Deforestation Monitoring in Rondônia (Brazil), 2001-2013

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INTRODUCTION

Deforestation has been a recurring concern throughout the South American country of Brazil, home to the world's largest tropical rainforest. Brazil's past efforts to become a prominent agricultural giant in the world economy, and a more urban country, have had an enduring impact on forest cover loss. In particular, the Brazilian state of Rondônia is widely known for deforestation related to cropland expansion, cattle ranches, and urban sprawl. The state was a national hotspot of extensive forest clearings from the mid-1970s to the late 1980s. Long-term satellite data archives provide a solution for deforestation monitoring at the decadal scale. A number of satellite-based products were developed to monitor forest cover for Rondônia, including PRODES (Programa Despoluição de Bacias Hidrográficas), implemented since late 1990s by Brazilian Government; and the University of Maryland Global Forest Watch (GFW) data, which has monitored global tree cover change annually since 2000. The goal of this study was to cross-validate both satellite-based products using a probability-based sample and Landsat time-series imagery as reference data (Hansen et al. 2013). To perform this, 30 x 30 meter pixels were visually classified as no-loss or loss. In addition, sample analyses enabled the disaggregation of gross forest loss by cause (clearing for cropland, pasture, urban, etc.). We also estimated the proportion of clearing of primary versus secondary forest. Our results can be tested for suitable for validating other remote sensing-based products over Rondônia, as well as for regional carbon accounting.

METHODS

Image interpretation

In order to determine loss or no-loss for sample pixels, Landsat images were evaluated based on:

- Color: Was there a change in color or shade in the sample pixel? (Images 1 & 2)
- Shape: What is the general form, structure, or outline?
- External Information: What spatial properties can be correlated to the pixel change?
- High resolution satellite images: Google Earth
- Reasoning: Logical inference

If a pixel was considered a loss pixel the **loss cause** and **land cover type**, before clearing, was determined by the same processes as above.

Quality Assessment

After classifying the sample pixels as either loss or no-loss, the aggregate data was cross checked for accuracy by an external analyst. Based on feedback any inaccurate data was revised.

Statistical Analysis

Simple random sampling was used to allocate 10,000 samples over the entire Brazilian Amazon. 909 samples randomly fall into the state of Rondônia. To estimate the proportion of forest loss from the total area sampled, the number of loss pixels for each year (2001-2013) in each loss category was divided by the total number of sample pixels in the state, and then multiplied by the total state sampled area, in square km. The purpose of this procedure was to determine the distribution of deforestation per year in relation to the forest loss cause. (Figure 1)

Validation

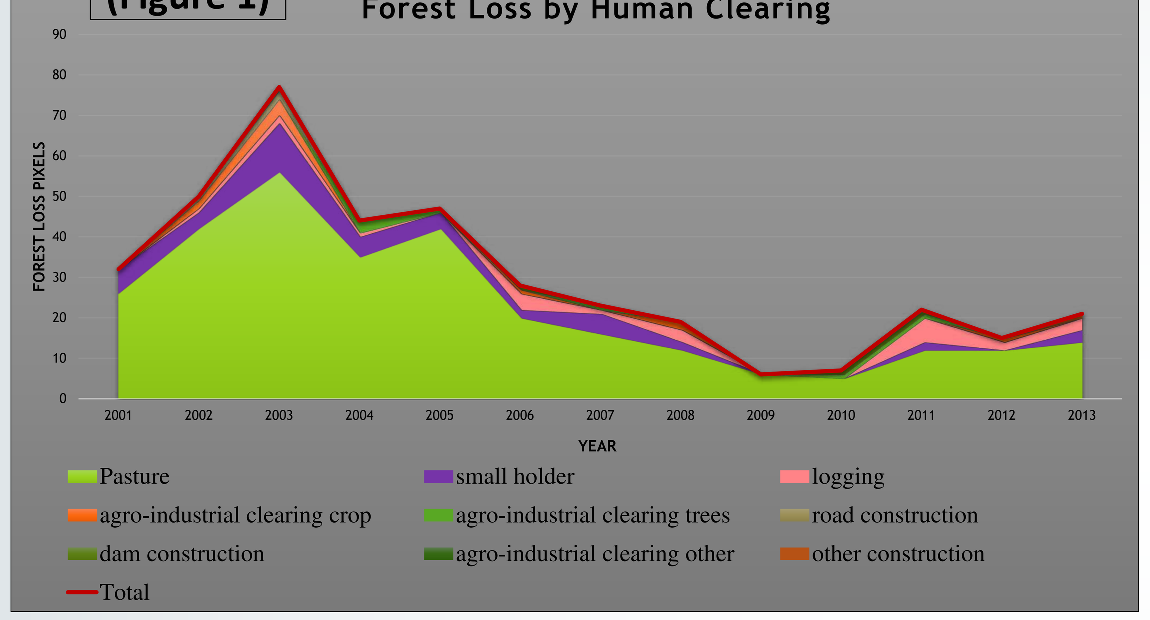
Figure 2 shows the results of the cross validation between GFW and PRODES with Landsat time-series imagery (Sample-based result) as the reference data.

