disciplinary collaborations, the spatial statistics group at MU far exceeds the output of the SSES group at Ohio State by any measure!*
- **Contribution to the Economy and Welfare of Missourians**: The following projects (described in more detail below), in which faculty from the department are either PIs or co-PIs, are directly linked to the Economy and Welfare of Missourians:
  - Breast cancer screening in St. Louis
  - Missouri hunting success rates, hunting pressure and harvest
  - Tornado intensity in Missouri related to El Niño
  - Short period weather forecasting of radar precipitation

  - Comprehensive study of the Missouri Ozarks forest ecosystem project
  - Missouri wildlife management survey

- **Pedagogical Effectiveness**: The department has had 3 Kemper Award winners over the last ten years. For a department averaging 11 FTE, this corresponds to 27% of the faculty having won this prestigious award.

- **Cross-Disciplinary Collaboration:** The faculty's work in spatial and Bayesian statistics has been significantly collaborative. A sample of the collaborative projects are listed below. Note that these projects are not just "consulting" projects. That is, each project required the development of new statistical methodology to accomplish the scientific task and the Statistics Department faculty member is either PI or coPI on the associated grants.

  - Breast Cancer Screening in St. Louis
  - Spatial variation of Breast Cancer
  - Spatial variation of amputations among African Americans
  - Hunting success rates, hunting pressure, and harvest in Missouri
  - Avian nest success
  - Forecasting El Niño and tornado occurrence
  - Modeling the spread of invasive species
  - Nowcasting radar precipitation
  - Modeling the ocean circulation
  - Modeling cognitive psychology for perception, learning and memory
  - Modeling activity in travel patterns
  - Comprehensive study of the Missouri Ozarks forest ecosystem project
  - Missouri wildlife management survey

  These projects are described in detail in the following section.

- **Student Interest, Success, and Placement:** Due in large part to the prominence and increased funding associated with the Statistics Department's emphasis in spatial statistics, graduate student enrollment in the department has nearly doubled in the last ten years. For example, the department had 29 and 23 graduate students in 1996 and 1997, respectively. In 2003 and 2004, the department had, respectively, 47 and 51 graduate students. Of these, roughly half are working in the proposed signature area.

  Our graduates have taken jobs in a variety of areas including medical and pharmaceutical research positions, positions at research universities, and positions at

research universities with a teaching focus. The number of students interested in, and successfully gaining employment in, research universities has steadily increased over the last ten years. A major reason for this is the growing need for statistical researchers with expertise in spatial statistics and substantive collaborative experience.

- **Departmental Expertise In Addition to the Signature Program:** The department has researchers with national and international prestige in the area of Biostatistics: J. (Tony) Sun is a renowned expert in survival analysis and is a leading researcher concerned with the statistical issues surrounding the estimation AIDS survival; N. Flournoy is a world-expert on the theory of the adaptive design of clinical experiments. In addition, F.T. Wright is a world-renowned scholar in the area of order restricted inference. Furthermore, the department has significant expertise in time series analysis (L. Thombs, S. Holan), genetics (C. Spinka), and microarray analysis (J. Qiu). The department has also developed strong collaboration and consulting operations in the social sciences (L. Thombs, D. Sun, P. Speckman) and in agriculture, natural resources and the life sciences (M. Ellersieck, L. Hearne, S. Holan, J. Qiu).

Examples of Projects Demonstrating the Department's Signature Role in Spatial Statistics

The following examples illustrate the breadth of projects (and extramural funding) that are directly tied to the Department of Statistics initiatives in spatial and Bayesian statistics.

A1. Cancer Incidence and Mortality; Epidemiology

Funded by NIH, MU Statistics faculty members D. Sun, C. He, and P. Speckman have been working with Dr. Mario Schootman of Washington University to develop new statistical methods to meet challenges in public health such as cancer screening, quality of life, geographic variation in breast cancer survival after incidence, and geography of amputations among African Americans.

1. **Breast Cancer Screening in St. Louis**

   Individual barriers to breast cancer screening are well documented. Although community factors, such as area deprivation or availability/distribution of medical providers, are independently associated with breast cancer incidence, survival, and with several behaviors (e.g., walking and smoking), their association with screening for breast cancer has received very little attention. The use of geographic information systems (GIS) and hierarchical (multilevel) Bayesian modeling facilitate new and exciting opportunities that have shed new light on potential barriers

to screening that could be used to increase breast cancer screening by multilevel interventions. GIS analyses is combined with quantitative epidemiological methods to examine the relationship of neighborhood characteristics to breast cancer screening. The goals of this population-based study are to determine areas where breast cancer screening is underutilized in St. Louis, if women living in neighborhoods characterized by adverse socioeconomic conditions are less likely to be screened for breast cancer, and if this association depends on the geographical classification used to obtain these community indicators.

