GIS and Landscape Modeling

NRE 534; Fall Semester 2014

Professor	Dan Brown (danbrown@umich.edu)
Office	3505 Dana; 763-5803 Office hours: 1-3 pm Thursdays
Course Meets	Tues, 10 am-12 pm,1006 Dana Thurs, 10 am-12 pm, 3325 Dana (Computing Lab)
Course Objectives	The goals of this class are to develop understanding of and skills in GIS-based approaches to modeling spatial patterns and changes and to understand their scientific and management applications. The focus of the approaches is on understanding, describing, and predicting spatially explicit patterns of land use and land cover. The course necessarily involves applications that bridge social and ecological sciences and touches on problems in urban, agricultural, and forested environments. The course builds on prior course work and skills in GIS, statistics, ecological and social sciences. Students completing the course will be able to evaluate the trade-offs among modeling approaches in different situations, and to implement (at least minimally) several of the approaches.
Prerequisites	Because the models we are exploring are both spatial and quantitative in nature, it is important that students have a background in these two areas. The following courses (or equivalents) are prerequisites: NRE 531 - Principles of GIS; NRE 538 - Natural Resource Statistics
Readings	There is no text. Required readings are assigned from the literature. All readings are (or will be) available for download from the *CTools* site set up for this course. In addition to pre-assigned readings, all students will report on a reading to the rest of the class (see below), and various resources are included with assignments. Optional resource: Allen, D.W. 2011. *Getting to Know ArcGIS ModelBuilder*. Redlands, CA: ESRI Press.
Computer Assignments	During the first half of the semester, five exercises will be assigned. They will use ArcGIS, R, or NetLogo, which will be available in most public campus computing sites. We will meet in the lab on Thursdays to go over the assignment and provide time for you to complete it (most will also require time outside class). A write-up of each exercise will be due on CTools one week after the assignment is made.
Journal Article Report	During the second half of the course, each student is required to select one to two articles on a modeling approach covered in class, and to read, review, and report to the class. Your articles must be approved by the instructor and fit the topic. The report will take the form of a written and oral summary and critique of the articles.
Final Project	An end-of-term project is required that applies concepts learned in the class. The project can take one of at least two forms: 1) create and analyze a new model in ArcGIS, R, NetLogo, some combination, or another approved platform, or 2) modify or run and analyze an existing model. Other options are possible, but should be approved by the instructor beforehand. More details to come.
Grading	Your grade will be determined on the basis of your combined performance on lab assignments (35%), final project (35%), article review (20%), and contribution to class discussion (10%).

GIS and Landscape Modeling - Provisional Schedule

Days	Topic(s)	Required Readings (subject to change)	Skills
Sep 2	Modeling and GIS Preliminaries LCLUC Definitions and scope	Turner et al. 2001 Brown et al. 2013	
Sep 4	lab - Terrain Modeling	*Gallant and Wilson 2000 Besnard et al. 2013	Arc Model Builder
Sep 9	Multi-criteria evaluation	*Jankowski 1995 Wang and Medley 2004 Sánchez-Lozano et al. 2013	
Sep 11	lab - Multi-Criteria		Nesting Models
Sep 16	Habitat modeling	*Guisan & Thuiller 2005 Imam et al. 2009 Teferi et al. 2013	
Sep 18	lab - Logistic Modeling	See resources in assignment	Linking to R
Sep 23	Machine learning alternatives and Introduction to dynamic models	*Hijmans and Elith 2013 (Ch 11) Phillips et al. 2006 *Smith 2000	
Sep 25	Catch up, discussion		Optional R
Sep 30	Cellular models	*White and Engelen 2000 Soares-Filho et al. 2006 + supplementary material Verburg et al. 2002	
Oct 2	lab - Cellular models		Looping
Oct 7	Agent-based Models	*Parker et al. 2003 *Brown 2006 Jepson et al. 2006	
Oct 9	lab – Agent-based modeling		NetLogo
Oct 14	*Fall Break*		
Oct 16	ABM follow-up; Model-based experiments	*Grimm, Revilla et al. 2005 Sylvester et al. 2014	
Oct 21	**Work on proposals - Brown in DC**		
Oct 23	Companion Modeling	*Barrateau et al. 2011 LePage et al. In Press	
Oct 28	Article reports (5-6)		
Oct 30	Spatial optimization (Hui Xu) ***Project proposals due***		
Nov 4	**Project work - Brown in Providence**		
Nov 6	Article reports (5-6)		
Nov 11	Land-use scenarios for the US	Brown et al. 2014 Workshop report	

Nov 13	Article reports (5-6)		
Nov 18 Nov 20	**Project work - Brown in DC** Coupling models for impact and policy assessment	 Robinson et al. 2013 Tang et al. 2005	
Nov 25	Article reports (5-6)		
Nov 27	*Thanksgiving*		
Dec 2 Dec 4 Dec 9	TBD Project Presentations Project Presentations *Final project due*		

*** For each section, the asterisked reading describes the fundamentals of the approach. The others are selected as applied examples.**

Assigned Readings

Barrateau, O., Bousquet, F., Etienne, M., Souchere, V., and d'Aquino, P. 2011. Companion modelling: A method of adaptive and participatory research. Ch. 1: in M. Etienne, editor. *Companion modelling: A participatory approach to support sustainable development*. Versailles Cedex, France: Editions Quæ, pp. 21-44.

