

**Land tenure, property rights and land cover and land use change at transboundary sites in the  
Mesoamerican Biological Corridor**

Grant Number: NNX13AC70G

Progress Report for reporting period:

January 1, 2015-December 31, 2015 (Year 3)

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## **1. Goals and Objectives Accomplished in Year 3 of Project**

### ***1.1 Progress of students supported on this grant***

The two Ph.D. students supported by this project – Peter Schlesinger and Carlos Muñoz Brenes – successfully completed their second academic year in May 2015 and began their third year at the University of Idaho (UI) in August 2015. One of the students is participating in a joint doctoral degree program between UI and the Center for Tropical Research and Education in Agriculture (CATIE) in Costa Rica, and resides at the CATIE campus to leverage the knowledge base about Mesoamerican LCLUC that exists at that institution. Both students have finalized their dissertation proposals, completed preliminary examinations, and advanced to PhD candidacy.

### ***1.2 Research objectives accomplished***

Major objectives for year 3 of this project included: 1) mapping LCLUC and comparing fine versus medium scale data products, 2) estimating the impact of land tenure and other drivers on LCLUC, and 3) manuscript preparation and submission. Progress toward each of these objectives is detailed below.

#### **1.2.1 Mapping LCLUC in Trifinio Region and comparing fine versus medium scale data**

We have compared existing secondary data sets created from approximately 25 years of medium scale imagery (Landsat sources -- CATHALAC, 2011; GLCF/GSFC, 2014; Hansen et al. 2013; Kim et al. 2014) across political borders to better understand observed and modeled changes in forest cover due to land use (particularly of agricultural sources -- coffee, agroforestry, food crops, and pasture) in order to better understand changes observed in fine resolution decade-old IKONOS and recent Worldview 2 images (made available through a partnership with the United States Fish and Wildlife Service). Through comparison with the high-resolution imagery, we have found evidence that the recent global Landsat products are masking anthropogenic impacts of coffee agriculture. Preliminary analyses show that the Landsat forest cover product released by Hansen et al. (2013) may be underestimating deforestation in the Trifinio Region of Central America by a factor of four. In a similar vein, it appears that the newest Kim et al. (2014) land cover map may miss up to 95% of coffee production activities. The results of this analysis are part of a submitted manuscript (Schlesinger et al. *in review*), and understanding how these errors may affect econometric estimates is an ongoing task.

We will complete our primary mapping of land cover change in the Trifinio Region in winter 2016. In multiple trials, we have found (as others have elsewhere) that the mixed forest cover type in the region is confused with coffee agriculture, partially because mixed forest type is used as a cover method for shaded multi-strata agroforests, and also because of spectral

similarity. To remedy this issue we are currently: 1) conducting classifications of key forest transitions (pasture, agriculture, urban, bare soil, and agroforestry where conclusively apparent) in Landsat using high resolution data (i.e., IKONOS, Worldview, and RapidEye) to direct the collection of training site polygons; 2) measuring greenness over time via tasseled-cap (offset by the classified forest transitions); and 3) carrying out similar classifications with high resolution data and comparing these to the Landsat classifications to confirm accuracy.

In the upcoming year, we will be testing additional questions about if and where conservation is impeding infrastructural and agricultural development, as intended in a tri-national land management agreement. In addition, we will research the relative importance of the proximity to roads and water resources, with regards to their importance for explaining transitions between agricultural and agroforestry land uses.

### 1.2.2 Evaluating the impact of land tenure and other drivers on LCLUC

We estimated econometric models of land cover change for the Trifinio region using a secondary Landsat-derived product for the years 1986, 2001 and 2010. We found strong correlations between forest cover loss and population growth and accessibility. Additionally, we have compared rates of change across countries and within countries, finding considerable unexplained heterogeneity within countries. The econometric model and findings are detailed in Schlesinger et al. (*in review*). In 2016, we will conduct interviews with municipality leaders to determine how differences in economic incentives and land governance within the same country are related to observed differences in remote sensing imagery and econometric models. This will result in one new publication that combines interview data with the econometric model of land cover change for Trifinio.

