Course Syllabus: GEOG531/EVPP531/CSS643: Land-Use Modeling Techniques and Applications

(Last updated September 19, 2008)

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Website: http://mason.gmu.edu/~dparker3

Meeting time and location: Thursdays 4:30-7:10 PM, IN 326

Class Web Site (Public): http://mason.gmu.edu/~dparker3/lumta_04/lumta.html

Course Description: The course surveys literature on spatially disaggregated (fine-scale) empirical models of land-use change (LUC). The course will begin with a discussion of factors that are hypothesized to drive land-use change across multiple spatial, institutional, and human scales and a discussion of issues related to LUCC modeling. The bulk of the course will be spent reviewing techniques for land-use modeling, including statistical and regression models, cellular automata, mathematical programming and other optimization models, agent-based models, and integrated models. We will conclude with a discussion of the strengths, weaknesses, and potential complementarities of the models discussed. The role of geographic information systems as a tool for data management, analysis and visualization in land-use modeling will be discussed throughout the course. Readings will consist of excerpts from Briassoulis (1999), supplemented by articles from peer-reviewed literature. It is helpful if student have a working understanding of spatial data structures, geographic information systems, and statistical regression analysis, and are comfortable with simple optimization problems and systems of linear equations. However, motivated students without this prior knowledge have done very well in the class.

The format of the class will consist of both lecture and discussion, with substantial emphasis on student participation. We have an exceptionally diverse and experienced population of graduate students at Mason, and I expect that you will learn at least as much from one another as you will from me. Thus, proportionally more class time will be devoted to interactive discussions than to lectures. Students will be expected to complete short writing assignments based on the week's readings before class, and students will share responsibility for presenting a portion of the scholarly articles. We will also have hands-on lab sessions for particular topics when feasible.

Goals of the Course: Having completed the course, students should be able to critically review and interpret a land-use model, whether presented in a report or scholarly article. They should have an understanding of the input data requirements, the ways in which the model output can be used, the spatial, temporal, and human scale over which the model operates, the disciplinary scope of the model, and the strengths, weaknesses, and limitations of the modeling technique used. Students should have an understanding of what empirical modeling techniques can be applied to a given data set. Finally, they should have an understanding of what modeling techniques are appropriate for particular research questions.

Recommended Prerequisites: An introductory GIS class, a quantitative methods class that includes statistical regression analysis, and the ability to follow and understand algebraic representations of systems of equations. Linear programming and calculus are helpful but not required. Students without all of these prerequisites, but with a willingness to apply themselves have been very successful in the past.

Readings: All assigned readings will be available electronically. Many are available on-line without restrictions on downloading. Others will be made available through the course website or a mini-drive. Readings for the first two weeks are available for download without restrictions. By Sept. 10, you should turn in to me a list of at least 4 readings that you are interested in presenting, and I will coordinate all requests and assign each person 1-2 articles to present. Your four selected readings must represent at least 2 modeling techniques. I will give you a spreadsheet to assist with article selection. Do not select articles labeled "Not for student presentation," or from the introductory or verification and validation sections. Most weeks you will have a **choice** of which readings you complete, as long as you complete at least two, and read the introduction and conclusion of the other papers. Please ask if there are any questions about your options.

Course Requirements and Grading: Your grade will be based on the following:

Short writing assignments and participation in class discussions (25%)

Each week, you will be required to complete either a short, informal writing assignments related to the week's reading or a lab report. These writing assignments should be coherent (complete sentences with reasonably correct grammar and spelling), but do not need to be highly edited and polished. SWAs will vary in format the first few weeks. From Weeks 5-12, they will follow the standard format described at http://mason.gmu.edu/~dparker3/lucc_class/questions.pdf. **Assignments should be e-mailed to me by 9 AM Wednesday.** YOU MUST FOLLOW ALL STANDARD CITATION LAWS AND CONVENTIONS AND MUST NOT COPY PHRASES FROM THE ARTICLES YOU ARE REVIEWING. Really. I will notice and will not accept the assignment, so don't do it. Late short writing assignments will not be accepted, but you may make up up to 2 assignments by reporting on a talk or seminar you attended, an additional article of interest that you have read, completing an optional lab, or sharing a new item that could be of interest to the class.

The 25% of your grade will be based on the combined content of both your short writings and participation in class discussion. Therefore, if you tend to be less verbose in class, you may want to put a bit more into the content of your short writings. Also, good questions and comments from you will contribute substantially to your participation grade.

