

Full Length Research Paper

Stock of *Prunus africana* stems on the mount Cameroon forest

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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 stock of the stems of *P. africana* was carried out in December 2010 – February 2011 on the Mount Cameroon forest, vast of 22 881.085 ha. The management inventory was conducted with a sampling intensity of 1.11% using the “Adaptive Clusters Sampling (ACS)” method. The average density of *Prunus* obtained is 3.43 stems/ha. The highest density of *Prunus* trees is recorded inside the national park of Mount Cameroon and is at least 1.5 times more higher than the density of trees recorded outside the park. This shows the key role of the Mount Cameroon national park in the conservation of *P. africana*. The total number of 79 660 *Prunus* trees was estimated, with 41 042 trees (51.52%) being the exploitable stock that can be harvested in sustainable manner by trade companies.

Key words: Threatened species, *Prunus africana*, Mount Cameroon, stock, adaptive clusters sampling, Convention on International Trade in Endangered Species (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, *Prunus* is used in traditional medicine

and for confectioning different materials. 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

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International Trade in Endangered Species of Fauna and Flora (CITES) in 1994, becoming effective in 1995 (Sunderland and Tako cit. Tieguhong and Ndoye, 2004). Once a species is listed in Appendix II of CITES, its exportation is regulated in terms of quota. 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. Although available data do not allow to establish 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 stock of stems 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' – 4°27' latitude North and 8°58' – 9°24' longitude East (Figure 1) 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 km², 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 Hawaiian 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 *Prunus africana*, *Schefflera abyssinica*, *Canthium dunlapii*, *Nuxia congesta*, *Clausena anisata*, *Syzygium staudii*.

Prunus inventories were carried out inside and outside the Mount Cameroon national park from December 2010 to February 2011. The method used is called "Adaptive Clusters Sampling (ACS)". This method has its basis in the known conventional forest inventory method often used in Cameroon in dense forests. In fact, in Cameroon, the classical forest inventory method is standardised (see arête n° 222) for management inventories (Ministry of Environment and Forestry, 2001).

Description of the classical method

Mapping

Materials used for mapping are made up of: a global positioning system (GPS) Garmin C76 x, a topographic map at scale 1:200 000 produced by the National Institute for Cartography (NIC), the forest photo interpretation manual produced by the former National Office for Forest Development (1987), aerial photos at scale 1:20 000 covering years 1983 to 1987 (5 to 6 km² over 21 km² analysed) obtained from the Forest Mapping and Remote Sensing Centre (CETELCAF), aerial photos at 1:50 000 ranging from 1949 to 1970 (28 km² over 81 km²) acquired from NIC, a 30 m-resolution-Landsat image of 2007 (15 m panchromatic). The GIS software used includes the ERDAS IMAGINE 9.3 and ARC GIS 9.3 computer packages.

The method used for mapping is: photo-interpretation by stereoscopy, supervised classification of the geo referenced satellite image in view of having the strata shown by the forest map updated, the classification of the Landsat image (supervised classification using 7 multi-spectral bands) and field visits for habitats description.

Sampling design and intensity

According to the national standards (Ministry of Environment and Forestry, opcit.), the sampling is systematic and stratified to 1 degree when the statistical unit is the plot. The samples or plots of 0.5 ha (250 m long × 20 m large) are distributed systematically throughout the entire population and not by stratum (forest type). The stratification is done definitively after the sampling. The systematic disposal of plots allows the assumption that the intensity of sampling for each stratum is proportional to its area in the forest. Results of the inventory and their accuracy are calculated for each stratum.

In practice, sampling is carried out along straight and continuous axes called "layons" or lines or transects. These "layons" are oriented along a predetermined magnetic 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 "layon" are contiguous (without alley or corridor of separation) and measure 250 m in the direction of the "layon" (length) and 20 m in the direction perpendicular to the "layon" (width). This gives a surface area of 0.5 ha for each plot. For the ACS method, additional circular plots of 0.2 ha will be added in respect of the conditions that will be clarified later.

