Global Research Journal of Agricultural and Biological Sciences Vol.3(4) pp.336 –346 October 2012.
Available online http://www.globalresearchjournals.org/?a=journal&id=grjabs

Full Length Research.

SUSTAINING PERICOPSIS ELATA (HARMS) VAN MEEUWEN IN THE TALA TALA FOREST, NORTH CONGO

Jean Lagarde BETTI[1] , Salomon Janvier BELINGA[2] , Dagobert SAMBA[3]

[1] Department of Botany, Faculty of Sciences, University of Douala, BP 24 157 Cameroon.

[2]Ministry of Forestry and Wildlife, Cameroon, Phone: 00 (237) 99 75 64 81.

[3]Ministry of Forestry and Wildlife, Cameroon, Phone: 00 (237) 94 52 43 39.

[1]Corresponding Author's E-mail: lagardebetti@yahoo.fr, Phone : 00 (237) 77 30 32 72.

Accepted 30th November 2011

A study for estimating the stock of the stems of Pericopsis elata was carried out in February – April 2011 in the Tala Tala forest management unit, vast of 621 120 ha, based in the north region of the Republic of Congo. The management inventory was conducted in four sites of at least 5 000 ha each, with a sampling intensity of 1.52%. Fifty height (58) trees of Pericopsis elata, a tree species listed in the Appendix II of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES), were recorded. The average density recorded is 0.18 trees/ha in the four sites. The density of P. elata is more high in logged forests (0.57 trees/ha) than in non-perturbed forests. Simulation of the minimum managed diameter was done based on growth rate, mortality rate, logging damages, and the rotation or the periodicity of logging. The best diameter which conciliates both the conservation and economic concerns on P. elata in the Tala Tala forest is 90 cm. This diameter yields a reconstitution rate of 1.55 (> 0.5) and is high than the minimum exploitable diameter fixed by the Congolese forest administration and which is 60 cm. Diameter 90 cm allows the local timber company to harvest a forest possibility of 3 483.26 m3 of P. elata in 15 833 ha of forest.

Keywords: Threatened species; *Pericopsis elata*; reconstitution rate, Tala Tala forest management unit; Stock; possibility; CITES.

INTRODUCTION

The Republic of Congo hosts 20 millions hectares of central African rain forests. These forests cover 60% of the country and comprise three main blocs including: the Mayombe coast forests which cover 1.5 millions hectares, the Chillu bloc in the centre and south, along the border with the Republic of Gabon (3.5 hectares), and the north forests with 15 millions hectares bordering the Democratic Republic of Congo, Cameroon and Gabon. The annual deforestation is weak, about 0.06% of the total forest area. The main timber species exported from the north Congo belong to the Meliaceae family group, namely Sapelli (*Entandrophragma cylindricum*) and Sipo (*Entandrophragma utile*). *Pericopsis elata* is one of the ten most exported timbers from the north Congo (Dickson *et al.,* 2005).

Pericopsis elata (Harms) van Meeuwen belongs to the Fabaceae family group of plants and is known under its trade/pilot name as Afrormosia or Assamela. It is a tree species of the close, Guinean-Congolese forest type (Vivien et Faure, 1985). Its natural range is discontinued, with several isolated sub-stands in Ghana, Côte d'Ivoire, South-eastern Cameroon, Northern Congo, the North-eastern portion of the Democratic Republic of Congo, and the South-Western portion of the Central African Republic (CAR).

Pericopsis elata is a semi-gregarious species with a limited but widely dispersed distribution. It is locally abundant in parts of its main range. *P. elata* is a high tree, up to 20m that can rich 1.3m of diameter at breast high. The trunk is tortuous and irregular. Trees with high diameter are often hollow or rotten in their heart (Vivien et Faure, 1985; Bourland, 2008). The bark is more characteristic (0.5-1cm), greyish and smooth. The trunk has brown to reddish stains. The slice of the trunk is yellow to orange, with an external green ring. The sapwood is well differentiated, yellow (1-2cm). The wood is brown yellowish. Leaves are light, on horizontal branches. Leaves are deciduous, composed of 7-11 small leaves (follioles in French). Fruits consist of linear indehiscent pods, with brown and smooth surface (Vivien et Faure, 1985).

The lack of natural regeneration for this species has been widely noted by many authors. Forni (1997) and Bourland (2008) reported low recruitment and regeneration levels under closed canopy conditions in unexploited forest in East region of Cameroon. The natural regeneration depends on the light conditions. This regeneration is high in areas where forest logging and forest roads have been realized (Kabala *et al*., 2008). In natural regeneration experiments, it has been observed that the seedlings of *P. elata* are scarce no

matter the overhead canopy is light, medium or dense. It has been suggested that, insect damage to the seeds may be the cause of the scarcity of regeneration. But it is not thought that this species is more liable to insect damage than others especially as its germination period is short. Growth is slow in early youth, but increases when overhead light is available (Dei-Amoah and Cardoso, 2008). It is said that a noticeable amount of natural regeneration for *P. elata* depends on some conditions such as: sufficient number of mother trees, ripe and abundant fruits, and sufficient quantity of seed, a soil well drained, and an optimal light of more than 40% (Peters 1994 cit. Kabala *et al*., 2008). However, natural seedlings are remarkably rare. *P. elata* produces flowers every year or every two years at the minor rainy season (March – May). Ripe and indehiscent pods, are wind-dispersed in strong winds and are produced from January to April (Bourland, 2008). Each pod contains (Vivien et Faure,1985) between 1-4 flat seeds (with diameter 1-1.5cm). Seedlings are reported to be drought tolerant. In early youth it is tolerant of overhead shade but would appear to be a light demander later (Dei-Amoah and Cardoso, 2008).

