

TECHNICAL REPORT PREPARED FOR

FORESTS MONITOR

**REAL TIME MONITORING OF LOGGING ACTIVITY USING
REMOTE SENSING**

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This study has been realized with support from Forests Monitor. The view and opinions expressed are those of the authors and are not necessarily those of Forests Monitor

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Executive summary

Auzel, Ph. 2003. Real time monitoring of logging activity using remote sensing. A report to Forest Monitor. 41 pages.

The remote sensing components of this report were supported by Dr. Nadine Laporte and Ms. Tiffany Lin of the Woods Hole Research Center in Massachusetts, USA. All satellite images were made available via INFORMS, *An Integrated Forest Monitoring System for Central Africa*, an on-going project funded by the NASA Land Cover and Land Use Change Program (web address: <http://www.whrc.org/africa>; email: nlaporte@whrc.org)

Introduction

This work aims to promote the debate on the use of new technology and the implementation of permanent mechanisms necessary to assess the sustainable management of forest resources and of the revenues that can be extracted from the forest sector as a basis to sustainable development in the Congo Basin.

This pilot study's main objective is to inform the major actors of the forest sector for a more accurate implementation of on-going reforms by Ministers in charge of forests that will attend the AFLEG meeting, scheduled to take place in Yaoundé, Cameroon, in October 2003.

Background

The importance of the industrialization in the Congo Basin is probably a key issue for the development of these areas and the improvement in livelihood for millions of inhabitants of the Congo Basin.

Illegal logging is a serious threat to the sustainable use of timber resources that most of the international community would like to promote with the elaboration and implementation of management plans for the forest concessions.

Through various mechanisms, like partnership between various operators and engagements like AFLEG, we should encourage private companies to implement sustainable forest management practices. These practices might be grouped under Forest Certification, “a tool to help consumers choose ethical and environmental products from well-managed forests”.

Materials and method

To illustrate our work we chose to present the situation of the Loubonga FMU. The Loubonga FMU was granted under a 15-year contract signed on February 09th, 1998¹ to the Société Congolaise de Recherche d'Industries, de Sylviculture, Transport, Agriculture et Location de Loubonga (CRISTAL).

¹ Arrêté 17/MEFP/DGEF/DSAF/SLRF signed on February 9th, 1998

Preliminary information on concession boundaries and more generally on zoning plans for northern Congo were collected among various actors involved in the area.

Landsat satellite images were used to detect logging roads in the concession. The sets of Landsat satellite imagery available were georeferenced, orthorectified, and assembled to realize mosaics of the Loubonga concession. Roads were digitized on computer screen using various combinations of false color composite of Landsat TM bands 3, 4, 5, and 7. All satellite images and remote sensing analysis were provided by project INFORMS (*An Integrated Forest Monitoring System for Central Africa*) at the Woods Hole Research Center (<http://www.whrc.org/africa>). A detailed description of the method used to derive the road network can be found in Laporte et Lin, 2003.

Results

Analysis of false color composites using Landsat channel 3, 4, 5 and 7 allows a good detection of recent openings in the canopy, with road construction work that expose earth to satellite signals resulting in very distinct reflectance compare with original canopy cover.

We see that most of the canopy disturbances, including some secondary roads, disappear after only a few months. This confirms with studies showing that the detection of logging roads could be as low as 50% two to five years after logging occurred (Auzel 2002).

In a Landsat image dated 2001-02-09, we witness the opening of the Loubonga concession with an important road going east and secondary networks in progress.

One year later, we can clearly see three areas where logging took place, first on the secondary road that was in progress and going north in early 2001. The road seems to have crossed the Congo-CAR border, and some logging seems to have occurred in the neighboring CAR FMU allocated to SCAD. In the south, west of the Loubonga FMU, two other areas appear to have been logged. The Landsat image from the end of 2002 shows that most of the area south of the main road has been logged using roads opened in a least three areas.

At this stage of the analysis, we have no clear idea of the origin of the roads going south, entering the concession south of Loubonga FMU, that appears on satellite images as early as February 2001. We believe this might be an access road to this concession.

On the basis of the three different set of Landsat images available between the beginning of 2001 and the end of 2002, which represent two years, we detected 302,9 km of roads opened in the Loubonga FMU.

On the basis of the one-km buffer applied around all detected logging roads, we estimated that some 52 100 ha, or up to 23 % of the total area, of the Loubonga concession, could have been logged in the between early 2001 and the end of 2002.

Using the actual rate of logging in the concession, with a hypothesis that this rate would be maintained in the coming years, the concession would be logged entirely by 2010, in less than a decade. The agreement with Congo Republic Government about Loubonga FMU ending in 2013, after 15 years, the operation seems to conform contract obligations.

² 181 been the column and 58 or 59 the row

Discussion

This preliminary work on a northern Congo FMU clearly shows that various actors have very different perceptions of the zoning plan that was established in northern Congo.

However, if the analysis done in this report shows that some improvement might be necessary, the actual tendency for most of the companies is that remaining in the limits of annual permits, here VMA, has become a key issue and very competent consulting firms have been contracted to help the companies develop the necessary skills.

Yet, partnering with private companies requires a careful approach on the objectives of the partnership. This is often the criticism that activists expose in their campaign to question the validity of certain partnerships where logging companies buy a “green credit”.

Analysis of false color composites using channel 3, 5, and 7 is a good tool for detecting openings in the canopy with road construction related to logging activity and therefore monitoring their extent in time within a given annual permit or concession, though, as we were able to see on the Loubonga concession images, the evidence of canopy opening (skid trails) can quickly disappear, especially in the rainy season.

Conclusion

The preliminary analysis of logging in the Loubonga concession clearly shows the importance of remote sensing in detecting the evolution of the main logging roads network.

We have seen the importance of having several images at different dates, to assess the road network evolution and follow logging which can be difficult to assess after few years and even months if it happens during the rainy season.

Using buffers around logging roads, we can therefore estimate the total area logged and the trend in disappearance of forest resources in a given concession. In the case of Loubonga FMU, if the current rate of logging continues, the entire concession will be logged before 2010, in less than 10 years.

We were not able to get the annual permit boundaries for this concession, and we believe that the next step would be to compare the existing road network with the VMA boundaries. This could be done in the framework of a bigger study that would allow field verification to assess the level of road detection in close collaboration with the administration of the Ministry of Forest Economy and Environment of the Congo Republic.

Recommendations

A clarification of the limits for all the concessions should be promoted, and the Ministry of Forest Economy should be assisted with training and equipment. The pending ITTO project should bring the necessary funds to establish a functional unit within MEFE. Field organizations like WCS Congo or ECOFAC should bring support to various DREF.

Logging companies should be encouraged to develop internal skills that will allow the company a strict respect of their concessions and VMA³ or AAC⁴. Even if consulting firms

³ Volume Moyen Annuel which could be translated by Average Annual Volume. The companies are allocated a known volume after prospecting the forest (100%). The volume is defined to meet the industry's needs which are themselves in accordance with concession surface in a sustainable management scheme based on rotational cutting.

are more often contracted for assessment, technical training should still be a priority. The Limbe Center promoted by DFID at the Limbe Botanical Garden, ERAIFT in Kinshasa and the ADIE in Libreville, could offer regular training sessions as they were organized in a common effort between DFID, ONF International and Limbe Center.

The priority for international agencies, such as NASA or SPOT, should be making as many satellite scenes as possible available for the Congo Basin. At the moment, Landsat-7 ETM+ satellite is handicapped by a mechanical failure, affecting the quality of the images acquired. To date, we have limited information on the usability of future Landsat-7 ETM+ satellite imagery in documenting the evolution of logging in the Congo Basin. SPOT satellite images remain very expensive and cover an area much smaller than Landsat: 3600 km² for SPOT compared to 32 400 km² for LANDSAT 7.

The donor community should support such effort and allow training of private companies and other components of the civil society to reinforce information availability and greater transparency in the forest sector of the Congo Basin.

This preliminary assessment, conducted on the basis of road network detected from satellite images, should be compared to the official VMA boundaries officially allocated to the company. This is necessary to establish the level of precision of the assessment and to answer questions related to activities that seems to have taken place outside the boundaries of the concession.

The rate of logging should be regularly checked for all the forest management units in order to have a better planning for the national availability of timber resources. This could also provide the opportunity to avoid massive illegal logging operations over time instead of having them clear entire concessions in a few years in the absence of any sufficient control.

⁴ Assiette de Coupe Annuelle which could be translated by and Annual Permit. The company is granted a logging permit of 2500 ha or 1/30 of the surface of the concession, still in a sustainable management scheme. The volume between different AAC are different in a concession and often there is no link between the available timber resource and the industries needs. This is the case in Cameroon.

Introduction

The development of logging activities in the Congo basin generates important revenues both at local and national level. Positive outcomes of logging development are direct with employment of qualified and unqualified workers and indirect with taxes paid by the companies. However, it is difficult to assess an increase in the quality of life of the many populations in contact with the activity (UNDP 1999). This situation brought international institutions, the donors community as well as NGOs to support the idea of a necessary control for companies involve in activities related to the forest sector (Forest Monitor 2001; Friends Of The Earth 1991).