In Cameroon, the sampling intensity for management inventories

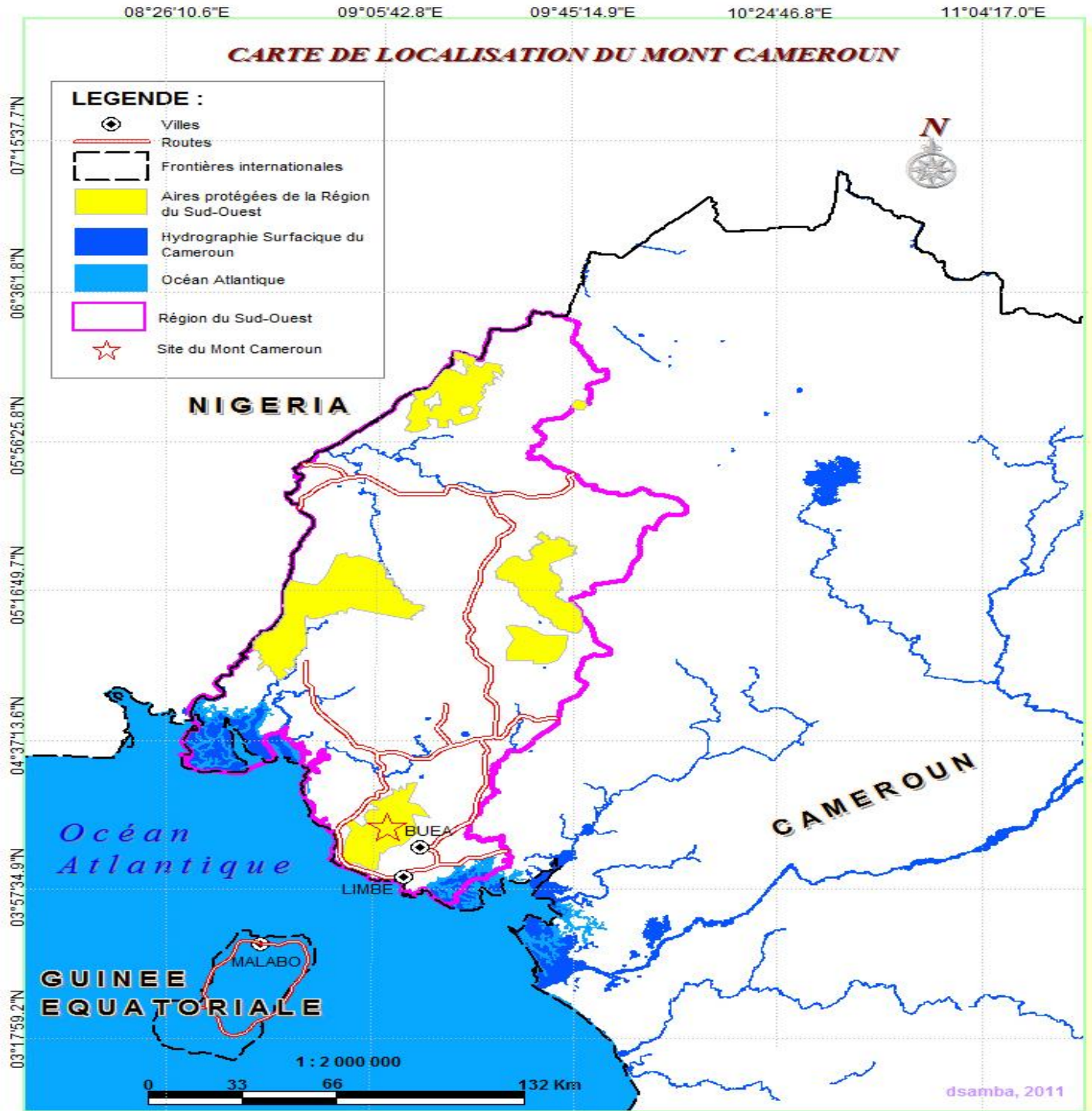


Figure 1. Location of Mount Cameroon in the South west region of Cameroon.

varies according to the surface area to be covered. For areas over 50 000 ha, the sampling rate should be comprised between 0.5 and 1%, while for areas less than 50 000 ha, the sampling rate should be more than 1%. The surveys conducted so far in Mount Cameroon and using the technique presented here have estimated the useful area of *P. Africana* in the both sub-mountain and

mountain forests to 22 000 ha (Ewusi et al., 1996).