Pericopsis elata is semi gregarious to gregarious tree and uses to grow on flat ground, valleys and slopes. It is found in high density along rivers (Vivien et Faure, 1985). *P. elata* is a true pioneer species, stimulated to germinate by gaps in the canopy (Forni, 1997; Dei-Amoah and Cardoso, 2008; Dimanche et Regner, 2008; Kabala *et al.,* 2008). This plant species accepts soils of "Reddish-yellow latosols", with an annual temperature of 23 – 26°C (Kabala *et al.,* 2008).

P. elata is classified by the World Alliance for Nature (IUCN) as endangered species (IUCN, 2001), which led to its listing in the Appendix II of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES). This decision had a significant impact on the revenues produced from this value timber species in the range countries. As it is, the species is indeed endangered and has become all but locally extinct in some countries where the exploitation and international trade in this species had begun some 55 years ago. Significant stocks of the species still exist, however, in the Congo Basin, including Cameroon, CAR, Democratic Republic of Congo, and Congo.

In Congo, *Pericopsis elata* is found in the North, in the Sangha basin to be précised. The total surface area of *P. elata* in the North Congo is 4 791 968 ha. The plant is found in five forest management units (FMU) including: Ngombé, Pokola, Kabo, Djoua-Ikié and Tala Tala.

The review of the significant trade (CITES, 2003) proposed that Congo should be listed in the Category 'Species of possible concern'. This is a category of countries for which it is not clear whether or not the provisions of Article V, paragraphs 2 (a) or 3 of the CITES are being implemented.

This paper aims to estimate the stock of *Pericopsis elata* in the Tala Tala Forest Management Unit (FMU) through the partial inventory as a contribution for making non-detriment findings on *Pericopsis* for Congo.

MATERIAL AND METHOD

Site

The Tala Tala Forest Management Unit is located in the north Congo, Sangha division, between 1°16' – 2°12' latitude North and 14°28' – 15°52'longitude East (figure 1). It covers an area of 621 120 hectares. The climate is equatorial and humid, of forest guinean type. Average annual rainfall is 1 600 mm – 1 800 mm, while annual temperature is 24 - 26°C. The Tala Tala forest is situated in the Congo basin on the Precambrian plateau. The rainy season extends from March to November and the dry season from December to March. October is the highest rainy month (238 mm). The altitude of this plateau slopes considerably in the west where we have more than 500 m.

Tala Tala FMU is the combination of three main domain areas including: the west zone formerly attributed by the Congolese Government for forest logging to the "Société Congolaise Arabe Libyenne" (SOCALIB) timber company from 1986 to 1990, the centre zone attributed to the "Société Forestière Algéro Congolaise" (SFAC) timber company from 1986 to 2003, and the area not yet attributed located at the Sembé – Souanké zone to be précised. Since 2010, SIFCO is working to develop the management plan of the Tala Tala FMU. The document of the management plan is supposed to be finalized by 2013 – 2014.

The Tala Tala FMU accommodates a variety of wildlife species including such endangered species as the forest elephants (*Loxodonta africana cyclotis*), the chimpanzees (*Pan troglodytes*), the leopards (*Panthera pardus*), as well as the forest buffaloes (*Tragelaphus euryceros*) and the gorillas (*Gorilla gorilla*). The main vegetation type is composed of drain and humid forests. There are many swamp forests, mostly along rivers. Degraded forests exist mainly along roads and former logging areas. Annonaceae, Combretacae, Ebenaceae, Irvingiaceae, Meliaceae, and Sterculiaceae are the most important plant families found in the Tala Tala forest.

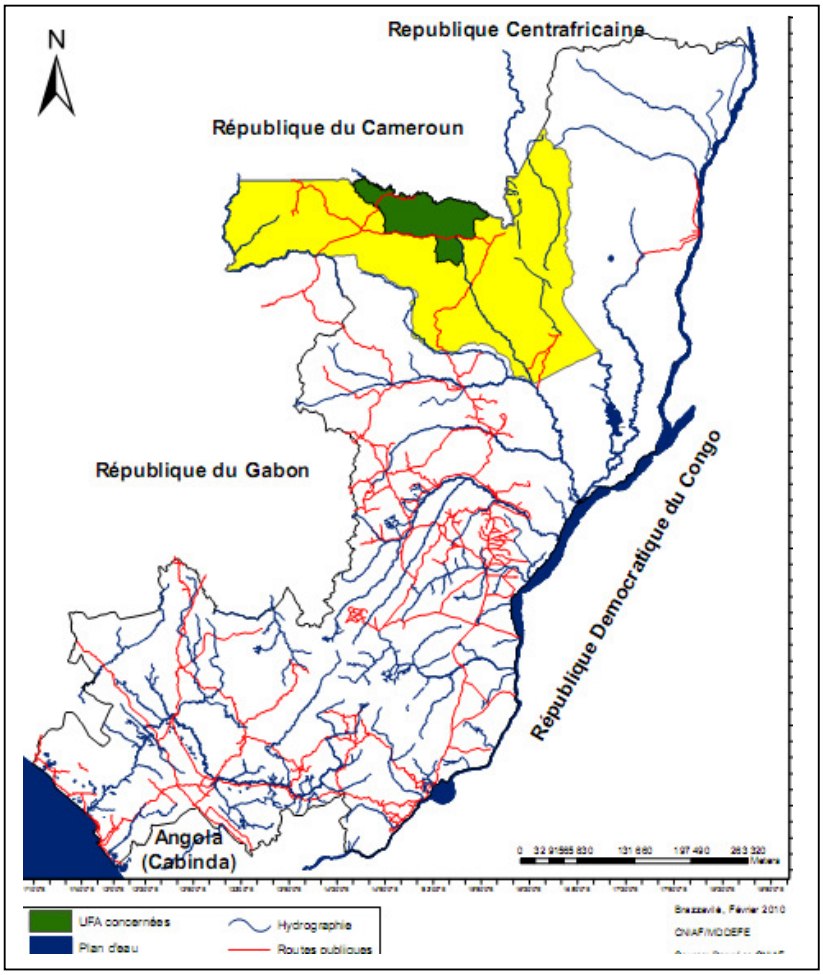

Figure 1 : Location map of the TalaTala forest management unit in the North Congo.

