

URBAN CHANGE - INTEGRATED MODELING ENVIRONMENT (UCIME)

Final Report for the National Science Foundation (NSF)

NSF Award ID: 9817761
Annual/Final Report for Period: 02/2002 - 01/2003
Principal Investigators: Clarke, Keith C. and Couclelis, Helen
Organization: University of California, Santa Barbara
Official Title: An integrated Modeling Environment for Urban Change Research

Books and Non-Refereed Papers

- Keith C. Clarke, Bradley O. Parks, Michael P. Crane (Eds), (2002) *Geographic Information Systems and Environmental Modeling*, Prentice Hall, Upper Saddle River, NJ.
- Clarke, K. C., Parks, B. O. and Crane, M. P. (2000) "Selected papers from the Fourth International Conference on Integrating GIS and Environmental Modeling (GIS/EM4)", *Transactions in GIS*, vol. 4, no. 3, pp. 177-180.
- Clarke, K. C., Parks, B. O. and Crane, M. P. (2000) "Integrating geographic information systems (GIS) and environmental models. Preface: A perspective on GIS-environmental model integration (GIS/EM)", *Journal of Environmental Management*, vol. 59, pp. 229-233.
- Aerts, J.. 2002. Spatial Decision Support for Resource Allocation, Doctoral Dissertation, Faculty of Science, University of Amsterdam, The Netherlands.
- Arthur, S.T. 2001. A Satellite Based Scheme for Predicting the Effects of Land Cover Change on Local Microclimate and Surface Hydrology. Doctorate Thesis, College of Earth and Mineral Sciences, Pennsylvania State University.

Refereed Journal Publications

- Herold, M., Clarke, K. C. & Scepan, J. (2002). Remote Sensing and Landscape Metrics to describe Structures and Changes in Urban Landuse, in *Environment and Planning A*, 34, pp. 1443-1458.
- Goldstein, N.C., J.T. Candau, K.C. Clarke. 2002. "Approaches to simulating the "March of Bricks And Mortar"". *Special Issue of Computers, Environment and Urban Systems on Geosimulation*, May.
- Couclelis, H.. 2002. Modeling Frameworks, paradigms and approaches. *Geographic Information Systems and Environmental Modeling*. K.C. Clarke, B.O. Parks and M.P. Cranes (editors). Prentice Hall, Upper Saddle River, NJ. pp. 36-50.

Publications in press:

- Herold, M, Goldstein, N. C. & Clarke, K. C. (2003). The spatio-temporal form of urban growth: measurement, analysis and modeling, *Remote Sensing of the Environment*, Special issue on applications of remote sensing to urban planning and urban ecology, in press.
- Herold, M., N.C. Goldstein, and K.C. Clarke. 2002. "The spatio-temporal form of urban growth: measurement, analysis and modeling". *Remote Sensing of Environment* (in press).
- Liu, X., and Andersson, C.. 2003. Assessing the impact of temporal dynamics on land-use change modeling. *Computers, Environment, and Urban Systems* (in press).
- Couclelis, H.. 2003. The construction of the digital city. *Environment and Planning B* (in press).
- Couclelis, H. 2003. Pizza over the Internet: e-commerce, the fragmentation of activity, and the tyranny of the region. *Entrepreneurship & Regional Development* (in press).
- Couclelis, H. 2003. The certainty of uncertainty: GIS and the limits of geographic knowledge. *Transactions in GIS* (in press).
- Herold, M., H. Couclelis and K. Clarke. 2003. Using spatial metrics with remote sensing in the analysis and modeling of urban growth and land change. *Computers, Environment and Urban Systems* (in press).

Conference presentations:

- Candau, Jeannette. 2000. Visualizing Modeled Land Cover Change and Related Uncertainty. First International Conference on Geographic Information Science, GIScience 2000. Savannah, Georgia, USA, October 28-31, 2000. ([Abstract of the paper](#), pdf file)