A total of 34 lines were proposed to cover the Mount Cameroon area for *Prunus* inventory including 20 lines inside the park, 4 outside the park and 10 covering the two sides of the park. The distance between two consecutive lines was 600 m. The sampling design is illustrated in Figure 2.

Implementing the sampling design

The inventory consists of two steps: “layons” or 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 “layons” opening that details on topography, habitat types, rivers and the corrected horizontal distance of the “layon” (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 sheet.

Counting: The counting step includes all operations relating to dendrological and dendrometric records. During the counting in rectangular and circular plots, several operations are made including: Identification of stems of *P. africana*, the measurement of stems with diameter at breast height (dbh = 1.50 m) \geq 5 cm, appreciation of the health state of the tree in three classes (dead trees, damaged trees, and living trees). The appreciation of the healthy status of the tree is mainly based on the health of the leaves and number of dried branches. Lines and plots are identified and numbered with their geographical coordinates and altitudes.

Theoretical basis of the “adaptive clusters sampling (ACS)” method

The ACS method is advised to capture the *Prunus* clustering characteristics. Considering y (total number of stems for example), the value of the parameter in the sampling unit (plot) of the traditional method, and C the condition (a limit number of stems for example) required to initiate an adaptive sampling. If $y \geq C$ in the indicated plot, additional circular plots are established in its periphery. If other units (circular plots) of the periphery have their $y \geq C$, then the process continues till obtaining a network of circular plots. The process stops when the condition can no longer be verified ($y < C$). If many units satisfy the conditions, then the sample will have many units in the entire population. The ACS method has many advantages: it allows to have a good idea on the distribution of *Prunus* clusters, it provides many data, and good precisions, it is almost similar to a systematic or total inventory mostly when the sample becomes too large, it is more efficient on statistical basis compared to the traditional method. The problem with the ACS method is that it is difficult to determine in advance the sampling intensity, and also that the method requires a mobilisation of important human resource-efforts and funds.

Due to the small distance between two consecutive plots and in regard to the available funds, the ACS method was limited to a maximum of one circular plot, the distance of settlement of circular plots was fixed at 100 m, and the condition C was fixed at 4 stems. This means that for each rectangular plot with $C \geq 4$ stems, we added one circular plot of 0.2 ha at 1.00 m in left side and one circular plot of 0.2 ha at 1.00 m in right side. The ACS stopped at this level, notwithstanding the number of *Prunus* stems found in the circular plots.

RESULTS

Sampling intensity

The Mount Cameroon forest concerned in present work is

about 22 881,085 ha. A total of 255.3 ha out of that surface area was covered by forest inventories giving an average sampling intensity of 1.11% (Table 1).

Density of *Prunus* stems

All trees

A total of 875 trees of *P. africana* were recorded in the 255.3 ha of the forest inventoried in Mount Cameroon. Six hundred sixty-five of those trees were recorded inside the national park, and 210 trees were recorded outside the park (Table 2). Table 3 shows the distribution of density of trees in different diameter classes. The average density obtained is 3.43 stems/ha.

Living (healthy) trees

In this work, living (healthy) trees are those which are looking well, without dried branches. A total of 780 (Table 4) living trees were recorded on the 255.3 ha, representing 89.1% of the total trees of the sample. About 76.9% of the living trees were recorded inside the Mount Cameroon national park. The average density of living trees is 3.06 stems/ha (Table 5). Figure 3 illustrates the specific curve of living *Prunus* stems in the natural forest of the Mount Cameroon.

Dead and wilt trees

In this analysis, we group all stems described in the field as being wilt (with some branches dried) or died in one category. A total of 71 dead or wilt *Prunus* trees were recorded in the sample (255.3 ha). The average density of those trees is 0.3 stems/ha. The percentage of dead or wilt trees is $100 \times 71/875 = 8.1\%$.

Total number of stems or stock of *P. africana* in mount Cameroon

Estimation of number of stems at the scale of the all mount Cameroon forest (22 881,085 ha) is presented in Table 6 for living trees and Table 7 for all trees. A total number of *Prunus* trees (living, wilt or dead) estimated for the whole Mount Cameroon area is 79, 659 trees. The number of living trees is 71, 115 while that of dead or wilt trees is 8, 544. The minimum exploitable diameter (MED) applied for *Prunus* in Cameroon is 30 cm. Among living trees, only 31, 461.38 trees representing 44.24% of the total living trees have reached the MED and can therefore be harvested.