In Cameroon, we witnessed a situation where lack of logging title allocation, the newly-created forest management units (FMU), lead to rampant development of illegal logging practices by companies which used this method to secure timber resources for their industries (CIRAD-Institutions & Développement 2000). Between 1997 and 2000, most of the logging sector, including the largest well-known international groups, relied on small permits of variable nature to ensure the survival of their industries. These years were characterized by almost systematic logging out of boundaries if not with no titles (Faure 2000; Fimba 1999). These illegal activities were responsible for tremendous loss as high as 150 million \$US per year for the State but also for the communities (Auzel 2002c). The uncontrolled development of such activities posse a serious threat to the integrity of the forest sector dedicated to permanent timber production and brings the industries to propose an extension of logging in the quasi entire agro forestry area with allocation of 120 small titles per year (Carret 2002).

The importance of the forest industry, directly and indirectly, is obvious for the economies of many Congo Basin countries, especially with the reduction in oil revenues for many countries (Karsenty 1998). The international community believes that the revenues originated from this sector of the economy could play a more important role in strategies aimed at poverty alleviation. This is why it is necessary to apply the necessary reforms in the forest sector and of the national institution responsible of controlling its sustainable use, and thus eradicate the non-sustainable use of tropical forest timber resources that are largely wasted at the moment.

This work ought to promote debate on sustainable forest management, with the necessary new tools, the use of new technology, and the implementation of a permanent surveillance mechanism. From this should follow the creation or the strengthening of the relevant institutions to assess the sustainable management of forest resources and a better use of the revenues that can be extracted from the forest sector as a basis to sustainable development in the Congo Basin.

Objectives

Main objective

This pilot study's main objective is to inform the main operators in the forest sector, leading to a more accurate implementation of ongoing reforms by Ministers in charge of forests who attended the AFLEG meeting that took place in Yaoundé, Cameroon, in October 2003.

Specific objectives

Assess the detection of logging activities in forest management units like Loubonga in northern Congo;

Compare logging activities detected with satellite images with known logging activities;

Test various satellite images as main tools to detect illegal logging and follow logging activities;

Elaborate recommendations to:

- Propose an improvement of the actual situation;
- Assess the importance of remote sensing to evaluate the dynamic of logging activities;
- Elaborate complementary procedures to strengthen the official unit in charge of following logging activities, within the frame of the ongoing Congo Basin forest sector reforms.

This report is a pilot study developed to assess remote sensing use as a tool for logging activity surveillance. Comparison between different satellite images will only be made in the full assessment of the state of forest concessions.

Background

The economy of logging and the dialectic of sustainable forest management

The importance of the developing industrialization in the Congo basin is probably a key issue for the development of these areas and the improvement in the livelihood of millions of inhabitants of the Congo Basin countries. This is so even if the straightforward relationship between this kind of industrialization and development can be discussed (Rain Forest Foundation 1998; Vermeulen 1999).

Since recently, most of the logging companies have to comply with requests regarding sustainable management for their concession for timber resources. Official requests following forest law reforms now include aspects regarding wildlife and its use or forest people who live inside or around their concessions. All these new requests appear very disturbing for most companies. The reflection presented by French expert R. Catinot clearly illustrate the debate:

“ In practice, this notion of sustainable forest management leads to serious translating difficulties from a forester's point of view, and would certainly necessitate a refinement in its objectives; it entails, in the spirit of the Brundtland report, to maintain at the end of each rotation period:

the same natural ecosystem: illusory objective;

the same number of exploitable trees in various commercial tree species;

the same number of exploitable trees in different commercial species;

the same exploitable volume in commercial species which would not necessary be the one of the first rotation.

... we have kept this last criteria as the objective, estimating that it is the only realistic one (Catinot 1997).

This last statement is fixing the arena of the debate, but also the opposition that existed at this point between traditional foresters and partisans of a more holistic approach to tropical forest and of their exploitation.

Following international declarations and increasing pressure from activists movements, the dialogue between private logging companies and ecologists was translated into technical studies, but also into plethora of discussions regarding certification with the criteria and indicators to assess sustainable forest management (Catinot 1999).

Recently, practical guidelines designed to help elaboration of management plans were drafted (ATIBT 2001), regarding first timber production, even if the ones regarding the human factor or biodiversity conservation are pending. Traditional use right and non-traditional usufruct rights, together with the necessity to maintain biodiversity in logged areas, are essential elements of forest policy in the Congo Basin (Vermeulen 2000).

Reforms to increase the contribution of the forest sector to the national economies of the Congo Basin

It is however admitted that the combined disappearance of the timber resource, illegally logged, and of the taxes that could have been extracted from its regular use constitute a tremendous loss for the Congo Basin states, but also for the forest people for whom development might be purely hypothetical after the disappearance of their main resource and related income.

In the Congo Basin, the growth of the informal sector dealing with illegal timber extraction is globally reducing the contribution of the forest sector to poverty alleviation, contributing at the same time to losses as high as hundreds of billions of F CFA, with non-recovered taxes or damages and interest for the illegal use of the state resources (Auzel 2002c).

Illegal logging activities: the extent of losses lead to international reaction

Illegal logging is a serious threat to the sustainable use of timber resources that most of the international community would like to promote with the elaboration and implementation of management plans for the forest concessions.

Illegal logging also leads to the disappearance of alternatives to the unsustainable use of other natural resources like wildlife (Auzel 2000). The bushmeat crisis is a combined result of urban market development and the non-existence of other alternative source of income for forest people entering the global economy and developing cash needs. However, the threat caused by the non-sustainability of logging can be extended to all the forest economy and to most countries of the Congo Basin (Auzel 2001b; Bahuchet 1997; Bakarr 2001).

A new window for certified products?

Despite the multiplication of official engagement in favor of a sustainable forest management from Governments, international institution or private companies, illegal logging and inconsiderate logging practices remain a reality in the Congo Basin.

While "business as usual" is going on in many places, and while discussions never seem to allow place for action, it is obvious that the rest of the world can seek ways to support conservation and the sustainable use of forests with a growing emphasis on the future of forest people (Sarageldin 1990). Considering this, there are two ways of approaching the problem using positive and a negative actions, positive action being in favor of providing incentive and financial or technical support to forest conservation in logging concessions and negative action being considering boycotting products extracted from tropical forests and other more spectacular actions.

Through various mechanisms, in the form of partnerships between various actors like the CEO working groups held by the World Bank (World Bank 2002) and the Global Forest Alliance between World Bank Group and WWF (The World Bank / WWF Alliance 2002) or in the form of engagement such as the AFLEG process, private companies should be encouraged to implement sustainable forest management related practices.

Funding agencies have recently committed millions of euros in this direction through various initiatives (Lejeune 2001). Critics remain however very important due to the lack of transparency on the operations and on their results. Other parties argue that companies involved in destruction of tropical forest should pay the price (not the tax payers in Europe or in the US), and often compare the situation with oil spill and the responsibility of oil companies (Ammann 1998).

These practices might be grouped under Forest Certification, “a tool to help consumers chose ethical and environmental products from well-managed forests” (FERN 2001). The first organization to propose a set of criteria and indicators to certify the sustainable management of tropical forests was the International Timber Trade Organization in 1992, following the 1992 United Nation Conference on Environment and Development in Rio.

There is an ongoing debate about criteria and indicators which seems to never end, with constant addition of initiatives, which led activists to think that the objective of the various fora are, above all, to distract the attention of the international community while logging goes on with very limited change in its modus operandi . However, certification is still a distant aim for African Forests.

Whether it is illegal logging or the lack of immediate action within the concessions under exploitation, there is a threat to the positive initiative of the companies that took actions, developing less destructive practices and mitigating plans for the most adverse effects of their logging operations.

On the other hand, partnerships with no substance other than a global quest for sustainability and international organizations, which main objective is to occupy “funding niches” with limited achievements, are also an important threat to positive actions and the development of an exchange between private logging companies and the international community.

Materials and method

The Loubonga Forest Management Unit

While industrial logging started in the forties mostly in the southern forests of Congo, northern Congo long remained intact until few logging companies (CIB, BoisSangha, SOCALIB, SCBO, etc.) undertook operations in the north forest block between the seventies and the eighties (Wilkie & Finn 1990; Wilkie 1992).

All Northern Congo has been divided into forest management units (FMU) that were recently allocated to logging companies (see Appendix 2). Sapelli (*Entandrophragma cylindricum*) and, to a lesser extent, sipo (*Entandrophragma utile*) both represent most of the logged timber: in 2000, they represent respectively 90,8% and 78,2% of the timber logged in the Likouala and the Sangha regions (MEFPRH 2001). Due to the distance from the closest harbor, at least 1200 km to Douala in Cameroon, the transportation costs and prices of other species on the international market only allow the exploitation of a few very valuable species.

To illustrate our work, we chose to present the situation of the Loubonga FMU (Figure 1). The Loubonga FMU was granted under a 15-year contract signed on February 09th, 1998⁵ to the Société Congolaise de Recherche d'Industries, de Sylviculture, Transport, Agriculture et Location de Loubonga (CRISTAL) which ends on February 09th, 2013.