- Candau, Jeannette, Steen Rasmussen and Keith C. Clarke. 2000. Structure and Dynamics of a Coupled Cellular Automaton for Land Use/Land Cover Change. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4). Banff, Alberta, Canada, September 2 - 8, 2000. ([Abstract of the paper](#))
- Candau, Jeannette. 2000. Calibrating a Cellular Automaton Model of Urban Growth in a Timely Manner. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4). Banff, Alberta, Canada, September. ([Abstract of the paper](#))
- Candau, Jeannette and Keith C. Clarke. 2000. Probabilistic Land Cover Modeling Using Deltatrons. URISA 2000 Conference. Orlando, FL; August. (paper)
- Candau, J.T. and N.C. Goldstein. 2002. Multiple Scenario Urban Forecasting for the California South Coast Region for publication in proceedings of the Urban and Regional Information Systems Association (URISA) 40th Annual Conference, Oct 26-30, Chicago, IL.
- Liu, X., and K. Clarke. 2002. Estimation of residential population using high resolution satellite imagery. Proceedings of 3rd International Conference on remote Sensing and Urban Area, Istanbul, Turkey, June 11-13, 2002.
- Robinson, Timothy H., Al Leydecker, John M. Melack and Arturo A. Keller. 2002. Nutrient Concentrations in Southern California Streams related to Landuse. Coastal Water Resources, AWRA 2002 Spring Specialty Conference Proceedings, Lesnick, John R. (Editor). American Water Resources Association, Middleburg, Virginia, TPS-02-1, pp 339-343.
- Robinson, Timothy H., Al Leydecker, John M. Melack and Arturo A. Keller. 2003. Santa Barbara Coastal Long Term Ecological Research (LTER): Nutrient concentrations in coastal streams and variations with land use in the Carpinteria Valley, California. California and the World Oceans '02 Conference. American Society of Civil Engineers. Santa Barbara, California. October.
- Herold, M., Menz, G. & Clarke K. C. (2001): Remote Sensing and Urban Growth Models - Demands and Perspectives, in Juergens, C. (2001): Proceedings of the Symposium on Remote Sensing of Urban Areas, Regensburg, Germany, June 2001, Regensburger Geographische Schriften Heft 35 (on supplement CD Rom).
- Herold, M., Mueller, A., Guenter, S. and Scean, J. (2002): Object-oriented mapping and analysis of urban land use/cover using IKONOS data, Proceedings of the 22nd EARSEL symposium, Prague, June 2002.
- Herold, M., Menz, G. and Clarke, K. C. (2002): A multi-scale framework in mapping and analysis of spatial and temporal urban growth pattern, Proceedings of the 22nd EARSEL symposium, Prague, June 2002.
- Herold, M., Goldstein, N., Menz, G. & Clarke, K. C. (2002): Remote Sensing based analysis of urban Dynamics in the Santa Barbara region using the SLEUTH urban growth model and spatial metrics, Proceedings of the 3rd Symposium on Remote Sensing of Urban Areas, June 2002, Istanbul, Turkey, 537-544.
- Liu, X.. 2002. Refining census population data using fine resolution satellite imagery. Annual Conference of American Association of Geographers, Los Angeles, CA, March 19-23, 2002. Presentation. (Abstract published)
- Goldstein, N.C.. 2002. "Using a Genetic Algorithm as an alternative method of SLEUTH Calibration". *Annual Meeting of the Association of American Geographers*. Los Angeles, March. Presentation.
- Herold, M., Goldstein, N., Menz, G. & Clarke, K.C.. 2002. Remote Sensing based analysis of urban Dynamics in the Santa Barbara region using the SLEUTH urban growth model and spatial metrics, Proceedings of the 3rd Symposium on Remote Sensing of Urban Areas, June 2002, Istanbul, Turkey. Presentation
- Goldstein, N.C.. 2001. A Design for a Coupled Fire Spread, Fire Regime, and Urban Growth Model. 2001 *Annual Meeting of the Association of American Geographers*, New York, February. Poster Presentation.
- Goldstein, N.C.. J. Candau, and M. Moritz. 2000. "Burning Santa Barbara at Both Ends: a study of fire history and urban growth predictions" *4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4)*. Banff, Alberta, Canada, September 2 - 8. <http://www.colorado.edu/research/cires/banff/pubpapers/60/> . Presentation.
- Goldstein, N.C.. 2000. "Do Cities Learn From Getting Burned?" *Artificial Life 7 Workshop Proceedings*, Edited by C.C. Maley and E. Boudreau. Portland Oregon. August. pp. 136-138. Presentation.
- Couclelis, H. 2002. "The certainty of uncertainty". GIScience 2002, Boulder, CO. - September.
- Couclelis, H. 2001. "Information technologies, the fragmentation of activity, and urban change: the case of e-commerce". Conference on Digital Communities: Cities in the Information Age. Allerton Plaza, Chicago, IL. - November.
- Couclelis, H. 2001. "Integrated urban-environmental models: issues in prediction and policy analysis". Department of Geography, University of Southern California - November.
- Couclelis, H. 2001. "Why I no longer work with agents". Workshop on Agent-Based Models of Land Use and Land Cover Change, Beckman Center, Irvine, CA - October.