Method

The partial inventory was carried out in the Tala Tala from February to April 2011. The method used is the known classical forest inventory method standardised for management inventories in Congo (Ministry of Forest Economy and Environment, 2005).

1. Sampling design

We used a Global Positioning System (GPS) and vegetation maps to settle our sampling plots.

As indicated in the national standards (Ministry of Forest Economy and Environment,2005), the sampling was systematic and stratified to 1 degree when the statistical unit is the plot. The samples or plots of 0.5 ha are distributed systematically throughout the entire population. The systematic disposal of plots allows to assume that the intensity of sampling for each stratum is proportional to its area in the forest.

In practice, sampling was carried out along straight and continuous axes or transects. These transects are oriented along a predetermined cardinal direction but are systematically arranged in such a way that they are mostly parallel, equidistant and perpendicular to the general direction of both drainage and slopes.

Rectangular plots arranged along a transect are contiguous (without alley or corridor of separation) and measure 200 m in the direction of the transect (length) and 25 m in the direction perpendicular to the transect (width). This gives a surface area of 0.5 ha for each plot.

The mapping activity allowed us to distinguish four main forest types including: the primary forest, the secondary forest, the swamp forest and the cultures (agricultural areas). Four zones or sites of at least 5 000 ha were delimitated in the Tala Tala FMU considering the slope and the vegetation type as follow:

- site 1: 5 269 ha is located in the north west of the Tala Tala FMU, on the road Mgbala - Sembé. It is composed of three forest types including agricultural areas along the road, primary forests and secondary forests;
- site 2: 5 411 ha is located in the north, closed to the Tala Tala village. The bloc is composed of degraded or secondary forest. The main characteristic of this site is that it is located in the former forest that has been logged by the SOCALIB timber company from 1986 to 1990.
- site 3: 5 500 ha is located in the south, closed to the Kokoua village. It is also a secondary forest, but we are not yet fixed on the origin of the perturbation (forest logging or agricultural activity?).

- site 4: 5 000 ha is located in the far south of the Tala Tala FMU, closed to the Séka and Makelien villages, in the north of the Odzala national Park. This site is almost totally composed of swamp forests.

The distance between two consecutive lines is 2 500 m. A total of 33 km of lines was planned per site. The sampling design is illustrated in figure 2.

2. Implementing the sampling design

The inventory consists of two steps: line opening/transect cutting and counting.

Line opening/transect cutting

This step consists of opening or cutting according to a defined magnetic direction, corridors or alleys of 1.5 m wide. These corridors are clearly cleaned by cutting shrubs, vines and branches that obstruct the passage. They are then identified by marks. “Layons” constitute the reference system which will be used by the subsequent counting team. It is during the line opening that details on topography, habitat types, rivers and the corrected horizontal distance of the transect (after reading the slopes) are given. It is also during this stage that the sample plots are identified and numbered. The data collected are recorded on specific sheets.

We planned to open 132 km of lines, but we finally opened 130.4 km of lines (table 1), which gives a lining effort of 98.79%. site I being the site where the lining effort was low compared to other sites (98.47%).