2. **Spatial Variation of Breast Cancer Survival**

   Breast cancer is the second leading cause of cancer death among women in the United States. About 80% of such deaths occur in women age 65 years or older. These women also have a lower survival rate and are less likely to receive recommended treatment. Identifying geographic areas where survival from breast cancer among women 65 years of age or older is lower and the underlying factors responsible is important to ensure that differences in treatment are addressed and that interventions can be designed at a level where they can be implemented. The aims of this study are to: (1) examine small-area geographic clustering of breast cancer survival among women 66 years of age and older; (2) determine the extent to which geographic variation of survival can be explained by the geographic variation in area social and economic deprivation among women age 66 and older; and (3) identify potential pathways by which area social and economic deprivation explains any geographic variation of breast cancer survival among women age 66 and older.

3. **Spatial Variation of Amputations Among African Americans**

   Nontraumatic lower-extremity amputations (LEA) are a devastating consequence of diabetes. Persons age 65 and older account for about 50% of those with diabetes who had nontraumatic lower-extremity amputations. African Americans age 65 or older with diabetes are at increased risk of such amputations. Internationally, substantial geographic variation exists in incidence of LEAs between and within nations. In the United States, comparisons between hospital referral regions has shown substantial variation. Historically, studies have not been conducted that assessed the extent of the variation of LEA among smaller geographic areas, such as counties. The study here considered geographic variation in diabetes-related incidence of LEA among African Americans age 65-99 in three southern states.

Grants

- 6/1/1996–6/30/1997: PI **R. K. Tsutakawa**; Co-PI **D. Sun**, *Geographic and Longitudinal Analysis of Mortality Rates.* Research Board grant of $19,541 from the University of Missouri-System.
- 01/01/2003– PI **D. Sun** . *Data Analysis of Cancer Incidence and Mortality*, Missouri Cancer Registry. A graduate student is supported with an annual stipend of $20,000 plus tuition and fee waiver.

- 07/01/2003–06/30/2005: (PI Mario Schootman, Washington University; Subcontractor and CoPI **D. Sun**.) *GIS and Breast Cancer Screening in Saint Louis.* NIH grant; direct cost $200,000. My part: $46,322 (one month/year).
- 09/01/2004-08/31/2007: National Cancer Institute, NIH, (PI Mario Schootman, Washington University; CoPI **D. Sun and C. Z. He**). *Geographic Variation of Breast Cancer Survival.* Total funding: $804,170; MU Statistics portion: $291,000.
- 10/01/2004-09/30/2006: National Cancer Institute, NIH. (PI Mario Schootman, Washington University; PI of subcontract **D. Sun**). *Geography of Amputations Among African Americans,* direct cost $200,000. MU Statistics portion: $75,000.
- (pending) 12/01/2005-11/30/2009: National Cancer Institute, NIH, PI: Mario Schootman, Washington University; PI of subcontract **D. Sun**; Co-PI of subcontract **C. Z. He**. *Neighborhood Effects on Quality of Life in Breast Cancer.* Total funding: $1.4 million. MU Statistics portion: $473,629.

A2. MDC Project I: Missouri Hunting Success Rates, Hunting Pressure and Harvest

The Missouri Department of Conservation (MDC) is the state agency in charge of wildlife management. Yearly post-season harvest surveys provide data used in the management of wildlife. Although most post-season harvest surveys are conducted at the state level, effective management of wildlife populations requires estimates of hunting success rate, hunting pressure, and harvest at the sub-area (such as management unit, regional, or county) level. Traditional estimates based on survey data are accurate at the statewide level. However, estimates at the sub-area level often yield unacceptably large standard errors due to small sample sizes. Knowing the hunting pressure on each day in each sub-area of the hunting season is important to the wildlife managers so that they may properly prepare facilities and also for safety considerations such as hunting regulations to reduce hunting accidents.

Since 1997, D. Sun and C. He have been supported by MDC to work with Steven L. Sheriff, on various issues related to turkey and deer hunting regulation.