- Couclelis, H. 2002. "Living with uncertainty: GIS and the limits of geographic knowledge". Accuracy 2002: 5th International Conference on Spatial Accuracy Assessment in Natural Resources and Environmental Sciences, Melbourne, Australia - July.
- Couclelis, H. 2001. "Pizza over the Internet: e-commerce, the fragmentation of activity, and the tyranny of the region". Workshop on Entrepreneurship, ICT, and the Region, Tinbergen Institute, Amsterdam, The Netherlands - June.
- Couclelis, H. 2001. "Integrated urban-environmental modeling: issues in prediction and policy analysis". University of Michigan, Ann Arbor, MI, Lecture Series on Geographic Information Science and the Disciplines - March.
- Couclelis, H. 2001. "The social construction of the digital city". EURESCO Conference on Digital Cities, Granada, Spain - June.
- Couclelis, H. 1999. "Integrated urban-environmental models: some theoretical and methodological challenges". Geography Department, Utrecht University, The Netherlands - March.
- Couclelis, H. 2001. "Towards a framework for integrated urban-environmental models". AAG Annual Meetings, New York, NY - March.
- Couclelis, H. 2001. "Modeling frameworks, paradigms, and approaches: what's what in environmental research?" CCRS, Natural Resources Canada, Ottawa, Canada - February.
- Couclelis, H. 2000. "Modeling frameworks, paradigms and approaches". Tutorial, 4th International Conference on GIS and Environmental Modeling, Banff, Canada - September.
- Couclelis, H. 2000 "Developing an integrated modeling environment for urban change research". Department of Geography, University of Iowa - May.
- Couclelis, H. 2000. "Landscape change: issues in environmental, social, and design science". NCGIA Workshop on Landscape Change, Santa Barbara - January.
- Clarke, K. 2001. The SLEUTH Urban growth model. Department of Geography, University of Southern California
- Clarke, K. 2001. Integrated models of urban land use change. ESRI Seminar Series.
- Clarke, K. 2001 Complexity and Modeling. AAG meeting in Los Angeles.
- Clarke, K. (2001) Land use change modeling. Invited Seminar. Complex systems institute, University of Michigan.
- Clarke, K. (2002) Land Use Change Modeling Using SLEUTH. Advanced training Workshop on Land Use and Land Cover Change Study, December 9-20th, Taiwan. Southeast Asia Regional Committee for START.
- Clarke, K. (2002) Modeling Land Use Change: A State of the Art. Learning from the application of land use change models: A workshop. Perryville Ohio, May 9-10.
- Onsted, J.. 2002. SCOPE and SLEUTH, the UCIME modeling environment. GIS Day, County of Santa Barbara. Presentations
- Candau, Jeannette. 2000. Modeling Land Cover Change Using Modified Cellular. Aurora Partnership Conference. Charleston, South Carolina; November. (Presentation).
- Couclelis, Helen and Xiaohang Liu. 2000. The geography of time and ignorance. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4). Banff, Alberta, Canada, September. ([Abstract of the paper](#))
- Couclelis, Helen. 2000. A Plenum Ontology of Spatial Change. First International Conference on Geographic Information Science. Savannah, Georgia, USA, October. ([Abstract of the paper](#), pdf file)
- Goldstein, Noah, Jeannette Candau and Max A. Moritz. 2000. Burning Santa Barbara at Both Ends: a study of fire history and urban growth predictions. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4). Banff, Alberta, Canada, September. ([Abstract of the paper](#))
- Goldstein, Noah. 2000. Do Cities Learn From Getting Burned?. Artificial Life 7 Workshop Proceedings, Edited by C.C. Maley and E. Boudreau. Portland Oregon, August. ([Abstract of the paper](#))
- Liu, Xiaohang. 2000. Urban Growth Modeling: a change amendment perspective. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4). Banff, Alberta, Canada, September. ([Abstract of the poster](#))
- Liu, Xingong and Michal E. Hodgson. 2000. Data Model and Operators for a Vector Field. First International Conference on Geographic Information Science. Savannah, Georgia, USA, October. ([Abstract of the paper](#), pdf file)
- Sutton, Paul. 2000. Progress in empirical measurement of the Urban Environment. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4). Banff, Alberta, Canada, September. ([Abstract of the paper](#))
- Ungerer, Matthew. 2000. Implementation of cellular automata models in a raster GIS dynamic modeling environment. 4th International Conference on Integrating GIS and Environmental Modeling (GIS/EM4). Banff, Alberta, Canada, September. ([Abstract of the paper](#))