The Industrial Processing contract entails several contractual obligations (see Appendix 3), including the realization of a management plan for the concession (MEFPRH 2001).

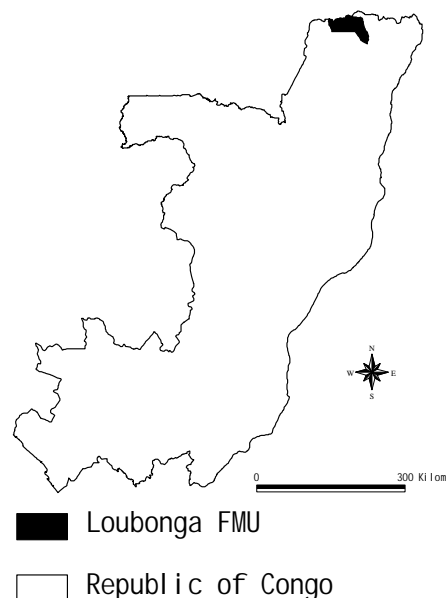


Figure 1: Location of the Loubonga Forest Management unit, Likouala Region, in northern Republic of Congo

⁵ Arrêté 17/MEFP/DGEF/DSAF/SLRF signed on February 9th, 1998

Gathering of preliminary information

Preliminary information on concession boundaries and more generally on the zoning plans for northern Congo was sought from various operators involved in the area:

consulting firms involved in management plans elaboration for logging companies;

a logging company operating in northern Congo;

Global Forest Watch of the World Resources Institute (WRI)

This is preliminary work, and a full assessment of the state of the forest sector in northern Congo would have to be done with the MINEF qualified services, to compare limits of annual permit allocated to logging companies with the extent of logging road network that can be detected by satellite images. This would also necessitate some more ground truthing to assess the level of detection of various kinds of logging roads.

We believe that the improvement of the actual situation will only occur through a constructive dialogue between partners interested in sustainable use of these forested areas.

Satellite imagery used for the preliminary analysis of logging in the Loubonga concession

The Loubonga concession is covered by 2 Landsat 7 ETM images with the following coordinates in the Landsat grid: 181-58⁶ and 182-58. As we see in table 1 images are not always available for various reasons, the most important being cloud cover over the forest that enable satellite channels to operate, at least in the channels that could be used for these assessments. We did some research on the area starting in the seventies to see when logging started in this region.

Table 1: Dates of satellite imagery used for the mapping of logging roads (*Table provided by the Woods Hole Research Center*)

Path-Row	181-58	182-58
1970	n/a	1979-03-18
1980	1986-12-09	1986-12-09
1990	n/a	1990-11-26
2000	2000-03-03	2000-02-09
	2002-01-02	2002-04-01
	n/a	2002-12-29

⁶ 181 been the column and 58 or 59 the row

All Landsat images were processed as part of the INFORMS project at the Woods Hole Research Center (<http://www.whrc.org/africa>). Georeferenced to the EarthSat Corporation orthorectified products of Geocover 1980, all registered images have an RMS error of < 1 pixel. All images were projected in UTM projection using WGS84 datum.

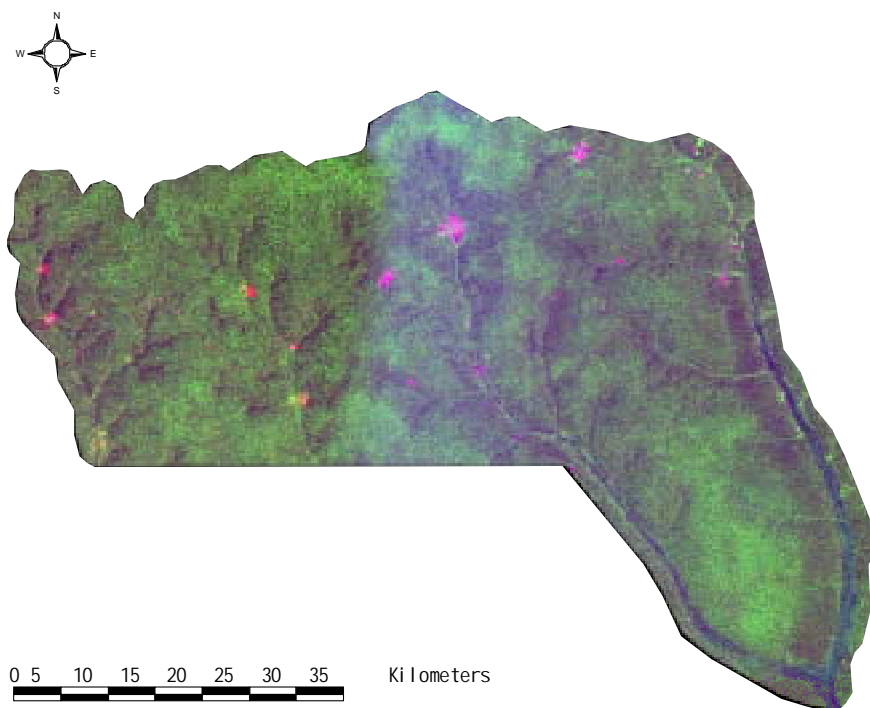


Figure 2 : Landsat-7 ETM+ mosaic of the Loubonga UFA with a 2-km buffer around the concession, 2002-02-09 imagery in false color composite RGB-543; boundary according to that of a forest management consulting company (*Figure provided by the Woods Hole Research Center*)

It is on these false color images that the detection of road network was going to be archived. The chronological series of Landsat 7 ETM images allows us to assess the dynamic of logging through the development of the road networks within or out of the concession boundaries.

Extraction of logging roads from Landsat 7 ETM false color composite imagery

Extraction of road networks is realized by direct screen digitalization and the creation of a poly-line theme (see figure 2) with the related tables where qualitative information can be found such as the date of detection of the road segment. Quantitative data are also put in the table with road segment length for further analysis on the number of kilometers of roads detected in a given area for example. The analysis was compiled in association with the INFORMS project at the Woods Hole Research Center (<http://www.whrc.org/africa>).

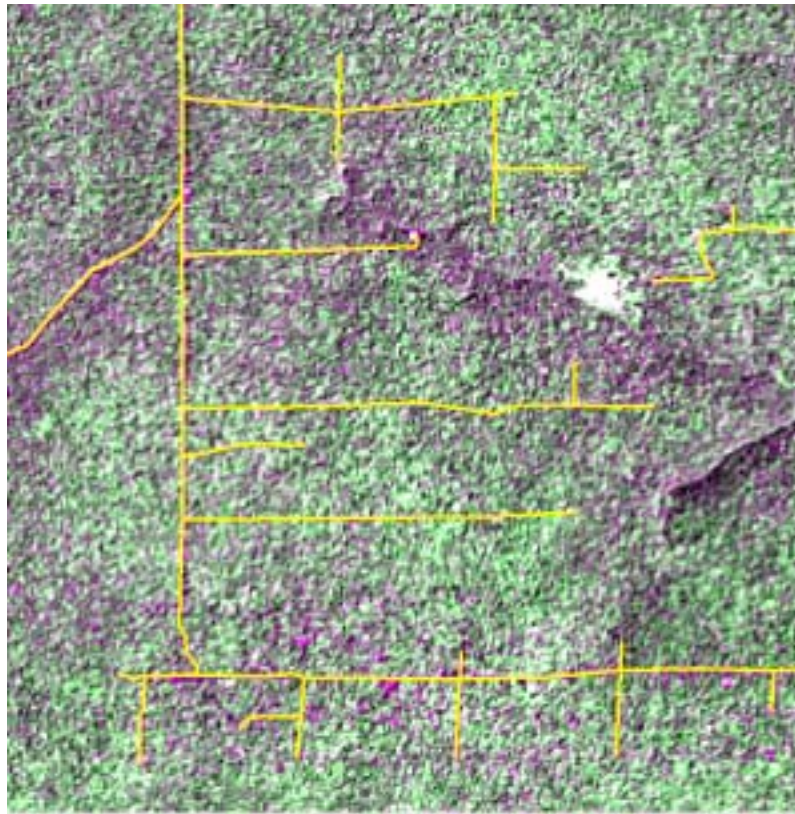


Figure 3: On-screen digitization of logging roads from a Landsat-7 ETM+ false color composite imagery (Figure provided by the Woods Hole Research Center)

Detection of logging roads often requires the modification of the false color composite image for better detection of various types of roads, especially when the vegetation is starting to colonize the deforested areas.

Evaluation of the extent and trends of logging

Once the logging roads were extracted, we worked on assessing the real spatial impact of these roads: the area being logged in the concession.

Most of the main roads were 2 km apart, which means that, on average, skidding is not done for more than 1 km away from the main road network. The skidding distance varies a lot and can range from 0,4 km to 2,5 km, depending on the nature of the operation and on the type of caterpillars available. Illegal operations often prove to have longer skid trails ranging from 1,5 to 2,5 km, especially if companies responsible of these operations know they might be observed through satellite imagery. Until recently, this was not the case and many companies did not even bother about this eventual problem.