DATA

- Sample pixels were generated from Landsat 7 satellite images. These pixels would be classified as loss or no loss.
- Landsat 7 images have a spatial resolution of 30 meters and a 30 x 30 meter reference box was used to select the pixel for analysis (Image 1).
- The samples were obtained from the time period of 2001 to 2013
- High-resolution reference images were obtained from Google Earth and used in the interpretation of each pixel. However, a number of their hi-res images were affected by cloud. interference. This interference was removed by the addition of a cloud mask layer.
- The data found in the maps were based on spatially referenced points from layers in ArcMap

RESULTS

(Figure 1)



(Figure 2)

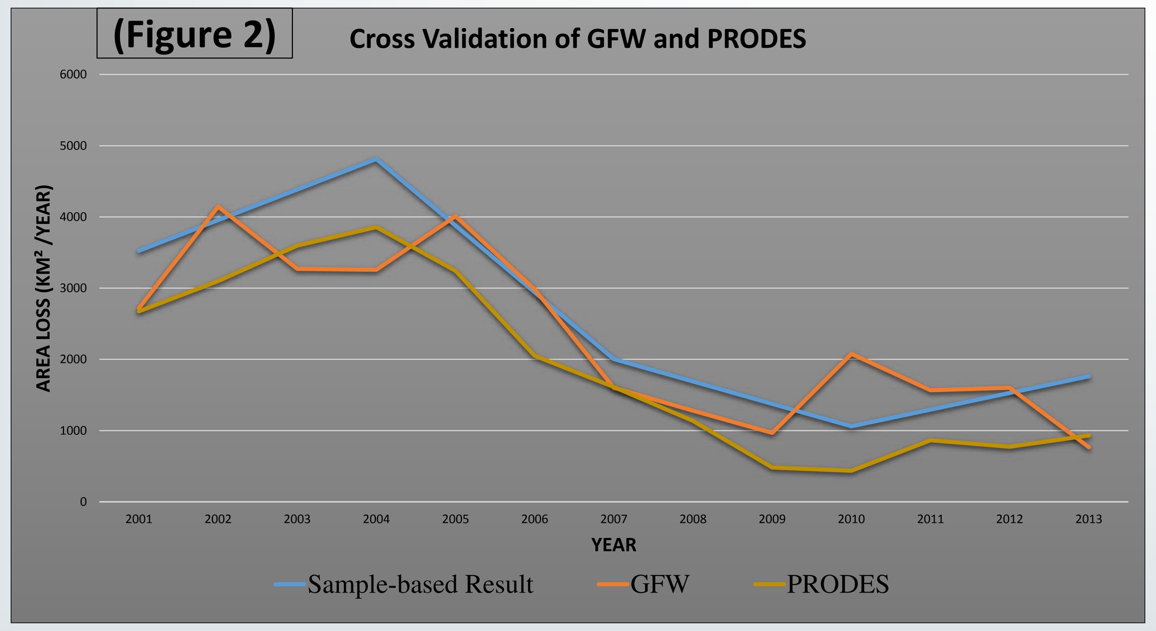
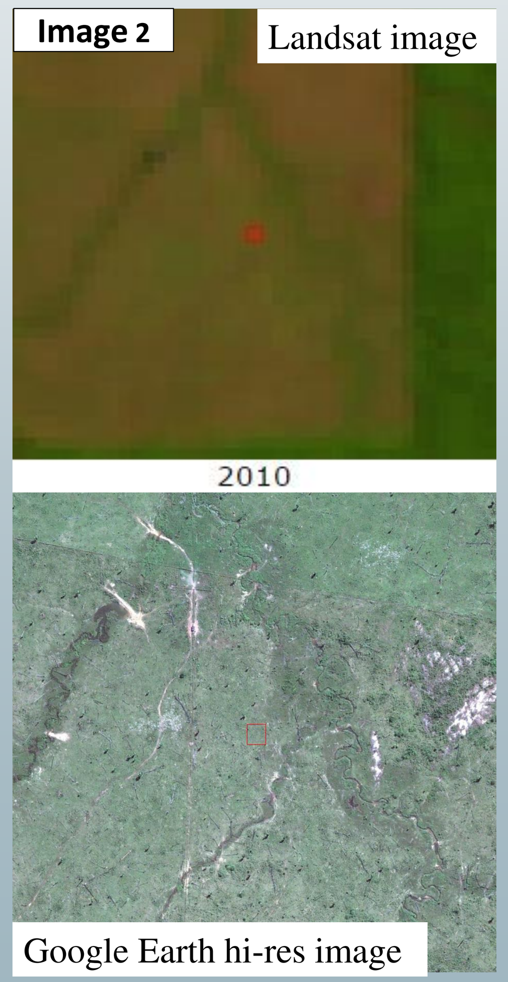
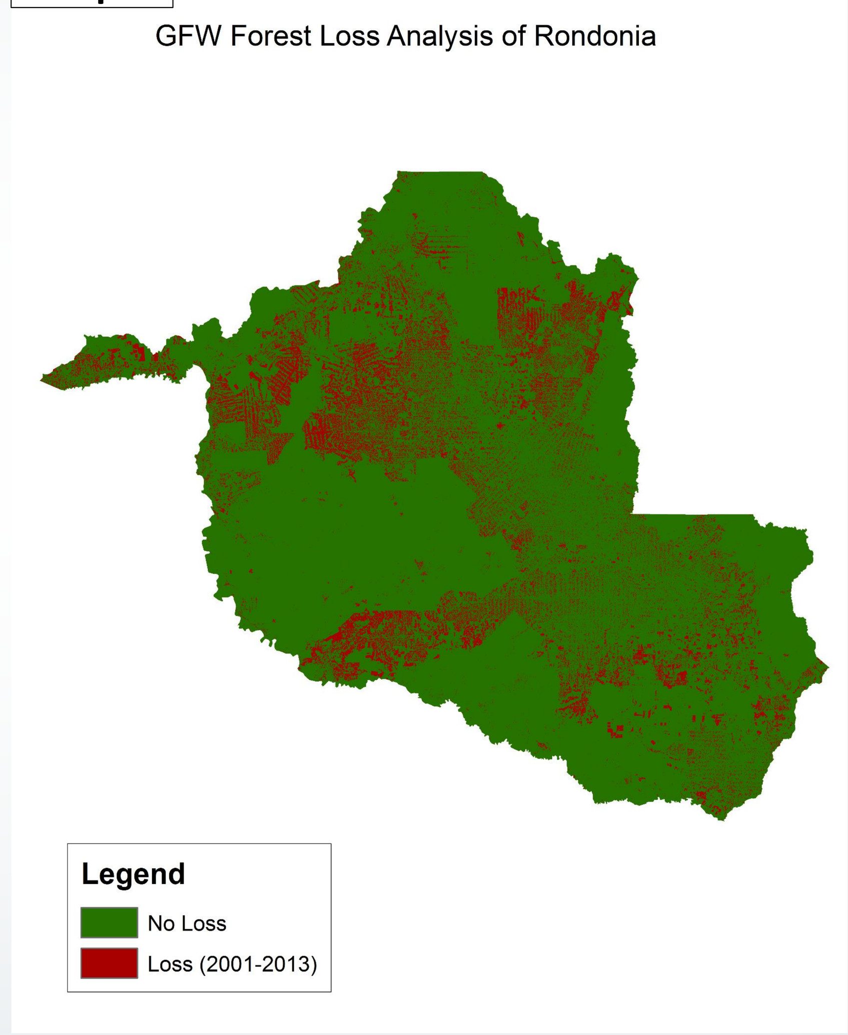


