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Exploitable Stock of Prunus Africana Stems in the Teza Forest, Kibira National Park, Burundi

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***Abstract* – *Prunus africana* (Rosaceae) / Pygeum or African cherry is mountain and light demanding tree species of the tropical Africa. The plant is considered as vulnerable and is listed in appendix II of the Convention on International Trade in Endangered Species of Fauna and Flora (CITES). This paper aims to assess the stock of exploitable stems of that tree species as a tool for enhancing its sustainable harvesting. The study was carried out in May – June 2013 in the Teza mountain forest, in the Kibira National Park, north Burundi. The management inventory was conducted in a production forest of 2 800 ha with a sampling intensity of 2.14% using the *"Adaptive Clusters Sampling"* method. A total of 184 trees of *Prunus africana* with diameter at breast high more than 10 cm was counted, with 93% of them being living trees. The average density of living trees is 2.85 stems/ha. The density of exploitable living trees is 2.27 stems/ha which yields a total number of 6 347 trees, considered as the stock that can be harvested in a sustainable manner for trade purposes. There are significant differences for what concerns the abundance of seedlings, the thickness of the barks, and the size of stems between the two sides of the park, separated by the Congo-Nil ridge. The specific curves of *Prunus* trees presented tend to show that the Congo side is less perturbed than the Nil side. This is confirmed by a high number of seedlings in the Nil side, as a result of reaction of light penetration in the forest. Similar research should continue as to cover the 30 000 – 35 000 ha of the production forest estimated in the national park of Kibira and other protected areas which host that tree species.**

***Keywords* – Vulnerable Species, *Prunus Africana,* Kibira National Park, Stock, Adaptive Clusters Sampling, Burundi, CITES.**

I. INTRODUCTION

Burundi is a small (27,834 sq km, land), densely populated country with a topography dominated by hills and mountains interspersed with seasonal and permanent wetlands in the low-lying areas. In some respects, the country's resource endowment is enviable. Burundi is blessed with a mild tropical equatorial climate, sitting on a high plateau with considerable altitude variation and an average annual temperature that varies with altitude from 23 to 17 degrees centigrade, but is generally moderate, as the average altitude is about 1,700 m. Agricultural production is problematic. With 420 persons per sq. km of arable land, Burundi has one of the highest population densities in Africa. Available land per household averages approximately 0.5 hectares, much of which may be located on hillsides or in drained marshlands (marais). Given the prevailing dependence on Burundi's natural resource base, many of the environmental problems facing the country stem from overuse of soils, forests, and water resources [1].

Key environmental threats in Burundi include soil erosion and fertility loss, deforestation, extensification into vulnerable lands (hillsides and bottomlands, e.g.), inadequate water supplies, and overgrazing on hilly terrains. Particularly in some areas, many of these problems are exacerbated by the resettlement of returning refugees from Tanzania and the Democratic Republic of Congo. In principal, Burundi's natural resources are managed by legislative frameworks and institutional structures, however in practice the management regime suffers from poor coordination resulting in redundancy or lack of clear responsibility among institutions, and conflicting and outdated legal codes. Overall responsibility for environmental management and protection in Burundi is housed in the Ministry of water, environment, land use and urbanism (Ministère de l'eau, Environnement, Aménagement du Territoire et Urbanisme = MEEATU). Two autonomous institutions with environmental mandates exist under the Directorate General of Environment and Forests: the National Institute for the Environment and the Conservation of Nature (INECN), and the Geographic Institute of Burundi (IGEBU). INECN has direct management responsibility for the protected areas, including national parks and natural reserves. The Department of Forestry, on the other hand, is concerned primarily with planted forests outside of protected areas, including agroforestry [1].

Prunus africana (Hook.f.) Kalkman (formerly *Pygeum africanum* Hook.f.) 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, Mozambique, Tanzania, Burundi and Cameroon. *P. africana* grows well in the sub-mountain and mountain forests at an altitude of 800 – 3000 m. *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 [2]-[3]-[4].