Following the previous findings, a 1-km buffer was applied around all the detected logging roads. For each date where we had an available satellite image we estimated the area that was thought to have been logged.

Trends were assessed applying a linear model of regression with the surfaces that were estimated to have been logged for a series of dates. The results are presented on a 2-axes graph showing the evolution of logging and the relative importance of this exploitation compared to the total area of the concession.

This is, of course, preliminary information that gives an idea of the consequences of logging progression in a given concession.

Results

Concession boundaries: the Loubonga forest concession, Republic of Congo

Our investigations among agencies and consulting firms or private logging companies allowed us to find at least 3 different boundaries for the Loubonga FMU and for the northern Congo zoning plan in general.

These various boundaries can be linked with changes in the zoning plan over time as companies develop management plans. However, this situation is potentially a source of tremendous problems if logging out of a limit is documented.

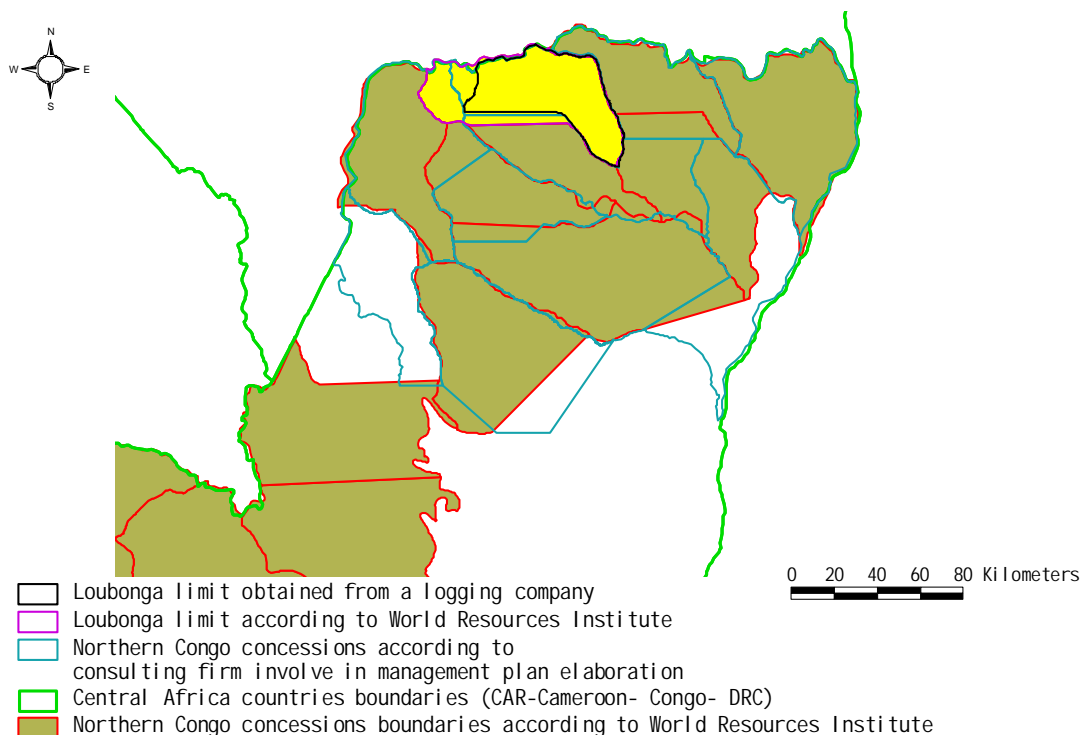


Figure 4: Several concession boundaries for northern Congo exist among various actors involved in logging, elaborating management plans, and monitoring

A more detailed look at the Loubonga FMU clearly shows the 3 potential boundaries that even seem to take some liberty with international boundaries (see figure 4 and 5).

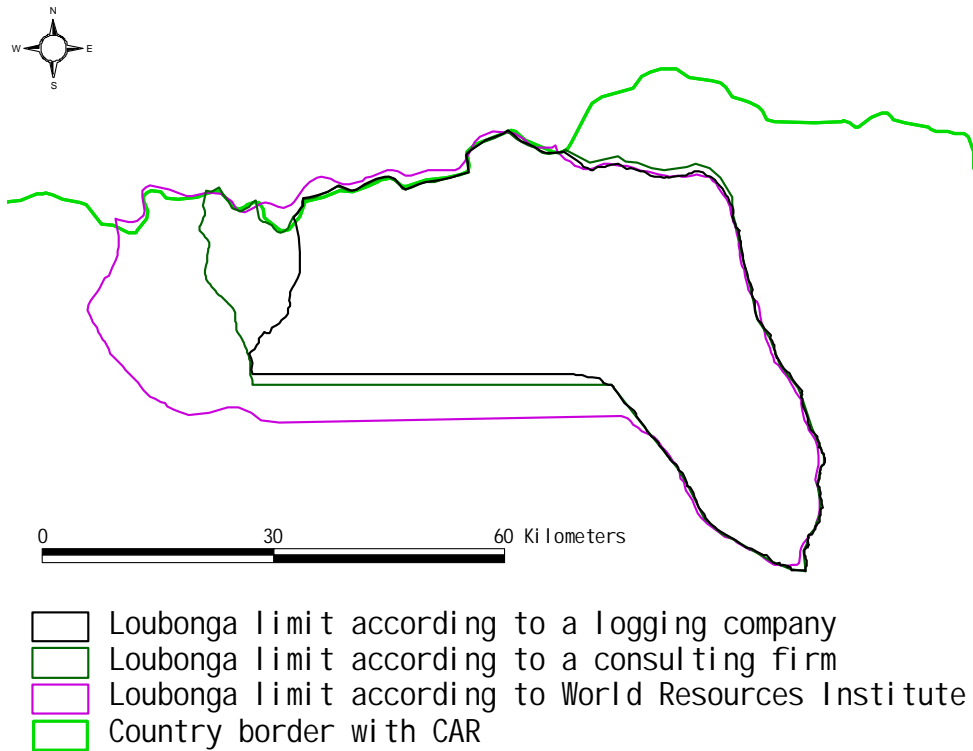


Figure 5 : Synthesis for the Loubonga concession

The boundary of the consulting firm was the closest to the official boundary because they have been drawing the shapefile using the official delimitations by MEFE as shown in table 2.

Table 2: Three versions of the Loubonga FMU boundary and its corresponding surface area

Source of the FMU limit	Surface of the FMU	% compared with MEFE figures
A logging company	201 776 ha	94,6 %
A consulting firm	227 110 ha	106,5 %
World Resources Institute	235 000 ha	110,2 %
MEFE statistics	213 200 ha	100 %

MEFE has a GIS service digitalizing maps of concessions in Brazzaville. Existing maps are however drawn on 1 / 200 000 maps and can be subject to discussion in their accuracy.

Detection of main road network

Detection of recent logging activities

Analysis of false color composite using channel 3,5 and 7 allow good detection of recent openings in the canopy, with road construction work that exposes earth to satellite signals, resulting in very distinct reflectance compared with canopy cover.

Therefore, various combinations of Landsat TM bands, including visible red, NIR, and MIR, allow a good detection of recent openings in the canopy.

Good road identification work entails playing with the contrast for each channel and with the color allocated to each channel or their super-imposition order.

Other logging disturbances with log ponds and felling-related openings are also clearly visible on figures 6 and 7, although if we compare these two figures openings are subject to quicker disappearance. The two figures represent the same area at the beginning and at the end of the year, with the intervening rainy season. We see that most of the disturbance visible on figure 7 disappears after a few months and the rainy season.

The main roads are even less visible after a few months, which confirms studies conducted in Cameroon where it has been shown that detection of logging roads could be as low as 50%, 2 to 5 years after logging occurred.(Auzel 2002d).

After the first stage of colonization by pioneer plants, some more complex analyses on vegetation index would be necessary to detect evidence of logging roads, this time with different reflectance between different types of vegetation. Pioneer trees like *Mussanga spp.* Create mono-dominant forest in the wide openings that contrast with regular forests or even with other particular forests like monodominant *Gilbertiodendron spp* forests.

This analysis option is only valid if the openings by logging roads are sufficient to create this kind of mono-dominant forest with pioneer plants.

