International Journal of Biodiversity and Conservation Vol. 3(7), pp. 267-279, July 2011
Available online http://www.academicjournals.org/ijbc
ISSN 2141-243X ©2011 Academic Journals

Full Length Research Paper

Mass of *Prunus africana* stem barks on the Mount Cameroon forest

Jean Lagarde Betti[1]* and Joseph Ambara[2]

[1]Department of Botany, Faculty of Sciences, University of Douala, BP 24 157 Cameroon.
[2]Ministry of Forestry and Wildlife, Cameroon.

Accepted 20 April, 2011

Prunus africana **is a species of the Rosaceae family, known under its trade/pilot name as pygeum or African cherry. The bark is the major source of an extract used to treat benign prostatic hyperplasia, an increasingly common health problem in older men in the western world. A study for estimating the mass of the stem barks of** ***P. africana*** **was carried out in December, 2011 on the Mount Cameroon Forest. Diameter at breast high and the thickness of the stem bark of each** ***Prunus*** **tree were recorded to establish the cubic tariff or the relation between the diameter and the volume of the stem bark. Some samples of stem barks were collected, and their volume and mass were noted, with view to establish the relation between the volume of the bark and its mass or the mass per volume metre. The best equation which links the volume (V) of fresh barks to the diameter (D) of each** ***Prunus*** **tree is** $V = 0.00005*D^{1.916}$**. The average mass of an exploitable** ***Prunus*** **tree is 99.86 kg. A suggestion is made to sustain** ***P. africana*** **in Mount Cameroon.**

Key words: Threatened species, *Prunus africana*, Mount Cameroon, Bitterlich's Relascope, cubic tariff, CITES.

INTRODUCTION

Prunus africana (Hook.f.) Kalkman (formerly *Pygeum africanum* Hook.f.) is a species of the Rosaceae family, known under its trade/pilot name as pygeum or African cherry. It is a mountain tree species of the tropical Africa including the Côte d'Ivoire, Bioko, Sao Tome, Ethiopia, Kenya, Uganda, South Africa, Madagascar, Congo, the Democratic Republic of Congo, and Cameroon. *P. africana* grows well in the sub-mountain and mountain forests at an altitude of 1500 to 3000 m. In Cameroon, the plant is largely found in five regions including Adamaoua, North west, Littoral, South west, and West. *P. africana* is an evergreen canopy tree to 30 m tall with thick, fissured bark and straight bole that can reach a diameter of 1.5 m. It is light demanding and responds well to cultivation (Hall et al., 2000; Vivien and Faure, 1985, Fraser et al., 1996; Tchouto, 1996).

In Cameroon the minimum exploitable diameter (MED) for *Prunus* trees is 30 cm and till 2006, the national CITES quota for *Prunus* dried barks was 2000 tons/year". The bark is the major source of an extract used to treat benign prostatic hyperplasia, an increasingly common health problem in older men in the western world. Bark extracts contain fatty acids, sterols and pentacyclic terpenoids (Cunningham and Mbenkum, 1993). The drugs processed from the bark extracts are sold under the brand-name of "Tadenan" in France by Laboratoire Debat, "Pygenil" in Italy by Idena Spa, and "Proscar" in UK by Merck Sharp and Dohme Ltd (ICRAF cit. Ndam, 1996). A total of 3,260 tons of *Prunus* dried bark was granted to 33 trade companies by the Cameroon forest administration in 2005 (2,000 tons) and 2006 (1,260 tons). A total of 2,558.37 tons of *Prunus* bark (78.5% of the granted *Prunus*) exported from the Douala port was recorded by the national database on trade forest products. The most important quantity of the barks was exported in 2005 (1,498.5 tons) and the remaining (1,059.87 tons) was exported in 2006 (Betti, 2008).

P. africana is classified by the World Alliance for Nature (IUCN) as vulnerable species, which led to its listing in the Appendix II of the Convention on International Trade in Endangered Species of Fauna and

*Corresponding author. E-mail: lagardebetti@yahoo.fr, lagardeprunus@gmail.com. Tel: 00 (237) 77 30 32 72.

Flora (CITES) in 1994, becoming effective in 1995 (Tieguhong and Ndoye, 2004). Once a species is listed in Appendix II of CITES, its exportation is regulate in terms of quota. In Cameroon, the national CITES quota for *Prunus* dried barks is 2000 tons/year and the minimum exploitable diameter (MED) for *Prunus* trees is 30 cm. Although available data do not allow the establishing of the decline in extent area of occurrence, it is clear that *Prunus* population decreases over the time in Cameroon in term of tree density, decline in area of occupancy, decline in habitat quality, and decline due to actual level of exploitation. *Prunus* can be considered at least as an endangered plant species in Cameroon according to population reduction as outlined in the IUCN check list for Non-Detriment Findings (IUCN, 2001). This explains the ban pronounced on October 2007 by the European Commission on Cameroon's *Prunus*. The *Prunus* ban impacts both the economic operators and the local people for whom *Prunus* represents an important non timber forest product. Cameroon was proposed for ban as there are concerns that some provisions regarding the sustainable harvesting of *Prunus* barks are not being fully met.

A key requirement of CITES is the non-detriment findings made by the Scientific Authority of the range State prior to export, certifying that export is not detrimental to the survival of the species. This requires information on the location, stocking, growth and condition of the species and on its ecology, regeneration and subsequent protection. Such information is often lacking, incomplete or imprecise making a proper evaluation of the sustainable levels of utilisation, establishment of quota and conditions attached to be difficult.

This paper aims to estimate the mass of the fresh bark of *P. africana* on the Mount Cameroon Forest as a contribution for making non-detriment findings on *Prunus* for Cameroon.

MATERIALS AND METHODS

Study site

The Mount Cameroon is located in the South west region of Cameroon, between 3°57' to 4°27' latitude North and 8°58' to 9°24'longitude East in the bottom of the Biafra bot berry in the Guinean gulf. It is up to 4095 m and covers a total area of 25 000 square kilometre (km^2), in the divisions of Fako and Mémé. The climate is a subequatorial type, on monsoon regime with two seasons: a short dried season from December to March and a long rainy season from April to November. The average temperature is 22°C in the altitude. The relative humidity remains at 75 to 80% due to the influence of clouds and fogs. Mount Cameroon is an active volcano of the Hawaïan type. Slopes are steep, soils are volcanic, fertile with a low capacity of water retention. Those soils, if well drained are good for agriculture (Ewusi et al., 1996).

