Modeling the Scale Dependent Drivers of LCLU Dynamics in NE Ecuador

- Stephen J. Walsh* & Richard E. Bilsborrow^, Department of Geography*, Department of Biostatistics^, & Carolina Population Center, University of North Carolina - Chapel Hill

- Joseph P. Messina, Michigan State University
- George P. Malanson, University of Iowa
- Kelley A. Crews-Meyer, University of Texas
- David Romo, San Francisco University, Ecuador
- Galo Medina, Ecociencia, Ecuador
- Eduardo Arguello, CEPAR, Ecuador

- http://www.cpc.unc.edu/projects/ecuador/

Introduction: Ecuador

- **Questions:** What are the rates, patterns, and mechanisms of forest conversion to agriculture, pasture, secondary plant succession, and urban uses? What is the relative importance of exogenous and endogenous variables on LCLU patterns? How do scale dependent drivers of LCLU dynamics and space-time patterns operate across multi-thematic domains? What are plausible scenarios of future land cover change and their policy implications?

- **Goals:** Simulate patterns of landscape change and assess their causes and consequences through multi-level models and cellular automata (CA), and derive policy implications. Linear and non-linear responses are investigated for ecologically critical landscapes to model responses to a range of spatial patterns of LCLU derived through hypothetical, modeled, and observed conditions.

- **Approaches:** Multi-level models are used to integrate household, community, and regional variables that affect farm household decision-making and mapped LCLU patterns. Spatial simulations are developed through CA approaches at annual and decadal scales. CA patterns are compared to actual patterns represented in the satellite time-series and assessed through image change-detections, change trajectories or pixel histories, summary correlations, and pattern metrics to compare expected vs. observed LCLU patterns.

Results: Ecuador

- **Most Significant:** Generalized Linear Mixed Models or Multi-Level Models are used to examine LCLU change patterns at the farm-level for 1990 and 1999. Results indicate that rapid population growth caused substantial subdivision of plots, which in turn created a more complex and fragmented landscape in 1999 than in 1990. Key factors predicting landscape complexity are population size and composition, plot fragmentation, location of the plot relative to roads and towns, age of plot, soil quality, and topography. Multi-level models combine variables and effects from multiple scales into an integrated approach of LCLU dynamics, which allows assessment of the scale dependence of variable interactions on LCLU patterns.

- **Future Steps:** CA models of LCLU dynamics will be examined for uncertainty through: a) incorporating stochastic elements of the derived statistical models assessed through the multi-level models, b) comparing initial conditions against the satellite image time-series, c) studying variations in the characterization of LCLU patterns through pattern metrics, d) examining impacts of time, including time steps of model simulations and time lags, spatial scale of the LCLU characterizations, and of integrating the effects of changes in both individuals/households and communities on model outcomes.

Conclusions: Ecuador

- **Most Important:** The complexity of human settlement in this frontier environment of extraordinary biodiversity is affected by positive feedbacks in the spatial pattern of LCLU change by migrant farmers. Exogenous and endogenous drivers represent a complex set of forces that affect LCLU change patterns in fundamental ways. The spatial pattern of forests and the nature of LCLU change trajectories are critical to understanding social and biophysical processes. CA approaches can test alternative views of landscape dynamics that can be explored within a policy context.
- **Selected Publications:**

- Messina, J.P. and Walsh, S.J., 2003. Dynamic spatial simulation modeling of the population-environment matrix in the Ecuadorian Amazon. *Environment and Planning B*, in review
- Malanson, G.R., Zeng, Y., Walsh, S.J., 2003. Complex frontiers in the Ecuadorian Amazon. *Environment and Planning A*, in review.
- Pan, W.K.Y., S. J. Walsh, R.E. Bilsborrow, B.G. Frizzelle, C.M. Erlien, F.D. Baquero. 2003. Farm-level models of spatial patterns of land use and land cover dynamics in the Ecuadorian Amazon. *Agriculture, Ecosystems, and Environment*, in press.
- Walsh, S.J., J.P. Messina, K.A. Crews-Meyer, R.E. Bilsborrow, W. Pan, 2002. Characterizing and modeling patterns of deforestation and agricultural extensification in the Ecuadorian Amazon. In: *Linking People, Place, and Policy: A GIScience Approach* (S.J. Walsh and K.A. Crews-Meyer, editors), Kluwer Academic Publishers: Boston, 187-214.