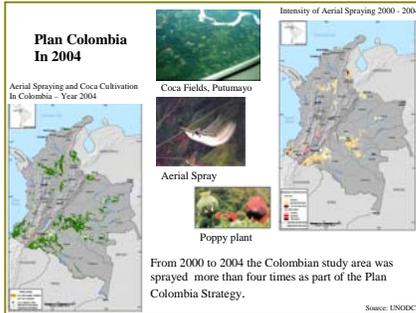


Simulating the Effects of "Plan Colombia" on Land Use and Land Cover in the Ecuadorian Amazon: A Complex System Approach

Abstract

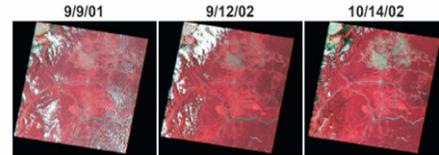
This research, using recently developed cellular automaton modeling procedures and a temporally rich case study, develops spatially-explicit model-based simulations of future land use and cover change (LUCC) scenarios for the Northwestern Amazon, specifically the humid tropics along the Colombian border. The research draws heavily upon recent work in remote sensing, complexity theory, and related social and biophysical disciplines. Remote sensing techniques, including fractional coverage (fc), are developed and presented that map and model landscape level changes. A cellular automaton (CA) model representing LUCC is developed, calibrated, and validated using a time series of remotely sensed images and sketch maps from the region in northeastern Ecuador linked to spatially referenced biophysical and socioeconomic coverages as input data combined with "rules" derived from empirical analyses of those data. Further, dynamic spatial simulation models are used to explore LUCC resulting from Plan Colombia (the US based program to eradicate drug production in bordering Colombia). Finally, Deviation from Neutral (DN), a new landscape modeling technique, is presented to illustrate the nature of change throughout the region.



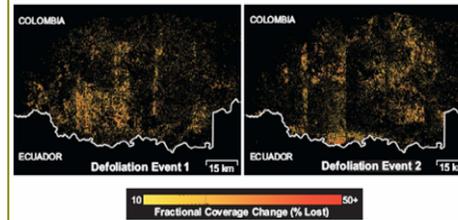
Plan Colombia Defoliation

Messina, J.P., and P.L. Delamater, (under review). "Defoliation and the War on Drugs in Putumayo, Colombia." *International Journal of Remote Sensing*.

Visual changes in the Putumayo region



Using fc to highlight areas with greater than 10% loss



Collateral damage to agricultural and non-coca land cover types in Putumayo, Colombia. Using a common color ramp, the broad scale vertical striping associated with aerial defoliation and the east-west shift in flight paths is displayed

LULC classification from ground digital video in a Palm Plantation - Ecuadorian Amazon -

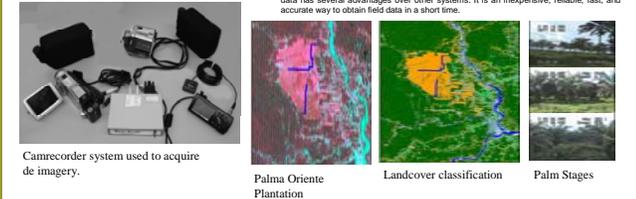
with Carolina Santos, Ph. D. Student, Geography Department, MSU

ABSTRACT

The acquisition and processing of remote sensing images at high spatial resolution is expensive and time intensive. Ground video data collection is an alternative to satellite data for detailed LULC classification. During the June 2005 a system composed of two Sony digital camcorders, coupled with a Garmin GPS and data integration unit was used to record ground video data in the northeast part of Ecuador in the Sucumbios Province. Over a 15 day sampling period, 17 hours of digital video data were collected. This research uses a sample of the digital video data to create a land use land cover classification inside and around the largest agro-industrial plantation in the Ecuadorian Amazon, Palma Oriente.



The LULC classes were visually assigned to a continuous field and passed into a 10 meter raster matrix. The video dataset was sub-sampled for assignment of classification information as well as for the accuracy assessment. From this ground digital video an accurate, high spatial resolution LULC classification was produced. Ground digital video data has several advantages over other systems. It is an inexpensive, reliable, fast, and accurate way to obtain field data in a short time.



Camrecorder system used to acquire de imagery.