Personnel development:

Liu is likely to accept a job offer from San Francisco State University. Her interview presentation is: Dasytetric mapping with remote sensing: estimating the spatial distribution of urban population using remote sensing and pycnophylactic interpolation. The schools I have given or will give a talk are: McGill University, San Francisco State University, the Ohio State University, and San Diego State University.

Noah Goldstein: went to Menlo Park to talk with the USGS folks in Spring 2000. Gave a presentation to the USGS Urban Dynamics group in Feb, 2001 on urban Modeling and wildfire risk.

Onsted, J.. 2002. SCOPE: The South Coast Outlook and Participation Experience. Annual meeting of the American Association of Geographers. Presentation. Completed MA thesis on the SCOPE model, part of the UCIME for Santa Barbara.

Paul Sutton accepted a position as Assistant Professor of geography, University of Denver.

Traci Arthur, Ph.D. Student in the Department of Meteorology, Penn State University. Used SLEUTH and modifications by Keith Clarke as the basis for her Ph.D. Dissertation. She coupled a hydrological and a transpiration model with SLEUTH, and analyzed the impacts on future landuse in Chester Co., PA. Dr. Clarke served on her Ph.D. Committee as external examiner.

Jaroen Aerts, Ph.D. Student at the University of Amsterdam, the Netherlands. Used SLEUTH and its forecasts using uncertainty levels as the basis for a chapter of his dissertation of decision-support using models and GIS. Dr. Clarke served as external examiner, and attended the Ph.D. Defense.

Elisabete Silva Ph.D. Student at the University of Massachusetts working with Dr., Jack Ahearn, used SLEUTH and its application and calibration in Portugal as the basis of her Ph.D. This work included a major workshop in Lisbon that Dr. Clarke attended, and a visit to Porto, where the model was also applied. Dr. Clarke served as external examiner on Silva's Ph.D. Committee.

Dr. Wei-Ning Xiang was supported by the project during a six-month sabbatical at UCSB in 2002. He worked with Drs. Clarke and Couclelis, and generated publications. Students in the class Geog 176C, which he guest taught, were instrumental in applying a further model (WhatIf?) to Santa Barbara. This work continues.

Project Participants**Senior Personnel:**

Name: Clarke, Keith C. (Dr. Keith C. Clarke)

Worked for more than 160 hours: Yes

Name: Couclelis, Helen (Dr. Helen Couclelis)

Worked for more than 160 hours: Yes

Name: Xiang, Wei-Ning (Dr. Wei-Ning Xiang)

Worked for more than 160 hours: Yes

Graduate Students:

Name: Benison, Sean (Mr. Sean Benison)

Worked for more than 160 hours: No

Name: Candau, Jeannette (Ms. Jeannette Candau)

Worked for more than 160 hours: Yes

Name: Liu, Xiahang (Ms. Xiahang Liu)

Worked for more than 160 hours: Yes

Name: Goldstein, Noah (Mr. Noah Goldstein)

Worked for more than 160 hours: Yes

Name: Robinson, Timothy H. (Mr. Timothy H. Robinson)

Worked for more than 160 hours: Yes

Name: Onsted, Jeff (Mr. Jeff Onsted)

Worked for more than 160 hours: Yes

Name: Kelly, Melissa (Ms. Melissa Kelly)

Worked for more than 160 hours: No

Name: Ungerer, Matthew (Mr. Matthew Ungerer)

Worked for more than 160 hours: No

Organizational Partners

- US Geological Survey (USGS).
- Los Alamos National Laboratory (LANL).
- University of Utrecht - Dr. Peter Burrough, transfer of PCRaster modeling software to the project.
- US Environmental Protection Agency (EPA).
- Santa Barbara Economic Community Project.