The Mount Cameroon has a high diversity of plant species. It is the only area in central Africa where the vegetation is continuous from the bottom at the sea level till the summit (ERM, 1998). From bottom to the summit of the mount, there are four main vegetation types including: the sub-mountain forest, the mountain forest, the sub-mountain meadow, and the mountain meadow. The mountain forest is less rich in plant species compared to the sub-mountain forest. Characteristic trees found in the mountain forest include: *P. africana, Schefflera abyssinica, Canthium dunlapii, Nuxia congesta, Clausena anisata, Syzygium staudii.*

METHOD

To estimate the mass of the stem barks of *P. africana*, we used an indirect method and proceeded in three steps: establishment of the relation linking the diameter at breast high (DBH) of each tree with the thickness of its stem bark, establishment of the relation linking the volume of the stem bark and its mass (weigh), and determination of the mass of the fresh bark for exploitable trees. Exploitable trees being trees with DBH ≥ 30 cm. A DBH is high at 1.5 m.

Relation diameter at DBH – Thickness of volume of the stem bark: Cubic tariff or volume based tariff

The volume based tariff or "Tariff de cubage" in French is a mathematical formula which gives the unit volume of a given tree according to different variables. These variables can be the diameter, the circumference, the high..... If only one variable is used, this is called a single entry tariff, but if several variables are used, this is called multi-entries tariff. The tariff is more valid for the area where the samples were collected (College of Forest Engineers of Quebec, 1996).

Diameters and highs of each tree section were collected using the "Bitterlich's Relascope with large bands" or "SPIEGEL RELASKOP nach D_r W. Bitterlich. RELASKOP-TECHNIK VERTRIEBGES. M.b.h. Salzburg, made in Austria". Data were collected in the mountain forest, found between the altitudes 1,600 and 2,100 m. For each tree selected, we chose the best position which allows the trunk to see clearly. In this paper, the trunk refers to the distance between the DBH and the first big branch of the tree. We measured the horizontal distance and the distance according to the slope between our position and the tree. We measured the logging high which is the DBH and the useful high which is the high of the trunk. We measured the diameter and the percentage of the slope at logging high (DBH) and the diameter and the percentage of the slope at the first big branch level. After these measures, we determined the intermediary levels or measures for the percentage of the slope (P_1, P_2, P_3) using the equi-distance formula which is:

$Eq = (P_u - P_a)/4$, with $P_1 = P_a + Eq$, $P_2 = P_1 + Eq$, $P_3 = P_2 + Eq$, and $P_u = P_3 + Eq$.

We measured the slopes and diameters at intermediary levels.

For each tree, we measured the thickness of the stem bark using the "Tarrière of Pressler". The unit volume (on or under the bark) was calculated using the formula of Relascope of Bitterlich of large bands (National Office for Forest Development,1992) which is:

$$V = (\pi d_h^2/8.10^6)*((P_1-P_a)*(D_1^2-D_a^2) + (P_2-P_1)*(D_2^2+D_1^2) + (P_3-P_2)*(D_3^2+D_2^2) + (P_u-P_3)*(D_u^2+D_3^2)).$$

Where:

$d_h = d_s \times \cos\alpha$ = corrected horizontal distance;

d_s = distance following the slope;

P_a, P_u, P_1, P_2, P_3 = percentage of the slope at the logging level (or useful level), at the first big branch level, at point 1, 2, and 3 respectively;

D_a, D_u, D_1, D_2 and D_3: diameter in Relascope unit (RU) obtained at the logging level, at the first big branch level, at point 1, 2, and 3, respectively.

We also used the Smalian's formula to estimate the volume:

$$V = \pi/8\ (D_a^2 + D_u^2) \times h$$

Where:
D_a = diameter at the logging level of the tree = DBH,
D_u = diameter at the first big branch level,
h = high of the trunk = distance between the logging level and the first big branch.
The volume of the bark was deduced from the following equation: $V_b = V - V_o$,
Where:
V_b = volume of the stem bark;
V = volume of the tree over the bark = with the bark,
V_o = volume of the tree under the bark = without the bark.
Assuming that $D_o = D - 2e$ with e = the thickness of the bark, D_o = diameter of the tree under the bark and D = diameter of the tree over the bark, the volume of the bark can be determined through the following equation:

$$V_b = (\pi h/2)^*(e \times (D_a + D_u) - 2e^2)$$

The cubic tariff or the relation between the diameter and the volume of the stem bark was performed using linear regression. The best equation is that for which the correlation coefficient (R^2) is near to 1.

Relation linking the volume of the stem bark and its mass (weigh) = cubic mass

The mass per volume metre or cubic mass or "masse volumique" in French of an entity is the ratio of the mass of that entity and the volume occupied by that mass. Some samples of the fresh bark were collected in some trees. For each sample we noted the volume, we weighted and found the equivalent mass. Equivalencies were made between the average volume of the samples and their corresponding fresh mass/weight. From those equivalencies, we deduced the cubic/volumic mass of *Prunus* barks in Mount Cameroon. The cubic mass is Cm = m/V with m = mass in kilogramme (kg) and V = volume of the stem bark in cubic meter (m^3).

Mass of the fresh bark for exploitable trees

In Cameroon, the minimum exploitable diameter (MED) for *Prunus* is 30 cm, this means that the stem bark can only be harvested from trees with diameter at DBH equal or more than 30 cm. We selected exploitable trees from the sample of trees used to yield the cubic tariff. The choice of the exploitable trees was guided by the fact that, when the diameter is less than 30 cm, the trunk of the tree is not tall enough (often less than 1.5 m) and also the thickness of the bark is too small (less than 10 mm). Having the volume of the bark for each tree, we estimated the mass using the formula of the cubic mass (m = V x Cm). The average mass of all the exploitable trees was considered as the mass of an exploitable tree of *P. africana* on the Mount Cameroon.

Indirect method was preferred to direct method. A direct method would require diameter tape and bark thickness measurements at the critical heights (BH, first branch, etc.), with some degree of verification through destructive sampling. Due to the current ban on the trade on *Prunus* barks in Cameroon, it was difficult to cut *Prunus* trees. As stated previously, indirect method was preferred to a direct method. A direct method would require diameter tape and bark thickness measurements at the critical heights (BH, first branch, etc.), with some degree of verification through destructive sampling. Due to the current ban on the trade on *Prunus* barks in Cameroon, it was difficult to cut *Prunus* trees. This element can affect some precisions on some results.