Table 1. Sampling intensity and number of plots per forest.

Forest of Mount Cameroon	<i>Prunus</i> area (ha)	Number of classical plots	Number of ACS plots	Sampling area (ha)	Sampling intensity (%)
Inside the national park	16 014.732	302	92	169.4	1.06
Outside the national park	6 868.719	159	32	85.9	1.25
Total/medium	22 881.085	461	124	255.3	1.11

Table 2. Distribution of number of trees recorded in the sample in different parts of the park and in different diameter classes (C<10, C10-20, ...C>120).

Diameter classes	Sampling area (ha)	C<10	C10-20	C20-30	C30-40	C40-50	C50-60	C60-70	C70-80	C80-90	C90-100	C100-110	C110-120	C>120	Stems with diameter < MED (< 30 cm)	Stems with diameter ≥ MED (exploitable stems)	Total
Inside the park	169.4	106	108	111	82	67	56	41	46	15	16	6	6	5	325	340	665
Outside park	85.9	43	61	38	16	19	15	8	2	5	1		2		142	68	210
Total / Medium	255.3	149	169	149	98	86	71	49	48	20	17	6	8	5	467	408	875

Table 3. Density of *Prunus* trees per diameter classes inside and outside the park.

Diameter classes	Sampling area (ha)	C<10	C10-20	C20-30	C30-40	C40-50	C50-60	C60-70	C70-80	C80-90	C90-100	C100-110	C110-120	C>120	Stems with diameter < MED (< 30 cm)	Stems with diameter ≥ MED (exploitable stems)	Total
Inside the park	169.4	0.63	0.64	0.66	0.48	0.4	0.33	0.24	0.27	0.09	0.09	0.04	0.04	0.03	1.93	2.01	3.93
Outside park	85.9	0.5	0.71	0.44	0.19	0.22	0.17	0.09	0.02	0.06	0.01	0	0.02	0	1.65	0.78	2.44
Total /Medium	255.3	0.58	0.66	0.58	0.38	0.34	0.28	0.19	0.19	0.08	0.07	0.02	0.03	0.02	1.82	1.6	3.43

Table 4. Distribution of living *Prunus* stems in different diameter classes (C<10, C10-20, ...C>120).

Situation according to the park	Sampling area (ha)	C<10	C10-20	C20-30	C30-40	C40-50	C50-60	C60-70	C70-80	C80-90	C90-100	C100-110	C110-120	C>120	Stems with diameter < MED (< 30 cm)	Stems with diameter ≥ MED (exploitable stems)	Total
Inside park	169.4	99	101	96	75	59	49	39	42	14	12	5	4	5	296	304	600
Outside the park	85.9	42	59	32	14	10	9	7	1	4	1		1		133	47	180
Total	255.3	141	160	128	89	69	58	46	43	18	13	5	5	5	429	351	780

Table 5. Density of living stems of *Prunus*.

Situation according to the park	sampling area (ha)	C<10	C10-20	C20-30	C30-40	C40-50	C50-60	C60-70	C70-80	C80-90	C90-100	C100-110	C110-120	C>120	Stems with diameter < MED (< 30 cm)	Stems with diameter ≥ MED (exploitable stems)	Total
Inside park	169.4	0.58	0.60	0.57	0.44	0.35	0.29	0.23	0.25	0.08	0.07	0.03	0.02	0.03	1.75	1.79	3.54
Outside park	85.9	0.49	0.69	0.37	0.16	0.12	0.10	0.08	0.01	0.05	0.01	-	0.01	-	1.55	0.55	2.10
Total	255.3	0.55	0.63	0.50	0.35	0.27	0.23	0.18	0.17	0.07	0.05	0.02	0.02	0.02	1.68	1.37	3.06