Grants

- 07/01/1998–06/30/2004: PI **D. Sun**. *Hierarchical Bayes Estimation of Small Area Estimation for Harvest Surveys.* Missouri Department of Conservation; direct cost of $155,678.
- 07/01/2004–06/30/2007: PI **C.Z. He**, Co-PI **D. Sun**. *Adjusting Nonresponse Biases for Attitude Surveys.* Missouri Department of Conservation; direct cost of $166,088.
- 07/01/2005–06/30/2008: PI **D. Sun** *WinBUGs Application in Hunting Survey*, Missouri Department of Conservation, direct cost of $104,100 plus tuition and indirect cost.

A3. MDC Project II: Capture and Recapture

D. Sun and C. He jointly advised a doctoral student who studied objective Bayesian methods for various capture and recapture models and analyzed a data set from MDC. The objective Bayesian approach considering spatial variation gives useful estimates of animal population sizes with more accuracy than conventional methods.

Grant

- 07/01/2001–12/30/2004: PI **D. Sun**, CoPI **C. Z. He**, *Bayesian Analysis for Capture and Recapture Models*, Missouri Department of Conservation, direct cost of $70,298.

A4. MDC Project III: Bayesian Survival Analysis with Applications to Avian Nest Success

Due to the population decline of many bird species, it is important to examine reproductive potential. One goal of nest survival studies is to obtain estimates of the probability of nest success. In a typical nest survival study, biologists locate active nests in the study area; these nests are then revisited at least once more. At each visit, biologists note whether nests have failed, are still active, or have succeeded (usually hatched or fledged). The estimation of age-specific survival rate is difficult because: (1) survival is often age-specific; (2) nests that failed to hatch before they would otherwise be discovered never come under observation; (3) once a nest is discovered, revisitation is often infrequent; and (4) nests are typically difficult to find, and the data-to-parameter ratio is typically disappointingly low.

Dr. He, Dr. Sun and collaborators developed the first Bayesian model for bird nesting studies. The Bayesian model considers age-specific survival assuming irregular revisits. The Bayesian method provides a much more accurate estimate of the total survival rate than the standard methods and enables the biologists to study the dynamic of survival rates during the entire nesting period.

Grants:

- 07/01/1996 – 06/30/1999, PI **D. Sun**, Co-PI **C. He**, *Bayesian Analysis for Nest Success Models*, Missouri Department of Conservation, $48,000.
- 06/01/2001 – 08/30/2002, PI **C. He**, *Bayesian Modeling of Nest Survival Rates*, University of Missouri Research Board, $19,632.
- 07/01/2000–12/30/2004: PI **C. He**, *Bayesian Estimation of Nest Survival Rates*, Missouri Department of Conservation, $80,848.
- (Pending) 07/01/2005 – 06/30/2008, PI **C. He**, *Studying the Sample Size and Revisit Frequency Requirements in Estimating Nest Survival Rates*, Missouri Department of Conservation, $106,905.

A5. Forecasting El Niño and Tornado Intensity

El Niño (warmer than normal sea surface temperature in the tropical Pacific ocean) and La Niña (cooler than normal sea surface temperatures) are two of the most important sources of variability in the climate system. Both events lead to dramatic, although temporary, changes in world weather patterns and are responsible for billions of dollars of damage in the U.S. alone. Dr. Wikle from the MU Statistics Department, along with colleagues at Ohio State University, developed a state-of-the-art spatially-explicit forecast model for El Niño/La Niña that uses the Bayesian paradigm. The model can predict these events up to 7 months in advance and accounts for a variety of sources of variability. It has been demonstrated to be more realistic than other models of these phenomena.

In addition, Dr. Wikle, along with colleagues at Iowa State University, has established a strong connection between the El Niño/La Niña phenomena and historical tornado counts over certain geographical regions of the U.S. For example, northern Missouri typically has fewer tornadoes than average during an El Niño event and more

tornadoes than average during a La Niña event. Such information can be used to predict the seasonal likelihood of tornadoes.

Both of these lines of research have generated both local and national media attention.

Grants

- 1/1/1999–12/31/2002: PI **C.K. Wikle**. *Hierarchical Statistical Analysis of Global and Regional Environmental Data* EPA STAR Grant/ Environmental Statistics award of $97,613.
- 8/1/2002–7/31/2005: PI **C.K. Wikle**. *Statistical Analysis of Uncertainty in Climate Change*, National Science Foundation award of $180,000.

