Analyzing the drivers of changes in landscape structure at the tropical forest margins of Cameroon (Central Africa)

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Background

At the tropical forest margins, structural processes of deforestation, reforestation and intensification combine with short term changes intrinsic to the local land management systems (e.g. fallow rotation). Distinguishing the drivers and impacts on landscape structure of these different land use (LU) changes is critical to maximize the synergies between carbon storage and biodiversity conservation in mitigation strategies within the REDD+ context (Koh and Ghazoul 2010). This study analyzes the drivers and spatial patterns of LU and LU changes in an area of Southern Cameroon located at the interface between the permanent forest and the forest convertible to agricultural land (Forestry Law 1994).

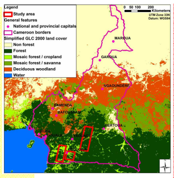

Fig.1. Location of the study area in Cameroon

Land cover (LC) in 2007 and LC change 2001-2007

Methods:

- Object-based classification of 2001 Landsat ETM+ and 2007 Aster data
- Post-classification comparison with majority filters and reclassification in major change trajectories

Results:

% gross deforestation: 4.2%

% gross degradation: 1.8% (forest to fallow)

% gross reforestation: 6.0%

% gross forest improvement: 2.2% (fallow to forest)

% of the classified image	2001	2007
Forest	84.4	84.5
Agriculture	15.4	15.2
Bare/cropped	12.4	12.5
Fallow	3.0	2.7
Intensity (crop / total agr.)	0.81	0.82

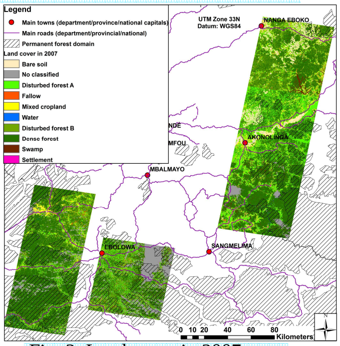

Fig. 2. Land cover in 2007

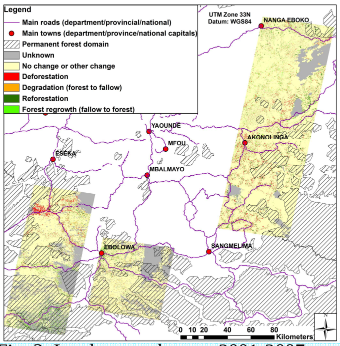

Fig. 3. Land cover changes 2001-2007

Spatial patterns of landscape and landscape changes

Methods:

1/ Landscape units with Voronoi polygons around settlements, in the convertible zone (non-permanent forest). 2/ K-means clusterings of spatial structure of LU changes, with % of gross and net deforestation, % degradation, % forest improvement, Mean patch size (MPS), Contrast index (CTR), Shannon index (SHAN). 3/ K-means clusterings of 2007 land cover (not shown).

Results:

Cluster 1: large patches & high diversity of changes, net reforestation. Close to roads, intermediate population density. Cluster 2: net reforestation, scattered texture of changes. Further from roads, low population density, high 2001 forest cover. Cluster 3: net reforestation, intermediate figures. Cluster 4: small patches and low diversity and heterogeneity of changes, low net changes. Closer to the roads, small units with high population density, thus more stable and settled landscapes. Cluster 5: high deforestation. Further from roads, intermediate population density, low 2001 forest cover.

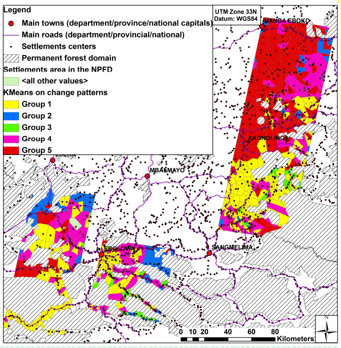

Fig. 4. Clusters of change in landscape structure

Conclusions and implications

- Between 2001-2007, the overall proportion of forest in the landscapes outside the production and protected forest was stable.

- Locally differentiated clusters of change show a net dominance of landscape units where shifting cultivation is expanding (Cluster 5), followed by landscapes with balanced forest clearing and regrowth (Cluster 1) and settled areas with stable fallow rotations (Cluster 4). The size, spatial arrangement and diversity of changes varies significantly among the landscapes.

- Drivers: in forest rich landscapes and in more intensive (i.e. dominated by crops and short fallows over long fallows) landscapes, net deforestation is lower but patches of deforestation are larger. Forest patches in 2007 are smaller in the more intensively cultivated landscapes and where net deforestation is larger.

- In highly dynamic landscapes at the tropical forest margin, aggregate deforestation rates used as reference for REDD do not reflect the ecological effects of deforestation on biodiversity and carbon. Monitoring carbon stocks for REDD+ requires accurate inventories of carbon fluxes within and among different "forest" land cover/uses, and spatially explicit measures are required to ensure biodiversity co-benefits of reducing aggregate deforestation.

Drivers of spatial patterns of LU and LU changes

Methods:

- Regressions on landscape units (Voronoi polygons around settlements) with max. likelihood corrected for spatial autocorrelation.
- Explanatory variables: (i) land use and landscape structure in 2001 (inc. intensification index: *(Bare soil + Mixed cropland) / (Bare soil + Mixed cropland + Fallow)*, (ii) rates and spatial structure of changes and (iii) population density (from AfriPop) and accessibility (distance to the main roads).
- Dependent variables are (i) the % of gross/net deforestation, and the structure of the changes (MPS, SHAN, and CTR), and (ii) the land use and landscape structure in 2007.

Results:

Estimates and significativity

	% Net defor.	MPS of defor.	MPS of forest in 2007
(Intercept)	20.9 *	-14.6 *	0.00664 .
%for2001	-39.8 ***	22.5 ***	0.000628
popdens	-0.0291	0.0201	0.00000271
settlarea_km2	0.220 ***	0.243 ***	0.000247 ***
2001_SHAN	9.46 .	8.91 .	-0.00336
2001_CTR	2.79	-0.0611	0.000548
2001_MPS	-0.00401 *	-0.00599	0.00000460 ***
intens2001	-35.4 ***	12.3 ***	-0.0116 ***
droads_km	0.107	-0.00437 ***	0.0000000412
%netdef	--	--	-0.0000924 ***
%defor	--	--	0.0000927
CHG_MPS	--	--	0.000000950

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Next steps

1/ Analyze the spatial pattern of change patches with a moving-window, then delineate landscape units as areas within which the structure of landscape changes is homogenous (see Messerli et al. 2009).

2/ Perform spatial regressions with socio-economic (SE) data at different levels (census data + village / household surveys) to link spatial pattern and SE processes.

References:

Koh LP, Ghazoul J. (2010). *Proc. Nat. Acad. Sci. USA* 107:11140–11144

Messerli P, Heinimann A, Epprecht M. (2009). *Hum. Ecol.* 37:291–304