A Spatial Pattern Analysis of Forest Loss in the Madre de Dios region, Peru

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Abstract

Previous studies have quantified the expansion of gold mining-related forest loss (Espjo et al., 2018; Arner et al., 2017; Swenson et al., 2011) in the Madre de Dios region of Peru. This study uses Spectral Mixture Analysis (SMA) in a cloud-competing platform to map general forest loss within and outside key land tenure areas in this region. Landsat 7 Enhanced Thematic Mapper Plus (ETM+) and Landsat 8 Operational Land Imager (OLI) Surface Reflectance data were utilized spanning 2013 and 2018 and spectral unmixing was performed to identify patterns of forest loss for each year. Planet Scope and RapidEye imagery were used to conduct an accuracy assessment and to identify potential drivers.

Study Area

Earth Observations

Datasets

Data Table - SHAPEFILE Source Last updated
MiningConcessions INGEMMET 06/19/2018
National Protected Areas (NPA) SERNANP 02/08/2018
NPA Buffer Zones SERNANP 06/11/2018
Indigenous Communities Amazonia Socio Ambiental/IBC 12/2015
Reforestation Concessions SERFOR 11/13/2017
Departments Boundaries MINAM No information
Interoceanic Highway OpenStreetMap 03/2019

Methodology

Objectives

- Quantify rates of forest loss within protected areas and indigenous communities
- Analyze how forest loss relates to other land tenures such as mining permits and reforestation concessions
- Identify potential drivers of forest loss to see if gold mining is the main driver and explain how these potential drivers relate to the land tenure

Spectral Mixture Analysis

We defined photosynthetic vegetation (PV), non-photosynthetic vegetation (NPV), water and shadow as endmembers and applied the spectral unmixing algorithm embedded in Google Earth Engine.

Change Detection

Forest loss was based on a modified version of the algorithm applied in Arner et al. (2009) and is indicated by a decrease in 50% of the PV fraction between a post composite and a pre composite.

Validation and Accuracy Assessment

For 2013, 20 scenes with 5-m resolution from RapidEye-1, RapidEye-2, RapidEye-3, and RapidEye-5 were utilized, and for 2018, 46 scenes with 3-m resolution from Planet Scope were utilized, covering the entire study area. A stratified sampling design with 1100 randomly generated points and proportional allocation was used according to Olstofen et al. (2014) guidelines.

High Resolution Imagery

Results & Discussion

The figures above illustrate the progression of forest loss across space and time, with concentrations revealed along the Malinowski River, within the Kotsimba community, on the northern border of the Tambopata National Reserve, and within the buffer zone of the protected areas. Many possible small-scale mining sites are located alongside the Inambari River. Overall Accuracy was 96%.

Extent and Rates (ha)

Drivers Comparison

<table>
<thead>
<tr>
<th>Drivers</th>
<th>Gold Mining</th>
<th>Agriculture</th>
</tr>
</thead>
<tbody>
<tr>
<td>Indigenous communities</td>
<td>58.7</td>
<td>122.2</td>
</tr>
<tr>
<td>Protected Areas</td>
<td>58.7</td>
<td>200.6</td>
</tr>
<tr>
<td>Forest</td>
<td>104.6</td>
<td>59.7</td>
</tr>
<tr>
<td>Mining concessions</td>
<td>2.8</td>
<td>0.0</td>
</tr>
<tr>
<td>Reforestation concessions</td>
<td>2.8</td>
<td>12.4</td>
</tr>
</tbody>
</table>

Conclusions

- Forest loss progression continues to prevail in this region, threatening specially the Kotsimba Indigenous Community
- Gold mining is not the only driver causing forest loss in the region, since Agriculture/Pasture represents 38% of the points identified
- The maps created with the use of Landsat data provide information for subsequent assessments on land cover planning and monitoring
- The use of the spectral mixture algorithm as a change detection technique provides accurate results