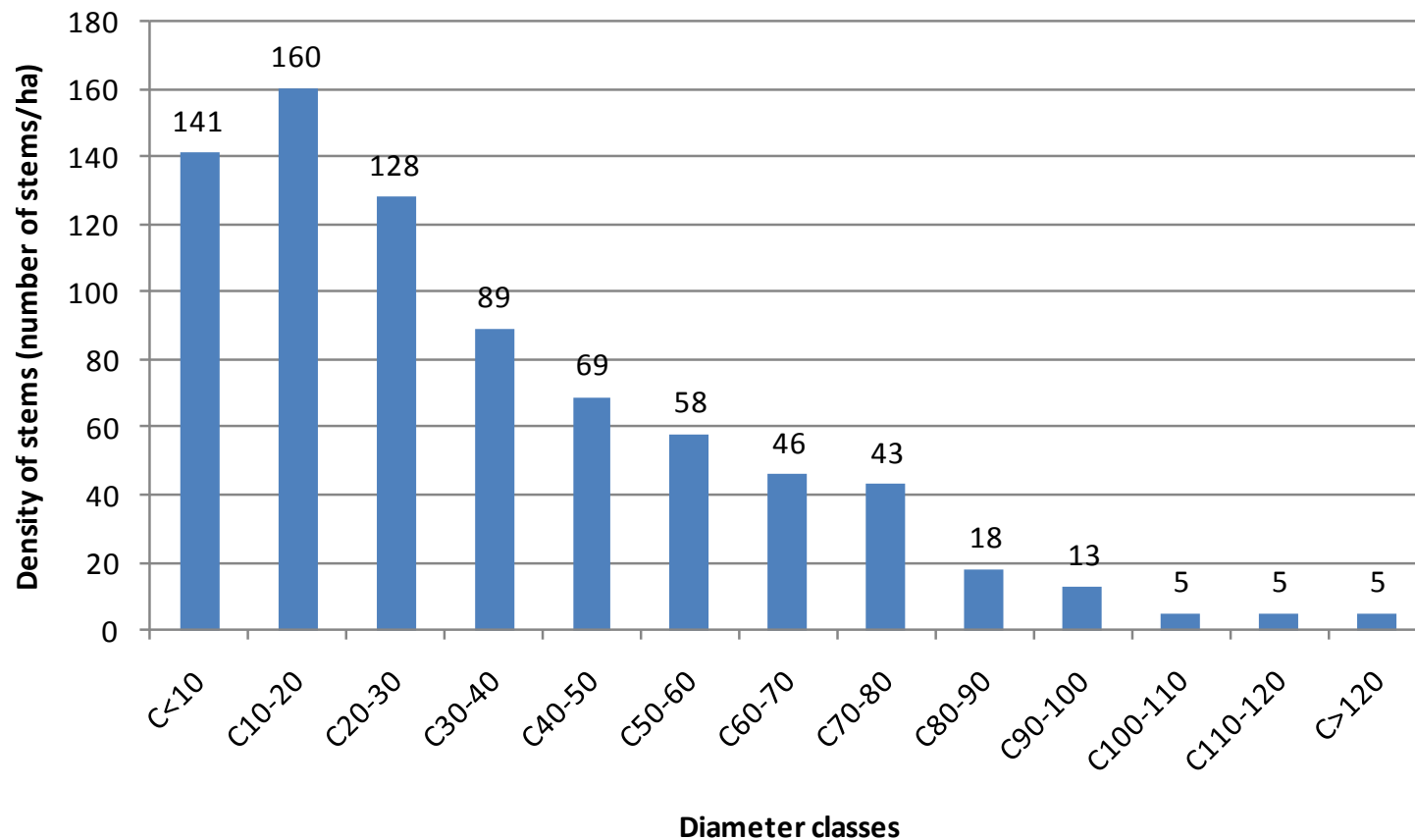


Figure 3. Distribution of *Prunus* trees per diameter classes in the Mount Cameroon.

Table 6. Total number (stock) of living stems.

Situation according to the park	Prunus area	C<10	C10-20	C20-30	C30-40	C40-50	C50-60	C60-70	C70-80	C80-90	C90-100	C100-110	C110-120	C>120	Stems with diameter < MED (< 30 cm)	Stems with diameter ≥ MED (exploitable stems)	Total
Inside the park	16 014.73	9 359.26	9 548.33	9 075.65	7 090.35	5 577.74	4 632.36	3 686.98	3 970.59	1 323.53	1 134.46	472.69	378.15	472.69	27 983.24	28 739.54	56 722.78
Outside the park	6 868.72	3 358.40	4 717.75	2 558.78	1 119.47	799.62	719.66	559.73	79.96	319.85	79.96	0.00	79.96	0.00	10 634.92	3 758.20	14 393.12
Total	22 883.45	12 638.33	14 341.37	11 473.10	7 977.39	6 184.72	5 198.75	4 123.14	3 854.24	1 613.40	1 165.24	448.17	448.17	448.17	38 452.80	31 461.38	71 115.91

Table 7. Total number of *Prunus* stems (stock) estimated in the mount Cameroon area.