RESULTS

Cubic tariff

A total of 151 trees of *P. africana* were measured for the estimation of the cubic tariff or the relation linking the diameter of the tree with the volume of its bark. Measures regarding the diameters, the percentages of the slope, the thickness of the bark were collected on all the 151 trees. Appendix Table 1 shows the data recorded and the corresponding volume per tree. The relation diameter of the tree at breast high – volume of the stem bark is illustrated in Figure 1. The best equation which links the diameter and the stem bark of the *Prunus* tree is: $V_b = 0.00004^*D^{1.916}$, where: V_b is the volume of the stem bark in m^3 and D is the diameter of the tree at breast high in cm. The correlation coefficient is high, $R^2 = 0.8207$.

Cubic mass

A total of 68 samples/trees of stem barks were collected for weighing, to determine the relation linking the volume of the bark with its mass. These samples do not depend on the previous trees used to yield the cubic tariff. Appendix Table 2 shows for each sample, its volume and the corresponding fresh mass in kilogram, the mean value of the ratio mass/volume is 1013.04 ± 41.35 kg/m^3.

The equation which links the volume of the stem bark and its mass is $M_b = V_b^*\ 1013.04$ kg/m^3, where M_b = mass of the fresh bark in kg and V_b = volume of the stem bark in m^3.

Mass of exploitable trees

From the 151 trees measured for the determination of the cubic tariff, 117 have their DBH ≥ 30 cm. These 117 trees were selected to simulate the average fresh mass of *Prunus* barks. Appendix Table 3 presents for each exploitable tree, its volume and the corresponding mass in kilogram. From the table, it can be deduced that an exploitable tree of *P. africana* has an average mass of 99.86 ± 51.5 kg.

DISCUSSION

Cubic tariffs are often used in forestry in three main areas including trade on forest products, forest management, and forest research, mainly oriented on forest productivity. The cubic tariff is an indispensable tool in forest management and forest inventories since it allows a quickly estimate of the stand volume of trees (Pardé and Bouchon, 1988; Rondeux et al., 1991). Important

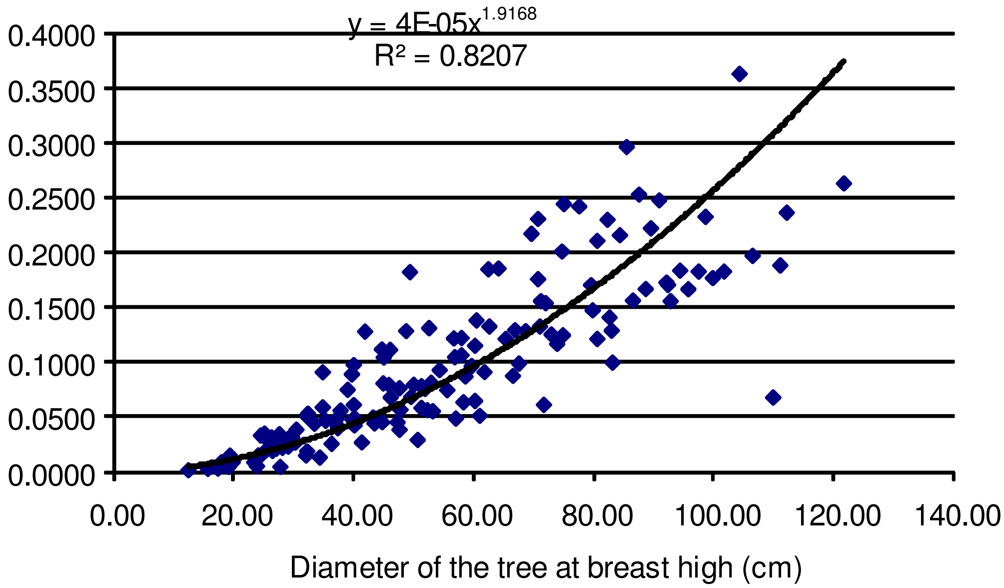

Figure 1. Volume of the fresh bark according to the diameter at breast high of the *Prunus* tree.

things to consider in the construction of the cubic tariff is to decide on the number of entries (parameters) to use and to select the best mathematical formula (College of Forest Engineers of Quebec, 1996). The choice of the entries is guided by their simplicity and their link with the volume. Most of cubic tariffs constructed in forest management are those which yield the standing volume of the timber based on its diameter at high breast. Our cubic tariff is built from one entry, the diameter at breast high to be précised. It yields the volume of the stem bark of a given *Prunus* tree according to its diameter at breast high. We could also decide to use the thickness of the stem bark as another entry (parameter) for building our cubic tariff. But we found that, this parameter cannot be easy for forest officers to collect it in the field. It is more easier to measure the diameter at breast high than measuring the thickness of the tree. For cubic tariff which concern a limit area with relatively homogenous growth conditions, the number of trees should vary from 30 to 100 (Rondeux, 1993; College of Forest Engineers of Quebec, 1996). This condition is respected in our study, since we worked on 151 trees of *P. africana* in the limit area of Mount Cameroon, and in the mountain forest found between 1,600 and 2,100 m to be précised.

In Cameroon*, Prunus* bark exploitation started in 1972, and many trees around the Mount Cameroon have been exploited several times with four-year intervals. Legally for all trees above 30 cm DBH, only two quarters of the bark are taken from the main stem up to the first big branch. Prior to 1985, Plantecam Medicam, as it was known then, operated within a strict monopoly in the exploitation of *P. africana* in Cameroon. Plantecam Medicam set and adhered to strict harvesting guidelines such as no felling and no girdling but only the stripping of opposite quarters of the tree to allow for bark regeneration. Thereafter, a breakdown in this monopoly came with the issuance of licenses to a number of companies and individuals. This led to a dramatic increase in field operatives working in an area with corresponding increase in unsustainable practices, notably the felling of trees, total bark removal and non-respect for quotas set. Many people were involved in the exploitation and the harvesting was done by untrained villagers. Many trees were debarked up to the smallest branches and others were felled with negative impact on the limited wild population of this tree species (Ndibi, 1996; Betti, 2008; Amougou et al., 2010).

Cameroon’s *Prunus* barks are exported in two forms: the raw bark and the “powder”. Powder here is referred to the bark shavings or the grinded barks. Whatever be the form, *Prunus* is exported in dried matter. The dried weight of *Prunus* barks to be exported is = 50% of fresh weight (Ingram et al., 2009).

