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Thesis Details

Title	MODELING UNPLANNED LANDSCAPE CHANGE: A COLOMBIAN CASE STUDY
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Abstract

The broad aim of this study is, to contribute to a broader and more comprehensive understanding of the patterns, processes and drivers of unplanned land cover change in the tropics, using Colombia as a study case. Land cover change is an important global issue because of the expanding ecological footprint of a rapidly increasing human population and per capita level of resource consumption. This has a major impact on natural ecosystems and their function at the local (hundreds of square kilometers) and global scales. The understanding of extent and rate of land cover change is an important issue confronting biodiversity conservation, land use planning, protected area management, and global climate change analysis. Tropical deforestation is the major source of global land cover change, with the highest absolute rates occurring in South America, especially in the Brazilian Amazon, where government planning is an important driver of deforestation. However, unplanned deforestation for cropping and ranching is also occurring in Colombia. This is of international concern because Colombia's diverse ecosystems support high levels of species richness and endemism. Improving the understanding of the spatial and temporal patterns and drivers ofland cover change (both deforestation and regeneration) is an important step in developing planning and conservation strategies to address this problem. I applied a spatial and temporal statistical modelling approach to predict changes in land cover in Colombia at the local (100 km2), regional (104 km2) and national (106 km2) levels, with a timeframe spanning from decades to centuries. As dependant variable data, binary forest/non-forest data are used. Explanatory variables comprise biophysical and socioeconomic data sourced from a broad range of information sources, including remotely sensed data from aerial photographs and satellite images, secondary sources of biophysical and socioeconomic data, and historical data. At the local-level, I addressed the deforestation process over the last 60

years using six case studies of 100 km2 of humid lowland forests, by applying logistic regression and spatial analysis. At the regional-level, I studied the deforestation in the Caquetá colonization front of the Colombian Amazon region from 1988-2004 by applying a forest-cover zoning method and logistic regression models to predict deforestation and forest regeneration from biophysical and socio-economic explanatory variables. At the national level, I quantified and analysed patterns and drivers of land cover change over the past 500 years for key periods of Colombian history, and identified the extent and duration of impacts on broad ecosystem types. At the national and regional-levels, I also modelled current landscape transformation patterns and predicted areas at a high risk of future deforestation using a joint logistic regression and regression tree approach. I discovered that the rate of deforestation across several lowland regions of Colombia follows a simple sigmoid pattern composed of four phases of transformation: an initial phase of gradual forest loss; an intermediate phase of rapid loss; a second intermediate phase where the rate of decline slows; and a final phase where the forest loss stabilises and is balanced by forest regeneration creating a dynamic equilibrium. At the end of this final phase, the landscape is in a highly transformed state with forest cover stabilizing at 2 to 10% of the original extent and an average forest patch size of 15.4 (± 9.2) ha. As a general rule, the transformed landscape will have two forest components: a stable component of remnant mature tropical forests, and a dynamic component of secondary forests of different ages that is repeatedly cleared. A second important discovery was that unplanned deforestation in the Colombian Amazon moves as a colonisation wave, extending from population centres. The rate of movement was 0.84 km.yr-1 between 1989 and 2002. The regional average annual deforestation rate was 2.6%, but varied locally between –1.8% (regeneration) and 5.3%. The parallel deforestation and regeneration processes operating within the colonization front showed consistent patterns and rates directly related to the proportion of forest in the neighbourhood, with the highest rates of deforestation occurring in the areas with intermediate (40-60%) forest cover, following an overall quadratic function, and therefore confirming the sigmoid pattern across an entire colonization front. Landscapes with intermediate forest cover also have the highest density of edge habitat, with the deforestation process mimicking the spread of disease. At the national-level, the study reveals two important outcomes. First, there are significant regional differences in the spatial and temporal patterns and drivers of land cover change. The importance of such regional differences in factors explainingland cover change is highlighted by the greatest discrimination ability shown by a regional-level classification tree model. The coefficients and significance of variables in a regional logistic regression model confirmed these differences. Overall, factors related to accessibility (distance to roads and towns) had the strongest influence on the probability of deforestation. The

second national-level outcome highlights the need for a longer-term historical perspective spanning centuries to understand present-day landscapes and their level of human impact. The historical analysis reveals that the main drivers of landscape change varied in the early colonial period, with cattle grazing becoming increasingly important, and finally the high impact of economic globalization in the 1990s. The historic land cover maps show the transformed areas increasing from approximately 15 million ha in 1500 to 42 million ha in 2000. Also, during this period, the transformed areas changed from predominantly cropping land uses in 1500 to predominantly (< 75%) grazing in 2000. The research outcomes collectively provide an understanding of the spatial dynamics of unplannedland cover change in tropical forest landscapes, by showing how deforestation and regeneration processes vary along a transformation gradient, and linking the amount of remnant forests is related to the rate of change. The work has implications for policy and management. For example, the method of calculating the movement speed of a colonization front provides a spatially explicit prediction of threat that can be used in conservation planning. The improved understanding of the deforestation and regeneration dynamics over an entire colonization fronts permits more accurate calculation of carbon budgeting for climate change applications. I recommend that future work test of the generalities presented here in both, countries with unplanned deforestation and countries with planned land clearing, to evaluate the effects government controlled planning has on the end result of human transformed landscapes in tropical and subtropical forest regions.