Poor establishment conditions for the seedlings, is known to be one of the main causes of the species population decline. Seedlings grow well when they are

established on exposed sites with good moisture such as road collapse [5]. The bark is black to brown, corrugated or fissured and scaly, fissuring in a characteristic rectangular pattern. The fruits of *Prunus africana* are drupaceous, fleshy and red-purple in colours and are said to be eaten by a variety of birds and mammals [6]. Frugivorous birds and mammals, however, must play an important role in seed dispersal. Observations indicated that dispersal from the parent tree was negligible and the majority of fruits had fallen within the crown line [5].

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. Prostate-related diseases increase in prevalence as men age. And as the average age of the world's population increases, the incidences of prostate diseases will increase as well, triggering a corresponding rise in demand for therapies. According to the World Cancer Research Fund International, prostate cancer is the second most common cancer in men worldwide. Around 910,000 cases of prostate cancer were recorded in 2008, accounting for approximately 14 percent of all new cancer cases in men [7]. Bark extracts contain fatty acids, sterols and pentacyclic terpenoids [6]. The drugs processed from the bark extracts are sold under the brand-name of "Tadenan" in France by Laboratoire Debat, "Pygenil" in Italy by Indena Spa, and "Proscar" in UK by Merck Sharp and Dohme Ltd [5]. The United Nations Food and Agriculture Organization (FAO) reported as far back as 1996 that the demand for the species' bark, which is used to produce treatments for prostate gland disorders, could lead to its over-exploitation [8]. In 1997, the global need is about 4 000 tons of dried barks per year for a value of 220 millions of USD. Two hundred kilogram of dried bark yield 5 kilogram of extract [9]. The trade in dried pygeum bark and bark extract is in the order of 3 000 – 5 000 tonnes a year [10] and the main sources are in Cameroon, Madagascar, Equatorial Guinea, Kenya, Uganda, and Tanzania.

In Burundi, *Prunus africana* is found in five protected areas being under the control of the INECN including two national parks (Kibira in the North and Ruvubu in the East), and three natural reserves (Bururi, Maragarazi, and Monge). The species is also found in the sacred forest of Mpotsa. The species is well known by Burundi peoples who designate it as "Muremera" in Kirundi, the first national language. Here, the species is not only used as a medicinal plant, but also as a of high-value timber together with *Entandrophragma excelsum* .

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. The Scientific Authorities also face obstacles due to inadequately trained and resourced staff. The National Institute for the Environment and the Conservation of Nature (INECN) is the CITES Scientific Authority for Burundi.

This paper aims to estimate the stock of exploitable stems of *Prunus africana* in the Teza forest in the South of the Kibira national park as a contribution for making non-detriment findings on P. africana for Burundi.

II. Materials and Methods

A. Study site

The Kibira National Park is a national park in northwestern Burundi. It is located between 2°54'52.79'' latitude South – 29°26'1'' longitude East and 2.9146639° latitude South – 29.43361° longitude East, overlapping four provinces and covering 40 000 ha. Kibira National Park lies atop the mountains of the Congo-Nil divide. It extends north from the provincial town of Muramvya to the border of Rwanda where it is contiguous with the Nyungwe National Park. Kibira mountains are up to 2 600 m. The average annual rainfall is up to 1 600 mm while the average temperature is 17°C.

Main vegetation strata include: *Entandrophragma excelsum, Parinari excelsa, Albizia gummifera, and Prunus africana stands, Parinari excelsa var. holstii and Polyscias fulva stands, Polyscias fulva, Macaranga neomildreadiana and Syzygium parvifolium stands, Hagenia abyssinica and Faurea saligna* secondary forest stands, *Philippia benguelensis* and *Protea madiensis high-altitude stands on ridges, Arundinaria alpin*a (pure bamboo) stands, stands along thalwegs and stands formed by recolonization of previously cultivated and grazed land. The Park is dominated by afromontane forests, including species such as *Parinari excelsa, Entandophragma excelsum, Albizia gummifera, and Prunus africana*. It is a zone rich in both animal and plant biodiversity: 644 plant species have been found in the park, as well as about 98 species of mammal (primates, servals, African civets, etc.). Bird life is also rich and varied, with 43 families and more than 200 species identified [1]-[11].