Our study reveals that the average mass of exploitable stems of *P. africana* in the Mount Cameroon is 99.86 ± 51.5 kg. This represents the fresh weight or fresh mass for the total stem bark of a given exploitable trunk/tree. Considering that for all trees above 30 cm DBH, only two quarters of the bark are taken from the main stem up to the first branch, the sustainable weight or mass of *Prunus* tree on Mount Cameroon will be about 50 kg of fresh bark per tree. Birdlife International, an international Non Governmental Organization (NGO), initiated two main projects in the North west region of Cameroon. The first project led from 1987 to 1992 and covered 10 000 ha in the Bui division, while the second project led from 1992 to 2004 and covered the same area in Boyo division. The two projects aimed to protect the mountain forests as the principal habitat of two birds, endemic and threatened in the Mount-Cameroon: Banded-water eye and Banama Touraco. For this, the project focused its activities on the domestication of *P. africana* and conservation of its wild populations, important plant species for local people and for the two birds. Birdlife International also trained local people on the suitable techniques for harvesting *Prunus* barks: harvesting trees of at least 17 years old, move the ½ opposite side, and return 4 to 6 years later to move the remaining sides on the same trees. According to the local divisional delegate of forestry and wildlife for the Bui division who has been working for the Birdlife project for a long time (Amougou et al., 2010), research activities conducted within the Birdlife project revealed that the length of the rotation varies with the zone (division). Hence, in the Boyo division where the weather is too hot, results obtained tend to show that the harvester can return to the same tree after 4 to 5 years, while in the Bui division where it is too cold, this harvester must wait 5 to 6 years before returning back to the same tree. At 15 to 17 years old without any fertilizer, *Prunus* can reach a diameter of 30 to 35 cm at high breast.

On Mount Oku in the North west region of Cameroon, Ondigui (2001) weighted samples of *Prunus* barks harvested in sustainable manner. Sustainable manner in this paper means, taking only two quarters of the bark from the main stem up to the first big branch. Ondigui (2001) found that the average sustainable mass/yield of fresh bark of *P. africana* was 55 kg/tree with four-year intervals. This result is quite similar to our findings.

Following what precedes and based on indirect method used, we suggest that for Mount Cameroon, the sustainable mass/yield of an exploitable *Prunus* tree is 50 kg of fresh bark with five-year intervals. This means that to sustain *P. africana* on the Mount Cameroon, trade companies or villagers should harvest, trees of at least 30 cm of diameter at breast high, move the 50 kg of stem bark on the ½ opposite sides, and return 5 years later to move the remaining sides on the same tree, or return 10 years latter to move the same side on the same tree. We assume that five years are enough to allow the recovery of the bark and the circulation of the sap between roots and leaves, while 10 years are enough to allow the harvested side to recover its maturity in term of bark thickness and active compounds.

Conclusion

The single data used for the construction of our cubic tariff is the diameter of tree at breast high. This data is well known by many foresters and is easy to collect in the field. The cubic tariff and the average mass of exploitable trees are two tools which can ease the estimation of stand bark volume for *P. africana* trees. Those two data can be used to quickly estimate the export quota of *P. africana* for Cameroon for the Mount Cameroon area. Our study reveals that, for Mount Cameroon, the sustainable mass of an exploitable *Prunus* tree is 50 kg of fresh bark with five-year intervals, this is harvesting trees of at least 30 cm of diameter at breast high, move the ½ opposite side, and return 5 years later to move the remaining sides on the same tree, or return 10 years latter to move the same side on the same tree. This information is crucial for making non-detriment findings for *Prunus* barks harvested on Mount Cameroon.

ACKNOWLEDGEMENTS

We thank all the villagers who collaborated with us in this study. The study was supported by the Join International Timber Organisation (ITTO) - Convention on International Trade in Endangered Species of Fauna and Flora (CITES) Program for Implementing CITES Listings of Tropical Tree Species, executed in Cameroon by the National Forestry Development Agency (ANAFOR).

REFERENCES

Amougou A, Betti JL, Ewusi NB, Mbarga N, Akagou ZHC, Fonkoua C, Essomba ER, Nkouna AC (2010). Preliminary report on sustainable harvesting of *Prunus africana* (Rosaceae) in the North west region of Cameroon. Report prepared for the National Forestry Development Agency (ANAFOR), the Cameroon CITES Scientific Authority for flora, in the frame of the project "Non-detriment findings for *Prunus africana* (Hook.f.) Kalman in Cameroon", p. 76.
Betti JL (2008). Non-Detriment Findings Report on *Prunus africana* (Rosaceae) in Cameroon. Report prepared for the International Expert Workshop on Non-Detriment Findings, Mexico, November 17th-22th, 2008.. *www.conabio.gob.mx/.../TallerNDF/...CS9%20Prunus/WG1-CS9-S.pdf.,* p. 52.
College of Forest Engineers of Quebec (1996). Forestry Handbook. The Laval University Press, p. 1428.
Cunningham AB, Mbenkum FT (1993). Sustainability of harvesting *Prunus africana* bark in Cameroon: A medicinal plant in international trade. UNESCO, Paris, France.
ERM (1998). Environmental impact assessment of plantation expansion in forested lowland of the Mount Cameroon region. Department for International Development (DFID), London, p. 161.
Ewusi BN, Tako TC, Acworth J (1996). Bark extraction: the current situation of the Sustainable Cropping of Prunus africana on Mount Cameroon. In Glyn D (eds). A strategy for the Conservation of Prunus africana on Mount Cameroon. technical papers and workshop proceedings, 21st and 22nd February, 1996, Limbé Cameroon. Mount Cameroon Project, pp. 39-54.
Fraser PJ, Healy JR, Cheek M (1996). Seedling identification. In Glyn D (eds). A strategy for the Conservation of *Prunus africana* on Mount Cameroon. technical papers and workshop proceedings, 21st and 22nd February, 1996, Limbé Cameroon. Mount Cameroon Project, pp. 1-11.
Hall JB, O'Brien EM, Sinclair FL (2000). *Prunus africana*: a Monograph. School of Agricultural and Forest Sciences Publication Number 18. University of Wales, Bangor, p. 104.
Ingram V, Owono A, Schure J, Ndam N (2009). Guidance for a national *Prunus africana* management plan, Cameroon. CIFOR, FAO, p. 158.
IUCN (2001). Critical category and the IUCN Red List: Version 3.1. Survival Commission of IUCN Species, IUCN, Gland, Switzerland and Cambridge, United Kingdom. ii + pp. 32.
National Office for Forest Development (1992). Standards study of trees. Forestry Branch, MINEF. Yaounde, Cameroon, p. 20 +

