Differential Impacts Across Farmers of a Deforestation Ban in Eastern Paraguay

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INTRODUCTION

MOTIVATION

- Forest cover in Eastern Paraguay's Atlantic Forest fell from 73% to 25% between 1975 and 2000 [1]. The deforestation was primarily driven by agriculture
- In December 2004, the Zero Deforestation Law made deforestation illegal in Eastern Paraguay

- Deforestation did not fall to zero

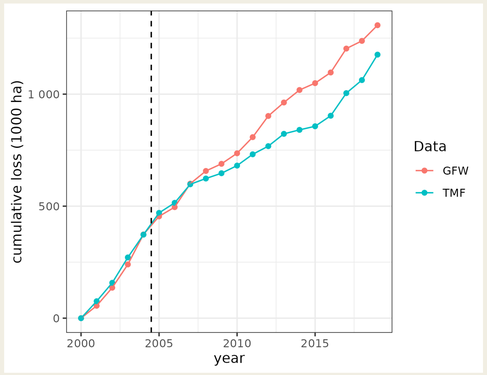

Fig 1: Cumulative deforestation in Eastern Paraguay from 2001 through 2019, based on the Global Forest Watch and the Tropical Moist Forests datasets. The dashed line indicates the implementation of the Zero Deforestation Law.

RESEARCH QUESTION

How were the impacts of the Zero Deforestation Law distributed across types of farmers in Eastern Paraguay?

Do changes in deforestation patterns result from changes in which land parcels are deforested, or changes in the land use of parcels that would have been deforested regardless?

CONTRIBUTION

- Evaluations of policies to lower deforestation traditionally focus on the efficiency of these policies in lowering aggregate deforestation

- This analysis shifts the focus from efficiency to the distribution of impacts
  - Deforestation policies have large impacts on local populations and can limit economic opportunities, regardless of the net impact on forest cover

  - After the Zero Deforestation Law was implemented, the incentives for and consequences of deforesting changed for local farmers, and these changes may not have been equally distributed

  - It is important to understand who is impacted by these policies and in what ways. Small- and large-scale agriculture are conducted by different groups in Eastern Paraguay

EMPIRICAL APPROACH

1. LAND USE DATA GENERATION

I generate a proprietary dataset of the agricultural use of recently deforested land in Eastern Paraguay.

The steps are:

1. Take a random sample of pixels that are deforested in the Global Forest Watch dataset between 2001 and 2010 and had an initial tree cover of at least 30%, with the number in each year proportional to the portion of total deforestation in that year.

2. Categorize the agricultural land use using Google Earth Pro imagery. Land use categories include:
   - Small: fields or pasture areas less than five hectares, often located within patterns of small-scale settlements
   - Large: mechanized fields greater than 5 hectares not located within a settlement pattern
   - Rangeland: non-cultivated cleared areas greater than 5 hectares not located in a settlement pattern

Small-scale agriculture:
Non-mechanized, often subsistence oriented. Produce mandioca, beans, maize, peanuts, and, until the 1990s, cotton. Small numbers of livestock including cattle.

Large-scale agriculture:
Mechanized, commercial production. Main products include soy, maize, wheat and sugarcane.

Rangeland:
Large pastures and rangeland for commercial cattle production

2. RANDOM FOREST MODELS

- Random forest machine learning models are trained using the generated land use data. These models predict the post-deforestation agricultural land use of recently deforested pixels
- Separate random forest models are trained using deforestation that occurred before the ban ("pre") and deforestation that occurred after the ban ("post")
- Explanatory variables come from the literature on drivers of deforestation [2]
  - measures of nighttime lights
  - proximity to roads
  - elevation
  - slope
  - soil group
  - ecoregion
  - measures of nearby tree cover
  - protected area status

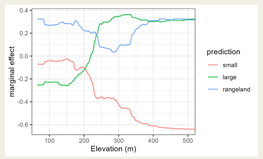

Fig 2: the marginal impact of elevation on the likelihood that a pixel is predicted to small, large, or rangeland use post-deforestation

3. LAND USE PREDICTION

- Land use predictions are generated for all pixels deforested in Eastern Paraguay between 2001 and 2019 using both the "pre" and "post" models
  - The "pre" model outputs the most likely land use of deforested pixels based on clearing patterns before the Zero Deforestation Law
  - The "post" model outputs the most likely land use of deforested pixels based on clearing patterns after the Zero Deforestation Law