More than three-quarters of the water in the country's largest dam – providing more than 50 percent of the hydroelectric energy consumed – comes from this forest. Thus the park, situated as it is on the Congo-Nil ridge, plays a fundamental role in regulating the hydrological system and protecting against soil erosion.

The Forest Code promulgated in 1985 (Law 1/02 of 25 March 1985) provides the basis for the various Burundian laws on forests, notably Law 1/010 of 30 June 2000 containing the environmental code for the country. The Kibira National Park was granted legal status in 2000 with Decree 100/007 of 25 January, establishing the park and four nature reserves.

The management plan of the Kibira national park dressed in 2008 – 2009 with the help of the Wildlife Conservation Society (WCS) has led to the subdivision of the park into four small management units or sectors (one sector for each province) distributed as follow from south to the north: Teza, Rwegura, Mabay et Musigati Each

sector is divided in subsectors. The KNP has a park supervisor and four sector heads, while each subsector has a forest warden and an assistant.

Lastly, the INECN and the Parks for Peace Project have established watchdog committees elected by the people at various levels – hills (the smallest administrative unit), sectors, zones and communes. The park supervisor supervises all activities in the park, the sector heads implement them in their respective zones, and the watchdog committees closely monitor the way the park is managed. Thus, the INECN, the local administration, the local population and the watchdog committees are the main actors in park management. Nearly 50 000 people from communes adjacent to the park are involved directly or indirectly in management of the park [1]-[12]-[13]. Areas boundaring the KNP have always been considered are densed in terms of Population, with Musigati and Muramvya being the two most densed councils of the park [13].

B. Method

Prunus inventories were carried out inside the Kibira national park, in a limit area of 2 800 ha of production forests, in the Teza sector. Production forests in this paper means forests that host *Prunus* trees. The inventory ran from May to June 2013. The method used is called "Adaptive Clusters Sampling (ACS)". This method has its basis in the known conventional forest inventory method often used in the Congo basin (Cameroon, Congo, DRC, …) in dense forests[14]-[15].

B.1. Description of the classical method Mapping

Burundi has not yet developed a detail map showing different forest types and usage forms. To solve this, we used a soil occupation map dressed in 2001 and a topographic map at scale 1:50 000 produced in 1985 by the Geographic Institute. As a starting and training step, we decided to assess the stock of *Prunus africana* in a limit area of 2 800 ha, in the Teza sector, in the south of the Kibira National Park. This area was supposed to be sampled in one month, with four teams of data collectors.

Sampling design and intensity

As described [14]-[15], 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 x 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 to assume 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. In this paper, the main gradient which influenced the orientation of our lines was the "Congo-Nil ridge". Lines were oriented perpendicular to the "Congo-Nil ridge" oriented East - West.

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.

A total of 15 lines were proposed to cover the 2 800 ha delimitated in the Teza sector as to get a minimum sampling intensity of 2%. The 2 800 ha are distributed as follow in the two sides of the park: Congo side (1 584.8 ha) and Nil side (1 212.4 ha). The distance between two consecutive lines was 5 00 m. The sampling design is illustrated in fig. 1.

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 (East – West in this case), 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 sheets.

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 *Prunus africana*, the measurement of stems with diameter at breast height (dbh = 1.30 m) >= 10 cm, appreciation (we counted the number of seedlings observed under each *Prunus* tree) of regeneration in four classes (1 : very low, from 1 to 10 seedlings; 2 : low, 11 - 20 ; 3 : medium, 21 - 30 ; 4 : abundant, 31 - 50 ; and 5 : too abundant, more than 50 seedlings), 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.

B.2. 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, which will increase the sampling intensity.

