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The effect of disaggregating land use categories in cellular automata during model calibration and forecasting

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Abstract

Spatial models of urban growth have the ability to play an important role in the planning process; if not in aiding in policy decisions, then in processes such as visioning, storytelling, and scenario evaluation. One question that has not adequately been addressed is to what degree does disaggregating land use types from urban/non-urban categories add to these simulations? This paper aims to answer this question by modeling urbanization in San Joaquin County (CA) using the SLEUTH urban growth model with two equal, but different datasets; one with urban/non-urban data, and the other with the same data, but the non-urban data disaggregated in nine land uses. The results show that there is an explicit link between the likelihood of urbanization, and the type of land use that will be converted to urban, and suggest that future exercises using spatial models should not ignore the impact of aggregating individual land use categories into urban–non-urban classes.

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1. Urban simulation and land use dynamics

Urban growth and land use change are dynamic spatio-temporal processes of great interest to planners, conservationists, ecologists, economists, and resource managers. Over the past decades, research in these disciplines has sought to develop models of these processes for forecasting future development, evaluating future plans, and identifying endangered natural areas. Despite past failures in urban modeling (Lee, 1973, 1994), there has been a renaissance of spatial modeling in the last two decades due to increased computing power, improved availability of spatial data, and the need for innovative planning tools to aid in decision support (Brail & Klosterman, 2001; Geertman & Stillwell, 2002). These models include the development of new computational methods, including micro-simulation, agent-based and cellular automata (CA), which show potential in representing and simulating the complexity of the dynamic processes involved in urban growth and land use change. Complexity and scaling approaches have provided an additional level of knowledge and understanding of the spatial and temporal patterns of land use change (Batty & Longley, 1994). Furthermore, the models have been used to anticipate and forecast future changes or trends of development, to describe and assess impacts of future development, and to explore the potential impacts of different policies (Jantz, Goetz, & Shelley, 2004; Landis & Zhang, 1998).

As previously implied, there are several different types of urban and land use models (EPA, 2000). Since planning is to some degree a management of an economic market, models have been developed to incorporate the economics of land use change (Alberti & Waddell, 2000; Irwin & Geoghegan, 2001). Others have suggested the uses of agents (Parker, Manson, Janssen, Hoffmann, & Deadman, 2003), simulating the decisions of individuals within a system. Cellular automata (CA) are yet another method for simulating urban-land use dynamics, where a set of rules and spatial constraints govern interaction among land uses and their transitions (Batty, Xie, & Sun, 1999; de Almedia et al., 2003; White, Engelen, & Uljee, 1997). We contend that there are currently two schools in CA modeling; both use the same basic foundation (CA), but have different approaches when it comes to incorporating increased details on the dynamics within a system by disaggregating data into multiple land use classes. The first approach is that of Ward, Murray, and Phinn (2000, 2003), Wu (2002), Yeh and Li (2001, 2002) and Li and Yeh (2001). The models that these researchers have developed, while elegant, treat the urban system as a basic entity, comprised of urban and non-urban components. These non-urban components may be referred to as rural or agriculture, but no matter what the nomenclature, the system is decomposed into two classes (we disregard the inclusion of a 'water' category, as this is largely stationary, and lacks the dynamic characteristics that other land uses possess)—urban and non-urban. The second school of CA modeling takes the approach that the landscape is comprised of multiple land uses, be they at the broad landscape level or within the city itself, and that the feedback and dynamics among these classes is essential in modeling. This school includes the works of de Almedia et al. (2003), Xie and Batty (2005) and White and Engelen (2000). Even more recent efforts in CA modeling have begun to integrate classical economic