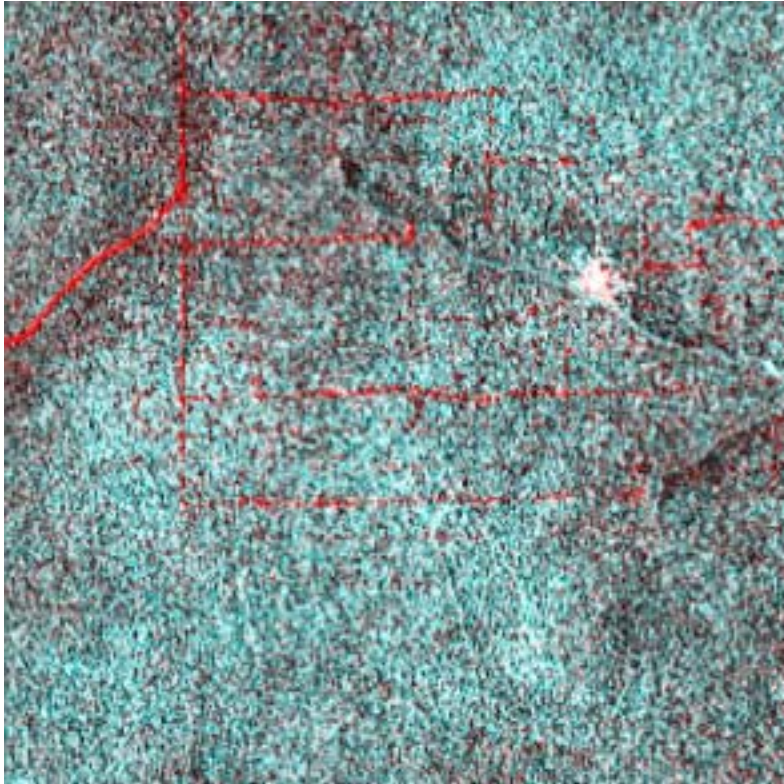


Figure 6 : Detection of skid trails and canopy disturbance in spring 2002 (*Figure provided by the Woods Hole Research Center*)

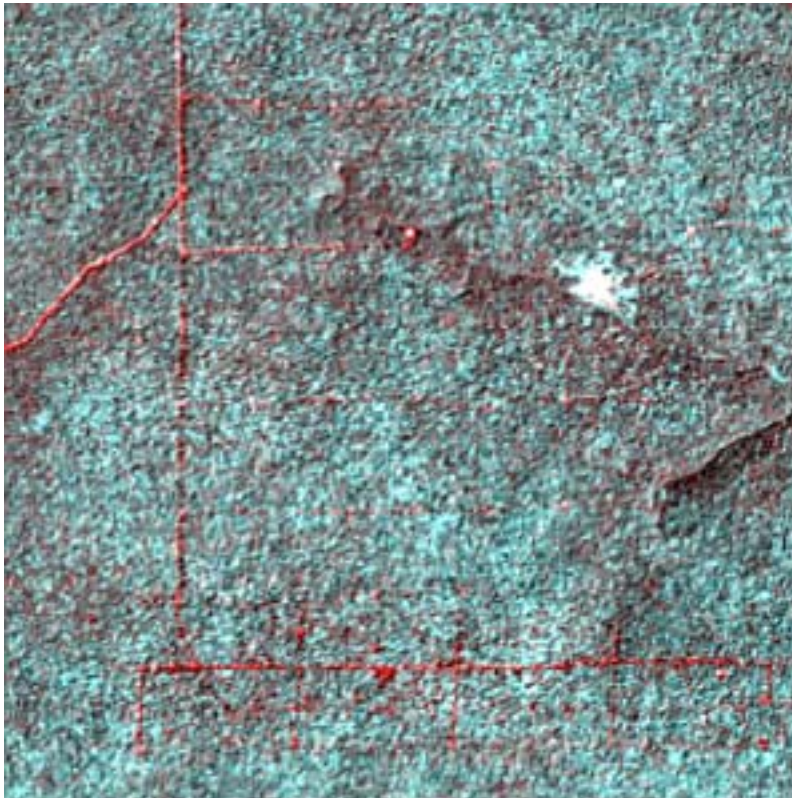


Figure 7 : Detection of skid trails and canopy disturbance in December 2002 (*Figure provided by the Woods Hole Research Center*)

Assessing the evolution of road building in the concession

In Figure 8, a satellite image from early 2001, we witness the opening of the concession with an important road network and also a secondary road network in progress. One year later, we can clearly see tree areas where logging took place (see figure 9), firstly on the secondary road that was in progress and going north in early 2001. The road seems to have crossed the Congo-Central African Republic border, and some logging seems to have occurred in the neighboring CAR FMU allocated to SCAD. In the southwest of the Loubonga FMU, two other areas appear to have been logged.

Figure 10 illustrates the situation at the end of 2002. It seems that most of the areas south of the main road have been logged, with roads opened up in a least 3 areas. At this stage, the southern border of the Loubonga FMU has been logged. The last operations at the end of 2002 obviously opened roads right on the FMU border as can be seen in figures 10 and 11.

The existence of logging roads ending straight on the concession border (see Figure 11) can be interpreted as a potential problem because the felling took place far beyond these limits, probably from 1 to 2 km away. This logging away from the last logging road is visible on the false color composite in Figure 7, where recent openings in the canopy are clearly visible way out of the end of the road that seems to end at the concession border.

At this stage of the analysis, we have no clear idea on the origin of the road going south, entering the concession south of the Loubonga FMU, that appears on satellite images as early as February 2001.

Two possible options are:

this is an access road for the concession south of the Loubonga FMU;

this is an incursion in the concession south of the Loubonga FMU by an unknown party.

Some ground truthing and further verification must be conducted by the appropriate department of MEFE.

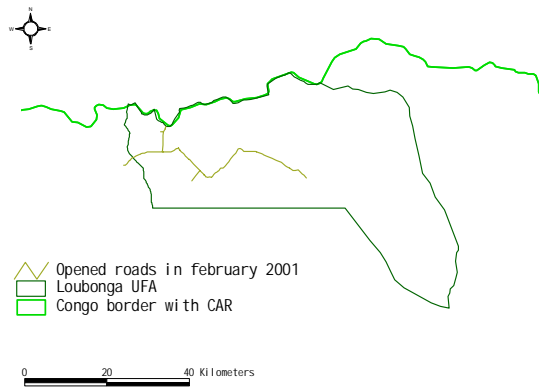


Figure 8: Road network detected on the February 2001 satellite mosaic

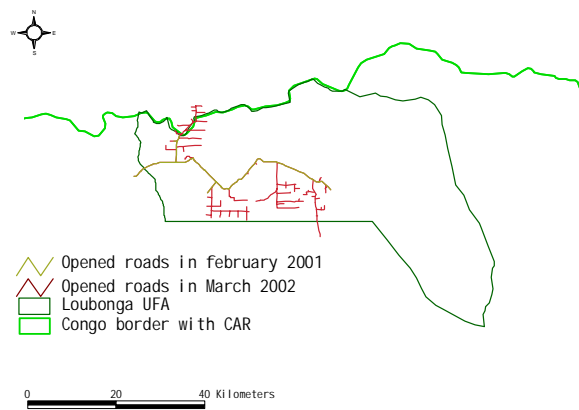


Figure 9 : Road network detected on the spring 2002 satellite mosaic

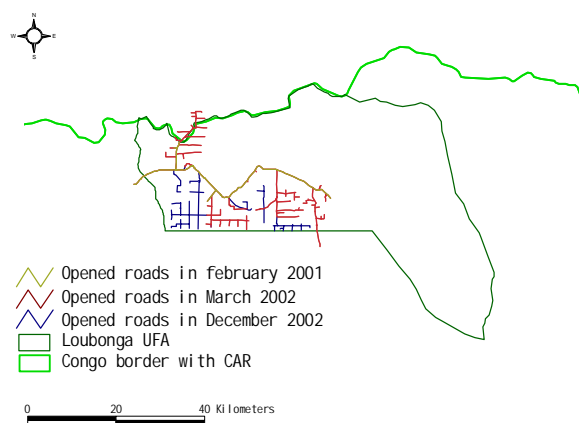


Figure 10 : Road network detected on the December 2002 satellite image

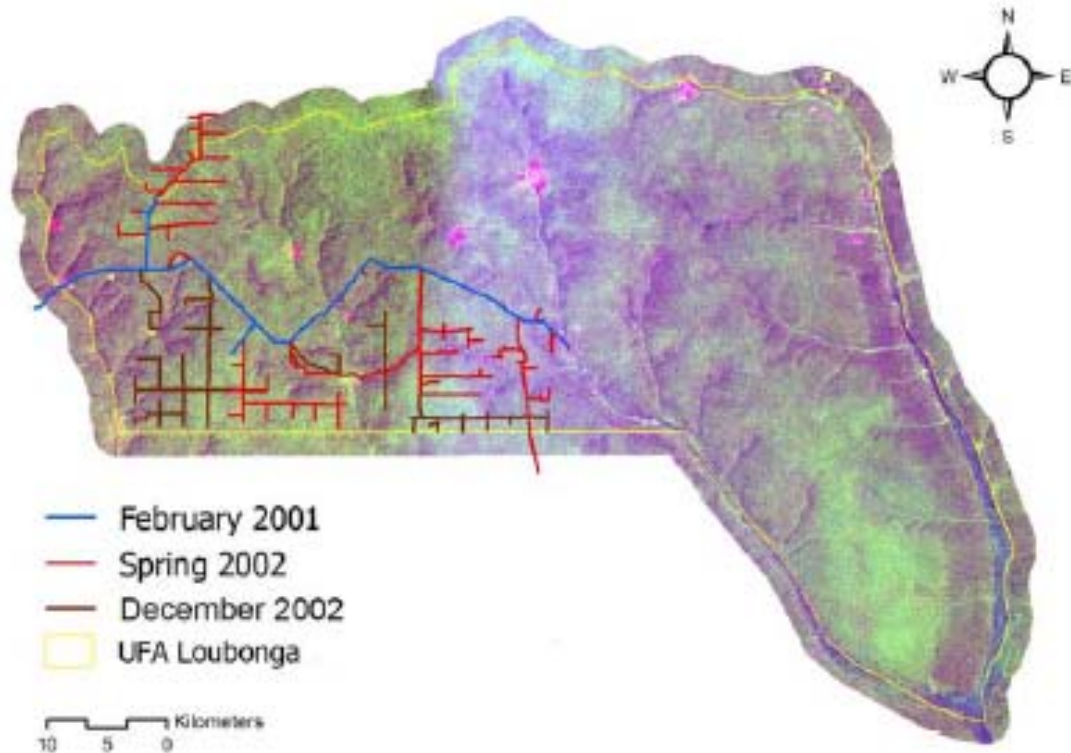


Figure 11 : Spatial expansion of logging roads in the Loubonga concession (Figure provided by the Woods Hole Research Center)

On the basis of the 3 different set of Landsat images available between the beginning of 2001 and the end of 2002, which represent 2 years, we can say that we detected 302,9 km of roads opened in the Loubonga FMU (Table 3).