Palma Oriente Plantation

Landcover classification

Palm Stages

with Paul Delamater, PhD student, Department of Geography, MSU

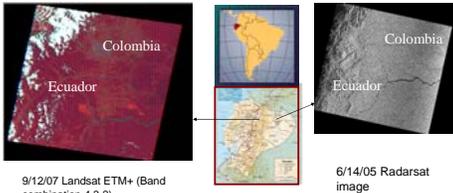
Field Work 1999 - present



PUBLICATIONS

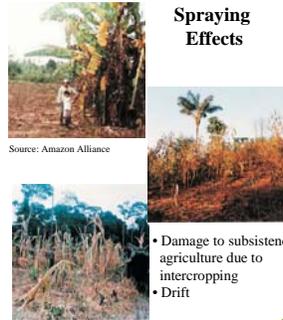
Walsh, S.J., Messina, J.P., Malanson, G.P., and C.F. Mena. (under review) From Cellular Automata to Experimental Agent Based Models: Evolving Questions and Approaches in the Study of Complexity and Land Use Change in the Northern Ecuadorian Amazon. *Geoforum*.
 Messina, J.P., Delamater, P.L., and C. M. Harty. (under review) Deviation from Neutral: Moving Pattern Metrics from Static to Dynamic. *Professional Geographer*.
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 Walsh, S.J., Messina, J.P., Crews-Meyer, K.A., Ribiccoro, R.E., and W.K. 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 eds.). Kluwer Academic Publishers: Boston, pp 187-214.
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Study Site – Regional view



The study site is located in the Northeast corner of Ecuador 60 miles from the Colombian border in the headwaters of the Napo and Aguarico river basins. This is an ideal area for data collection given the absence of seasonality in the vegetation. However, changes in vegetation and LULC as a result of colonization processes, oil field exploitation, and expansion of the agricultural frontier are common in the region.

Spraying Effects

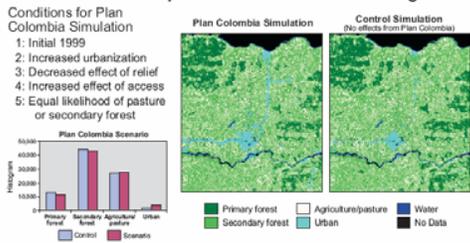


• Damage to subsistence agriculture due to intercropping
 • Drift

Complex Systems Modeling

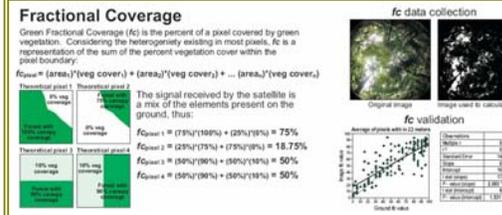
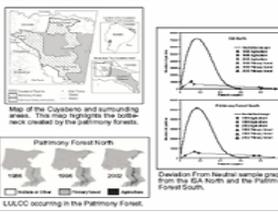
- Spatial and aspatial LUCC predictions
- Alternative theoretical framework for modeling the world

Plan Colombia Comparative Test Simulation through 2010



Ecuadorian National Parks

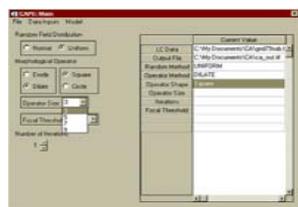
Messina, J.P., J.L. Weeks, C.F. Mena, and P.L. Delamater. 2006. "Land Tenure and Deforestation Patterns in the Ecuadorian Amazon: Conflicts in Land Conservation in Frontier Settings." *Applied Geography: People and Parks*.



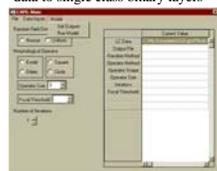
CAPE: Cellular Automata Potential Energy

With Chris Barber, M.A. student, Department of Forestry, MSU

Cellular Automata: How it works
 • Dynamic, discrete space-time systems
 • Regular grid of cells each in a finite state
 • Iterative updated via discrete time steps
 • A cell state is determined by the states of the neighboring cells in the previous time step
 • Ability to grow, vary rates, or reverse direction
 • Capability to infuse concepts of thresholds, feedbacks, and hierarchy



Main Menu
 • Read input "initial-state" LC data layer
 • Binary decomposition of input LC data to single class binary layers



Random Field Options
 • Combination of each LC class w/new random value field and default PE layers



Mathematical Morphology
 • Layer thresholding
 • User-defined morphological operator



Modeling Process
 • Classes recombined at the end of the iteration
 • Result decomposed for next iteration or written to output file



Significant Milestones

- Graduate Student Thesis: "Mapping and Modeling Tropical deforestation: A Case Study on the Effects of Plan Colombia" Paul Delamater, May 2004
- Current Ph.D. students: Carolina Santos and Paul Delamater
- 16 papers/chapters/proceedings published or in press
- 25 presentations including to the Ecuadorian Minister of the environment and the Deputy Director of Intelligence of the drug and Enforcement Agency
- Field work in the summer of 2003, 2004, 2005 and 2006
- Deviation from Neutral Landscape Metrics (DN)
- CAPE: education aid and modeling tool