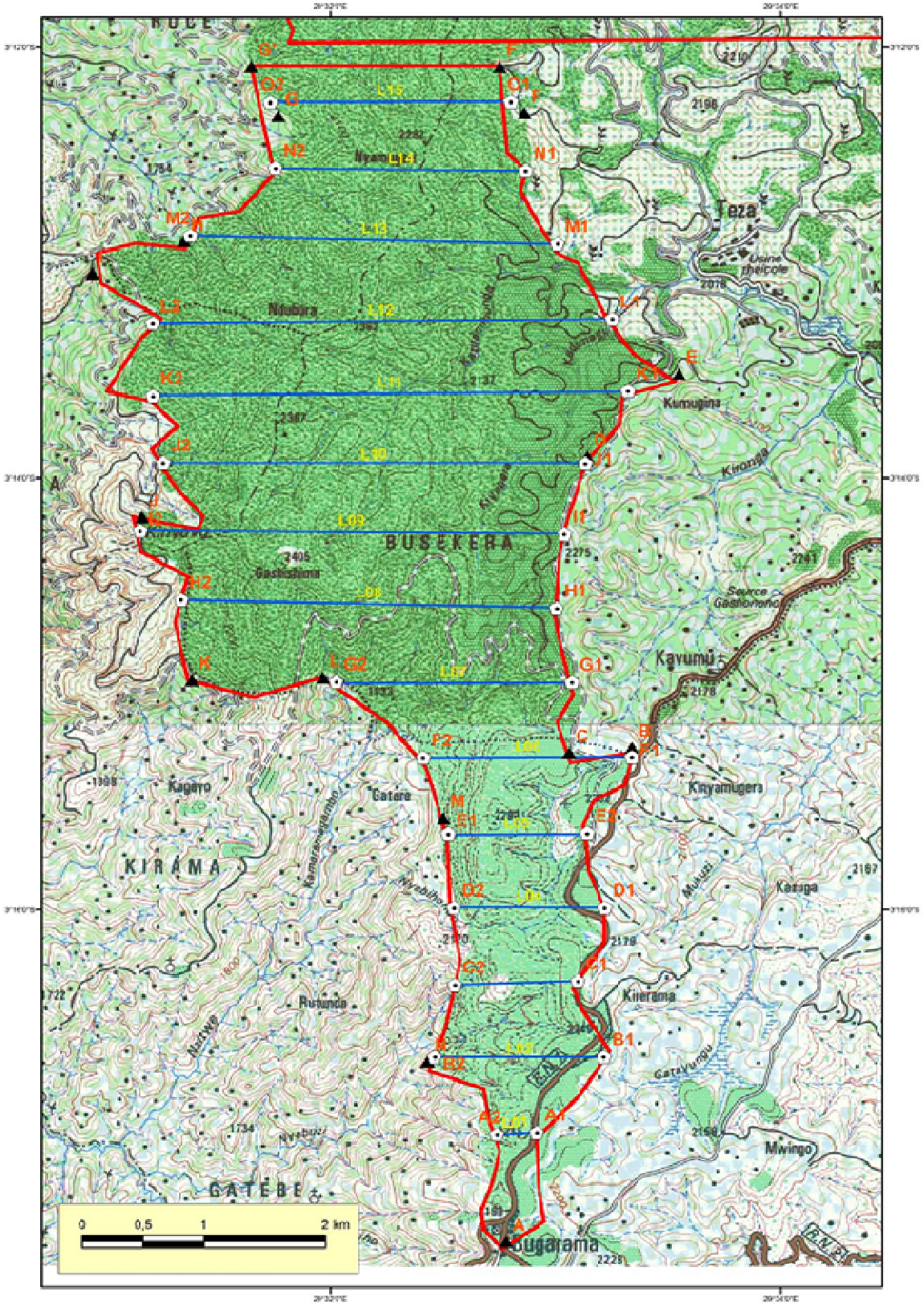

Fig.1. Sampling design of *Prunus* inventory in the Teza sector, KNP

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, we limited the ACS method to a maximum of one circular plot, we fixed the distance of settlement of circular plots at 1 00 m, and we fixed the condition C at 4 stems. This means that, for each rectangular plots with C ≥ 4 stems, we added one circular plot of 0.2 ha (radial = 25.23 m) at 1 00 m in left and one circular plot of 0.2 ha at 1 00 m in right side. The ACS stopped at this level whatever be the number of *Prunus* stems found in the circular plots.

B.3. Data analysis

Analyses focused on densities (all trees, living trees, exploitable trees), total number of living trees, stock (total number of exploitable living trees), and comparison of the two sides of the park.

