Mapping Mbalmayo Forest

Remote sensing helps with the management of Cameroonian forest reserve

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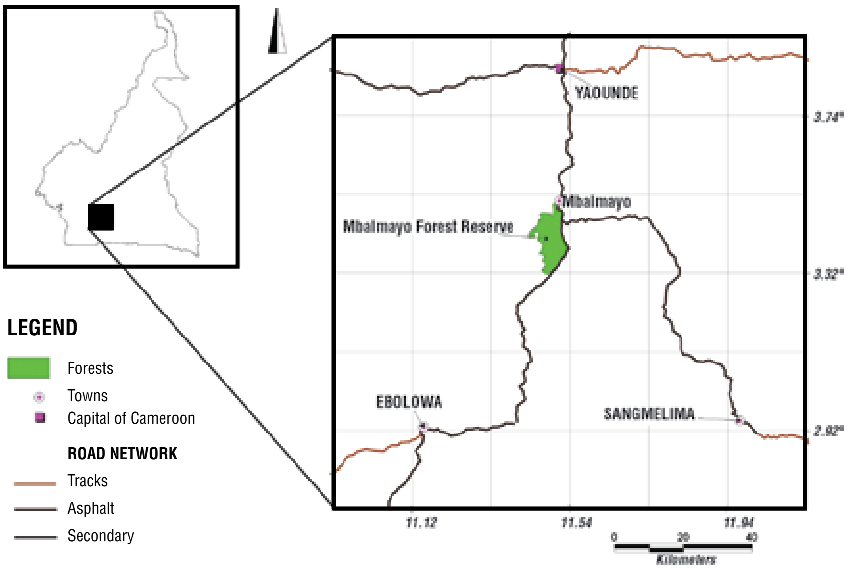
ESTABLISHED IN 1947 by the French colonial administration, the Mbalmayo Forest Reserve (MFR) ranks among the oldest protected areas of Cameroon. The majority of Cameroon's forests, including the reserves, are now threatened by degradation and advancing fragmentation due to the steady increase in local populations (Whitemore 1997, Lawrence and Bierregaard 1997, Simberloff 1986).

Previous studies undertaken in the MFR (Yonta, 1994; Owona, 2006; Temgoua, 2007) show that this area is utilized and inhabited by local communities. The activities of such populations, combined with other natural causes lead to changes in vegetation, biodiversity and landscape, to an extent which is not well recognized.

The resulting landscape units are made up of a mosaic of agricultural plots associated with disconnected wooded areas of varied size and shape (Galochet *et al.*, 2002). A land use study was undertaken in the MFR in order to produce a spatialized database. Starting from three high resolution Landsat satellite images and field validation surveys, this study mapped the current land use status in the MFR. The thematic mapping of landscape units thus produced could be used as a reference in future analyses of the Reserve's dynamics.

Where

Figure 1: Location of Mbalmayo Reserve



The study aims at contributing to the generation of information for decision-makers in charge of the environmental policy and management of this protected area, including for local communities since forest policy in Cameroon is increasingly focused on transfer of forest management responsibilities to communities.

Mbalmayo Forest Reserve

The MFR is located about fifty kilometres from Yaoundé, the administrative capital of Cameroon, in the department of Nyong and So'O of the central province. It is bounded to the East by the asphalted Yaoundé-Ebolowa road , to the North and the West by the Nyong river and to the South by the So'O river *(Figure 1)*.

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organisms such as flying insects and mammals need further research; however, these also appear to be protected to some extent. Strict compliance with the international principles, criteria and indicators of SFM maintains the abundance of keystone fruit species, standing dead snags, large stems, foliage and litter on which animals depend for food and habitat, and appears to maintain plant and animal diversity relatively intact. Lowered harvest volume and minimal impacts from skid trails help to keep the microclimate nearly intact. However, this does not mean that all certified tropical forests maintain biodiversity equally well because principles, standards and auditing systems can vary depending on the certifying body and location.

The island of Borneo where Deramakot is located has lost a vast area of tropical rain forests in recent years due to forest fire and land conversion. The area of strictly protected natural parks comprises only several percent of the total land area. Production forests function as the habitat for biodiversity in the current degraded landscape of Borneo, especially for large wildlife which has wide home ranges. Well-managed production forests, as described here, are expected to play a major role in the conservation of values like biodiversity and carbon stocking. The adoption rate of RIL and forest certification is, however, marginal because most producers cannot secure adequate revenue. Unless additional financial values are attributed to well-managed forests and the revenue available to forest managers thereby supplemented, the present situation of marginal adoption rate will not improve. It seems clear that the timber-related revenue from well-managed forests needs to be supplemented by the payment for other ecosystem services of global importance. Biodiversity and carbon storage are two ecosystem services of global importance that a tropical rain forest can provide, and adequate financial remuneration based on the additionality of conserving biodiversity and carbon storage potential in improved forest management will give producers a better economic incentive to undertake it.

