

Forecasting land-climate interactions in the Amazon Basin: A methodology and application

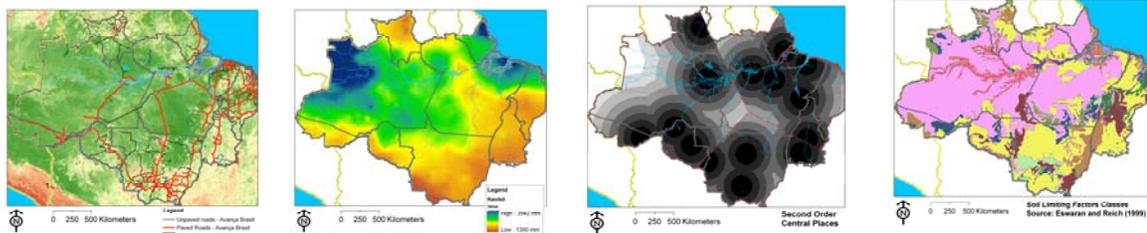
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This poster is based on early work under the LBA phase III project entitled, "Spatially Explicit Land Cover Econometrics and Integration with Climate Prediction: Scenarios of Future Landscapes and Land-Climate Interactions." A prime goal of the project is to develop and implement a methodology for climate prediction that accounts for uncertainty. The idea is as follows. Econometric models of land cover change are capable of providing probabilistic estimates of landscapes, given their theoretical foundation. We exploit this characteristic to generate "stochastic landscapes." These then serve as inputs to a regional climate model (RCM), which is executed for each landscape, using variable forcing inputs to account for uncertainty in the climate domain. Statistical moments (mean, variance) of key variables (e.g., precipitation) can then be described directly from the RCM outputs to indicate likely climate conditions associated with different scenarios of land cover change and development. In this application, we show preliminary results for climate impacts associated with deforestation, under best case (BCS) and worst case development scenarios (WCS).

Land Cover Change Model

The statistical model used is a probit model, which takes its dependent variable as a binary state (deforested/not deforested) defined on 1km grid cells, as classified by PRODES 2004 from INPE (see grid dsf1km04). The model independent variables include distance to paved roads, distance to unpaved roads, distance to first order central places (Belém, Cuiabá, and Porto Velho), distance to second order central places (municipios with population larger than 50,000 AND at least 200 km apart from first order central places), rainfall (from the CAMREX project-University of Washington), and a series of dummy variables representing indigenous lands, federal conservation units under *full protection*, federal conservation units under *sustainable use*, state conservation units under *full protection*, state conservation units under *sustainable use*, and soils. Areas originally not forested are masked out (e.g. *cerrado*, *campinaranas*, etc). The estimation is based on 4,063,451 observations.

Various independent variables

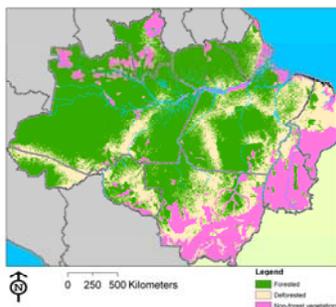
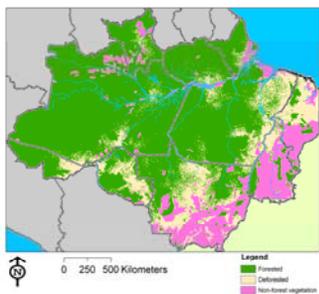


The land cover simulations generating input to the regional climate model were performed as follows:

- 1) First, the probit model was fit under the independent variables defining best and worst cases.
- 2) Coefficients for the projection were then assigned by randomly drawing values from a normal distribution with mean equal to the estimated parameter and standard deviation as reported in the probit estimates results.
- 3) Next, the coefficients were multiplied by the given variables to produce a z value ($i = 1, \dots, 4,063,451$), which was then plugged into a cumulative normal density function to calculate the p values (estimated probabilities).
- 4) These probabilities were then compared to a random number drawn from a uniform distribution. If greater, observation (cell) i was taken to be deforested.
- 5) Finally, all observations were passed through a filter to aggregate deforestation areas. The filter, a 3x3 moving window, defined a center cell as deforested if already deforested prior to the passage of the filter, and as deforested if at least five cells in the 3x3 window had been originally deforested. This rule was created prior to simulation by estimating the model, generating deforested cells, and finding the filter that equated estimated deforestation with actual deforestation in 2004.

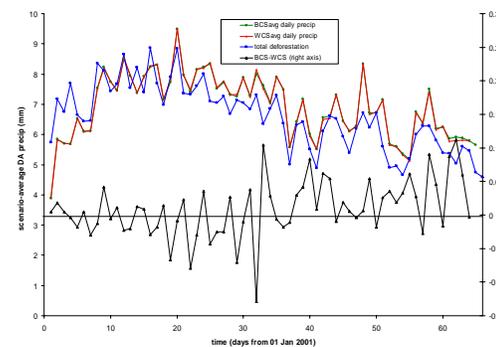
In the best case scenario (BCS), no deforestation occurs in any type of protected area or indigenous lands, and no roads are paved in the future according to *Avanço Brasil*

In the worst case scenario (WCS), all paving projects indicated by *Avanço Brasil* are completed, and protected areas have no effect on curbing deforestation.



Regional Climate Model

The land cover simulation output was input to the Regional Atmospheric Modeling System (RAMS) version 4.4, including the LEAF-2 module for the representation of surface-vegetation processes. RAMS is a three-dimensional, nonhydrostatic, general purpose atmospheric simulation system which solves the equations of motion, heat, moisture, and mass continuity in a terrain-following coordinate system. RAMS is often used as a limited area model because many parameterizations have been originally designed for mesoscale or high resolution cloud scale grids. The model boundary conditions were derived from National Centers for Environmental Prediction (NCEP) atmospheric reanalysis product. The land cover classes are from Global Land Cover 2000, crosswalked to appropriate biophysical parameters in LEAF-2.



To date, given computational intensity of the modeling process, we have only two months of output, for five simulations under the two scenarios. The domain averaged results for rainfall can be observed above, which plots daily mean rainfall values for BCS in green (n=5) and WCS in red (n=5), as well as results for the extreme case of a totally deforested basin (in blue). The results suggests little difference between best and worst case precipitation. This result is reinforced by the small effect associated with total deforestation. However, the basin-scale aggregate results conceal distinct spatial patterns, as shown for albedo and rainfall below.