The density (d) is obtained by the formula: d = n/Sa; where d represents the density expressed in number of stems or trees/ha; n: number of stems or trees; and Sa = sampling area expressed in hectares (ha).

The total number of stems for a given side of the park is obtained from the product of the density by the total productive surface area of that side.

The two sides of the park (Congo vs Nil) were compared for what concerns the abundance of the *Prunus* seedlings, the size of the trees in term of the diameter at breast high, and the thickness of the stem bark. For these (abundance of seedlings, size of the trees, and the thickness of the bark), data analysis was performed using the R2.10.0 statistical package. The two sides of the park were compared for each factor using the One way ANOVA [16].

III. Results

A. Sampling intensity

Table I shows the area of the production forest delimitated in the Teza sector, the layons opened and counted and the distance of each layon. Thirteen (13) out of the fifteen layons (15) designed were opened and counted. The layon n°01 was eliminated since it passed totally inside a plantation forest of *Eucalyptus sp*, settled as a ridge to protect the park from surrounding populations' activities. The layon n°06 was abandoned during the opening step, since it was badly oriented by the team leader. If the team continued, they risked to meet (cut) the layon n°05. The total distance of the layons opened is 27 932 km.

Table I: Sampling features for the *Prunus* inventory realized in the Teza sector, in the KNP

N° Layon	Distance of the layon (m)
2	830
3	930
4	994
5	850
7	2 779
8	2 550
9	2 500
10	3 150
11	3 424
12	3 244
13	2 200
14	2 265
15	2 216
Total	**27 932**

The Kibira national park is characterize by a long line of mountains which separate it in two sides. The east side or the Nil versant, and the west side or the Congo versant. This element may influence the behavior and the feature of the *Prunus* trees. Table II presents the distribution of plots sampled in different sides of the slope in the KNP. A total of 126 plots including 10 circular and 116 rectangular plots were systematically assessed for the inventory of *Prunus africana* in the Teza sector, in the Kibira national park. A total of 60 ha was completely assessed in the 2 800 ha of the forest delimitated in the Teza sector; which gives a sampling intensity of 2.14%.

B. Distribution of the health of trees recorded in the two sides of the KNP.

A total of 184 trees (table III) of *Prunus africana* of diameter ≥ 10 cm were recorded in the 60 ha of the forest inventoried in the Teza sector. A total of 13 stems recorded in the Teza sector are wilt or dead, representing 7.06% of the total number of stems. The Congo side is the one which hosts the high percentage of wilt or dead trees, 9.4% compared to the Nil side (4%).

Table II: Distribution of sampling plots in the two sides of the KNP

Side of the Slope	Circular Plots		Rectangular Plots		Total	
	Number	Area (ha)	Number	Area (ha)	Number	Area (ha)
CONGO	7	1.4	70	35	77	**36.4**
NIL	3	0.6	46	23	49	**23.6**
TOTAL	**10**	**2**	**116**	**58**	**126**	**60**

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Table III: Distribution of the health of *Prunus* trees in different sides of the Kibira national Park in the Teza sector

Health of the tree	Side of the slope		
	Congo	Nil	Total
Wilt	2	0	2
Dead	8	3	11
Living	96	75	171
Total	106	78	184

C. Abundance of seedlings

Table IV compares the abundance of seedlings observed under each *Prunus* tree between the Congo and the Nil sides. The average value of the regeneration in the Teza sector is 2.21 ± 0.72, which illustrates a low regeneration. This value is comprised between a minimum of 1.70 found in the Congo side (very low regeneration) and the maximum of 2.73 obtained in the Nil side. The two means are significantly different as shown in table 4 ($p < 0.005$).