annexes.
Ndam N (1996). Recruitment patterns of *Prunus africana* (Hook F.) Kalkman, on Mount Cameroon: a case study at Mapandja. In Glyn D (eds). A strategy for the Conservation of *Prunus africana* on Mount Cameroon. technical papers and workshop proceedings, 21st and 22nd February, 1996, Limbé Cameroon. Mount Cameroon Project, pp. 19-34.
Ndibi BP (1996). Regulatory framework for the exploitation of medicinal plants in Cameroon: the case of *Prunus africana* on Mount Cameroon. In Glyn D (eds). A strategy for the Conservation of *Prunus africana* on Mount Cameroon. technical papers and workshop proceedings, 21st and 22nd February, 1996, Limbé Cameroon. Mount Cameroon Project, pp. 55-67.
Ondigui BRP (2001). Sustainable Management of a Wild Plant Species for the Conservation of Mountane Forest Ecosystems and the Welfare of Local Communities: A Case Study of *Prunus africana* in the Mount Cameroon Area. In Sustainable Management of a Wild Plant Species. Proceedings of the World Mountain Symposium. Interlaken, Switzerland, p. 9.
Pardé J, Bouchon J (1988). Mensuration, 2nd edition, Nancy. Ecole nationale du Genie Rural, Water For., p. 328.
Rondeux J (1993). Measuring trees and forest stands, Gembloux, Belgium, Press agronomic, p. 521.
Rondeux J, Laurent C, Lejeune P (1991). Stand volume tables for Douglas-fir *Pseudotsuga menziesii* (Mirb.) Franco average and Upper Belgium. Rev.for. sen, 43(6): 507-513.
Tchouto P (1996). *Prunus* population on Mount Cameroon. In Glyn D (eds). A strategy for the Conservation of *Prunus africana* on Mount Cameroon. technical papers and workshop proceedings, 21st and 22nd February, 1996, Limbé Cameroon. Mount Cameroon Project, pp. 12-18.
Tieguhong JC, Ndoye O (2004). Development of trade and marketing of non-wood forest products for poverty alleviation in Africa. A report prepared for the project Lessons learned on the Sustainable Forest Management in Africa, KSLA/AAS/FAO, p. 46.
Vivien J, Faure JJ (1985). Arbres des forêts d'Afrique Central denses. Ministère des Relations Foreign Trade, Coopération et Développement - ACCT, Paris, p. 551.

Appendix

Table 1. Data recorded and the corresponding volume per tree.

No. of tree	CBH	DBH (cm)	P_a	P_u	d_h	h (m)	LB	SB	D_u (cm)	e (mm)	V (m^3)
1	182	57.96	12	76.5	11	7.10	1	4	44	11	0.122
2	141	44.90	16	84	9.4	6.39	1	4	37.6	10	0.081
3	334.2	106.43	22	84	14.6	9.05	2	1	65.7	7	0.170
4	101.2	32.23	5	55	6	3.00	1	2.5	19.5	8	0.019
5	300.6	95.73	-18	40	13.7	7.95	2	2	68.5	6	0.122
6	91.4	29.11	8	46	9.8	3.72	1	0.5	22.05	8	0.023
7	258.3	82.26	9	68	13.3	7.85	1	4	53.2	6	0.099
8	83	26.43	-53	8	6.6	4.03	1	4	26.4	9	0.029
9	109.4	34.84	55	181	6.34	7.99	1	3	22.19	8.5	0.059
10	327.4	104.27	-17	56	13.8	10.07	1	3.5	51.75	6	0.147
11	285.4	90.89	32	93	12.8	7.81	2	2.5	67.2	6	0.115
12	39.1	12.45				0.89			11.91	5	0.002
13	235	74.84	40	116	11.8	8.97	2	1	53.1	6.5	0.116
14	107.8	34.33	9	33	5.1	1.22	2	4	30.6	11	0.013
15	148.5	47.29	22	73	10	5.10	1	3	35	7	0.045
16	149.5	47.61	-10	43	11.6	6.15	1	2.5	37.7	9.5	0.076
17	117.3	37.36	-49	-3	12.4	5.70	1	0.5	27.9	7	0.040
18	184	58.60	-26	32	8.2	4.76	2	2	41	12	0.087
19	319.3	101.69	-23	54	12.7	9.78	2	3	69.85	6.5	0.170
20	191.5	60.99	-29	14	11.6	4.99	2	0.5	49.3	6	0.051
21	161	51.27	6.5	53.5	9.6	4.51	2	1	43.2	12	0.078
22	170.5	54.30	27	112	12	10.20	1	1	30	7	0.093
23	291.3	92.77	-27	40	13	8.71	2	3	71.5	6	0.134
24	189.8	60.45	-14	48	16	9.92	1	1	40	6.5	0.100
25	274.8	87.52	28	90	13.2	8.18	2	1.5	62.7	7	0.134
26	345	109.87	-24	7	9.7	3.01	4	4	97	7	0.068
27	60.8	19.36				3.50			18.28	7.5	0.015
28	253	80.57	6	98	8.8	8.10	3	1	57.2	6.5	0.113
29	250.6	79.81	51	128	10.4	8.01	2	2.5	54.6	7	0.117
30	182	57.96	1.5	63	9.4	5.78	2	1	42.3	12	0.107
31	249.7	79.52	65	136	12.4	8.80	2	1.5	58.9	6.5	0.123
32	144.9	46.15	-12.5	56.5	12	8.28	1	1	30	7	0.068
33	313.4	99.81	-28	40	14	9.52	1	3	49	6.5	0.143
34	61.5	19.59				3.70			18.34	6	0.013
35	260.5	82.96	-34	29	12.8	8.06	2	2	64	6.5	0.120
36	54.6	17.39				1.23			16.59	5	0.003
37	174.5	55.57	12	96	10	8.40	1	4	40	6	0.075
38	122.4	38.98	-11	48.5	12	7.14	1	1	30	10	0.075
39	159	50.64	6.5	51	8	3.56	2	1.5	38	6	0.029
40	196.5	62.58	15	118.5	10	10.35	1	2	30	9	0.133
41	161	51.27	12	115	8	8.24	2	2	40	5	0.058
42	83.1	26.46	-23	15	8.4	3.19	1	1.5	23.1	8	0.019
43	135.7	43.22	13	50	10.8	4.00	1	3	37.8	10	0.050
44	124.6	39.68	-9	53	13.8	8.56	0	3	20.7	7	0.055
45	290	92.36	26	80	15.8	8.53	2	2	79	6.5	0.148
46	382	121.66	12	67	13.7	7.54	3	3	102.75	10	0.263
47	58.4	18.60				2.30			16.43	5	0.006
48	235.5	75.00	32	110	15	11.70	1	4	60	10	0.244
49	296.3	94.36	11	75	13.6	8.70	2	1.5	64.6	6.5	0.140

Table 1. Contd.

