A Basin-Scale Econometric Model for Projecting Future Amazonian Landscapes LC-24

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Abstract

The proposed project seeks to develop a basin-scale econometric model for use in predicting land cover change scenarios in the Amazon basin. It will combine the region-scale of the GIS-based approach, with the behavioral rigor of the micro-level studies, in constructing a model that can predict land cover change over large areas with theoretical grounding, and empirical testing. Three key issues will be addressed in the research in order to improve upon existing aggregate models for the Amazon. First, the model will not only incorporate economic theory for individual decisions, but also theory related to macro-level effects on land cover, as generated by state policies. Second, the model will account for spatial heterogeneity in the determinants of land use across the region by drawing on empirical research from multiple sites with contrasting settlement histories. And third, in both estimation of the effects of land-cover drivers and landscape projections, "endogenous" road construction following initial deforestation along major roads will be accounted for. These three innovations will allow an improved econometric model from which coefficients used in projections are based on observed historical deforestation in the basin. This empirical approach also facilitates the evaluation of confidence intervals for coefficients and comparison of model predictions with out-of-sample new data.

The proposed research thus addresses the LBA-ECO theme "land cover and land use change." By focusing on construction of an econometric statistical model of deforestation for the entire Amazon basin, this analysis seeks to help answer the second-tier NASA research question (F2): "What changes are occurring in the global land cover and land use, and what are their causes?"It also seeks to address the related question (LC-Q1): "What are the rates and mechanisms of forest conversion to agricultural land uses, and what is the relative importance of these land uses?" In addressing such questions, the proposed project will provide projections of land use, with error bounds, contributing to understanding of future land-use and vegetative-cover scenarios for the Amazon basin. That could also prove of value for second-tier issues such as (P5) regarding the "reliability of models predicting future atmospheric concentrations of carbon dioxide and methane." The research will involve key informant interviews at several field sites to address the issue of road endogeneity, satellite image interpretation to provide data for dependent variables that will be used in statistical modeling, and specification and estimation of an econometric model. In addition, an explicitly spatial model will be developed for implementation in the Santarém/Tapajos sub-region.

Objectives

We propose to construct an econometric model of land cover change for the Amazon basin in order to inform projections of future landscapes in the region. The overarching goal is to generate landscape projections for the Amazon that reflect state policies, which can influence the economics of land use decisions. To accomplish this, we focus on three key objectives that together advance beyond the limitations of prior land use models and projections. First, we will draw explicitly on social and economic theory in order to outline a behavioral model of land use decisions under specific conditions. Second, we will incorporate findings from empirical land use models from diverse local sites in order to account for spatial variation in the effects of key determinants of land use across the Amazon. And third, we will conduct field research on a heretofore unrecognized issue, namely the conditions of road extensions by local land users following initial land settlement and deforestation along state highways. These three objectives inform the specification of an appropriate econometric model on which the projections will be based.

Approaches

Our approaches stem from the social sciences, and in particular human geography, economics, and sociology. In building our basin-scale model, we will integrate the field based approach of human geographers, development sociologists, and anthropologists, with the modeling framework of econometricians. We will also rely heavily on remote sensing activities to identify areas of road-building and to produce variables to be used in the statistical models.

Plan for Integrative Science

Modeling LBA seeks to provide a regional comprehension of how the Amazon basin functions as an environmental unit, and for this reason has supported a wide spectrum of research efforts. These range from studies of the human factors driving land use and land cover change to the processes of gaseous fluxes between vegetative cover and the atmosphere. One over-riding motivation for the program is the policy context in which the Amazonian system is changing. This involves both national and international concerns about the Amazon forest. Consequently, LBA has sought to cover the gamut of research issues in an effort to answer questions such as:

"*What are the rates and mechanisms of forest conversion to agricultural land uses, and what is the relative importance of these land uses (LC-Q1)?*" & "*What is the (climatically driven) seasonal and interannual variability of the carbon dioxide flux between the atmosphere and different land cover/use types? (CD-Q1)?*"

One shortcoming to date is that the program has not answered integrated questions, such as how the mechanisms driving forest conversion impact upon the carbon dioxide flux to the atmosphere. This means that as a program we are not yet in a position to answer derivative policy/planning questions:

"*What will be the impact on carbon flux of the developmental processes in the Amazon Basin?*" & "*How will policy X affect this flux over the next 10 years? The next 20 years?*"

Thus, the LBA program has not yet addressed its underlying motivations with an approach that synthesizes scientific findings such that they can be deployed in the interest of policy assessment. One reason is that research pursuant to question LC-Q1 has been focused on household dynamics. Such work has a tightly bounded spatial focus, given the effort required to build up the data sets. An implication is that, while we have highly detailed work for several sites in the Amazon Basin, these case studies exploring the links between household dynamics and land cover change do not provide an obvious way to link to broad-scale assessments of land dynamics at a regional scale. Consequently, an essential part of our proposed research is to do precisely this, to scale-up from household-level work to the basin as a whole. The very nature of this proposal is to build upon previous LBA-funded research. Our plan is to elaborate a behavioral model informed by the theoretically-founded empirical work accomplished to date on how smallholders make their land use decisions. Along precisely these lines, we will also contact the LBA projects that have conducted such household scale work on human drivers, and the variables utilized in previous econometric work will be reassessed and refined on the basis of these consultations. In addition, we will work cooperatively with other projects in order to "scale-down," from aggregate regional projections to spatial outcomes of land cover change dynamics for sub-regional sites. In addition to addressing the scale issue, interacting with other projects working on different sites will also provide guidance in specifying spatial heterogeneity in the land cover dynamics we seek to model. This will involve discussions on how best to partition the Amazon Basin into sub-regions with varying land cover change processes. Once our econometric model is in place, we will be able to provide projections of land-cover change for the basin, as a function of many different potential inputs and scenarios. At this point, we will reach out to two communities. First, we will consult those interested in policy simulations, and inquire about their questions of interest. One such possible question might be:

"*What impact will the current plan for Avança Brasil have on the carbon cycle over the next 20 years?*"

And then, on the basis of such questions, i.e. on the appropriate, relevant focus for particular scenarios in the eyes of those in Brazil and elsewhere who are concerned with such policies, we will identify the projects in LBA that are generating data which, when joined with our land-cover projections, can improve policy-relevant scenarios. One mechanism for accomplishing this will be LBA-wide meetings.

Remote Sensing Remote sensing is key to our proposed research, which provides for a novel use of the technology in the development of a "human driver" land cover change model, as well as an actual integration of various remote sensing products in a unified effort at representing deforestation at basin scale. Thus, the modeling effort can be regarded as highly synthetic of remote sensing, behavioral theory, and econometric technique.

1) *Use of remote sensing in model elaboration*. In the past, remote sensing has mainly been used to represent two-dimensional patches of land cleared for agricultural purposes. We argue, however, that road building may be fundamentally causal to the creation of such patches, which has serious implications for econometric modeling. Thus, we are proposing to use remote sensing to identify road extensions. The identification of roads necessarily involves the deployment of a high resolution sensor (ETM+) given the dimensions involved (i.e., roads are narrow). Thus, we will be using satellite images to provide a "dependent variable," namely road extensions, that will then be incorporated as an independent variable in the integrated model.

2) *Integration of different remote sensing products*. The primary equation in the overall model implements deforestation as a dependent variable, an area measured for individual counties (or census tracts). Since this will be observed at basin scale, we will rely on existing data (collected by INPE and organized into data bases by IPEA), as well as updates that we will create from moderate resolution images (MODIS). Thus, the model we plan to implement will require the integration of high and moderate resolution remote sensing products.

In summary, our project achieves integration along various dimensions. In particular, the vary structure of the model we propose to built will integrate remote sensing products, and more generally will integrate remote sensing technology into the development and deployment of an econometric model. In fact, use of remote sensing will be key to resolving one of the econometric issues we have identified, namely the problem of road endogeneity. Beyond such technical integration within our own activities, we will also seek cooperative engagement with other LBA projects in developing our model structure, as well as in addressing the fundamental issue of scale in models of land cover change. And finally, we will reach out to the LBA community and beyond in an effort to develop policy relevant simulations. These will be undertaken pursuant to our strong interest in providing a link between LBA and the policy community, which we regard as crucial to bringing the significance of LBA findings to a public forum. Thus, in a broad sense, we will seek to integrate science and public interest, in order to contribute to the discussion on sustainable development in one of the world's critical environments.