

**Final Progress Report**  
**Sustainability Science Program, Harvard University**  
**Term: September 1, 2011 – August 31, 2012**  
**Submitted: July 2012**

**Name:** Angélica M. Almeyda Zambrano

**Your field(s):**

Anthropology, Land use, and land cover change

**Your degree program, institution and (expected) graduation date:**

PhD, Department of Anthropology, Stanford University  
Expected August, 2012

**Faculty host(s) at Harvard name and department:**

William C. Clark, Kennedy School of Government  
Theodore C. Bestor, Department of Anthropology

**Description of SSP-related research activity:**

**Title:** Road infrastructure development and deforestation in Southwest Amazonia: a tri-national frontier study

**Abstract:** Infrastructure development is a priority in many tropical countries. Road infrastructure in particular has been linked to deforestation. However, there is little understanding of how road infrastructure interacts with population and market dynamics to influence forest clearing. To address this question we conducted a large-scale interdisciplinary research project in the tri-national Amazonian frontier of Peru, Brazil, and Bolivia, encompassing 101,463 km<sup>2</sup>. This setting, a gradient of young to old Amazon frontier areas, provides a unique opportunity for the study of human environment interactions under varying stages of road infrastructure development while holding significant variation in biophysical variables constant. We couple multivariate statistical approaches on roads, population, markets, and deforestation with multitemporal spatial analysis of deforestation and infrastructure development using remote sensing and geographic information systems. This study highlights the dynamic conditions occurring in Amazonian frontier regions, showing rapid road infrastructure development, expansion of markets and decrease in forest cover. We found that travel time to the nearest market dominates deforestation dynamics, with infrastructure development representing decreased travel cost to these markets. Findings from this study support a deforestation framework focusing on urban population and market dynamics, versus rural smallholders, and highlight the importance of modeling landscape deforestation using travel time versus spatial proximity approaches. Results are directly applicable to both furthering the theoretical understanding of human-environment interactions in frontier landscapes, as well as for applied environmental conservation and sustainable development efforts in the tropics.

**Identification of the problem you address:** The Amazon is the largest contiguous tropical forest and concern with its deforestation is motivated by the irreversible loss of biodiversity, the negative effects of such land use changes on key ecosystem services, and the observation that these losses are greater than the economic and social gains. Approximately 30 million people live within the Amazon basin and about 1.5 million are colonists often surviving through subsistence agriculture and maintenance of small cattle herds. Road improvement is an important priority in many Amazonian countries because transportation plays an important role in development. But deforestation is also concentrated within 50 km of paved highways and there is little understanding of how road investments influence land use among colonists.

**Key question asked about the problem:**

How do development policies, specifically road investments, influence forest clearing at the landscape scale?

**The methods by which you answered that question:**

To address this question we conducted a large-scale interdisciplinary research project in the tri-national Amazonian frontier of Peru, Brazil, and Bolivia encompassing 101,463 km<sup>2</sup>.

**Principle literature upon which the research drew:**

Political Ecology, Land Change Science, and Ecological Anthropology.

**Empirical data acquisition description:**

GPS (Geographic Information System) points representing the variability of land uses were collected from 300 households in the three sides of the border. Over 70 Landsat satellite images were analyzed to create forest cover maps for the years 1990, 2000 and 2007.

**Geographical region studied:**

Tri-national Amazonian frontier of Peru, Brazil, and Bolivia

**Recommendations that might be relevant for your problem:**

Results of this study support a deforestation framework focusing on urban population and market dynamics, and highlight the importance of modeling landscape deforestation using travel time versus spatial proximity approaches.

**A description of the final product(s) you have/are aiming to produce:**

The study "Road infrastructure development and deforestation in Southwest Amazonia: a tri-national frontier study" is now a chapter in my dissertation and it is currently in preparation for submission to a journal.

Almeyda Zambrano, Angélica M. 2012. The Political Ecology of Land Conversion in the Tri-National Border of Southwest Amazonia. PhD dissertation, Anthropology Department, Stanford University.

**Description of major other intellectual or professional advancement activity(ies) over the past academic year:****Journal articles published**

Broadbent, Eben N., Angélica M. Almeyda Zambrano, Rodolfo Dirzo, William H. Durham, Laura Driscoll, Patrick Gallagher, Rosalyn Salters, Jared Schultz, Angélica Colmenares and Shannon Randolph. 2012. The effect of land use change and ecotourism on biodiversity: a study of Manuel Antonio, Costa Rica, from 1985-2008. *Landscape Ecology* 27:731-744.

**Journal articles in review**

Duchelle, Amy E., Angélica M. Almeyda Zambrano, Sven Wunder, Jan Börner, Karen A. Kainer. *In review*. Livelihoods and conservation in smallholder-managed forests in Southwestern Amazonia: the role of Brazil Nut. *World Development*.

**Journal articles in preparation**

Chavez, Andrea B., Angélica M. Almeyda Zambrano, and Eben N. Broadbent. *In prep*. Detection of twenty-year deforestation and land conversion in Southeastern Peru.

Almeyda Zambrano, Angélica M., Eben N. Broadbent, Amy E. Duchelle, Gregory P. Asner, David E. Knapp, Sven Wunder, and William H. Durham. *In prep*. Household land cover and land use in a dynamic frontier: integrating landscape and landholding scales.

Almeyda Zambrano, Angélica M., Eben N. Broadbent, Amy E. Duchelle, Gregory P. Asner, David E. Knapp, Sven Wunder, Ronnie Babigumira, and William H. Durham. *In prep.* Livelihood trajectories and deforestation among smallholders in Southwest Amazonia.

**Citations for reports, papers, publications and presentations that built on your fellowship research:**

Almeyda Zambrano, Angélica M. 2012. The political ecology of land conversion in the tri-national border of Southwest Amazonia. Dissertation. Department of Anthropology, Stanford University. Stanford, California.

Almeyda Zambrano, Angélica M., Eben N. Broadbent, Gregory P. Asner, David E. Knapp, Amy E. Duchelle, Sven Wunder, and William H. Durham. *In prep.* Road infrastructure development and deforestation in Southwest Amazonia: A tri-national frontier study.

**Principal collaborators outside Harvard:**

William H. Durham, Department of Anthropology, Stanford University

Gregory P. Asner, Department of Global Ecology, Carnegie Institution for Science

Amy E. Duchelle, Center for International Forestry Research

Sven Wunder, Center for international Forestry Research