Besnard, A. G., La Jeunesse, I., Pays, O., & Secondi, J. 2013. Topographic wetness index predicts the occurrence of bird species in floodplains. *Diversity and Distributions*, *19*(8), 955-963.

Brown, D. G. 2006. Agent-based models. *The Earth's Changing Land: An Encyclopedia of Land-Use and Land-Cover Change*. H. Geist. Westport, CT, Greenwood Publishing Group**:** 7-13.

Brown, D.G., Verburg, P.H., Pontius, R.G., and Lange, M.D. 2013. Opportunities to improve impact, integration, and evaluation of land change models. *Current Opinion on Environmental Sustainability*, 5(5):452-457.

Brown, D.G., Polsky, C., Bolstad, P., Brody, S.D., Hulse, D., Kroh, R., Loveland, T.R. and Thomson, A., 2014. Ch. 13: Land Use and Land Cover Change. *Climate Change Impacts in the United States: The Third National Climate Assessment*, J. M. Melillo, T.C. Richmond, and G. W. Yohe, Eds., U.S. Global Change Research Program, 9-1–9-nn.

Gallant, J. C. and J. P. Wilson. 2000. Primary topographic attributes. *Terrain Analysis: Principles and Applications*. J. P. Wilson, Gallant, J. C. New York, John Wiley and Sons**:** 51-85.

Grimm, V., E. Revilla, et al. 2005. Pattern-oriented modeling of agent-based complex systems: Lessons from Ecology. *Science* **210**: 987-991.

Guisan, A., & Thuiller, W. 2005. Predicting species distribution: Offering more than simple habitat models. *Ecology Letters*, *8*(9), 993-1009.

Hijmans, R.J. and Elith, J. 2013. Species distribution modeling with R. http://cran.r-project.org/web/packages/dismo/vignettes/sdm.pdf (accessed Aug 2014)

Imam, E., S. P. S. Kushwaha, et al. 2009. Evaluation of suitable tiger habitat in Chandoli National Park, India, using spatial modelling of environmental variables. *Ecological Modelling* **220**(24): 3621-3629.

Jankowski, P. 1995. Integrating geographical information systems and multiple criteria decision-making methods. *International Journal of Geographical Information Science* **9**(3): 251-273.

Jepsen, M. R., Leisz, S., Rasmussen, K., Jakobsen, J., Møller-Jensen, L., & Christiansen, L. 2006. Agent-based modelling of shifting cultivation field patterns, Vietnam. *International Journal of Geographical Information Science*. 20(9), 1067-1085.

LePage, C. et al. In Press. Interactive simulations with a stylized scale model to codesign with villagers an agent-based model of bushmeat hunting in the periphery of Korup National Park (Cameroon). *Journal of Artificial Societies and Social Simulation*.

Parker, D. C., S. M. Manson, et al. 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.

Phillips, S. J., Anderson, R. P., & Schapire, R. E. 2006. Maximum entropy modeling of species geographic distributions. *Ecological Modelling*, 190(3): 231-259.

Robinson, D.T., Sun, S., Hutchins, M., Riolo, R.L., Brown, D.G., Parker, D.C., Filatova, T., Currie, W.S., and Kiger, S. 2013. Effects of land markets and land management on ecosystem function: A framework for modelling exurban land change. *Environmental Modelling and Software*, 45:129-140.

Sánchez-Lozano, J. M., Teruel-Solano, J., Soto-Elvira, P. L., & Socorro García-Cascales, M. 2013. Geographical Information Systems (GIS) and Multi-Criteria Decision Making (MCDM) methods for the evaluation of solar farms locations: Case study in south-eastern Spain. *Renewable and Sustainable Energy Reviews*, *24*, 544-556.

Smith, R. D. 2000. Simulation. *Encyclopedia of Computer Science.* A. Ralston, Reilly, E. D., Hemmendinge, D. New York, Nature Publishing Group**:** 1587.

Soares-Filho, B. S., D. C. Nepstad, et al. 2006. Modelling conservation in the Amazon basin. *Nature* **440**: 520-523.

Sylvester, K.M., Brown, D.G., Leonard, S.H., Merchant, E., and Hutchins, M. In Press. Exploring agent-level calculations of risk and returns in relation to observed land-use changes in the US Great Plains, 1870-1940. *Regional Environmental Change*.

Tang, Z., Engel, B.A., Pijanowski, B.C., Lim, K.J. 2005. Forecasting land use change and its environmental impact at a watershed scale. *Journal of Environmental Management* 76 (1), 35-45

Teferi, E., Bewket, W., Uhlenbrook, S., & Wenninger, J. 2013. Understanding recent land use and land cover dynamics in the source region of the Upper Blue Nile, Ethiopia: Spatially explicit statistical modeling of systematic transitions. *Agriculture, Ecosystems & Environment*, *165*, 98-117.

Turner, M. G., R. H. Gardner, et al. 2001. *Landscape Ecology: In Theory and Practice*. New York, Springer-Verlag.

Verburg, P., W. Soepboer, et al. 2002. Modeling the spatial dynamics of regional land use: The CLUE-S Model. *Environmental Management* **30**(3): 391-406.

Wang, D. H. and K. E. Medley 2004. Land use model for carbon conservation across a midwestern USA landscape. *Landscape and Urban Planning* **69**: 451-465.

White, R. and G. Engelen 2000. High-resolution integrated modelling of the spatial dynamics of urban and regional systems. *Computers, Environment, and Urban Systems* **24**(5): 383-400.