Situation according to the park	Total number of living stems (LS)	Number of dead and wilt stems (or the bonus)	Total number of stems	Number of living stems ≥ MED	Number of living stems ≥ MED + Bonus	Number of stems retained for simulation of quotas (SRSQ)
Inside the park	56722.78	6144.97	62867.75	28739.54	34884.51	34885
Outside the park	14393.13	2398.85	16791.98	3758.2	6157.05	6157
Total	71115.91	8543.82	79659.73	32497.74	41041.56	41042

DISCUSSION

Sampling intensity

The average sampling intensity is 1.11%. This is higher than 1% and is in accordance with the national standards which state that the sample intensity should be at least 1% for surface areas less than 50,000 ha in Cameroon (Ministry of Environment and Forestry, 2001).

Density of *Prunus* stems

The average density obtained is 3.43 stems/ha. Inventories carried out with the traditional method in Mount Cameroon found a density of 3.5 stems/ha (Ewusi et al., 1996). Those carried out in the same region with the ACS method proposed a density of 3.52 stems/ha (Ingram et al., 2009).

The highest density of *Prunus* trees is recorded inside the park: 3.93 stems/ha. This density is at least 1.5 times more high than the density of trees recorded outside the park, which confirms the key role of that protected area in the conservation of *P. africana*.

The specific curve or the curve which shows the distribution of *Prunus* stems in different diameter classes tend to show that we are in front of a normal situation where young individuals abound. This means that *P. africana* population does not globally encounter problems of regeneration in the Mount Cameroon region. About 8.1% of trees recorded are dead or wilt. Many studies confirm that *Prunus* trees have been harvested using unsustainable techniques (debarking from roots to the branches) and 25% of those trees died or were dying (Akagou, 2010; Ewusi et al., 1996; Tchouto, 1996).

Prunus bark exploitation started in 1972, and an

important number of trees around the Mount Cameroon have been exploited several times with four-year intervals. Legally for all trees above 30 cm diameter at breast high, only two quarters of the bark are taken from the main stem up to the first branch. However, since 1985, several peoples were involved in the exploitation and the harvesting was done by untrained villagers. As a result of this, 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. Prior to 1987, Plantecam Medicam, as it was known then, operated within a strict monopoly in the exploitation of *P. africana* in Cameroon. They 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.

The lesson to be learnt here may be that increasing commercial competition without putting in place adequate management regimes, based on sound inventory data may probably lead to a corresponding increase in the amount and intensity of bark exploited. Therefore, the issuance of permits is not necessarily a guarantee of sustainability, especially when permits are issued with no harvesting controls being implemented (Sunderland and Tako cit. Tieguhong and Ndoye, 2004).

A total number of *Prunus* trees (living, wilt or dead) estimated for the whole Mount Cameroon area is 79, 659 trees. The number of living trees is 71, 115 while that of dead or wilt trees is 8, 544. The MED applied for *Prunus* in Cameroon is 30 cm. Among living trees, only 31, 461.38 trees representing 44.24% of the total living trees have reached the MED and can therefore be harvested. If we consider wilt and dead *Prunus* trees as the bonus that should be harvested, then the total number of trees or the stock to be harvested in the Mount Cameroon is 41, 042.

Conclusion

The estimation of the stock of *Prunus* 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 Cameroon forest administration. The ACS method used is suitable for capturing *Prunus* clustering characteristics. The highest density of *Prunus* trees is recorded inside the national park of Mount Cameroon and is at least 1.5 times more higher than the density of trees recorded outside the park. This confirms the key role of that protected area in the conservation of *P. africana* in Mount Cameroon. The stock of *Prunus* to be harvested in the Mount Cameroon is 41, 042 trees. The next step should consist of estimating the total mass of *Prunus* stem bark that can be sustainably obtained from those stems.

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