50	153	48.73	-12	73	10.7	9.10	1	2.6	35.31	11	0.129
51	95.6	30.45	6	71	10	6.50	1	1	25	7	0.039
52	83	26.43	-11	36	10	4.70	1	1	25	7	0.026
53	222	70.70	29	105	9.4	7.14	3	1	61.1	16	0.231
54	126	40.13	-19	26	10.3	4.64	1	2.7	34.505	8	0.043
55	131.5	41.88	14.5	115	11.1	11.16	1	2	33.3	10	0.128
56	125.6	40.00	-7.5	51	9	5.27	1	4	36	10	0.061
57	144.6	46.05	4	75	10.4	7.38	1	3	36.4	12	0.111
58	125	39.81	-6	41	10	4.70	1	2	30	9.5	0.048
59	210	66.88	-27	39	11	7.26	1	3	38.5	11	0.129
60	281	89.49	8	98	10.6	9.54	2	3.5	60.95	7	0.156
61	212	67.52	13	58	13	5.85	1	2.5	42.25	6	0.060
62	178	56.69	78.5	160	8.72	7.11	3	0.5	54.5	10	0.122
63	56.2	17.90				2.30			17	6	0.007
64	155	49.36	27	129	11.6	11.83	1	2	34.8	12	0.182
65	253	80.57	2	91	9.7	8.63	3	1	63.05	11	0.211
66	116	36.94	0	69	8.8	6.07	1	3	30.8	7	0.044
67	105	33.44	-21	43	11.8	7.55	0	3	17.7	6	0.036
68	226	71.97	-27	47	14	10.36	1	1	35	9	0.154
69	155.6	49.55	-11.5	25	9.1	3.32	2	1	40.95	15	0.068
70	100.6	32.04	-20	11	6	1.86	2	1	27	9	0.015
71	76.8	24.46	-13	11	12	2.88	0	3.5	21	7.5	0.015
72	101.3	32.26	-12	60	10	7.20	1	1	25	8	0.050
73	222	70.70	-44	1.5	13	5.92	2	1	58.5	15	0.176
74	110.8	35.29	-41.5	-5	13.5	4.93	0	4	27	10	0.047
75	352.1	112.13	-22	46	13.3	9.04	2	3	73.15	6	0.157
76	223	71.02	19	87	11	7.48	1	4	44	10	0.133
77	196	62.42	31	98	14.8	9.92	1	1.5	40.7	6.5	0.103
78	79	25.16	-22	62	8.2	6.89	1	0.5	18.45	7	0.032
79	187.2	59.62	-24	37	11	6.71	1	4	44	9	0.097
80	79.7	25.38	23	65	8.4	3.53	1	1	21	8	0.020
81	234.5	74.68	-26	49	12.4	9.30	2	0.5	52.7	6.5	0.120
82	49.3	15.70				1.40			12.89	5	0.003
83	289.2	92.10	34	99	11.8	7.67	2	2	59	5.5	0.099
84	278.3	88.63	-56	-0.5	13.7	7.60	2	2	68.5	6	0.112
85	218.54	69.60	25	86	11.6	7.08	2	3	63.8	15	0.217
86	87.5	27.87	20	80	8.4	5.04	1	1	21	7	0.026
87	87.8	27.96	-4	96	7.1	7.10	1	2.5	23.075	5	0.028
88	348.7	111.05	21	101	12.3	9.84	2	2.5	64.575	5.5	0.148
89	223.5	71.18	15.5	77	14.8	9.10	1	3	51.8	9	0.156
90	116.6	37.13	27.5	87.5	10.5	6.30	1	2.5	34.125	7	0.048
91	77	24.52	-68	93	4.73	7.62	1	1	11.825	8	0.033
92	229	72.93	-28	54	10	8.20	2	2.5	52.5	7	0.112
93	271.6	86.50	-13	45	14.7	8.53	2	1	66.15	6.5	0.132
94	91.4	29.11	-58	0.5	7.8	4.56	1	2.5	25.35	8	0.030
95	215.5	68.63	19	62	12	5.16	2	3	66	12	0.129
96	165	52.55				9.50			46.97	9	0.131
97	90.4	28.79	-38	15	8.8	4.66	1	1	22	6.5	0.024
98	125.6	40.00	-6	91	9.6	9.31	1	2	28.8	10	0.098
99	75.5	24.04	13	49	7.5	2.70	1	2	22.5	8	0.015

Table 1. Contd.