Image 1

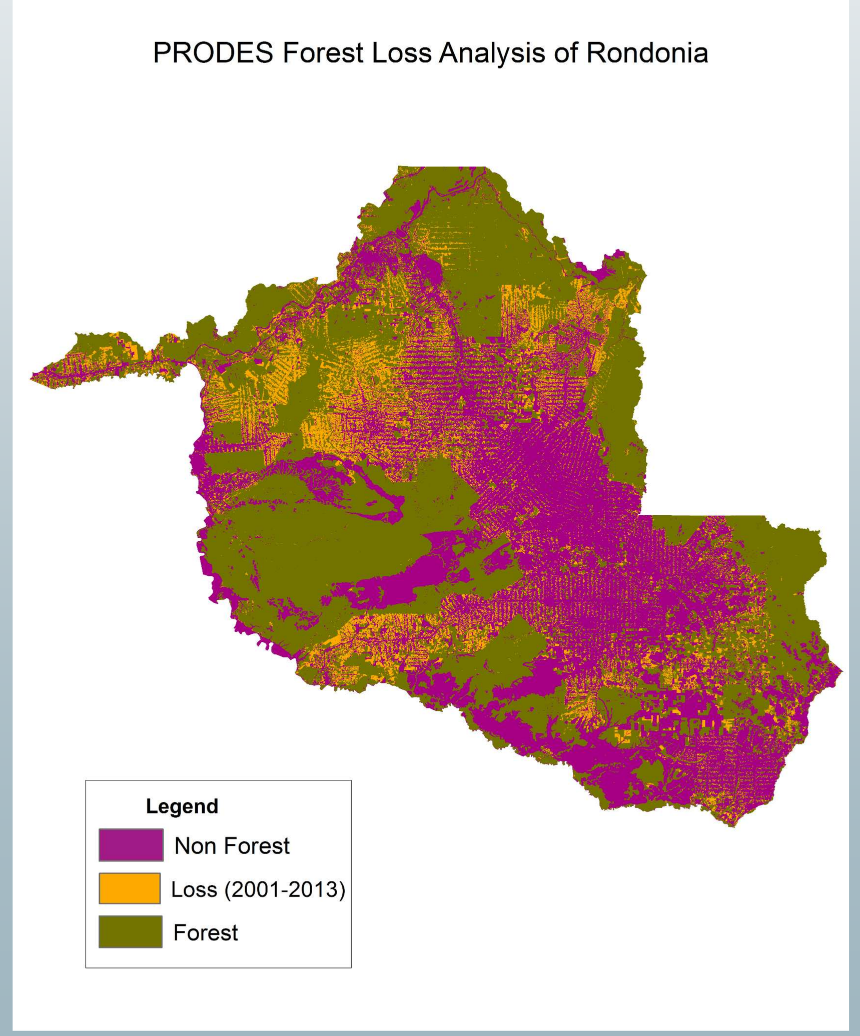
Image 2



Map 1



Map 2



DISCUSSION

Based on the results of the cross-validation of GFW, PRODES, and the reference data there was a similar decline in deforestation across the study period of 2001-2013 (figure 2). Most noticeable was the decline in deforestation from approximately 2004 to 2009. Declining deforestation could be the result of the decline in profitability of Brazilian soy production in 2005 and the launching of the Detection of Deforestation in Real Time system (Nepstad et al., 2014).

PRODES data generally displayed a lower average area loss to deforestation because it only considers clearing from primary forest to bare ground as deforestation, whereas GFW takes into account clearing from primary, secondary, woodland, parkland, and forest plantation. Similarly, the use of a Minimal Mapping Unit of 6.25 ha in PRODES further explains this lower average area loss to deforestation. Maps 1 and 2 show aggregate forest loss from 2001-2013 in relation to no-loss as portrayed by GFW and PRODES respectively. It is important to note the non forest feature in the PRODES representation, (Map 2) which consists of land that was cleared before 2001 or land that was considered non primarily forest by the PRODES data.

CONCLUSION & FUTURE RESEARCH

The cross-validation of the two satellite-based products with the Landsat reference data showed a general agreement between the forest cover loss estimates. This confirms that our results are suitable for validation of other remote sensing-based products over the State of Rondônia, as well as for carbon accounting.

Future Research

With less forest available, deforestation may arise in other areas such as within indigenous reserves *("A Clearing in the Trees")*. In the future, deforestation within indigenous reserves could be a significant contributor to deforestation in not only Rondônia, but throughout the rest of Brazil.

REFERENCES

1. "A Clearing in the Trees." *The Economist*. The Economist Newspaper, 23 Aug. 2014. Web. Accessed 16 July 2015.
2. Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J, Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O., Townhend, J.R.G. 2013. High-Resolution Global Maps of 21st-Century Forest Cover Change. Science 850-853
3. Nepstad et al. "Slowing Amazon deforestation through public policy and interventions in beef and soy supply chains." *Science* 6 June 2014: 344 (6188), 1118-1123.