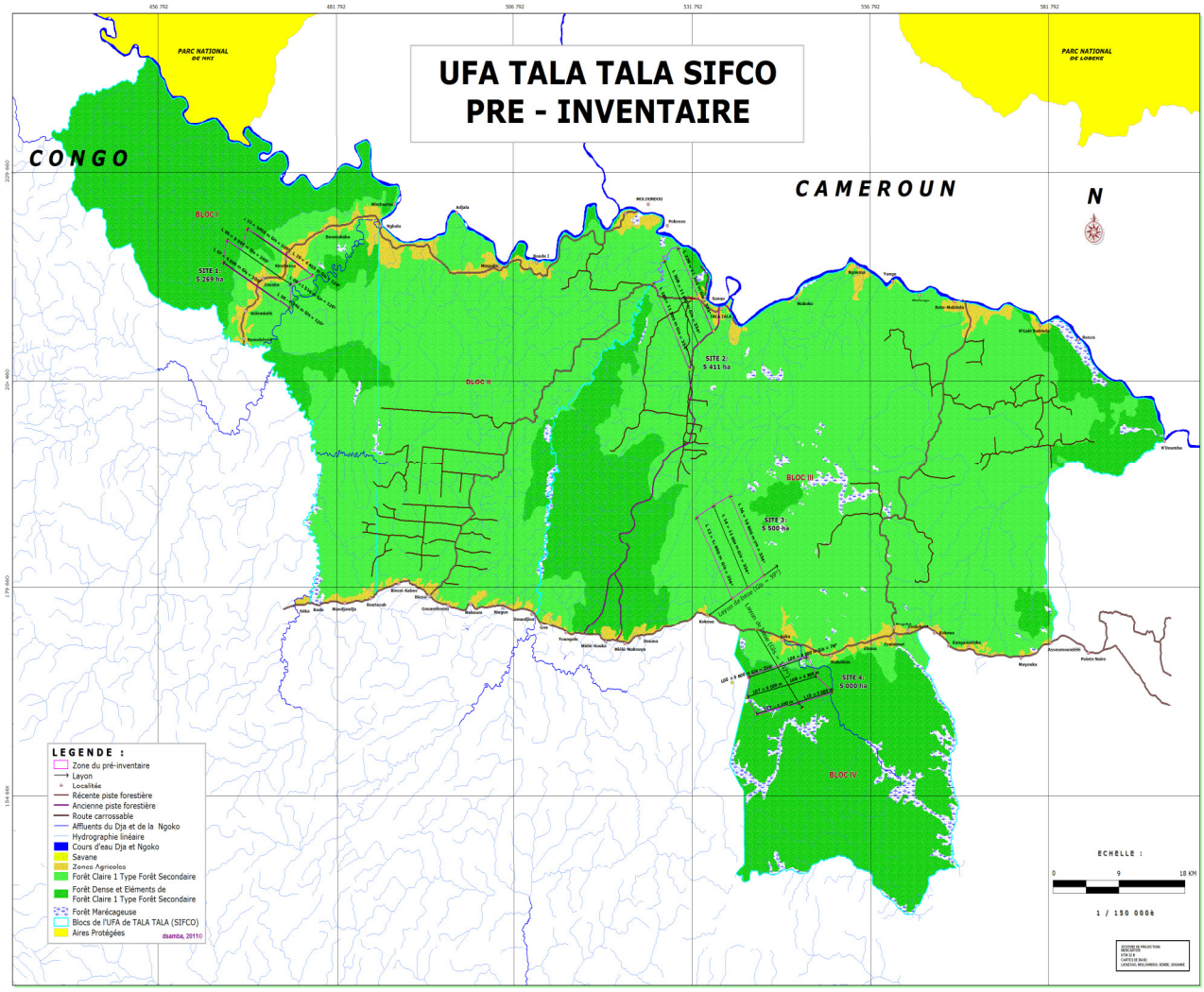

Figure 2: Sampling design for the partial inventory of the Tala Tala FMU, north Congo.

Table 1: Distribution of lines in different sites with the rate of realization

Site	Number of lines	N° of the line	Previsions (m)	Realization (m)	Rate of realization (%)
1	6	L6	5350	5350	100%
		L7	5650	5625	99.56%
		L8	1600	1525	95.31%
		L9	9000	9000	100%
		L10	4450	4450	100%
		L11	6550	6450	98.47%
Sub - total			**33 000**	**32 400**	**98.41**
2	3	L18B	11 000	11 000	100%
		L20B	11 000	11 000	100%
		L22B	11 000	11 000	100%
Sub-total			**33 000**	**33 000**	**100%**
3	3	L12	11 000	11 000	100%
		L14	11 000	11 000	100%
		L16	11 000	11 000	100%
Sub-total			**33 000**	**33 000**	**100%**
4	6	L5	6700	6700	100%
		L6	4300	4300	100%
		L7	6 000	6 000	100%
		L8	5 000	4 000	80%
		L9	6 000	6 000	100%
		L10	5 000	5 000	100%
Sub-total			**33 000**	**32 000**	**96.97%**
Total			**132 000**	**130 400**	**98.79%**

Counting

P. elata is a high tree species which can reach 50 cm height and 150 cm of diameter. In Congo, the minimum exploitable diameter (MED) for *P. elata* has been fixed by the forest administration at 60 cm. This is, only trees with diameter equal or high than that value are authorized to be logged.

The counting step includes all operations relating to dendrological and dendrometric records. During the counting, several operations are made including: identification of stems of trees, the measurement of stems with diameter at breast height (dbh = 1.50 m) >= 20 cm. Lines and plots are identified and numbered with their geographical coordinates and altitudes.

Table 2 presents for each site, the total surface area, the number of plots, the sampling area, and the sampling rate (intensity). A total of 644 plots of 0.5 ha each were inventoried in 24 lines. The four sites have a total surface area of 21 102 ha. A total of 322 ha out of that surface area was totally covered by forest inventories giving an average sampling intensity of 1.52%.

3. Data analysis

For analysis, we determined the number of stems in different diameter classes, the density (number of stems/ha), the minimum management diameter or the sustained diameter (MMD), the stock of *P. elata* stems and the volume of *P. elata* per ha, per site, and in different diameter classes.

In this paper, the MMD referred to the minimum diameter for which the exploitation (logging activity) of *P. elata* can be considered as sustainable. The MMD was determined through the recovery rate/or reconstitution rate (Re) formula developed by the Pilot Management Project (API) in Cameroon (Durieu De Madron and Forni, 1997). The reconstitution rate is an index which allows to know if the logged stems will be replaced by other stems situated below of the MED at the end of the rotation and at which proportion. The reconstitution of the resource is good when Re is more than 0.5. The method through the reconstitution rate is interesting since it takes in consideration the rotation, the growth rate, the mortality rate, the damage rate. Only trees with diameter MED + 3 classes are logged. Trees with diameter > MED + 3 are left in the forest as mother trees as to ensure the regeneration of the resource. Rotation is the delay between two successive harvests. It is the time spent between two successive logging years in the same space. In Congo, it is fixed at 30 years. However, this can increase in case of some specific constraints revealed by the analysis of the inventory data. The growth rates currently used in Congo for forest management are those developed in Central African Republic (Bedel *et al.,* 1998). For *P. elata*, the growth rate is 0.4 cm/year.

$$\%RE = (No\ (1-\Delta)\ (1-\alpha)^{T})/Np$$

Where:

α: natural mortality (1%) per year;

Δ : mortality caused by logging damage. In Congo, the forest administration has fixed it at 10%, which is high than the limit used in Cameroon (7%).