Table IV: Comparison of the abundance of seedlings of the *Prunus* between the two sides of the Kibira national Park in the Teza sector.

	mean	**sd**	**n**	**F value = 12.245**	**Pr < 0.0005866 *****
Congo	1.70	1.94	106		
Nil	2.73	1.97	78		
All sides	2.21	0.72	184		

NB: the F value and Pr are from the comparison between the Congo and the Nil side
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

D. Thickness of the bark of living trees

The analyses done below are limited to living trees. In this work, living (healthy) trees are those which are looking well, without dried branches. The comparison of the two sides of the park in term of the thickness of the stem bark of living trees is showed in table V. The average thickness of the bark of *Prunus* trees in the Teza sector is 1.21 ± 0.16 cm. This value is comprised between the minimum of 1.09 cm for *Prunus* stems found in the Congo side and the maximum of 1.33 cm for trees situated in the Nil side. The means of the thickness of the barks illustrated in table 5 are significantly different ($p < 0.005$).

Table V: Comparison of the thickness of the barks of the Prunus between the two sides of the Kibira national Park in the Teza sector.

	mean	**sd**	**n**	**F value = 9.4462**	**Pr < 0.002467 ****
Congo	1.09	0.46	96		
Nil	1.33	0.55	75		
All sides	1.21	0.16	171		

NB: the F value and Pr are from the comparison between the Congo and the Nil side
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

E. Size of the trees

Table VI compares the *Prunus* trees found in the two sides of the park in term of the size (diameter at breast height) of the tree. The average size of the *Prunus* tree in the Teza sector is 55.82 ± 12.60 cm. this value is comprised between the minimum of 46.90 cm for trees belonging to the Nil side and the maximum of 64.73 cm for trees situated in the Congo side. The two means of the size of the trees illustrated in table VI are significantly different ($p < 0.005$).

Table VI: Comparison of the size (diameter) of the *Prunus* trees between the two sides of the Kibira national Park in the Teza sector.

	mean	**sd**	**n**	**F value = 16.541**	**Pr <** 7.288e-05 ***
Congo	64.73	26.37	96		
Nil	46.90	30.88	75		
All sides	55.82	12.6	171		

NB: the F value and Pr are from the comparison between the Congo and the Nil side
Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

F. Specific curves of Prunus africana in different sides of the park.

A total of 171 trees recorded are living, representing 92.9% of the total trees of the sample (table VII).

Table VII: Distribution of living trees recorded in different sides of the park in the Teza sector and in different diameter classes

Diameter classes	Congo	Nil	Total
Cl10_20	3	12	15
Cl20_30	5	15	20
Cl30_40	8	14	22
Cl40_50	14	5	19
Cl50_60	12	7	19
Cl60_70	18	5	23
Cl70_80	12	6	18
Cl80_90	8	3	11
Cl90_100	8	2	10
Cl100_110	2	2	4
Cl110_120	3	3	6
Cl>120	3	1	4
Total	**96**	**75**	**171**

Diameter classes are defined as follow: Cl10_20: trees with diameter between 10 cm and 19.9 cm; Cl20_30: diameter between 20 cm and 29.9 cm.

Fig. 2 illustrates the specific curve of *Prunus africana's* population found in the Congo side of the Kibira national park. The specific curve of *Prunus* is characteristic of climax forests, with high number of trees in the medium classes compared to low and high diameter classes.

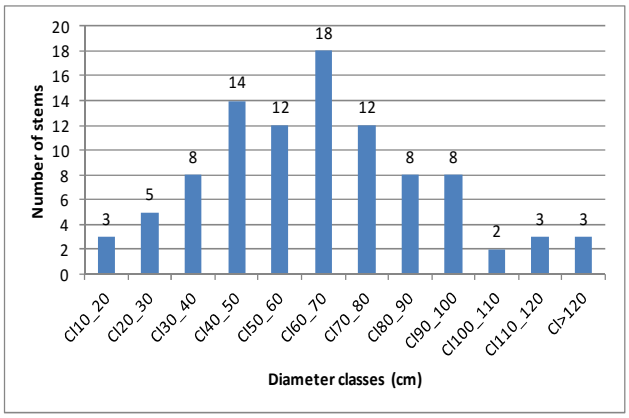

Fig.2. Specific curve of *Prunus* in the Congo side

Fig. 3 illustrates the specific curve of *Prunus africana* in the Nil side, in the Kibira national park. This figure shows the relative high importance of natural regeneration, with high number of trees in small diameter classes compared to the Congo side.