In-class presentations of required readings (25%)

Each student will be responsible for presenting 1-2 papers (depending on final student numbers and student preferences) from the methods sections of the course (weeks 5-12). You will have the opportunity to request your preferred papers. Please note when you select articles if you have a preference for doing one extended 40 minute presentation (which should include a review of related literature and a model demo), or two shorter 20 minute presentations. Because the class schedule is very tight, paper presentations can't be made up, so be sure that you can present on your chosen day(s). For your assigned papers, please give a structured overview of the research question addressed by the paper, the modeling methodology used, the input data used by the model, the model outputs, and the authors' interpretation of these outputs. Also, please comment on how effectively the model methodology addresses the research question posed by the authors, potential input data issues, the strengths and limitations of the authors' approach, and improvements, extensions, or alternative applications of the model. Your presentation should also answer the short writing assignment questions (see above). Your presentation should be no longer than 20 minutes. You should prepare an electronic presentation (powerpoint, keynote, pdf, etc) and post the slides to the course web site, or e-mail to me if the file size is too large.

Term paper (25%)

For the term paper, students may complete a targeted literature review, focusing either on application of a particular technique to specific phenomena, or on LUC models of a particular geographic region. Ideally, the relevant literature for the paper should encompass no more than 10-15 articles. (In other words – choose a well-focused topic!) Students with the requisite technical background and interest may undertake a simple LUC modeling project using one of the techniques that we review. The final paper should be 20-30 pages in length, double spaced 12 points font, including tables, figures, and bibliography. An extended abstract (750-1000 words) and paper bibliography will be due Oct. 16, and final papers will be due Nov. 19 and will be presented during the last two weeks of the class. Late papers will be penalized a quarter of a letter grade per day. Both abstracts and papers will be distributed to the rest of the class. Please review your potential paper topic with me before getting started. Your final paper grade is a weighted average of your abstract grade (25%), your presentation grade (25%), and your manuscript grade (50%).

Take-home final exam (25%)

The take-home final exam will be distributed the last day of class (Dec. 4) and will be due at the end of our scheduled final exam period (Dec. 11, regular class time). Late final exams cannot be accepted, due to the short amount of time I have to post grades after the final (48 hours).

Abstracts and term papers will be evaluated using Turnitin, a plagiarism-detection service. Please see the writing center resources (http://writingcenter.gmu.edu/resources/plagiarism.html) for very helpful guidelines. Hopefully you will be able to check your own papers before you turn them in to me, so that there are no surprises.

Please check before class to ensure that cell phones and pagers are turned off. Note that George Mason is an honor code university.

Weekly Schedule and Required Readings:

I. Introduction: Issues in Land-Use Change modeling and Drivers of LUC

Week 1 (August 28): General introduction

- Introduction to course, instructor, and fellow students
- Trends in LUC and their consequences
- LUC modeling concepts: definitions and discussion
- Brainstorming session: Drivers of LUC in Northern VA

Required readings *(You do not need to complete these before the first class)*:

Briassoulis: Chapter 1 (Introduction) and Sections 4.1 and 4.2 (Modeling section introduction and classifications)
http://www.rri.wvu.edu/WebBook/Briassoulis/chapter1(introduction).htm
http://www.rri.wvu.edu/WebBook/Briassoulis/Chapter4(Models1).htm#4.1
http://www.rri.wvu.edu/WebBook/Briassoulis/Chapter4(Models1).htm#4.2

Global Land Project science plan: Executive summary, Introduction, Theme 1, and Theme 2: http://www.glp.colostate.edu/report_53.pdf

Further reading:

Lambin, E. F., H. Geist, and E. Lepers. 2003. Dynamics of land-use and land-cover change in tropical regions. *Annual Review of Environmental Resources* 28: 205-241.

Vesterby, M., and K. S. Krupa. 2001. Major Uses of Land in the United States, 1997. Washington, DC: Economic Research Service, USDA Publication 973. http://www.ers.usda.gov/publications/sb973/.

Week 2 (Sept. 4): Overviews of LUC models. Guest lecture, Dr. Darla Munroe. Required readings:

Verburg, P., K. Kok, R. G. Pontius, A. Veldkamp, A. Angelsen, B. Eickhout, T. Kram, S. J. Walsh, D. C. Parker, K. Clarke, D. Brown, K. P. Overmars, and F. Bousquet. 2006. Modelling land-use and land-cover change in E. Lambin and H. Geist, eds. Land-use and Land-cover Change: Local Processes, Global Impacts. Springer Berlin Heidelberg, New York.