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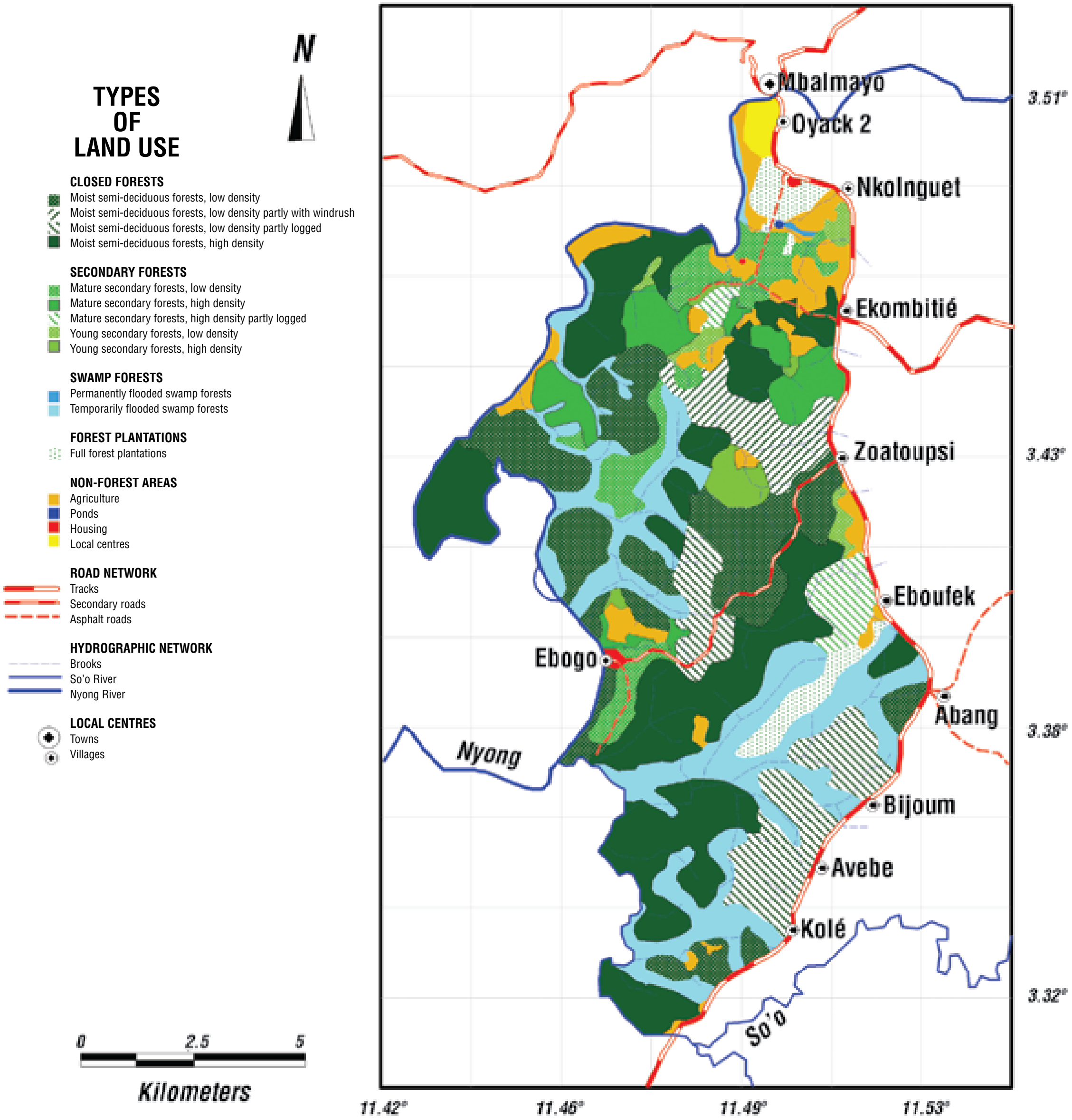
Mosaic of uses

Figure 2: Land-use map for the MFR



The MFR covers an area of 9700 hectares, with its center situated at 3.24 degrees latitude north, and 11.30 degrees east longitude. It is characterized by a Guinean bimodal climate with an average annual rainfall of 1600 mm. The average annual temperature is about 23°C and the average relative humidity is 78%. It is situated at an altitude of 640 metres, on soil with yellow desaturated ferralitic sesquioxides on a bedrock of schist. The natural vegetation of this zone is a transition between semi-deciduous forest and closed evergreen forest.

