DETECTING SELECTIVE LOGGING IN THE BRAZILIAN AMAZON: A PILOT TEST WITH SENTINEL-2A DATA

Thais A. Lima, PhD Candidate

PhD in Forestry, Department of Forest Resources Management,
Faculty of Forest, The University of British Columbia,
Vancouver, Canada
thais.lima@forestry.ubc.ca

Abstract

Forest degradation caused by selective logging is a pervasive activity in the tropics. There is still questions regarding the better way to detect them through remote sensing techniques. Sentinel-2 data have a finer spatial resolution and could improve the mapping of these areas. In this pilot test, two methods were tested to map the areas affected by logging in a study area located in the Central Amazon. In this case study, the dNBR approach seems to better mapping the areas of selective logging. However, this analysis will be dependent of the quality of both images (year 1 and year 2), once small variations (haze for instance), can overestimate the areas mapped as logged. The results of the present study still need field work validation, which will be done late in this year.

Introduction

In the Brazilian Amazon selective logging is a major source of forest degradation and could double the previously reported deforestation area (Asner et al. 2005). In addition, previously logged forests, are at a high risk to be converted into non-forest land-use types (Asner et al. 2005). The majority of logging operations in the Amazon are still illegal and while forest degradation continues at a rapid pace, it lowers the opportunities for conservation and for sustainable development in general. While deforestation has been intensely studied, forest degradation is a process still poorly understood.

Spectral mixture models are commonly used to assess areas of selective logging in the Amazon, mainly in single date detection approaches (Souza et al. 2013, Grecchi et al. 2017). However, change detection approaches, such as the delta normalized burn ratio (dNBR), have not been tested in Amazon. By using this two methods we can see the effects of applying a single date detection approach and a change detection approach, in a new logging frontier located in the Brazilian Amazon that has been scarcely studied so far.

Objectives

This research has the objective of mapping selectively logged forests in a case-study area located in the Brazilian Amazon using Sentinel-2 data. The study area is located in the southern portion of the state of Amazonas, Brazil (Figure 1). Amazonas is the biggest state of Brazil and it holds the largest area of intact forests within the Brazilian Amazon. The mapping has been done in an area of interest circa 10,000 km^2, 100 × 100 km (MGRS tile 20MPS) (coordinates -62.05, -7.23; -61.11, -8.21).
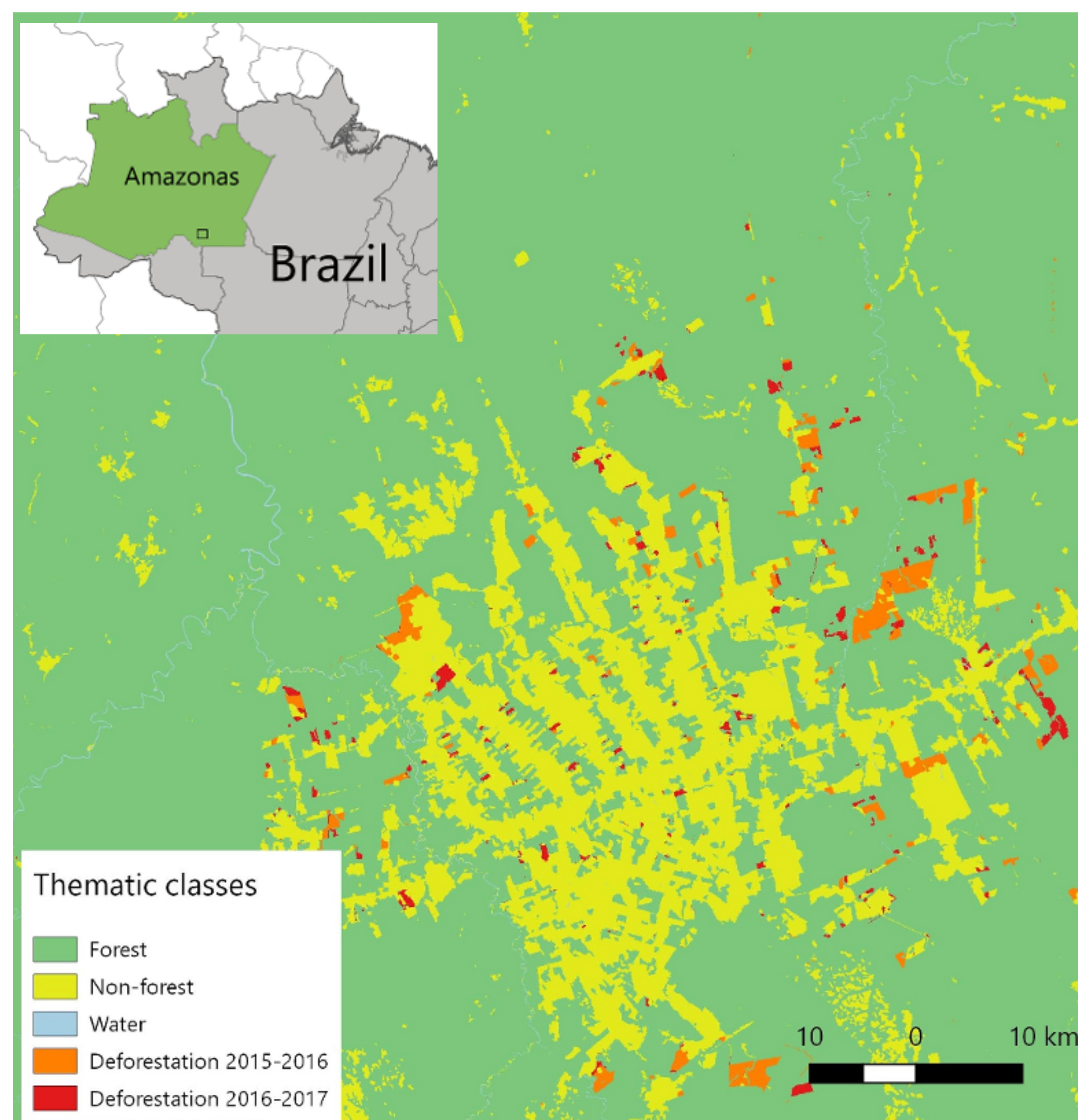