A6. Models for Predicting Invasive Species

The spread of invasive populations has long been of interest to ecologists and mathematicians. Whether it be the invasion of gypsy moths in North America, soybean rust in Southern Africa and South America, avian influenza in Asia, or seemingly countless other invasive species and emerging diseases, it is clear that the invasion of ecosystems by exotic organisms is a serious concern. Given the increasing economic, environmental, and human health impact of such invasions, it is imperative that in addition to understanding the basic ecology of such processes, we must be able to monitor them in near real-time, and to combine that data and our basic ecological understanding to forecast, in space and time, the likely spread of the population of interest. Perhaps more importantly, we must be able to characterize realistically and account for various types of uncertainty in such forecasts. Dr. Wikle and collaborators at the United States Geological Survey have developed Bayesian spatial models that can predict the spread in space and time of invasive species. These models have been used to successfully predict the spread of the Eurasian Collared Dove.

Grants

- 8/1/2004–4/30/2005: PI **C.K. Wikle**. *Sampling designs and statistical models for estimating the occurrence, spread, and imperfect detection of an invasive species*. USDI Geological Survey award of $40,000.
- 3/1/2002 - 6/30/2006: PI **C.K. Wikle**. *Vegetation Monitoring on Lower Hamburg Bend Conservation Area*, Missouri Department of Conservation award of $27,170.
- 7/1/2002–/31/2005GIS: PI H. He – MU Forestry; Co-I **C.K. Wikle**. *Interpolation and Spatial Inference of Witness Tree Records of Pre-European Settlement in Missouri*, USDA Forest Service award of $52,202.

A7. Nowcasting Radar Precipitation

For many hydrological applications, especially flash flood warning and urban drainage management, a good short-term forecast (i.e., a ”nowcast”) of heavy rainfall is required. Typically, this involves forecasting the movement and/or development of radar-based estimates of precipitation over fairly short time-scales (on the order of an hour or less). In the nowcasting problem, one seeks to forecast the pattern and intensity of such radar reflectivities at times into the immediate future, given the sequence of observed radar images. Drs. Wikle and Micheas in the MU Statistics department and Dr. Fox in Atmospheric Science have developed a new approach to this problem, based on the Bayesian

hierarchical methodology. This work is being funded by a major NSF interdisciplinary grant. It should also be noted that this methodology is being considered as a forecasting tool for the Beijing 2008 Olympic games.

Grants

- 10/1/2004–9/30/2008: PI **C.K. Wikle**–MU Statistics, Co-PI **A. Micheas**, N. Fox – MU Soil, Environmental and Atmospheric Science. *Statistical Methods for Precipitation Nowcasting and Verification*, National Science Foundation award of $750,000.

A8. Statistical Modeling of the Ocean

Understanding the ocean circulation is fundamental to understanding the weather and climate of the atmosphere. The two systems are linked by a variety of elaborate physical and biological mechanisms. Unlike the atmosphere, however, there are relatively few observations of the ocean circulation. Thus, it is imperative that one utilizes these sparse observations very efficiently. Dr. Wikle has been involved in several research projects, with investigators from Duke, Florida State, Ohio State, the National Center for Atmospheric Research, and Colorado Research Associates, to develop Bayesian models that can combine expert knowledge about the ocean circulation with the relatively sparse observations.

Grants

- 9/1/2002 - 8/31/2005: PI **C.K. Wikle** . *Ocean Circulation Climatology and Dynamics Using Bayesian Hierarchical Methods*, National Science Foundation award of $134,520.
- 6/1/1999 - 5/31/2002: PI **C.K. Wikle**. *Bayesian Hierarchical Air-Sea Interaction Modelling: Application to the Labrador Sea*, NASA Physical Oceanography Program award of $51,413. (part of $432,007 grant over 4 institutions)
- 03/01/2005–02/28/2007: PI **C.K. Wikle**. *Bayesian Hierarchical Models to Augment the Mediterranean Ocean Forecast System*, Offi ce of Naval Research award of $41,344.
- 7/9/2002 –12/31/2002: PI **C.K. Wikle**. *Surface Vector Winds in Models and Syntheses of Climate Processes: Bayesian Hierarchical Model Pilot Projects in OVWST Research*, Northwest Research Associates award of $11,781.

A9. Hierarchical Models and Bayesian Smoothing Splines

Nonparametric spline smoothing has been widely used in curve fitting. One difficulty is the choice of the smoothing parameter. Some ad hoc methods have been proposed. However, these can be unstable in practice. Funded by NSF, D. Sun and P. Speckman jointly developed models for Bayesian smoothing. A key component of this work involved the development of models for spatial processes in this setting. These methods have been used in many other spatial applications.