RESULTS

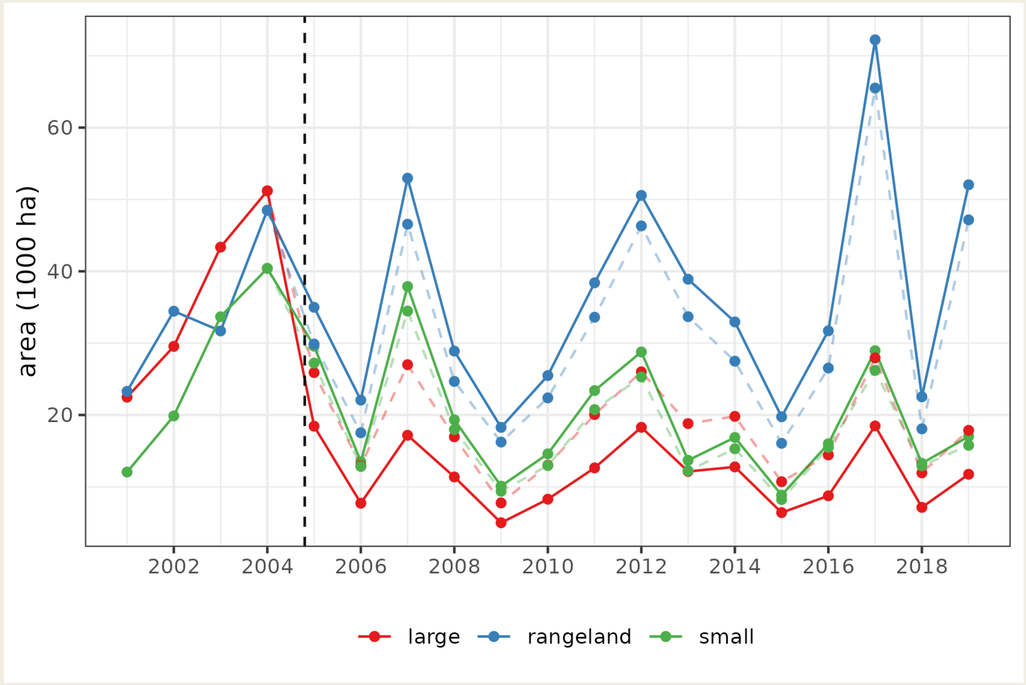

Fig. 3: Agricultural land use predictions for pixels deforested between 2001 and 2019. Every pixel deforested in each year in Eastern Paraguay is predicted to be later used for large-scale agriculture, small-scale agriculture, or rangeland. Solid lines indicate predictions generated using the model appropriate for the deforestation year: the "pre" model until 2004, and the "post" model after 2004. The dashed lines shows the predictions generated using the "pre" model in the post-implementation period.

- Large-scale farmers were most impacted by the Zero Deforestation Law
  - After implementation, the deforested area predicted as large-scale agricultural land use drops
  - A similar drop is not observed for predicted small-scale agricultural or rangeland use

- The net change in deforestation can be broken down into two parts:

  Composition effect:
  - Pixels that are deforested after the Zero Deforestation Law are not the same pixels as would have been deforested if the law were not passed
  - This can be seen in the drop in area predicted as large-scale use after the ban even when predictions are generated with the "pre" model (the post-2004 dashed line). Pixels that would have been cleared for large-scale agriculture before the ban are no longer being cleared, so they absent from the input dataset of all deforested pixels

  Land use effect:
  - Pixels that would have been deforested for large-scale agricultural use before the Zero Deforestation Law are more likely to be deforested for rangeland or small-scale use after
  - This can be seen in the comparison between "pre" and "post" model predictions after the Zero Deforestation Law is passed. After 2004, the "pre" model (post-2004 dashed line) predicts more deforestation for large-scale uses and less deforestation for small and rangeland uses than the "post" model when given the same input data.

DISCUSSION

- A decrease in clearing for large-scale systems is a potential benefit for biodiversity, due to higher crop diversity and increased natural habitat around small-scale fields and rangelands

- It is also a potential benefit from an equity perspective, since decreases in deforestation are not gained at the expense of the more economically vulnerable small-scale farmers

- Future research will investigate possible spillovers from the decrease in clearing for large-scale agriculture into already deforested land using agricultural production data

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[2] Busch, J., & Ferretti-Gallon, K. (2017). What drives deforestation and what stops it? A meta-analysis. Review of Environmental Economics and Policy, 11(1), 3–23. https://doi.org/10.1093/reep/rew013