^{T} : rotation (30 years);

Np: total exploitable stems (MED + 3) to be reconstituted;
%Re: percentage of reconstitution (reestablishment).
No: number of stems of diameter classes < MED, which are used for the reconstitution (reestablishment) of the ligneous resource. This referred to the number of trees which will reach the MED after the first rotation (30 years). N0 is determined from the low limit (Li) of diameter classes which will reach the MED after the first rotation as follow:

Li = MED - (AGR x T) with

Li = Low limit of the diameter classes which will reach the MED after the first rotation;

AGR = Annual Growth Rate in diameter = 0.4 cm/year.

At MED 60 cm (or diameter class 60 – 69 cm) for example, N0 will be the number of stems with diameter between Li and MED with Li = 60 cm – (0.4 x 30) = 48 cm.

This means that N0 will be the number of stems with diameter found between 48 and 60 cm. This is represented by the diameter class 50 – 60 cm.

When using the reconstitution rate approach, one should have in mind two assumptions: (1) current conditions will be maintained during a certain time (at least during the incoming century) for what concerns the climate and the growth of trees, and (2) the growth rate and the mortality rate defined in the literature using stations data can be applied on the whole forest of Tala Tala, vast of 621 120 ha.

The volume of *P. elata* was deduced using the cubage tariff (mathematical formula) developed in the Kabo FMU, located not far from Tala Tala FMU, in the same forest district. The cubage tariff is a mathematical formula which links the diameter at breast high of a tree with its stand volume. For *P. elata* and other timber species, that relation is given through the following regression equation: $V = 14.1062\ D^2 - 1.3180$; where V is the stand volume in m^3 and D the diameter at high breast in cm. This cubage tarif was adopted by the Congolese National Centre for forest inventory and management (National Centre for forest inventory and management, 2006).

Table 2 : Sampling intensity per site

Site	Surface area (ha)	Number of plots	Sampling area (ha)	Sampling Intensity (%)
1	5 269.00	152	76	1.44
2	5 411.00	168	84	1.55
3	5 500.00	164	82	1.49
4	5 000.00	160	80	1.60
Total	**21 102**	**644**	**322**	**1.52**

RESULTS

Specific curve

Figure 3 illustrates the distribution of *P. eleta* trees in different diameter classes or the specific curve. The high number of stems is found in diameter class 50 – 59 cm, with 20 stems. It is interesting to note also a high number of stems in small diameter classes; in fact, diameter classes 20 – 29 and 30 – 39 totalise 25.8% of the total number of stem.

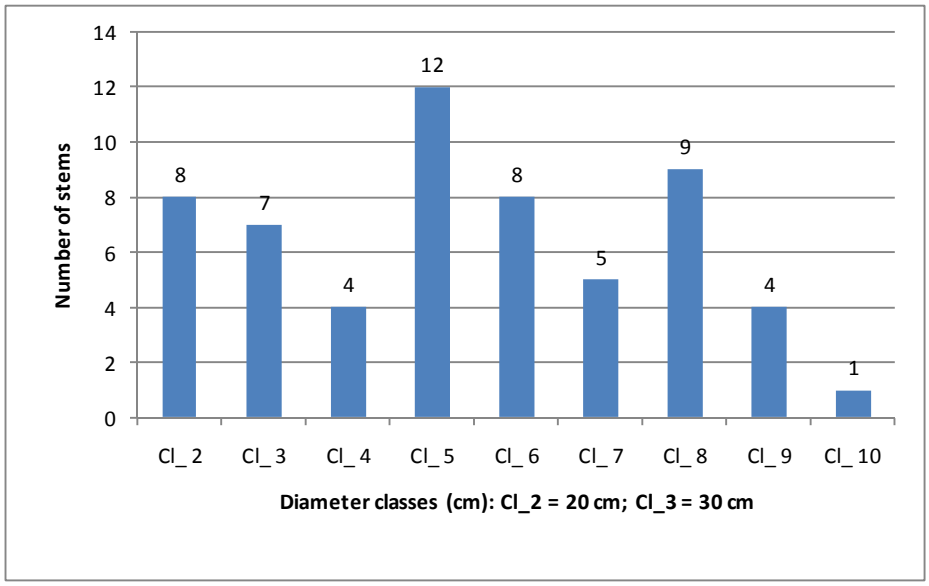

Figure 3. Distribution of *Pericopsis* stems in different diameter classes in the Tala Tala forest.

Density of *Pericopsis* stems

Fifty height (58) trees of *Pericopsis elata* were recorded (table 3), which gives a density of 0.18 trees/ha in the four sites. No stem of *P. elata* was recorded in site IV. If we limit the analysis on the three sites which host *P. elata*, the average density of that tree species becomes 0.23 trees/ha. But this density varies largely from one site to another (table 4). Site II is the one that hosts the high density of *P. elata* trees (0.57 trees/ha).

Table 3 : Distribution of number of stems of *Pericopsis elata* in different diameter classes and per site. MMD = 90 cm

Sites	Cl_2	Cl_3	Cl_4	Cl_5	Cl_6	Cl_7	Cl_8	Cl_9	Cl_10	Stems to keep for the regeneration (Diameter < 90 cm)	Exploitable Stems (Diameter >= 90 cm)	Total
I	1		1	2			1		1	5	1	6
II	7	6	3	10	8	4	7	3		45	3	48
III		1				1	1	1		3	1	4
Total	8	7	4	12	8	5	9	4	1	53	5	58

Table 4: Distribution of density (number of stems/ha) of *Pericopsis elata* in different diameter classes and per site.