Remote sensing and mapping

The data used within the framework of this study are high resolution satellite data. The images were captured with the ETM+ sensor of the Landsat satellite, obtained from images taken on 21st October 2001 with a 28.5 meter resolution. The images were obtained from the archives of Yaoundé University, whose geography laboratory was used for image processing. It was not possible to obtain more recent images free of charge.

The first stage of processing consisted of roughly differentiating objects in the images according to their spectral signature. An analysis of the main components and convolution filters (High pass and Gamma) were used in order to improve the image contrast. These operations, coupled with the use of a 1991 ONADEF stratification handbook for southern Cameroon and a topographic chart of the MFR, enabled the identification of four main layers, i.e.: swamp forests, closed forests, secondary forests and bare soil. A preliminary classification and land use chart was prepared using the maximum probability method; this allowed points of control for field monitoring to be identified.

The digitization of the objects appearing on the processed images was carried out using the MapInfo 7.5 GIS software. Sets of pixels distinctive in terms of contrast, color and texture were digitized under three specific headings: hydrographic network, vegetation and roads.

Field missions consisted mainly of surveying the site under study. Two types of surveys were carried out: (1) surveys to validate and refine the land use types, and (2) surveys among local stakeholders.

The transect method (Galochet *et al*, 2002) was used for the validation surveys, with the transects established systematically every kilometer along the main access road. In total, 21 transects were surveyed. Using a GPS receiver, the changes in vegetation along the transect (type and physical appearance) were recorded as geographical co-ordinates. The data thus obtained enabled a comparison of the typology derived from the image processing with the actual findings on the ground, and to define new land use and/or vegetation classes by refining the preliminary chart.

Mostly forest

Table 1: Breakdown of land use in the MFR

TYPES OF LAND USE OBSERVED	SURFACE AREA PER TYPE *(hectares)*	FOREST SURFACE AREA *(total %)*	MFR SURFACE AREA *(%)*
Moist semi-deciduous high density forest	2 837	28	25
Moist semi-deciduous low density forest	1 825	18	16
Moist semi-deciduous low density forest, partly with windbrush	439	4	4
Moist semi-deciduous low density forest, partly logged	995	10	9
Mature high density secondary forest	623	6	5
Mature high density secondary forest, partly logged	286	3	3
Mature low density secondary forest	657	7	6
Young high density secondary forest	172		2
Young low density secondary forest	141	1	1
Permanently flooded swamp forest	9	0	0
Temporarily flooded swamp forest	2 110	21	19
SUB-TOTAL OF NATURAL FORESTS	**10 094**	**100**	**89**
Full forest plantations	343		3
SUB-TOTAL OF FULL FOREST PLANTATIONS	**343**		**3**
Agriculture	788		7
Local centres	89		1
Housing	26		0
Ponds	3		0
SUB-TOTAL OF NON-FOREST AREAS	**906**		**8**
TOTAL	**11 343**		**100**

Land uses and vegetation classes in MFR

Through the field missions and using the ONADEF handbook on the stratification of the territory, 7 classes of land use and 11 subclasses were identified *(Table 1)*, resulting in the chart of land uses in the MFR shown in *Figure 2*. This chart was developed by superimposing the following layers of information which were digitized using MapInfo: vegetation, roads, land utilization, hydrographic networks and topography.

The units of vegetation identified/located by photo-interpretation were verified during the field surveys and adjustments were made to take into account the slight modifications of land uses which had occurred between the dates of the satellite images and of the field missions. However, ambiguities exist in the classification of some layers, including moist evergreen versus moist semi-deciduous forests; closed versus mature secondary forests; forest line plantations versus secondary forests; and temporarily flooded swamp forests versus permanently flooded swamp forests.