Figure 1. Location of the study area and main land-cover classes for the years 2015, 2016 and 2017.

Methods

The mapping was done for Sentinel-2A images from August 2015, July 2016 and July 2017. The forest mask was built for the July 2016 image, once this image is completely free of clouds and haze. Images bands analyzed had unsigned 8bit integer values, ranging from 0-255.

The multiresolution segmentation algorithm was applied to generate image-objects in eCognition©. The parameters used here were: scale factor 30, shape 0.2 and compactness 0.8. A thematic map was built, with three classes: water, old-growth forest and "non-forested areas" (Figure 1). Non forested areas include: old deforestation, urban areas, regrowth and other wooded lands, in this case savannas and pioneer vegetation. The objects were then classified following a tree classification approach. A second multiresolution segmentation was performed for the year 2017, now, just inside the thematic layer "forest". The image layers used to perform the multiresolution segmentation algorithm were Red, NIR and SWIR-1, with weight equals to 1, 2 and 1, respectively. The other parameters remained the same. All objects with NDVI less than 0.55 and SWIR-1 greater than 45 were assigned as "new deforestation". The image from July 2017 has clouds, thus objects with mean values in the blue band more than 40 were classified as "clouds". Objects with NDVI difference between July 2016 and July 2017 more than 0.33, shade fraction more than 205 and mean NDVI for July 2017 less than 0.40 were classified as shadow. Objects classified as shadow and clouds were manually corrected and then reassigned as "no data". Unclassified objects were classified as "remaining forests". The deforestation from 2015-2016 was mapping using the forest mask for the year 2016. The multiresolution segmentation was performed inside the areas of "non-forest" from the year 2016, and then objects with NDVI values more than 0.45 and reflectance values in the short wave infrared band (band 11) less then 35 were assigned as forested areas in the year 2015, indicating that they were deforested in the subsequent year.

Forest disturbances detection were assessed inside the areas of "forest", through two different methodologies. Using the soil fraction image derived from a spectral mixture analysis and the Normalized Burn Ratio (dNBR). To perform the spectral mixture analysis, permanent water bodies, the Transamazon Highway (not paved) and remote forested areas were chosen as "pure pixels" points. The endmembers were chosen directly in each image.

The thresholds to classify pixels as "disturbed" area were visually chosen from an area of logging explored in 2016 and 2017 (Figure 2).

Results

In 2016 the recorded forest cover was circa 9,104 km^2, the deforestation between 2015-2016 was 104.65 km^2 and 2016-2017 was just 46.60 km^2.

In this preliminary study it was recorded, for the years 2015-2016, an area potentially affected by logging of 32.90km^2 and 61km^2, considering the dNBR and the soil fraction approach, respectively. On the other hand, for the years 2016-2017 the area mapped was 48.80km^2 and 146.47km^2, for the the dNBR and soil fraction, respectively.

