New insights in tropical forest diversity mapping in Central Africa using low resolution remote sensing

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Congo basin forests: tipping points for biodiversity conservation and resilience of forested social and ecological systems (CoForTips)
The EU-CoForTips project is focused on predicting the effects of global Changes (anthropogenic and climatic) on forest biodiversity in the Central African region.

The objective of the study presented here is to characterize the spatial patterns of tropical forests in the Central Africa area in relation with climatic variables (rainfall and light intensity).

Hypothesis

Temporal remote sensing acquisition permits to identify forest structure and functioning (evergreen/deciduous) as a response to climatic environment.

The land cover new vision allows a better understanding of spatial forest types distribution to promote a better management of the Central African forests.
Remote sensing material

Vegetation Indices 16-day L3 Global 250m (MOD13Q1c5) to collect the Enhanced Vegetation Index (EVI) information

\[
EVI = 2.5 \times \frac{(NIR - R)}{(NIR + 6R - 7.5B + 1)}
\]

- 16-day composite images
- Data from 2000 to 2013
- Each 16-day image is revisited 14 times

This process calculates the mean of the 14 years available (based on non-noisy pixels for each 16-day period)
Remote sensing method

1st 16-day images of the data base
Remote sensing method

14-year average. Example for the 1st 7th 15th 16-day period (MOD13Q1c5)

An isodata classification was used to separate pixels clusters
Field inventories

37.898 plots of 0.5ha were used (6 million of hectares)
Field inventories

Tracks:
- From 2 to 3 km
- From 2 to 69 km

Plots:
- All trees with a diameter above 30cm are identified
- Each plot is 0.5ha
- 200 or 250m
- 20 or 25m

Tracks Plots
First result from the remote sensing approach
Validation using field inventories

Different lowercase letters (P<0.001) indicate significant differences in the pair wise Wilcoxon test.

Test for differences in plot basal area (up) and degree of deciduousness (down) among classes with pair wise Wilcoxon test and Bonferroni’s adjustment for multiple comparisons. Only for Congo and Centrafrican Republic.
Interpretation of the phenology

Greenness is driven by rainfall and light seasonality
Validation using existing maps

Contingency matrix between MODIS classes and Cameroon vegetation map

<table>
<thead>
<tr>
<th>MODIS classes</th>
<th>pixels</th>
<th>km²</th>
<th>savannah</th>
<th>degraded</th>
<th>semi-degraded</th>
<th>degraded</th>
<th>semi-degraded</th>
<th>overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>gallery forests</td>
<td>3397</td>
<td>27.75</td>
<td>10</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>closed savannahs</td>
<td>7716</td>
<td>61.28</td>
<td>104</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>savanna-evergreen</td>
<td>20276</td>
<td>163.48</td>
<td>568</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>closed evergreen forests</td>
<td>2436</td>
<td>19.61</td>
<td>30</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>open evergreen forests</td>
<td>12378</td>
<td>99.37</td>
<td>357</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>swamp forests</td>
<td>12378</td>
<td>99.37</td>
<td>357</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Letouzey 1985
Use of the forest mask provided by UMD
Use of the swamp forest mask (Betbeder et al., 2014)
<table>
<thead>
<tr>
<th>Class</th>
<th>Colour</th>
<th>Description</th>
<th>nb pixels</th>
<th>km²</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Red</td>
<td>Evergreen cloud forests</td>
<td>22 610</td>
<td>1 413</td>
<td>0%</td>
</tr>
<tr>
<td>2</td>
<td>Light green</td>
<td>Mid-altitude (Mount Cristal) evergreen forests under the influence of coastal climate</td>
<td>899 736</td>
<td>56 234</td>
<td>3%</td>
</tr>
<tr>
<td>3</td>
<td>Dark-blue</td>
<td>Deciduous and gallery forests under the influence of southern climate</td>
<td>1 014 356</td>
<td>63 397</td>
<td>3%</td>
</tr>
<tr>
<td>4</td>
<td>Yellow</td>
<td>Evergreen forests under the influence of coastal climate</td>
<td>3 499 002</td>
<td>218 688</td>
<td>12%</td>
</tr>
<tr>
<td>5</td>
<td>Cyan</td>
<td>Semi-deciduous forests and old-growth secondary forests under the influence of northern climate</td>
<td>5 005 165</td>
<td>312 823</td>
<td>17%</td>
</tr>
<tr>
<td>6</td>
<td>Pink</td>
<td>Semi-deciduous forests under the influence of southern climate</td>
<td>4 461 902</td>
<td>278 869</td>
<td>15%</td>
</tr>
<tr>
<td>7</td>
<td>Dark-purple</td>
<td>Secondary and degraded deciduous forests under the influence of northern climate</td>
<td>2 973 438</td>
<td>185 840</td>
<td>10%</td>
</tr>
<tr>
<td>8</td>
<td>Dark-green</td>
<td>Mixed evergreen and semi-deciduous forests</td>
<td>5 513 491</td>
<td>344 593</td>
<td>19%</td>
</tr>
<tr>
<td>9</td>
<td>Purple</td>
<td>Semi-deciduous forest under the influence of southern climate</td>
<td>3 671 464</td>
<td>229 467</td>
<td>13%</td>
</tr>
<tr>
<td>10</td>
<td>Orange</td>
<td>Secondary and degraded deciduous forests under the influence of southern climate</td>
<td>2 256 306</td>
<td>141 019</td>
<td>8%</td>
</tr>
<tr>
<td></td>
<td>Total</td>
<td></td>
<td>29 317 470</td>
<td>1 832 342</td>
<td>100%</td>
</tr>
</tbody>
</table>
Conclusion

**Most important findings:**

- Photosynthetic activity is highly seasonal and driven by rainfall and light availability in Central Africa

- The gradients are spatially organized (West-East and North-South) going beyond the usually evergreen tropical forest map

**Implication:**

- Central African forest map is of crucial importance to evaluate ecosystems resilience facing global changes and increasing anthropogenic pressures

- The new vision of the Central African forests characterization should imply adapted future management and conservation policies
Thanks for your attention

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