A large effort was undertaken this year to detail governance and land use decisions within and around protected areas in the Trifinio Region, an important land tenure category for the Mesoamerican Biological Corridor. There is a growing emphasis on rigorous evaluation of the effectiveness of protected areas (Ferraro and Pressey 2015); however, many of these efforts do not include local level information. In our project we are combining best practices on evaluating the impact of protected areas on deforestation with detailed, qualitative information on how protected area governance is related to deforestation. In fall 2015, a survey was developed to assess:

1. Decision making authority, responsibilities and administrative capacity of protected areas;
2. Relationships between protected areas and local communities; and
3. Perceived threats to protected areas.

A total of 11 staff members of protected areas in Trifinio, and 1 staff member of the Trifinio Commission, were interviewed. These interviews provided information on 20 of the 22

protected areas located within the Trifinio Region. Interviews have been transcribed and data are currently being extracted. Data analysis will start in winter 2016. We anticipate at least two papers with these data: a paper detailing protected area management in Trifinio and a paper that evaluates the effectiveness of protected areas via remote sensing imagery, that draws on the interview data to contextualize results.

### 1.2.3 Publications and Conferences

We have two papers from this project in review at peer-reviewed journals. The first paper synthesizes LCLUC for the Trifinio Region. This paper uses Landsat imagery to describe land cover changes between 1986 and 2010 and presents an econometric model of land cover drivers. Additionally, the paper provides a comparison between globally-derived Landsat products, specifically Hansen et al. 2013 and Kim et al. 2014, and locally-derived Landsat products. The paper is in review at *Ecology & Society* (Schlesinger et al., *in review*). A second paper in review ( at *Water Policy*) covers the topic of water management in Trifinio Region and reports on perceptions of changes in forest cover and its relation to water quality and quantity. It also presents an empirical model of willingness to participate in community-based water monitoring (Jennewein et al., *in review*).

In addition to the publications in review, we showcased research from this project at two venues in 2015. First, we presented project results at the annual LCLUC team meeting in MD in April 2015. Second, PhD student Muñoz Brenes attended a specialized course on “Integrated Land Use Systems” (ILUS) in Freiburg Germany in June 2015. There were participants from all over the world presenting case studies from their region. Muñoz Brenes presented preliminary findings in the Trifinio region, Central America as a case for ILUS, entitled: “Integrating Conservation Approaches and Drivers of Land Cover and Land Use Change in Central America”. The presentation focused on the history of Trifinio in Central America, a description of the landscape and characteristics of integrated land uses systems in the region (e.g., protected areas and mixed uses in an around the reserve of the biosphere), and knowledge gaps and potential for further research on ILUS.

## **2. Delays in Meeting Established Goals**

We are approximately 9-12 months behind schedule due to the delayed start of the project: instead of ramping up in January 2013 when the award was made, graduate students did not come on board and we did not have our first field visit and team meeting until August 2013. With our no-cost extension for 2016 we will complete our LCLUC mapping and econometric modeling by December 2016, with at least two new manuscripts submitted in 2016, and an additional three to four from this project submitted in 2017.

## Citations

- Ferraro, P.J. and R.L. Pressey. 2015. Measuring the difference made by conservation initiatives: protected areas and their environmental and social impacts. *Phil Trans R Soc B* doi: 10.1098/rstb.2014.0270.
- Hansen, M.C. et al. 2013. High-resolution global maps of 21<sup>st</sup>-century forest cover change. *Science* 342: 850-853.
- Jennewein, J.S. and K.W. Jones. *In review*. Examining 'Willingness to Participate' in Community Based Water Management in a Transboundary Conservation Area in Central America. *Water Policy*.
- Kim, D.H. et al. 2014. Global, Landsat-based forest-cover change from 1990 to 2000. *Remote Sensing of Environment* 155: 178-193.
- Schlesinger, P., C.L. Muñoz Brenes, K.W. Jones, and L. Vierling. *In review*. "The Trifinio Region: a case study of transboundary forest change in Central America." *Ecology & Society*.