Comparing demographic and lot effects in an agent-based simulation of land use change in the Brazilian Amazon

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Abstract

Recent research on the human-environment interactions influencing land use change in parts of the Brazilian Amazon has focused on the importance of the household as an agent of change. In areas of the rainforest that are characterized by household-based agricultural colonization, such as the area near Altamira, research has begun to reveal how patterns of deforestation are, or are not, affected by a variety of factors operating locally. In an effort to further explore the influence of household demographics on land use change in this region, a series of models of increasing complexity are utilized to explore the relative influence of factors including household demographics and lot effects. Output from a series of four models was compared with observed patterns of land use change in the study region to explore the relative importance of demographic and lot effects in shaping land use decisions.

Background and Relevance

When it comes to exploring connections between farming household decision making and land use change, one study site that has been of interest to researchers is a government-sponsored settlement area along the TransAmazon highway, to the west of the city of Altamira, Pará state, Brazil. When the region was opened for settlement in 1970, settlers obtained provisional rights to approximately 100 hectare properties that were generally rectangular in shape with 500 meters of road frontage and 2000 meters deep, with rights conditional on improving the property by clearing, cultivation and the construction of homes and other infrastructure.

The study of population and environment interrelations in the Altamira study area began with ethnographic observations by Emilio Moran, made from the 1970s until the present, combined with a theoretical model of the developmental cycle of households drawn from Anthropology (Goody 1958). This model of the developmental cycle of households was combined with the concepts of age, period and cohort effects from demography to hypothesize that land use (and land cover) in a particular property is a function of the age (developmental stage) of the owner's household, current macroeconomic conditions (period effects), and the time that the property was settled (settlement cohort) (Brondizio et al. 2002).

More recent research work in the study area has questioned the relative importance of household demographic effects and lot history effects on patterns of land use. With a view to exploring these alternate theories of household land use decision making, a simulation was developed that represents households as agents that interact with a raster grid representing the landscape of the region.

Methods and Data

The LUCITA simulation represents individual households as agents that interact with each other and a set of georeferenced raster grids, representing soil quality and land use, where each cell in the grid covers one hectare. Cells in the land use grid are allocated to individual properties in a pattern that matches the 100 hectare farm plot configuration laid out by the Brazilian Government prior to colonization.

A series of simulations were run using LUCITA, starting with a homogeneous set of agents (Lim et al. 2002). Following this, the effects of agent heterogeneity (cohort effects) were explored by varying the input parameters for the agents in each set of simulations. These cohort effects were examined by comparing simulations in which agents are added in such a way as to represent the cohorts that arrived on the frontier over time. Household agents were allocated to plots using a randomized procedure that favoured the occupation of plots along the main highway above those on the side roads, and the occupation of plots closer to the city of Altamira (Deadman et al. 2004).

Results

Starting with a homogeneous collection of household agents and no outside source of labour, we observe that the agents in the simulation tend to follow a pattern of land conversion that was theorized in the conceptual trajectory (McCracken et al. 2002). Manipulating the input parameters of the simulation indicates that, as expected, households with more resources (labour and capital) deforest properties more rapidly than those with limited resources (Deadman 2005).

Parameterizing the model to reflect the demographic characteristics of the different cohorts of households outlined in Brondizio et al. (2002) results in changes to the overall deforestation rates produced by the simulation, but no discernable trends. More significantly, the addition of a labour market, in which cheap outside labour is readily available, reduces the effects of household demography on deforestation rates. With readily available cheap outside labour, households need not depend on their own labour when making land use decisions. Finally, household agents settling on previously occupied properties behave significantly differently from those that settle on forested properties. On previously occupied properties, agents do not follow the theoretical trajectory, but show low rates of deforestation. As would be expected, household agents are not removing established perennials or pasture to plant annuals.

Conclusions

Recent research has challenged the traditionally accepted model that household decisions regarding land use are heavily influenced by household demographics and the life-cycle stage of the household. Simulation modeling has a role to play in this research by providing a virtual platform for exploring these theories under alternate scenarios. The results of this preliminary simulation work indicate that further efforts are needed to explore property and period effects in the simulation. Field research efforts that are

designed to explore the factors driving decision making and the reasoning behind specific decisions would lead to better informed models.

References

Brondizio, E., McCracken, S. D., Moran, E. F., Siqueira, A. D., Nelson, D. R. and Rodriguez-Pedraza, C., 2002. The Colonist Footprint: Toward a Conceptual Framework of Land Use and Deforestation Trajectories among Small Farmers in the Amazonian Frontier. In: Wood, C. H. and Porro, R. (Eds.), Deforestation and Land Use in the Amazon. Gainesville, Florida, University Press of Florida pp. 133-61.

Deadman, P., Robinson, D., Moran, E. and Brondizio, E., 2004. Effects of Colonist Household Structure on Land-Use Change in the Amazon Rainforest: An Agent-Based Simulation Approach. Environment and Planning B 31 (5), 693-709.

Deadman, P. J., 2005. Household Decision Making and Patterns of Land Use Change in LUCITA: An Agent Based Simulation of the Altamira Region, Brazil. Paper presented at the MODSIM 05, Melbourne Australia.

Goody, J. e., Ed. 1958. The developmental cycle of domestic groups. Cambridge Papers in Social Anthropology. Cambridge, UK, Cambridge University Press.

Lim, K., Deadman, P., Moran, E., Brondizio, E. and McCracken, S., 2002. Agent-based simulations of household decision making and land use change near Altamira, Brazil. In: Gimblett, H. R. (Ed.) Integrating Geographic Information Systems and Agent-Based Modeling Techniques for Understanding Social and Ecological Processes. Oxford, U.K., Oxford University Press.

McCracken, S. D., Siqueira, A. D., Moran, E. F. and Brondizio, E. S., 2002. Land-Use Patterns on an Agricultural Frontier in Brazil; Insights and Examples from a Demographic Perspective. In: Wood, C. H. and Porro, R. (Eds.), Land Use and Deforestation in the Amazon. Gainesville Florida, University Press Florida pp.