Sites	Cl_2	Cl_3	Cl_4	Cl_5	Cl_6	Cl_7	Cl_8	Cl_9	Cl_10	Stems to keep for the regeneration (Diameter < 90 cm)	Exploitable Stems (Diameter >= 90 cm)	Total
I	0,01		0,01	0,03			0,01		0,01	0,07	0,01	0,08
II	0,08	0,07	0,04	0,12	0,10	0,05	0,08	0,04		0,54	0,04	0,57
III		0,01				0,01	0,01	0,01		0,04	0,01	0,05
Average	0,05	0,04	0,02	0,07	0,10	0,03	0,04	0,02	0,01	0,21	0,02	0,23

Determination of the minimum managed diameter (MMD)

Table 5 presents for each diameter class, the Number of stems reserved for the reconstitution (N0), the Number of exploitable stems (NP), the reconstitution rate (Re) or the percentage of reconstitution (Re (%)). The reconstitution rate is low for diameters 60 – 89 cm, less than 0.5. it is high at diameter class 90 – 99 cm (1.197) and very high at 100 – 110 cm. Figure 4 illustrates the evolution of the reconstitution rate in different diameter classes.

Table 5. Number of stems and reconstitution rate in different diameter classes.

Diameter class (cm)	Number of stems reserved for the reconstitution (N0)	Number of exploitable stems (NP)	Reconstitution rate (Re)	Re (%)
60 - 69	12	26	0.306	30.6
70 - 79	8	19	0.280	28.0
80 - 89	5	14	0.237	23.7
90 - 99	9	5	1.197	119.7
100 - 109	4	1	2.660	266.0

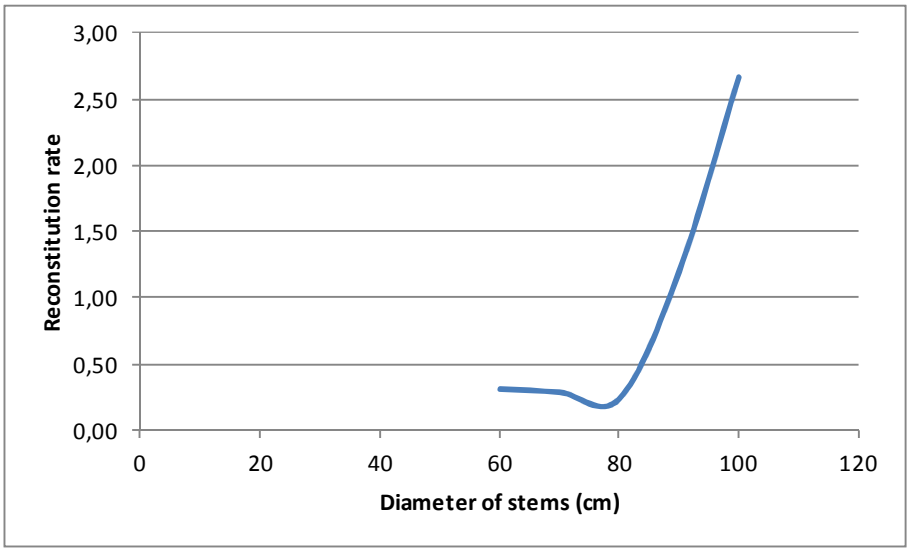

Figure 4. Evolution of the reconstitution rate with the variation of the diameter.

Determination of the possibility (logging volume) of *P. Elata*

Table 6 presents the distribution of the volume/ha of *P. elata* in different sites and in different diameter classes. The average volume/ha recorded for the three sites was 0.82 m^3/ha. The highest volume being obtained in site II (1.86 m^3/ha). The average logging volume is 0.22 m^3/ha at MMD 90 cm. This gives the possibility (logging volume) of 0.22 x 15 833 ha = 3 483.26 m^3 for *P. elata*. At MMD 100 cm, the possibility is 0.17 x 15 833 ha = 2 691,61 m^3.

Table 6 : Distribution of the volume/ha of *Pericopsis elata* in different diameter classes and per site.

Sites	Cl_2	Cl_3	Cl_4	Cl_5	Cl_6	Cl_7	Cl_8	Cl_9	Cl_10	Stems to keep for the regeneration (Diameter < 90 cm)	Exploitable Stems (Diameter >= 90 cm)	Total
I			0,01	0,06			0,10		0,17	0,17	0,17	0,33
II			0,03	0,26	0,36	0,27	0,64	0,36		1,56	0,36	1,86
III						0,07	0,09	0,12		-	0,12	0,28
Average			0,02	0,16	0,36	0,17	0,28	0,24	0,17	0,58	0,22	0,82

DISCUSSION

Background on the legal frame on forest sector in Congo

Since 2000, the Government of Congo has engaged important forest reforms (Ministry of Forest Economy and Environment, 2004, 2005). In Congo, the forest logging is conducted through the logging convention. The attribution of these different conventions is subordinated by the validation of the management plan by an Inter ministerial Committee presided by the forest administration. Forest Management Units (FMU) are vast forests of more than 100 000 ha, assigned to the sustainable production of the wood and other resources (non timber forest resources for example) in respect to the conditions that allow the preservation of ecological functions of the forest. When allocating the FMU to a given company, a preliminary three years convention is signed between the Forest administration and the forest company. The terms of this preliminary convention precise that the forest company has to produce within the three-years of the convention and before the definitive convention has been signed, three types of documents in respect to the norms and rules indicated in the forest law, and including: a management plan for the whole concession (FMU), a five-years management plan (for the forest logging unit), and the operation plan of the first year of activity. At the end of the preliminary convention, a definitive convention is then signed between the forest Company and the Congo Government for a renewable period of 15 years. At any step of the elaboration of the management plan, the forest administration verifies what has been realized in the previous step before giving his approval for the next step (Ministry of Forest Economy and Environment, 2005).