Briassoulis: Chapter 2 (Historical Overview of Studies of LUC)
http://www.rri.wvu.edu/WebBook/Briassoulis/Chapter2(Histoverview).htm

Agarwal, C., G. M. Green, J. M. Grove, T. Evans, and C. Schweik. 2002. A review and assessment of land-use change models: Dynamics of space, time, and human choice. Burlington, VT: USDA Forest Service Northeastern Forest Research Station Publication NE-297.
http://www.fs.fed.us/ne/newtown_square/publications/technical_reports/pdfs/2002/gtrne297.pdf.

Week 3 (Sept. 11): *Article requests for paper presentations due by 9 AM on Sept. 10***.** Urban and rural drivers of LUC, Lab session: Von Thunen model. Readings:

Either: Irwin, E. G., and N. Bockstael. 2006. The Spatial Pattern of Land Use in the U.S. in R. Arnott and D. McMillen, eds. *A Companion to Urban Economics*

Or: Anas, A., R. Arnott, and K. A. Small. 1998. Urban Spatial Structure. *Journal of Economic Literature* 36 (3): 1426-1464

Either: Geist, H., and E. F. Lambin. 2002. Proximate causes and underlying driving forces of tropical deforestation. *Bioscience* 52 (2): 143-150.
http://www.geo.ucl.ac.be/LUCC/pdf/02_February_Article_Geist_.pdf.

Or: Angelsen, A., and D. Kaimowitz. 1999. Rethinking the causes of tropical deforestation: Lessons from economics models. *The World Bank Research Observer* 14 (1): 73-98. http://www.worldbank.org/research/journals/wbro/obsfeb99/pdf/article4.pdf.

II. Evaluating LUCC model performance

Week 4 (Sept. 18): **Model verification and validation and map comparison**. Required readings:

Turner, M. G., R. Costanza, and F. Sklar. 1989. Methods to evaluate the performance of spatial simulation models. *Ecological Modelling* 48 (1/2): 1-18.

Oreskes, N., K. Shrader-Frechette, and K. Belitz. 1994. Verification, validation, and confirmation of numerical models in the earth sciences. *Science* 263: 641-646.

Visser, H., and T. d. Nijs. 2006. The Map Comparison Kit. Environmental Modelling and Software 21 (3): 346-358.

Map comparison kit lab: http://www.riks.nl/mck/

III. Cellular Automata Models

Week 5 (Sept. 25) CA models, week 1.

Required: (not for student presentation or SWA) Batty, M. 1997. Cellular automata and urban form: A primer. *Journal of the American Planning Association* 63 (2): 266-274.

Batty, M. 2005. Urban Growth Models in D. J. Maguire, M. F. Goodchild, and M. Batty, eds. *GIS, Spatial Analysis and Modeling*. ESRI Press, Redlands, CA..

Standard format weekly SWAs start from this week (Write one for next week on one of the two readings.)

Week 6 (Oct. 2) CA models, week 2; intro to stats models. Readings: (Read one of two):

Jantz, C. A., S. J. Goetz, and M. K. Shelley. 2004. Using the SLEUTH Urban Growth Model to Simulate the Impacts of Future Policy Scenarios on Urban Land Use in the Baltimore-Washington Metropolitan Area. Environment and Planning B 30: 251 - 271.

Soares-Filho, B. S., G. C. Cerqueira, and C. L. Pennachin. 2002. Dinamica—a stochastic cellular automata model designed to simulate the landscape dynamics in an Amazonian colonization frontier. Ecological modelling 154 (3): 217-235.

IV. Statistical Models

Week 7 (Oct. 9): Developing country models:

Required, not for student presentation or SWA: Anselin, L. 2002. Under the hood: Issues in the specification and interpretation of spatial regression models. *Agricultural Economics* 27 (3): 247-267. OR Briassolis, Chapter 4.3, Statistical and Econometric Models: http://www.rri.wvu.edu/WebBook/Briassoulis/Chapter4(models2).htm#4.5

Required, not for student presentation or SWA: De Pinto, A. and G. Nelson. 2007. Modelling deforestation and land use change: sparse data environments. *Journal of Agricultural Economics* 58 (3): 502-516.

Read one of three:

Reilly, J. (2003). The New Jersey (USA) Growth Allocation Model:

development, evaluation and extension. In S. Geertman & J. Stillwell (Eds.), Planning Support Systems in Practice (pp. 373-389). Berlin: Springer.

Mertens, B., and E. F. Lambin. 2000. Land-cover change trajectories in Southern Cameroon. *Annals of the Association of American Geographers* 90 (3): 467-494.

Müller, D., and M. Zeller. 2002. Land use dynamics in the central highlands of Vietnam: a spatial model combining village survey data with satellite imagery interpretation. Agricultural Economics 27 (3): 333-354.