Grant

- 8/1/1999–6/30/2003: PI **D. Sun**, Co-PI **P. L. Speckman**, *Bayesian Nonparametric Regression and Density Estimation using CAR Priors.* National Science Foundation grant, $127,750.

A10. Objective Bayesian Methods and Theory

Because it can effectively use a researcher's prior information, Bayesian analysis is very useful for solving difficult statistical problems. However, implementing a Bayesian

analysis may require considerable effort and time to find a suitable prior distribution that properly summarizes this information. Statisticians have developed a variety of so-called noninformative priors that allow researchers much of the benefit of a Bayesian analysis without the difficulty of obtaining an informative prior. Jointly with leading experts in the area, several colleagues, and several former Ph.D. students, D. Sun has worked to enrich the class of available noninformative priors. One interesting application is to a 1990 EPA standard (EPA 540189-002, Vol 1, 6-21) for finding confidence intervals for the product of independent normal means. By developing a suitable class of priors, Sun and Ye implemented a method that is far more accurate than the EPA standard. Sun received one year research leave to work on a book with Jim Berger and Jose Bernardo, entitled *Objective Bayesian Analysis*. Furthermore, funded by NSF, Sun is the chair of organizers and program committee of *The Fifth International Workshop on Objective Bayesian Methods* to be held at Branson, Missouri, June 4-9, 2005.

Grants

- 3/1/1996–6/30/1997: PI **D. Sun**, *Investigations in Bayesian Analysis, Simulation and Development of Noninformative Priors.* National Security Agency, $15,000.

A11. Bayesian Modeling in Psychology

Experimental psychology has provided profound insights into the nature of perception, learning, and memory. Unfortunately, current experimental practice is limited to comparatively simple traditional models that are not sensitive enough to differentiate between competing modern theories. Funded by NSF, Dr. J. Rouder of the MU psychology department, P. Speckman and D. Sun have been working to introduce modern Bayesian methods to these experiments. While these studies do not involve spatial relationships in a physical sense, spatial methods have great potential. For example, we have used spatial methods to explore the precise nature of how learning takes place. Bayesian hierarchical models coupled with spatial techniques are shedding new light on results in cognitive psychology.

Grants

- 6/1/2001 – 3/1/2005: PI J.N. Rouder, Co-PI **D. Sun, P. Speckman**, *A Parametric, Hierarchical Statistical Framework for Inference with Skewed Distributions*, a National Science Foundation award of $299,998.00.
- 7/1/2004 – 6/30/2007: PI **P.L. Speckman**, co-PI **D. Sun**, J.N. Rouder. *Bayesian hierarchical models for inference with behavioral models*, a National Science Foundation award of $299,998.00.
- 6/1/2005 – 5/31/2008: PI J.N. Rouder, Co-PI **D. Sun and P. Speckman**. *Bayesian hierarchical models for psychological research*, to be awarded by the National Institutes of Health, $247,274.00.

A12. The TRANSIMS Activity Generator

TRANSIMS is a comprehensive transportation computer modeling system developed by Los Alamos National Laboratory. The program simulates all the streets (including lanes and signals) and the movement of all the vehicles people in a city. With funding from NSF through Los Alamos and the National Institute of Statistical Sciences,

P. Speckman and D. Sun developed the activity generator module for TRANSIMS. This program provides the daily activities for each person with location and type of transportation from one activity to the next. Development of the activity generator made extensive use of spatial modeling. TRANSIMS has been used to model the Portland, Oregon transportation network and is currently being implemented in Chicago. A key feature of TRANSIMS is that the people in the simulation react to changes in their environment. This allows planners to study the effects of highway construction on congestion and air pollution, for example, before actual construction takes place. TRANSIMS has enormous potential to allow us to make better use of our increasingly scarce resources.

Grants

- 9/1//1996 – 8/31/1999: PI **P.L. Speckman**. *Generating Activity Travel Patterns for Synthetic Populations*, a National Institute of Statistical Sciences contract of $153,418.

A13. Comprehensive Statistical Models for Missouri Ozarks Forest Ecosystem Project (MOFEP).