The Congo Government distinguishes two main steps in conducting forest management inventories: the partial inventory and the total inventory. The first step is the partial inventory that must be conducted in at least three areas of 5 000 ha each representing the main forest strata of the FMU. The sampling intensity in each area should be at least 1.5%. When the partial inventory has been done in fair manner and after the forest administration authorities have approved the work, then the timber company is authorized to go forward to the total inventory of its FMU with the sampling intensity which is about 1% depending on the targeted precision.

Sampling intensity

In this paper, sampling intensity includes both lining effort and counting effort. The average sampling intensity is 1.52%. this is high and is in accordance with the national standards which state that the sampling intensity should be at least 1.5% for the partial inventory (Ministry of Forest Economy and Environment, 2005). Site I is the zone where both the lining (98.47%) and counting (1.44%) efforts are low. This can be explained by the geomorphology of that area, characterized by high slopes, more than 500 m of altitude. Some lines delimitated were not totally opened and some opened lines were not totally counted by our teams in the field. This site should be excluded of any logging activity to avoid accidents and to avoid to abandon trees in the forest. That site can be devoted for conservation and research.

Specific curve/diameter structure

Pericopsis elata is one of the most important timber for the SIFCO timber company who is working in the Tala Tala forest management unit. The tree is classified in group I, which is the group of the most valuable timber species. *P. elata* was found in three sites including sites I, II, and III. The high number of stems is found in diameter class 50 – 59 cm. Data compiled from management inventories conducted in 28 forest concessions covering 2 173 320 ha in south east Cameroon revealed that, the high number of *P. elata* stems was found in diameter classes 50 – 59 cm and 60 – 69 cm. Small stems were scarce (Akoa *et al*. 2009). *P. elata* is a light demanding tree species. As most of light demand tree species such as Ayous (*Triplochiton scleroxylon*) or Emien (*Alstonia boonei*), the number of small stems is often low in primary or non perturbed forest, due to the lack of light (Durieu de Madron and Forni, 1997). A high number of stems of small diameter found in Tala Tala forest may be caused by the fact that, some of those forests, site II to be précised, have been subjected to forest logging in past years.

Density of *Pericopsis elata* stems

The average density obtained for *P. elata* in the three sites is 0.23 stems/ha. This density is not too far from the 0.26 stems/ha found in the same area by N'zala *et al.,*(2011) and illustrates the high richness of Tala Tala on *P. elata*. However, the density is twice less than what is seen in the south east zone of Cameroon (0.53 stems/ha) which borders the north Congo (Akoa *et al*., 2009). The highest density is found in site II with 0.57 stems/ha. This site hosts more than 83% of stems. The history of the Tala Tala forest reveals that, the site II is located in a secondary forest, where forest logging was conducted in pass years, between 1986 and 1990 by SOCALIB timber company to be précised. *P. elata* being a high light demanding plant species has found in that area a favourable milieu for growing. This fact enforces the idea which stipulates that forest logging can be an important tool for *P. elata* regeneration (Delvingt *et al*., 2009; Kabala *et al*., 2008; Durieu De Madron and Forni, 1997; N'zala et al., 2011). The lack of natural regeneration for this species has been widely noted in unexploited forest in East region of Cameroon. Low recruitment and regeneration levels were reported under closed canopy conditions (Durieu De Madron and Forni, 1997).

Minimum managed diameter (MMD)

As defined before, the MMD referred to the minimum diameter for which the exploitation of *P. elata* can be considered as sustainable. In practice, the rotation can vary according to the forest type and the proposed management scheme. Because future harvests will take off the cumulative production obtained during the first rotation, a sufficient number of young stems

(diameter less than the MED) should be left in forest to ensure the regeneration. The rotation length is therefore directly link to the time that young individuals need to reach an exploitable diameter. Data presented in this paper show that *P. elata* reconstitution is effective from diameter 90 cm. This diameter is the least which allow the species to be reconstituted after the first rotation of 30 years in Tala Tala forest. This diameter is high (three diameter classes more) than the minimum exploitable diameter fixed by the congolese forest administration and which is 60 cm. It is possible that the fixation of this MED (60 cm) was supported by the scheme of the diameter of regular fructification. The diameter of regular fructification (DRF) for a given tree species represents the diameter for which more than 70% of individuals (trees) produce regularly viable fruits. Studies conducted in the Democratic Republic of Congo revealed that the DRF for *P. elata* is 35 cm (Sépulcre *et al*. 2008 cit. Delvingt *et al*., 2009) and is therefore low compared to the MED.

Diameter 100 cm provides a very high reconstitution rate (266%) for *P. elata*, but with a low possibility (logging volume/ha). According to timber companies who are working in the south east Cameroon, *P. elata* stems at diameter ≥ 100 cm are wilting, and stems of many of them are rotten. Those individuals are therefore often abandoned in the forest, which lead to an economic loss for both the timber company and the government (Betti, 2008; Akoa *et al*. 2009).

Following what precedes, we propose 90 cm as the MMD which should be used for sustaining *P. elata* in the Tala Tala forest management unit. This diameter allow *P. elata* to regenerate and reconstitutes itself after the first rotation of 30 years, and allows the SIFCO timber company to harvest good quality stems of *P. elata*.