The confusion between moist evergreen forests and moist semi-deciduous forests results from two factors: (1) the reserve is situated in a zone of transition and the forest therefore comprises a mix of the species characteristic of these two types of formations; and (2) the study was carried out during the rainy season when the foliage of almost all the trees is dense. Not having taken an inventory in the various layers, it was difficult to estimate the proportion of the species which are characteristic of these formations within each layer. As regards the ambiguity between closed forest and mature secondary forest, it was easily resolved on the ground by observing the undergrowth and identifying the heliophile species. Confusion between forest line plantations and secondary forests is due to the forestry techniques used to enrich the forest. At the end of the 1940s, the French colonial administration undertook enrichment in the area by applying several forestry practices, among which were regeneration and line planting. The plantations resulting from these two techniques are perfectly integrated within the secondary forests. Therefore, all these formations were included in the category of secondary forests. However, obvious forest plantations, such as the arboretum, were classified separately.

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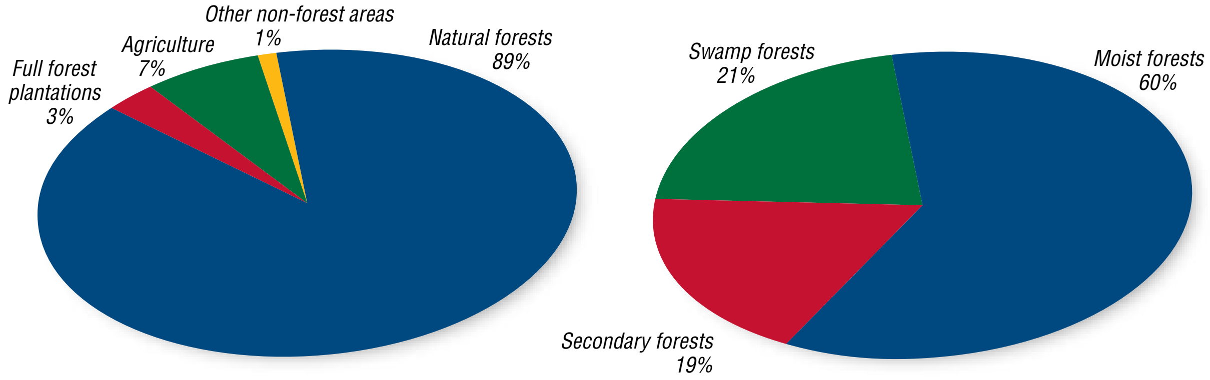
The surface areas of the various vegetation and land-use classes charted were estimated using the GIS software (Table 1 and *Figure 3*). The MFR, including the Ebogo and Bilik enclaves, comprises 10 094 hectares, with forest formations covering approximately 89% of its area. Moist semi-deciduous forests make up the largest forest type,

Land and forest

Figure 3: Breakdown of MFR surface area by land use *(left)* and natural forest type *(right)*



accounting for almost 60% of the cover; the swamp forest group is the second largest at approximately 20%; secondary forests account for approximately 18%, and forest plantations 3% of the forest cover. Cultivation is carried out over approximately 7% of the reserve area.

Conclusions

Remote sensing has a very significant potential for practical applications in tropical environments (Gong and Brognoli, 2005). Satellite high spatial resolution data offer substantial possibilities for mapping the features of tropical vegetation (De Wispelaere, 1993). However, the limits between mature secondary forests and adjacent moist forests remain difficult to distinguish insofar as there are no obvious distinctions between these two types of forests, as is also the case for the limits between permanently flooded swamp forests and temporarily flooded swamp forests. The impact of agriculture on the landscape also appears small (approximately 7% of the MFR's surface area) although some cultivated land may be included in areas categorized as secondary forests. These ambiguities, together with inaccuracies inherent to the mapping process, considerably influence the accuracy with which the size of each type of land use is determined and mapped. However, the field surveys show that agriculture is the main impact on the dynamics of the reserve's landscapes. Nevertheless, it will also be necessary to take into account the impact of forestry techniques, illegal logging and abiotic disturbances (e.g. wind-throw) in future studies of the MFR.

This study resulted in an inventory of the current status of land uses in the Mbalmayo Forest Reserve. Satellite photo-interpretation and the use of GIS software, coupled with field surveys, made it possible to identify and describe the landscape units in this tropical environment. However, the results achieved in this study contain some ambiguities in terms of categorizing forest types and land uses which need to be resolved by the implementation of more complete floristic inventories and land-use surveys.

Acknowledgements

The authors wish to thank Robert Nasi, Nicolas Fauvet, Jean-Claude Bruneau, Ibrahim Lindjiouom, Appolinaire Nankam and Rahoul Mbida for their contributions to the implementation of this work.

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