The Missouri Ozark Forest Ecosystem Project (MOFEP) is a centuries-long, landscape-scale experiment to test effects of forest management practices on the flora and fauna of upland oak ecosystems. A wide array of ecosystem attributes has been studied on the MOFEP sites. More specifically, MOFEP includes 32 related projects of such diverse attributes as neotropical migrant songbirds, small mammal communities, herptofaunal communities, oak herbivore dynamics, leaf litter arthropod dynamics, genetic diversity of trees, armillaria distribution and root rots, coarse woody debris dynamics, vegetation composition and dynamics, acorn production, mechanical damage to forest by harvesting, microclimatic effects of harvesting, tree cavity abundance and density, lichen composition and dynamics, soil response and nutrient dynamics, and ecological land-type responses. Dr. He is working with Steve Sheriff of the MDC on statistical issues related to these data. The research is very timely and is presented at a critical stage in MOFEP's progress. That is,, MOFEP has been conducted long enough to generate the spatially-referenced data needed for investigating relationships among the many different ecosystem attributes from the many different MOFEP studies. Additionally, it will make significant progress towards meeting our objectives long before the implementation of the second harvest entry scheduled for 2011. Finally, the findings may suggest where sampling schemes of the various existing MOFEP projects are inadequate and need to be modified prior to implementing the second harvest entry.

Grants

- 7/01/2002 – 6/30/2006: PI **C. He**. *Developing a Comprehensive Statistical Models for Missouri Ozarks Forest Ecosystem Project (MOFEP)*. Missouri Department of Conservation award $143,710.

Hosting International and National Workshops

The Department of Statistics signature program in spatial and Bayesian statistics is further exemplified by its hosting two national and international conferences on the topic. Both of these conferences have been funded in part by the National Science Foundation.

B1. The Fifth International Workshop on Objective Bayesian Methodology

The Fifth International Workshop on Objective Bayesian Methodology will be held in Branson, Missouri, June 4-8, 2005. Objective Bayesian methodology is, for the most part, oriented toward the development of probability distributions in Bayesian statistical models that can be used automatically, i.e. that do not require subjective input other than the specific probabilistic model chosen to describe the data. There are three quite distinct statistical domains in which this development has taken place: parametric estimation, model selection, and prediction. Objective Bayesian methodology is of increasing importance today since application of Bayesian analysis is rapidly growing among nonspecialists, most of whom seek automatic or objective Bayesian procedures. This meeting will emphasize prediction, practical applications such as spatial-temporal models, multiple comparisons and goodness-of-fit. The workshop will bring together leading researchers from around the world who are active in the area of objective Bayesian methodology. The main objectives of the meeting will be to facilitate the exchange of recent research developments within this community, to provide opportunities for new researchers and underrepresented groups, and to establish new collaborations that will channel efforts into pending problems and open new directions for investigation.

Grants

- 06/01/2005–05/30/2006: PI **D. Sun**, Co-PI **P. L. Speckman**. National Science Foundation, *The Fifth International Workshop on Objective Bayesian Methodology*, $12,000.
- 06/01/2005–05/31/2006: PI **D. Sun**, Co-PI **Paul L. Speckman**. National Security Agency, *The Fifth International Workshop on Objective Bayesian Methodology in Branson, MO, June 4-8, 2005*. Request, $14,900.

B2. Conference on New Developments of Statistical Analysis in Wildlife, Fisheries, and Ecological Research

This conference was held at MU in October, 2004.

As technology has advanced dramatically in recent years, both statistical research and wildlife, fisheries, and ecological research have moved into a new era. However, the use of advanced statistical methods, such as spatial statistics, in wildlife, fisheries, and ecological research is in its infancy. There remain many fundamental statistical and computational issues.

During the mid-1980s, ecologists started to study the ways in which plants, animals, and microbes interact with each other and with their physical environment. At the scale of large systems, from a single watershed to entire lakes, from one year to 10-30 years, these interactions are the special province of ecologists. The data from these large scale studies are large, complex and often unstructured. Unfortunately, traditional statistical approaches often fail to cope with the underlying complexity of such massive datasets.

The goal of the conference was to advance the understanding of statistical problems in wildlife, fisheries, and ecology. In particular, the goal is to identify future research needs and to encourage and facilitate collaboration among biological and statistical scientists and to pursue the interdisciplinary research programs. Participants included prominent researchers with national reputations in both statistical and biological science.

Grants

- 9/01/2004 – 8/31/2005: PI **C. He**, Co-PIs **N. Flournoy, D. Sun, L. Thombs, C. Wikle**. National Science Foundation, *Conference on New Development of Statistical Analysis in Wildlife, Fisheries, and Ecological Research* $20,000.