Week 8 (Oct. 16) Dr. Parker out of town. Possible guest lecture TBA. *Extended paper abstracts and bibliographies due.*

Week 9 (Oct. 23) Urban and ex-urban statistical models, intro to optimization models. Readings:

Required (not for student presentation or SWA): Bell, K. P., and E. G. Irwin. 2002. Spatially explicit micro-level modelling of land use change at the rural-urban interface. *Agricultural Economics* 27 (3): 217-232.

Read one of three:

Lynch, L., and S. Lovell. 2003. Combining Spatial and Survey Data to Explain Participation in Agricultural Land Preservation Programs. *Land Economics* 79 (2): 259-276.

Lewis, D., and A. J. Plantinga. 2007. Policies for Habitat Fragmentation: Combining Econometrics with GIS-Based Landscape Simulations. *Land Economics* 83 (2): 109-127

Mueller, J. M., and J. B. Loomis. 2008. Spatial Dependence in Hedonic Property Models: Do Differnt Corrections For Spatial Dependence Result in Economically Significant Differences in Estimated Implicit Prices? *Journal of Agricultural and Resource Economics* 33 (2): 212-231. http://purl.umn.edu/42459.

V. Optimization Models

Week 10 (Oct. 30) Applications of optimization; intro to ABM. Readings

Required (not for student presentation or SWA): Hazell, P. B. R., and R. Norton. 1986. Chapter 2: The Farm Model. Pages 9-32. Macmillan Publishing Company, New York. http://www.ifpri.org/pubs/otherpubs/mathprog.htm (Concentrate on pages 9-14, 16-21, 28-31. You may also want to read Chapter 3.)

(Read one of three):

Chuvieco, E. 1993. Integration of linear programming and GIS for land-use modeling. *International Journal of Geographical Information Systems* 7 (1): 71-83 (Good introductory article).

Maatman, A., C. Schweigman, A. Ruijs, and M. H. van Der Vlerk. 2002. Modeling Farmers' Response to Uncertain Rainfall in Burkina Faso: A Stochastic Programming Approach. *Operations Research* 50 (3): 399-414. (Very technical in parts)

Carpentier, C. L., S. A. Vosti, and J. Witcover. 2000. Intensified production systems on western Brazilian Amazon settlement farms: could they save the forest? *Agriculture, Ecosystems and Environment* 82 (1-3): 73-88.

VI. Multi-Agent System Models

Week 11 (Nov. 6): Readings:

Required (not for student presentation or SWA) Parker, D. C., S. M. Manson, M. A. Janssen, M. Hoffmann, and P. Deadman. 2003. Multi-agent systems for the simulation of land-use and land-cover change: A review. *Annals of the Association of American Geographers* 93 (2): 314–337.

Read one of two:

Manson, S. M. 2006. Land use in the Southern Yucatan Peninsular Region of Mexico: scenarios of population and institutional change. Computers, Environment, and Urban Systems 30 (3): 230-253. http://dx.doi.org/10.1016/j.compenvurbsys.2005.01.009 ID: 4112

Berger, T. 2001. Agent-based spatial models applied to agriculture: A simulation tool for technology diffusion, resource use changes, and policy analysis. *Agricultural Economics* 25 (2-3): 245-260

Optional: Parker, D. C., and V. Meretsky. 2004. (Not for student presentation, OK for SWA) Measuring pattern outcomes in an agent-based model of edge-effect externalities using spatial metrics. *Agriculture, Ecosystems and Environment* 101 (2-3): 233-250

Optional SLUDGE ABM lab (executable to be distributed)

VII. Integrated Models

Week 12 (Nov. 13) Readings (Read two of three):

Engelen, G. 2002. Xplorah: The Spatial Decision Support System for Puerto Rico. Maastricht: RIKS Publication.

Tang, Z., B. A. Engel, B. C. Pijanowski, and K. J. Lim. 2005. Forecasting Land Use Change and Its Environmental Impact at a Watershed Scale. *Journal of Environmental Management* 76: 35-45.

Verburg, P. H., W. Soepboer, A. Veldkamp, R. Limpiada, V. Espaldon, and S. S. A. Mastura. 2002. Modelling the spatial dynamics of regional land use: The Clue-S model. *Environmental Management* 30 (3): 391-405.

VIII. Model Comparisons, Open Questions and Student Paper Presentations

Week 13 (Nov. 20) *Final student papers due by 9 AM Nov. 19.* Student paper presentations and discussion.

Week 14 (Nov. 27) Thanksgiving holiday, no class

Week 15 (Dec. 4) *Final exam distributed.* Student paper presentations and discussion.

Week 16 (Dec. 11) *Final exam due via e-mail and/or web post, 7:10 PM.*