100	136.4	43.44	0.5	62	10.7	6.58	1	1.5	29.425	6	0.044
101	82.6	26.31	37	110	8.5	6.21	1	1	21.25	7	0.031
102	208.81	66.50	25	83	9.5	5.51	3	1	61.75	8	0.088
103	164.06	52.25	27	82	9.5	5.23	2	2	47.5	7	0.056
104	157	50.00	-9	63	9.2	6.62	1	4	36.8	9	0.080
105	201.3	64.11	-35	47	12.7	10.41	1	2.5	41.275	6	0.102
106	150	47.77	23	101	7	5.46	2	4	42	7.5	0.057
107	79	25.16	11.5	115	6.7	6.93	1	1	16.75	8	0.035
108	109.4	34.84	10	98	11.3	9.94	1	0.5	25.425	6.5	0.060
109	259.4	82.61	-29	48	10.8	8.32	2	2	54	6	0.106
110	86.7	27.61	-17	72.5	7.3	6.53	1	2	21.9	7	0.035
111	189	60.19	17	58	10	4.10	2	0.5	42.5	10	0.065
112	268.4	85.48	37	123	12	10.32	1	4	48	6	0.129
113	138.5	44.11	7	52	10.5	4.73	1	2	31.5	9	0.049
114	189	60.19	-22.5	37	10.6	6.31	2	1	47.7	11	0.115
115	140.5	44.75	-12.5	47	9.6	5.71	2	0.5	40.8	6	0.045
116	126.8	40.38	-4	44	8.5	4.08	1	3	29.75	11	0.048
117	118.7	37.80	-8	59	9.8	6.57	1	1	24.5	9	0.056
118	85	27.07	8	49	9.8	4.02	0	4	19.6	7.5	0.021
119	140.3	44.68				13.00			35	7	0.112
120	225	71.66	3	30	11.8	3.19	2	1	53.1	10	0.061
121	167	53.18	8	47	9	3.51	2	3	49.5	10	0.055
122	93.5	29.78	29	71	10.7	4.49	1	0.5	24.075	8	0.029
123	183	58.28	13	53	10	4.00	2	1	45	10	0.064
124	261	83.12	7	57	10.1	5.05	3	3	75.75	8	0.100
125	141.3	45.00	13	110	10	9.70	1	2.6	33	9	0.104
126	309.6	98.60	4	74	11.6	8.12	2	4	69.6	11	0.233
127	232	73.89	-23	14	10	3.70	2	3	55	16	0.117
128	243.5	77.55	38	115	13.6	10.47	1	3	47.6	6.5	0.132
129	306	97.45	-27	48	12.6	9.45	2	2	63	5.5	0.130
130	166	52.87	-12	45.5	9.6	5.52	2	1	43.2	10	0.082
131	144	45.86	1	68	10.2	6.83	1	3.5	38.25	9	0.079
132	59.3	18.89				2.91			16.72	6	0.009
133	179	57.01	-10	23	10.7	3.53	1	3	37.45	9.5	0.049
134	264.8	84.33	12	96	10.6	8.90	2	3	58.3	6	0.119
135	178.5	56.85	27	81	11	5.94	2	1.5	52.25	10.5	0.105
136	205	65.29	31	76	14	6.30	2	0.5	59.5	10	0.121
137	101.6	32.36	-12	58	8.6	6.02	1	2	25.8	10	0.053
138	149.5	47.61	10	75	8	5.20	1	4	32	6	0.038
139	163	51.91	9	64	9.5	5.23	2	2	47.5	9.5	0.076
140	194	61.78	5	51	11	5.06	2	2	55	10	0.091
141	62.2	19.81	-33	16	7	3.43	0	4	14	5	0.009
142	95	30.25	-35	25	6.5	3.90	1	4	26	8	0.027
143	56.4	17.96				3.50			15.76	5	0.009
144	73.5	23.41	-4	24	8	2.24	1	1	20	6	0.009
145	60.2	19.17				1.20			17.77	7	0.005
146	74.9	23.85				0.92			23.37	8	0.005
147	114	36.31	2	38	10	3.60	1	2	30	7	0.026
148	87.2	27.77				0.68			27.7	8	0.005
149	88.3	28.12	28	60	13.4	4.29	0	3	20.1	7	0.022
150	129.8	41.34	-17	9	10	2.60	1	2.8	34	9	0.027
151	57	18.15	-2	36	9	3.42	0	3.5	15.75	4	0.007

CBH: circumference of the tree at breast high, DBH: diameter of the tree at breast high, P_a: percentage of the slope at the logging level or at breast high, P_u: percentage of the slope at the first big branch level, d_h: horizontal distance, h: high, LB: number of large bands in relascope unit, SB: small band: number of small bands, D_u: diameter of the tree at the first big branch level, e: thickness of the bark, V: volume of the bark.

Table 2. Volumes of stem bark samples with their corresponding mass.

No. of tree	Long (cm)	Large (cm)	Thickness (mm)	Volume (m^3)	Mass (kg)	Ratio (m/v)
1	23.75	8.5	7.25	0.00	0.15	1024.87
2	18.6	12.83	9.83	0.00	0.29	1214.93
3	16.73	11.57	11	0.00	0.22	1033.24
4	27.7	6.06	8.5	0.00	0.15	1051.28
5	30.7	4.76	9.5	0.00	0.15	1080.49
6	28.76	11.22	9.49	0.00	0.32	1044.97
7	29	6.28	7.5	0.00	0.15	1061.57
8	28.9	5.88	9	0.00	0.17	1078.86
9	25.5	6.38	10.25	0.00	0.18	1079.41
10	25.65	9.5	11	0.00	0.29	1081.92
11	25.46	8.12	11.75	0.00	0.26	1070.34
12	13.75	12.5	9.75	0.00	0.17	1014.45
13	29.25	6.6	11.5	0.00	0.23	1036.00
14	27.1	8.1	11.33	0.00	0.26	1025.31
15	23.95	5.65	8.75	0.00	0.13	1097.95
16	25.85	5.4	11	0.00	0.16	1042.01
17	27.25	6.7	8.5	0.00	0.16	1031.00
18	20.16	10.1	8	0.00	0.18	1105.02
19	24.8	9.65	11.04	0.00	0.29	1097.61
20	26.43	9.72	8.64	0.00	0.24	1058.74
21	18.1	10.26	11	0.00	0.21	1028.02
22	14.35	13.73	8	0.00	0.14	888.21
23	25.7	7.35	6.36	0.00	0.13	1040.48
24	23.6	8.88	15.1	0.00	0.33	1027.03
25	23.75	11.2	6.12	0.00	0.17	1044.28
26	27.9	10.43	9	0.00	0.30	1145.49
27	23.8	6.8	8.75	0.00	0.15	1023.94
28	22.8	6.4	8.5	0.00	0.11	846.56
29	28.5	6.73	7.16	0.00	0.14	983.02
30	26	5.5	9.63	0.00	0.14	1016.64
31	26.5	10	7.75	0.00	0.21	1022.52
32	31	7	7.13	0.00	0.16	1034.12
33	26.75	8.25	8.75	0.00	0.20	1009.83
34	29	13.5	7.8	0.00	0.26	835.05
35	21.5	9.77	9.5	0.00	0.20	977.19
36	25.25	6.95	9	0.00	0.17	1076.37
37	29.9	6.1	7.5	0.00	0.12	877.24
38	24.4	7.2	7.63	0.00	0.11	820.63
39	29.8	9	8.25	0.00	0.19	858.70
40	25.3	8.5	8.88	0.00	0.20	1047.32
41	28	8.95	8.62	0.00	0.21	949.00
42	26	6	7.25	0.00	0.11	972.59
43	27.8	6.5	8	0.00	0.16	1072.22
44	24.8	9.2	8.75	0.00	0.20	1001.80
45	27	10.42	13.37	0.00	0.39	1023.52
46	28	10.25	8.57	0.00	0.26	1057.09
47	16.33	11.45	9.62	0.00	0.21	1139.69
48	16.45	11.3	10	0.00	0.16	833.85
49	18.8	11.9	8	0.00	0.19	1033.66
50	15.9	8.5	10.13	0.00	0.14	1022.59
51	16.3	10.6	11	0.00	0.20	1026.00

Table 2. Contd.