Table 3: Length of logging roads mapped in the Loubonga Concession (Table provided by the Woods Hole Research Center)

Path-Row	181-58	182-58	Roads detected (km)
1970	n/a	1979-03-18	No roads
1980	1986-12-09	1986-12-09	No roads
1990	n/a	1990-11-26	No roads
2000	2000-03-03	2000-02-09	61.3 km
	2002-01-02	2002-04-01	206.9 km
	n/a	2002-12-29	302.9 km

Assessing the evolution of logging in the FMU

Estimating the evolution of logging in the Loubonga concession by applying buffer on logging roads

The 1 km buffer around detected logging roads clearly shows the potential problem with areas logged out of the concession:

In Central African Republic, in the concession allocated to SCAD

In Congo, in the FMU south of Loubonga FMU

These figures are indicative and should therefore be used eventually to conduct a field assessment to verify what seems problematic in the light of the information available for this study.

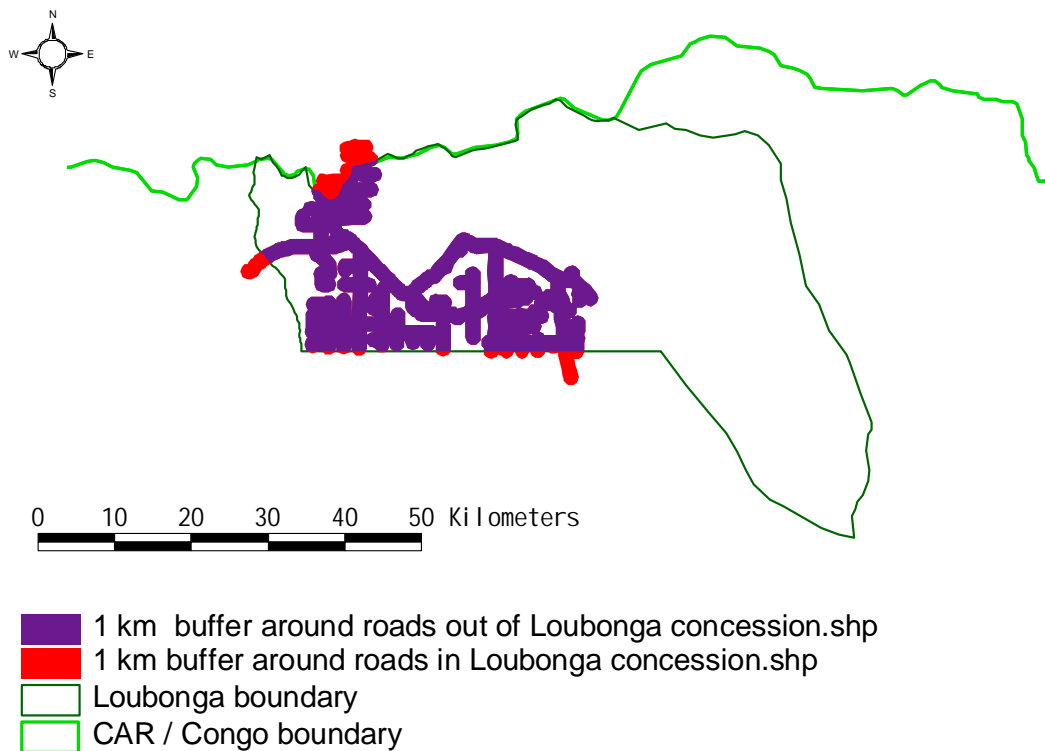


Figure 12: Estimating the extent of logging in a concession applying a 1 km buffer around logging road network extracted from Landsat false color composite

On the basis of the 1 km buffer applied around detected logging roads, we estimated that to date some 52 100 ha, up to 23 % of the total surface, could have been logged in the Loubonga concession between early 2001 and the end of 2002 (see Table 4).

Table 4 : Estimating concession surface logged from detected logging roads with a 1 km buffer representing the extent of skidding and therefore of logging within the concession

Path-Row	181-58	182-58	Concession estimated to be logged	
			Surface	% of the concession
1970	n/a	1979-03-18	None	
1980	1986-12-09	1986-12-09	None	
1990	n/a	1990-11-26	None	
2000	2000-03-03	2000-02-09	130 km ²	5,7 %
	2002-01-02	2002-04-01	347 km ²	16,5 %
	n/a	2002-12-29	521 km ²	23 %

Predicting the end of primary forest in the Loubonga concession

Using the actual rate of logging in the concession, and with a hypothesis that this rate would be maintained in the coming years, the concession would be logged entirely by 2010, in less than a decade (Figure 13).

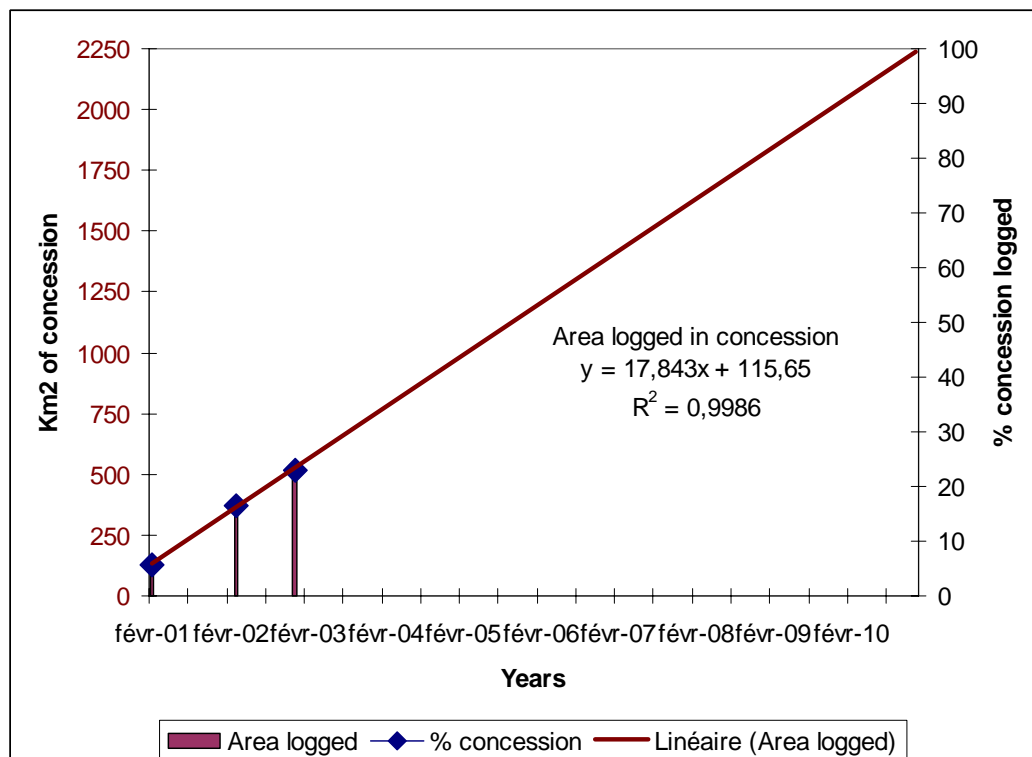


Figure 13: A scenario for the evolution of logging in the Loubonga concession based on the actual rate of logging estimated with road network evolution since early 2001.

Discussion

Concessions and annual permit boundaries

This preliminary work on a northern Congo FMU clearly shows that various operators have a very different perception of the zoning plan that was established in northern Congo. Datasets available from a logging company, from the World Resources Institute and from a consulting firm involved in management plan elaboration clearly acknowledge the situation. Further analysis was done on the consulting firm version of the zoning plan that we considered as being the more accurate, as they used the official text to draw their shapefile.

In other countries of the Congo basin, logging companies with poor deontology have been widely playing with boundaries, whether they were the ones of their concessions or the ones of annual permits allocated within the concession (Auzel 2002a, b, 2001a).