CONCLUSION

The estimation of the stock of *Pericopsis elata* trees is one of the most important tool for making non-detriment findings for that CITES listing tree species. The work described in this paper was done in accordance with national standards settled by the Congolese forest administration. The density of *P. elata* is more high in logged forest than in non-perturbed forest, which shows that forest logging is a suitable tool for sustaining *P. elata* in Tala Tala forest. The best minimum managed diameter which conciliates both ecological and economic concerns for sustaining *P. elata* in the Tala Tala forest is diameter 90 cm. This diameter is high than the one fixed by the forest administration and which is 60 cm. Diameter 60 cm cannot allow the reconstitution of the resource, even if the SIFCO company improves its logging protocol by mitigating the damage rate. If adopted, MMD 90 will allow SIFCO to harvest a total of 3 483.26 m3 of *P. elata* timber in the three sites where the species was found.

ACKNOWLEDGEMENTS

We thank all the villagers and labourers who collaborated with us in this study. The study was supported by the SIFCO timber company as a contribution to the join International Tropical Timber Organization (ITTO) - Convention on International Trade in Endangered Species of Fauna and Flora (CITES) Program for Implementing CITES Listings of Tropical Tree Species.

REFERENCES

Akoa A, Betti JL, Bindzi I, Bilong P, Tchatat M, Ndam N,Onana M, Mbarga N, Belinga SJ, Koulbout D, Tieguhong Chupezi J, Assembé S 2009 Non-detriment findings report on *Pericopsis elata* (Fabaceae) in cameroon. Report prepared for the National Forestry Development Agency (ANAFOR), Cameroon's CITES Scientific Authority for flora, P. 97.

Bedel F., Durieu de Madron L., Dupuy B., Vavrichon V., Maître H.F., Bar Hen A., Narboni P. 1998 Dynamique de croissance dans les peuplements exploités et éclaircis de forêt dense africaine – dispositif de M'baiki en République Centrafricaine – Série FORAFRI (1), p. 72.

Betti J L. 2008 Non-Detriment Findings Report on *Pericopsis elata* (Fabaceae) in Cameroon. Report prepared for the International Expert Workshop on Non-Detriment Findings, Mexico, November 17th-22th, 2008. 54 p. www.conabio.gob.mx/.../TallerNDF/...CS2%20Pericopsis/WG 1-CS2.pdf

Bourland N. 2008 synthesis on the ecology of *Pericopsis elata* in south east Cameroon. ITTO - CITES regional training workshop: ensuring that international trade in *Pericopsis elata* is non-detrimental to its conservation, Kribi, Cameroon, 2 - 4 April 2008, p. 6.

CITES 2003 Review of Significant Trade: *Pericopsis elata*, PC 14 Doc. 9.2.2.

Dei-Amoah C., Cardoso R.D. 2008 Sustainable trade in *Pericopsis elata* in Ghana. National report presented at the ITTO - CITES regional training workshop: ensuring that international trade in *Pericopsis elata* is non-detrimental to its conservation, Kribi, Cameroon, 2 - 4 April 2008, p. 8

Delvingt W, Cassagne B., Bayol N 2009 L'importation d'Afrormosia dans l'Union européenne : cas de la RDC. Association Technique International des Bois Tropicaux (ATIBT), Publication 01/2009, Commission forêt, p. 14

Dickson B, Mathew P, Mickleburgh S, Oldfield S, Pouakouyou D, Suter J (2005) An assessment of the conservation status, management and regulation of the trade in *Pericopsis elata*. Fauna & Flora International, Cambridge, UK, p. 68

Dimanche L., Regner P. 2008.sustainable management of *Pericopsis elata* in the Central African Republic. ITTO - CITES regional training workshop: ensuring that international trade in *Pericopsis elata* is non-detrimental to its conservation, Kribi, Cameroon, 2 - 4 April 2008, P. 6.

Durieu de Madron L, Forni E 1997 Forest management in East Cameroon : stand structure and logging periodicity. Bois et Forêts des tropiques, n° 254 (4): 39 – 50.

Forni E 1997 Forest types in east Cameroon and diameter structure of some tree species. Memoir for the Diploma in Agronomic Science and Biology. Faculté Universitaire des Sciences Agronomiques de Gembloux

Kabala Tshikala F, Kutelama-a-Seleko D, Toirambe Bamoninga B, Massudi Mayan'Kenda C 2008 Sustainable use of Afrormosia in the Democratic Republic of Congo : situation observed from 2005 to 2007. National report presented at the ITTO - CITES regional training workshop: ensuring that international trade in *Pericopsis elata* is non-detrimental to its conservation, Kribi, Cameroon, 2 - 4 April 2008, p. 19.

IUCN (2001). Critical category and the IUCN Red list: version 3.1. Survival Commission of IUCN Species, IUCN, Gland, Switzerland and Cambridge, United Kingdom, p. 32.

Ministry of Forest Economy and Environment (2005) National standards for management inventories of forest resources in the Republic of Congo.

Ministry of Forest Economy and Environment (2004) Forest code of 2000. Editions Hémar, Brazzaville, p. 142.

National Centre for Forest Inventory and Management 2006 Tarifs de cubage utilisés pour l'UFA Kabo, Nord Congo.

N'zala D, Loumeto J, Kami E, Yoka J, Mombeki S, Imbounou A, Samba JL, Ossebi-Mbila S, Banzouzi JC (2011). Non-detriment findings report for *Pericopsis elata* in North Congo. Join International Tropical Timber Organization (ITTO) - Convention on International Trade in Endangered Species of Fauna and Flora (CITES) Program for Implementing CITES Listings of Tropical Tree Species, P. 86.

Vivien J, Faure JJ (1985). Trees of Central African forests. Ministry of foreign relations, cooperation and development – Cultural and Technical Cooperation Agency (ACCT), Paris, P. 551.