52	16	10.43	9.25	0.00	0.16	1004.12
53	24.3	8.25	8.75	0.00	0.16	912.12
54	18.65	11.25	8	0.00	0.16	953.23
55	28.7	8.83	8.5	0.00	0.21	974.89
56	24.2	9	5.75	0.00	0.13	998.12
57	16.5	9.2	12.63	0.00	0.19	991.01
58	17.5	6.65	10.13	0.00	0.13	1060.33
59	17.83	10	12.25	0.00	0.23	1030.14
60	31.27	10.2	7.75	0.00	0.26	1031.60
61	31.95	5.15	7.65	0.00	0.13	1032.77
62	25.77	11.4	7.13	0.00	0.21	978.69
63	25.47	9.83	9	0.00	0.24	1042.90
64	24.7	11.88	7	0.00	0.20	973.69
65	31.45	6.33	7	0.00	0.14	1004.63
66	31.7	7.26	7.88	0.00	0.17	909.83
67	26.5	10.55	7.13	0.00	0.20	978.24
68	28.4	6	7.38	0.00	0.12	954.23
Mean						1013.16423

Table 3. Productivity of exploitable *Prunus* trees in term of the mass of the fresh bark

No.	DBH (cm)	Volume (m^3)	Masse (kg)
142	30.25	0.02677	27.1244
51	30.45	0.03861	39.1157
70	32.04	0.01504	15.2412
4	32.23	0.01889	19.1373
72	32.26	0.05034	50.9979
137	32.36	0.05308	53.7744
67	33.44	0.03553	35.9944
14	34.33	0.01326	13.4349
9	34.84	0.05899	59.7617
108	34.84	0.05984	60.6250
74	35.29	0.04664	47.2526
147	36.31	0.02568	26.0172
66	36.94	0.04427	44.8539
90	37.13	0.04837	49.0046
17	37.36	0.04003	40.5566
117	37.80	0.05613	56.8715
38	38.98	0.07508	76.0723
44	39.68	0.05546	56.1905
58	39.81	0.04760	48.2310
56	40.00	0.06117	61.9738
98	40.00	0.09766	98.9457
54	40.13	0.04252	43.0758
116	40.38	0.04787	48.4960
150	41.34	0.02702	27.3718
55	41.88	0.12817	129.8533
43	43.22	0.04957	50.2252
100	43.44	0.04442	45.0082
113	44.11	0.04928	49.9260

Table 3. Contd.

119	44.68	0.11184	113.3126
115	44.75	0.04538	45.9809
2	44.90	0.08079	81.8530
125	45.00	0.10444	105.8149
131	45.86	0.07948	80.5280
57	46.05	0.11136	112.8281
32	46.15	0.06802	68.9123
15	47.29	0.04534	45.9364
16	47.61	0.07649	77.4927
138	47.61	0.03841	38.9145
106	47.77	0.05675	57.4974
50	48.73	0.12854	130.2321
64	49.36	0.18226	184.6606
69	49.55	0.06845	69.3477
104	50.00	0.07956	80.6045
39	50.64	0.02932	29.7080
21	51.27	0.07827	79.2984
41	51.27	0.05839	59.1612
139	51.91	0.07599	76.9911
103	52.25	0.05647	57.2176
96	52.55	0.13117	132.8977
130	52.87	0.08152	82.5944
121	53.18	0.05548	56.2145
22	54.30	0.09293	94.1515
37	55.57	0.07468	75.6584
62	56.69	0.12183	123.4316
135	56.85	0.10477	106.1514
133	57.01	0.04874	49.3862
1	57.96	0.12224	123.8474
30	57.96	0.10659	107.9879
123	58.28	0.06360	64.4410
18	58.60	0.08709	88.2392
79	59.62	0.09654	97.8062
111	60.19	0.06481	65.6678
114	60.19	0.11512	116.6357
24	60.45	0.10037	101.6898
20	60.99	0.05126	51.9313
140	61.78	0.09119	92.3863
77	62.42	0.10303	104.3908
40	62.58	0.13276	134.5082
105	64.11	0.10220	103.5487
136	65.29	0.12145	123.0465
102	66.50	0.08765	88.8024
59	66.88	0.12937	131.0685
61	67.52	0.05983	60.6148
95	68.63	0.12855	130.2388
85	69.60	0.21730	220.1558
53	70.70	0.23078	233.8203
73	70.70	0.17580	178.1087
76	71.02	0.13273	134.4718
89	71.18	0.15585	157.9000
120	71.66	0.06140	62.2109

Table 3. Contd.

68	71.97	0.15396	155.9878
92	72.93	0.11177	113.2442
127	73.89	0.11682	118.3543
81	74.68	0.11966	121.2343
13	74.84	0.11590	117.4249
48	75.00	0.24431	247.5228
128	77.55	0.13235	134.0939
31	79.52	0.12320	124.8186
29	79.81	0.11706	118.5989
28	80.57	0.11275	114.2376
65	80.57	0.21085	213.6254
7	82.26	0.09924	100.5502
109	82.61	0.10608	107.4729
35	82.96	0.11987	121.4471
124	83.12	0.09975	101.0666
134	84.33	0.11863	120.1875
112	85.48	0.12859	130.2853
93	86.50	0.13168	133.4165
25	87.52	0.13385	135.6097
84	88.63	0.11169	113.1550
60	89.49	0.15626	158.3173
11	90.89	0.11540	116.9146
83	92.10	0.09935	100.6543
45	92.36	0.14807	150.0153
23	92.77	0.13380	135.5573
49	94.36	0.14004	141.8861
5	95.73	0.12203	123.6379
129	97.45	0.13003	131.7438
126	98.60	0.23278	235.8474
33	99.81	0.14331	145.1932
19	101.69	0.16989	172.1241
10	104.27	0.14692	148.8507
3	106.43	0.16985	172.0830
26	109.87	0.06790	68.7960
88	111.05	0.14829	150.2434
75	112.13	0.15683	158.8931
46	121.66	0.26311	266.5677
Mean			99.8725