Other Collaborators or Contacts

- Collaboration with Prescott College, Arizona, Dr. Will Orr.
- Collaboration with Penn State University, Dr. Toby Carlson and PhD student Traci Athur.
- Collaboration with the University of Massachusetts, PhD student Elisabete Alves Da Silva, implementation of the model in Lisbon and Porto, Portugal.
- Collaboration with the County and City of Santa Barbara, specifically the regional Economic Community Project (ECP) (with support from the Community Environmental Council (CEC)) PhD student Jeff Onsted, implementation of "See the Future" model for the City.

Activities and Findings

Project Activities and Findings:

Research findings:

- That coupled systems of models, especially those coupling human and physical attributes, often have non-linear feedbacks between inputs and outputs that lead to near-impossibility of joint-model calibration.
- That combined models can be effectively loose-coupled by precomputing a range of outputs that are presented to users for visualization.
- That users prefer to be able to manipulate models only rarely, and are more favorable to interacting with scenarios.
- That scenario-based planning that uses models is an underdeveloped area of research.
- That web-based tools for scenario exploration and choice can be successfully integrated into model-based informed planning decision-making.

Specific accomplishments

- Created and implemented the UCIME (See: <http://zenith.geog.ucsb.edu/scenario>) (Papers to follow)
- Finalized Version 3.0 of the model code. The new web page contains documentation and download instructions.
- Drs. Couclelis and Clarke successfully completed two semester long seminars at UC Santa Barbara entitled on Cellular Urban Modeling and on Land-Use Change Modeling, 20 graduate students participated. The seminar web page is <http://www.geog.ucsb.edu/~kclarke/ucime/seminar2001.htm>.
- Invited Dr. George Leavesley (USGS, Denver) to give a seminar on The Modular Modeling System, sponsored the UCIME project team and by the NCGIA.

- Project team members participated in the Urban Dynamics Research Program meeting at the Santa Fe Institute, January.
- Monthly project team meetings, minutes posted on project web page.

Research Training:

- GIS skills.
- Modeling experience.
- General research preparation and conference presentations.
- Population density can be partially modeled using returns from the Defense Meteorological Satellite program.

Education and Outreach Activities:

- Revised and update regularly the project web page at <http://www.geog.ucsb.edu/~kclarke/ucime/index.html>.
- Hosted a UCIME research and review meeting at UCSB, March 2000.

Web/Internet Sites:

- <http://www.geog.ucsb.edu/~kclarke/ucime/index.html>
- <http://www.geog.ucsb.edu/~kclarke/ucime/seminar2000.htm>
- <http://www.geog.ucsb.edu/~kclarke/ucime/seminar2001.htm>
- <http://zenith.geog.ucsb.edu/scenario/>
- <http://zenith.geog.ucsb.edu/newindex.html>

Other Specific Products:

Contributions

Contributions within the Discipline: The SLEUTH model has accumulated users, and is now supported with an on-line discussion forum. A significant number of books, papers, conference presentations and other seminars were given. We have significantly advanced the theme of model integration, perhaps best indicated by the central role of the project in the Banff GIS/EM4 meeting.

Contributions to Other Disciplines: The Xiang and Clarke paper under review will, we believe, have an impact in planning. The model integration theme and the human/physical model linkage themes extend beyond Geography, and may impact other disciplines.

Contributions to Resources for Science and Technology: Several Ph.D. And MA theses resulted directly from this project. Several important exchanges took place: with the Netherlands, Portugal, with UNC Charlotte, and elsewhere. The UCIME tool is currently in use in Santa Barbara during planning for the new Regional Impacts of Growth study: likely to influence local planning for decades into the future. The large number of presentations and workshops have had a high multiplier effect in interest in land use change. Several new proposals have resulted.

Contributions beyond Science and Engineering: Overall, the project has had significant influence in the social sciences, including planning. The results of the scenario work are generic, and apply in many disciplines.

Special Requirements

Objectives and Scope: None.

Change in Objectives or Scope: None.

Special Reporting Requirements: None.

Unobligated Funds: Less than 20% of current funds.

Animal, Human Subjects, Biohazards: None.