Improvement of skill to implement sustainable forest management in concessions

If the analysis done in this report shows that some improvement might be necessary, the tendency for most of the companies is that remaining within the limits of their respective concessions has become a key issue and very competent consulting firms have been contracted to help the companies develop the necessary skills.

This very positive movement should be encouraged by international NGOs and have some support from funding agencies. The actual change in NGOs' attitude toward partnership with private companies could become a framework for the development and generalization of such skill (Lejeune 2001).

However, partnership with private companies needs a careful approach to their objectives. This is often the criticism that activists expose in their campaign, questioning the validity of certain partnerships where logging companies buy a "green credit".

Using remote sensing to follow the evolution of logging

Analysis of false color composite using Landsat ETM channels 3, 5 and 7 is a good tool for detecting openings in the canopy, with road construction related to logging activity, and therefore monitoring their extent over time and within a given annual permit or concession.

However, as we were able to see on the Loubonga concession images, the evidence of canopy opening can quickly disappear, especially with a rainy season that gives a boost to the vegetation trying to colonize the newly-opened areas. After the first stage of colonization by pioneer plants, some more complex analysis on vegetation index would be necessary to provide evidence of logging roads.

Similar studies in Cameroon have shown that logging roads were not visible on Landsat 7 ETM scenes after a few years (Auzel 2002d). An assessment of logging extent in a concession without knowing the permit allocation history can underestimate the state of logging in the concession by 50%. This is especially so if the road network opened was not as wide as it is in certain operations conducted in northern Congo.

Conclusion and recommendations

Conclusion

The preliminary analysis of logging evolution in the Loubonga concession clearly shows the importance of remote sensing to detect the evolution of the main logging road network.

We have seen the importance of having several images at different dates to assess the road work evolution and following logging which can be difficult to assess after few years, and even a few months if it happens during the rainy season.

Using buffers around logging roads, we can therefore estimate the area logged and the trend in disappearance of forest resource in a given concession. In this case, if the current rate of logging is to be confirmed, the concession will be logged out before 2010, in less than 10 years.

We were not able to get the annual permit boundaries for this concession and we believe that the next step would be to compare the existing road network with VMA boundaries. This could be done in the framework of a bigger study that would allow field verification to assess level of road detection and in close collaboration with the administration of the Ministry of Forest Economy and Environment of the Congo Republic.

Recommendations

A clarification of the limits for all the concessions should be promoted and the Ministry of Forest Economy and Environment should be helped with training and equipment. The pending ITTO project should bring the necessary funds to establish a functional unit within MEFE. Field projects like ECOFAC or the operations run by WCS Congo should consider helping MEFE in concession monitoring by helping developing the DREF control capacities.

Logging companies should be encouraged to develop internal skills that will allow the company a strict respect of their concessions and VMA⁷ or AAC⁸ in the Congo Basin. Even if consulting firms are more and more contracted for assessment, technical training should be a priority. The Limbe Center, promoted by DFID at the Limbe Botanical Garden, both offer some training and, could easily propose regular sessions as they were organized in a common effort between DFID, ONF International and Limbe Center.

The priority for international agencies, such as NASA or SPOT, should make available as much satellite scene as possible for the Congo basin. At the moment, Landsat 7 ETM seems to be handicapped by fatal technical problems that cannot be solved. To date we have no information on the availability of Landsat 7 ETM satellite images to document the evolution of the situation in the Congo Basin. SPOT satellite images remain very expensive and cover

⁷ Volume Moyen Annuel which could be translated by Average Annual Volume. The companies are allocated a know volume after prospecting the forest (100%). The volume is defined to meet the industry's needs which are themselves in accordance with concession surface in a sustainable management scheme based on rotational cutting.

⁸ Assiette de Coupe Annuelle which could be translated as Annual Permit. The company is granted a logging permit of 2500 ha or 1/30 of the surface of the concession, still in a sustainable management scheme. The volume between different AAC are different in a concession and often there is no link between the available timber resource and the industries needs, which is the case in Cameroon.

an areas much smaller than Landsat 7: 3600 km² for SPOT IMAGE compare to 32 400 km².for LANDSAT 7.

The donor community should support such efforts and allow training of private companies, but also support the training of other components of the civil society to reinforce the information availability for a greater transparency in the forest sector of the Congo Basin.

This preliminary assessment conducted on the basis of road network detected from satellite images should be compared to boundaries of VMA officially allocated to the company in this concession. This attempts to establish the level of precision of the assessment and to answer questions related to activities that seem to have taken place out of the boundaries of the concession.

The rate of logging should be regularly checked for all the forest management units in order to facilitate better planning for the national availability of timber resources. This could also provide the opportunity to avoid massive illegal logging operations in time instead of having them clear entire concessions in a few years in the absence of any efficient control.

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Appendix

Appendix 1 : terms of reference

Using remote sensing to assess the state of production forest in Central Africa : a pilot study of Loubonga concession, northern Congo

INTRODUCTION

Logging activities development in the Congo basin generates important revenues both at local and national level. Positive outcomes of logging development are direct with employment of qualified and unqualified workers and indirect with taxes paid by the companies. Although, it is difficult to assess an increase in the quality of life of the many populations in contact with the activity.

In Cameroon, we witnessed a situation where lack of logging title allocation and the newly created forest management units (UFA) lead to rampant development of illegal logging by companies which used this method to secure timber for their industries. Between 1997 and 2000, most of the logging sector, including the largest well known international groups, relied on small permits of various nature to ensure the survival of their industries. These years were characterized by almost systematic logging out of boundaries, which today pose a serious threat on the integrity of the forest sector said to be dedicated to permanent timber production.

The importance of the forest industry, directly and indirectly, is obvious for the economies of many Congo basin countries, this especially with the reduction in oil revenues for many countries. The international community believes that the revenues originating from this sector of the economy could play a more important role in strategies aimed at poverty alleviation. This is why it is necessary to eradicate the non sustainable use of tropical forest timber resources that are largely wasted at the moment.

The objective of this pilot study is to start a new debate on the management of forest resources and of the revenues that can be extracted from the forest sector as a basis to sustainable development in these forested areas.

This recognizing the importance of the developing industrialization in these areas, even if the straight relation between industrialization and development can be discussed. It is however admitted that the combined disappearance of the timber resource, illegally logged, and of the

taxes that could have been extracted from its regular use constitute a tremendous loss for the Congo basin states but also for the forest people for whom development might be purely hypothetical after the disappearance of their main resource and related income.

Illegal logging is a serious threat to the sustainable use of timber resources that most of the international community would like to be promoted to the elaboration and implementation of management plans for the forest concessions. Although, the bushmeat crisis being a combined result of urban market development but also of the non existence of other alternative source of income for forest people entering the global economy and developing cash needs, the threat caused by the non sustainability can be extended to the whole forest economy.

In the Congo basin, the growth of the informal sector dealing with illegal timber extraction is globally reducing the contribution of the forest sector to poverty alleviation, contributing at the same time to losses as high as hundreds of billions of F CFA, with non recovered taxes or damages and interest for the illegal use of the state resources. Illegal logging also lead to the disappearance of alternatives to the unsustainable use of other natural resources like wildlife.

OBJECTIVE

Despite the multiplication of official engagement in favor of a sustainable forest management, illegal logging remains a reality in tropical forests.

This pilot study's main objective is to inform the main actors of a procedure for a more accurate implementation of ongoing reforms by Ministers in charge of forests, who attended the AFLEG meeting in October of 2003.

SPECIFIC OBJECTIVES :

Assess the detection of logging activities in forest management units like Loubonga in northern Congo;

Test various satellite images as main tools to detect illegal logging and follow logging activities;

Compare logging activities detected with satellite images with know logging activities;

Elaborate recommendations to :

- An improvement of the actual situation;
- Assess the importance of remote sensing to evaluate the dynamic of logging activities;
- Elaborate complementary procedures to strengthen the official unit in charge of following logging activities, this within the frame of the ongoing of the Congo basin forest sector reforms.

SITE

To date most of the forested parts of the Congolese forest dedicated to permanent timber production was allocated to logging companies that have signed conventions with the Congolese Ministry in charge of Forest Economy and Environment. Some specific actions like roads building or anti poaching financing are requested from all these companies that also have to develop a management plan for their concessions.

The Forest Management Units of interest are in northern Congo :

East of the Sangha river :

UFA Mokabi (Rougier) :	370 000 ha
UFA Loubonga (Cristal) :	213 200 ha
UFA Lopola (société Bois et Placages de Lopola) :	199 900 ha
UFA Ipendja (Thanry) :	461 296 ha
UFA Enyellé Ibenga :	352 500 ha
UFA Mimbéli (ITBL) :	322 100 ha
UFA Bétou (Dassi) :	300 000 ha
UFA Missa (Dassi) :	225 500 ha
UFA Pokola (CIB) :	480 000 ha
UFA Kabo (CIB):	280 000 ha
UFA Loundoungou (CIB):	390 100 ha
UFA Toukoulaka (CIB):	162 600 ha

West of the Sangha river :

UFA Ngombé (IFO) :	1 350 000 ha
UFA Tala Tala (SOCALIB) :	496 020 ha
UFA Souanké (TBI) :	317 783 ha
UFA Sembé (SIAS) :	221 567 ha
UFA Pikounda Nord (CIB):	93 970 ha

The 4 Forest Management Units located near the Nouabalé Ndoki National Park (Pokola, Kabo, Loundougou and Mokabi UFA) received the support of the Wildlife Conservation Society which manage the NP with the Congolese Government. These companies have the support of WCS to develop the wildlife management plan and biodiversity conservation parts of their management plans.