Discussion & Conclusions

The soil fraction methodology seems to double the estimated area affected by logging in the year 2016. Since the soil fraction analysis carried out here is a single date mapping, it could have included areas with exposed soil that are not logged areas (Figure 2). Small rock outcrops (<1.0 ha), existing inside forested areas could have contributed to overestimate the area classified as "logging". In the analysis of the year 2017, the high values recorded for the soil fraction could be attributed to the haze in this image, highlighting the importance of the careful preprocessing in this context.
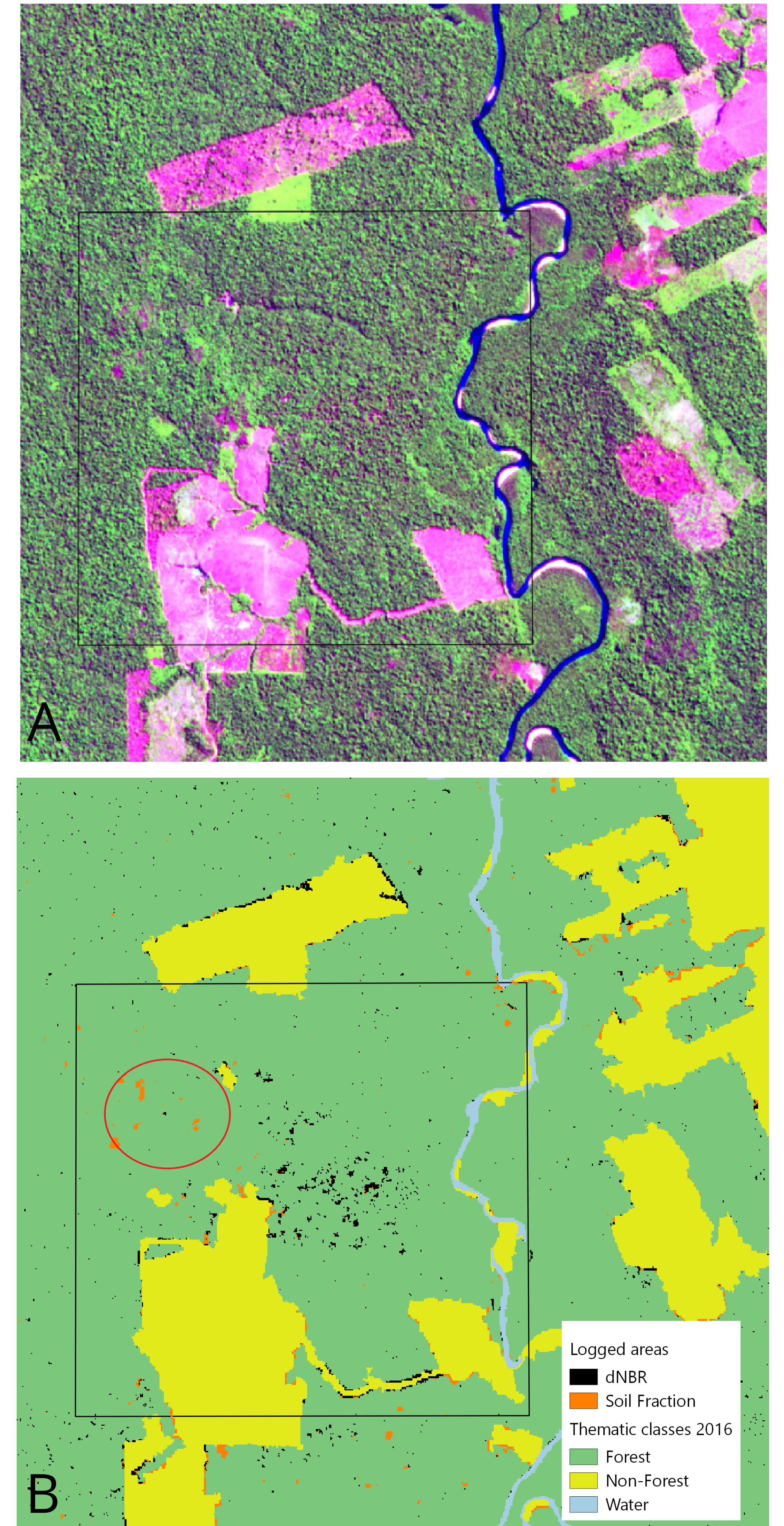

Figure 2. A) Example a logged area (black rectangle), RGB composite (bands 11, 8, 4) of Sentinel- 2A from July 2016; B) Classification of potentially logged areas, the red circle represents an area of small rocky outcrops, incorrectly classified as logging using the soil fraction methodology.

Considering the image of 2016, without haze, it seems that the dNBR approach could be better for mapping the study area, once it excludes the area of of small rock outcrops. It needs to be highlighted that the thresholds used to classify an area as "disturbed" will vary according to the visual interpretation of the analyst, once they are not directly derived from field measurements. Therefore, the next step in this study is to validate the mapping in the field. During the field campaign, canopy properties, such as the canopy cover, will be collected to subsidy a better mapping, based in more reliable thresholds.

References

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