Most of the other companies need some support to prepare this part of their management plans. Although some consulting firms specialized in management plan elaboration for logging concessions have been contracted to conduct the investigation prior to the management plans elaboration but also to plan an evolution of actual practices toward a more sustainable use of the forest resources.

In Northern Congo, the Bétou, Enyellé and Missa, Forest Management Units have been partially logged since 20 years while logging started recently in the other FMU.

In the Ouesso area (east of the Sangha river) large scale logging started in the 80s even if small scale operations existed some 20 years before, mainly along the Sangha river. Logging starting in the same period on the western side of the Sangha river with a progression west where 2 new FMU were recently created (Sembe and Souanke).

An important road network was developed as part of the Convention signed between the Congolese Government and the logging companies, linking Congo with Cameroon and the Central African Republic. This road network opening will bring major changes in northern Congo which remained quite inaccessible until recently.

Even if the newly allocated FMU have a very low population, the newly build road network is quickly increasing the pressure on wildlife with an new facilities to penetrate the forest and extract wildlife which is than directed toward concentration of population (Bangui, Nola, Mbaïki, Bétou, Boyéllé, etc). with roads and river network.

This first phase and pilot study will focus on Loubonga FMU (213 200 ha), on the Central African Republic border.

A second phase could achieve an assessment of the state of all the FMU in northern Congo (more than 5.5 million ha).

METHODS

Partners and complementarities with other projects

The Woods Hole Research Center will be in charge of the preliminary work on Landsat images. During the second phase of the study, Spot images will also be used to assess the interest of the various products actually available. Some partnership might be requested with SPOT Image for this specific part.

In Congo, NGO and other partners will be consulted for relevant information and verification of the information extracted from satellite images.

ACTIVITES

This study will start by :

information gathering on the Loubonga Forest Management Unit to gather some preliminary information on VMA allocation or logging development these last decades.

Extraction of roads to be confronted to various boundaries to assess importance of logged compare to logged areas;

The full study will add to these activities the following :

Identification and synthesis of the existing information on irregularities known to have occurred.

Combined field reconnaissance and satellite image analysis will permit a better understanding of the logging history in these FMU.

Appendix 2 : Forest Management Units in Republic of Congo

Source: Ministère de l'Economie Forestière et de l'Environnement (MEFE) et Global Witness (GW) mis à jour

No.	Dénomination de l'UFA	Localisation	Superf. (ha)	UFA/lots de production	Sf expl. (ha)	Entreprises/gestion.	Capital
1	Sud 1 Pointe Noire	Kouilou	693 200	UFE Doumanga	5 600	Christiane Goma	Congo
				UFE 1b	25 100	Bisson & Cie	France
				UFE ex-Nlle Cafan	12 000	Kimbakala, Boungou	Congo
2	Sud 2 Kayes	Kouilou	662 400	UFE Kamba & Bada	65 400	FORALAC	Portugal
				UFE Nkola	91 760	FORALAC	Portugal
				UFE Sexo	31 250	FORALAC	Portugal
				UFE 2a Cotovindou	93 630	Man Fai Tai	Hongkong
				UFE Noubi	63 040	COFIBOIS-TAMAN	Malaysia
				UFE Nanga	33 560	QUATOR	Congo
3	Sud 5 Kibangou	Niari	639 800	UFE Doubassi	26 730	MAV-Congo	
				UFE 5C Ngoua 2 Sud	15 100	Nzougou	Congo
				UFE 5A Banda	100 000	retourné (ex-CITB)	
4	Sud 6 Divénié	Niari	305 300	UFE 6A Moutsangani	40 690	SOBODI-TAMAN	Malaysia
5	Sud7 Mossendjo	Niari	1 151 200	UFE 1	110 600	FORALAC	Portugal
				UFE4	13 000		
				Lot 2	282 560	CIBN-TAMAN	Malaysia
				Lot 3	22 600		
				UFE ex Mountou	15 100	Gabriel Nzougou	
				Lot	104 000	AFRIWOOD-TAMAN	Malaysia
				UFE ex Ngambou	41 000	Atelier de la Louessé	
				Lot 2, Majoko, Tsinguidi	104 000	Man Fai Tai	Hongkong
6	Sud 8 Sibiti	Lékoumou	603 800	Lot	17 600	SFD	
				Lot 1	54 000	retourné (ex-CEBT)	
				Lot 3	47 000	V. Mougondo	Congo
				UFE 2	118 700	V. Mougondo	Congo
				UFE 9	120 000	FORALAC	Portugal
7	Sud 10 Zanaga Nord	Lékoumou	1 104 400	UFE 9	99 600	FORALAC	Portugal
				Lot	134 200	STCPA	France
				UFE Ingoumina	170 600	STCPA	France
				UFE A&B, Mbelesse-Bambama	125 000	Man Fai Tai	Hongkong
8	Sud 11 Zanaga Sud	Lékoumou	380 600	UFE	70 400	SFGC-TAMAN	Malaysia
				UFE 11B	36 000	SFGC-TAMAN	Malaysia
				UFE 11D	27 000	SFGC-TAMAN	Malaysia
				Lot	80 000	J. Ngoma	Congo
Total bloc forestier Sud			5 540 700		2 396 820		

No.	Dénomination de l'UFA	Localisation	Superf. (ha)	UFA/lots de production	Sf expl. (ha)	Entreprises/gestion.	Capital
9	Ouest-Talatala	Sangha	496 000		496 000	SOCALIB	Lybia
10	Est-Ngombe	Sangha	1 350 300		1 350 300	IFO	Germany
11	Souanke	Sangha	317 803		317 800	TBI	Leban/Cam.
12	Sembe	Sangha	221 567		221 600	SIAS	Leban/Cam.
13	Pokola	Sangha	377 550		377 550	CIB	Switz/Ger
14	Kabo	Sangha	267 050		267 050	CIB	Switz/Ger
15	Pikounda nord	Sangha	93 970		70 000	CIB	Switz/Ger
17	Toukoulaka	Likouala	162 600		162 600	CIB	Switz/Ger
18	Loundougou	Likouala	390 100		390 100	CIB	Switz/Ger
19	Mokabi	Likouala	370 500		370 500	Groupe Rougier	France
20	Loubonga	Likouala	213 200		213 200	Cristal	Leban/Cam.
21	Lopola	Likouala	199 900		199 900	BPL-BITAR	Leban/Ghana
22	Mimbeli	Likouala	322 100		322 100	ITBL	France
23	Enyele-Ibenga	Likouala	352 500	nouveau découpage	352 500	ITBL	France
24	Ipendja	Likouala	461 300		461 300	Groupe Thanry	France
26	Missa	Likouala	225 500		225 500	Likouala Timber	Italy
27	Betou	Likouala	300 000		300 000	Likouala Timber	Italy
Total bloc forestier nord			6 121 940		6 098 000		

Appendix 3: Contractual engagements for the Loubonga FMU, Likouala region, Congo Republic

Engagements contractuels	Niveau d'exécution au 31 décembre 2000	Situation sur le terrain
Elaboration du plan d'aménagement de l'UFA	Non exécuté	Activités en cours
Construction à Loubonga d'une case de passage pour les agents des Eaux et Forêts	Non exécuté	
Livraison de 2 ordinateurs complets à la DGEF	Exécuté	
Livraison de 1 photocopieuse (FM) à la DGEF	Exécuté	
Fourniture de 3 GPS à la DGEF	Exécuté	
Livraison de 1 véhicule Suzuki 4 portières à la DGEF	Exécuté	
Livraison de 3 machines mécaniques des agents E&F, Douane et Gendarmerie au poste frontière avec la RCA	En cours d'exécution	
Fourniture de 2 ordinateurs portatifs avec micro imprimante à la DGEF	Non exécuté	
Livraison de 4 presses à briques à la DGEF	Exécuté	
Livraison et installation de 2 plaques photovoltaïques pour l'électrification des DGEF de la Likouala et Pool	Non exécuté	
Livraison de 01 coque polyestère de 4 places à la DREF/Likouala	Non exécuté	
Livraison de 01 moteur hors bord 25 CV à la Brigade des E&F de Mossaka	Non exécuté	
Contribution au financement des travaux de la boucle de la Likouala	Exécuté	
Contribution à l'achèvement du Lycée d'Impfondo (10 millions de F CFA)	Exécuté	
Contribution à l'entretien de la rivière Libenga	Engagement exécuté	
Livraison et installation de 02 systèmes de pompage et de réserve d'eau dans les DREF Likouala et Pool	Engagement non exécuté	

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