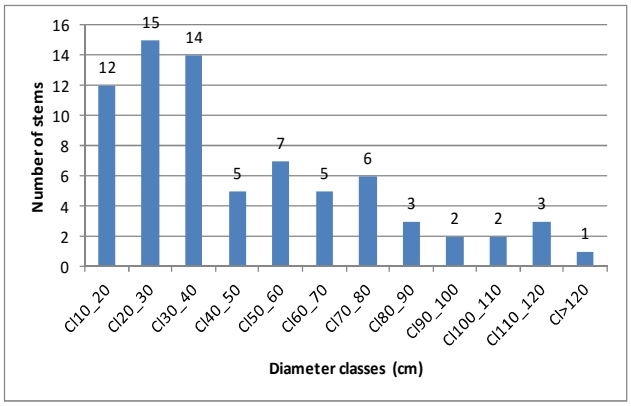

Fig.3. Specific curve of *Prunus africana* in the Nil side

G. Density of living Prunus trees

G.1. All living trees

The density of living *Prunus* stems is presented in table VIII. The average density of *Prunus* stems obtained is 2.85 stems/ha. The high density is found in the Nil side, 3.18 stems/ha.

Table VIII: Density of living *Prunus* stems

Diameter class	Congo (36.4 ha sampled)	Nil (23.6 ha sampled)	Total
Cl10_20	0.08	0.51	0.25
Cl20_30	0.14	0.64	0.33
Cl30_40	0.22	0.59	0.37
Cl40_50	0.38	0.21	0.32
Cl50_60	0.33	0.30	0.32
Cl60_70	0.49	0.21	0.38
Cl70_80	0.33	0.25	0.30
Cl80_90	0.22	0.13	0.18
Cl90_100	0.22	0.08	0.17
Cl100_110	0.05	0.08	0.07
Cl110_120	0.08	0.13	0.10
Cl>120	0.08	0.04	0.07
Total	**2.64**	**3.18**	**2.85**

G.2. Stock of exploitable living trees

Exploitable stems are trees with diameter at breast high at least equal to 30 cm. Table IX presents the density of exploitable living *Prunus* trees. The high density is in the Congo side (2.42 stems/ha).

Table IX: Density of exploitable living trees

Diameter class	Congo (36.4 ha sampled)	Nil (23.6 ha sampled)	Total
Cl30_40	0.22	0.59	0.37
Cl40_50	0.38	0.21	0.32
Cl50_60	0.33	0.30	0.32
Cl60_70	0.49	0.21	0.38
Cl70_80	0.33	0.25	0.30
Cl80_90	0.22	0.13	0.18
Cl90_100	0.22	0.08	0.17
Cl100_110	0.05	0.08	0.07
Cl110_120	0.08	0.13	0.10

Cl>120	0.08	0.04	0.07
Total	**2.42**	**2.03**	**2.27**

The total number of exploitable living trees estimated for the Teza area in the Kibira national park is shown in table X. The exploitable stock of the *Prunus* trees estimated is 6 347 trees. The Congo side hosts almost the three quarters (3/4) of the exploitable stock of *Prunus* trees in the Teza sector.

Table X. Stock of exploitable trees of *Prunus* in the Teza sector, Kibira national park.

Diameter class	Congo (1 584.8 ha of productive forest)	Nil (1 212.4 ha of productive forest)	Total (2 800 ha)
Cl30_40	373.33	653.33	1026.67
Cl40_50	653.33	233.33	886.67
Cl50_60	560.00	326.67	886.67
Cl60_70	840.00	233.33	1073.33
Cl70_80	560.00	280.00	840.00
Cl80_90	373.33	140.00	513.33
Cl90_100	373.33	93.33	466.67
Cl100_110	93.33	93.33	186.67
Cl110_120	140.00	140.00	280.00
Cl>120	140.00	46.67	186.67
Total	**4 106.67**	**2 240.00**	**6 346.67**

IV. Discussion

A. Sampling intensity

The average sampling intensity is 2.14%, which is good for the area delimitated (less than 5 000 ha).

B. Specific curves of Prunus trees in different sides of the park.

Specific curves are good indicators for illustrating the statues of the regeneration for a given plant specie. Fig. 4 and 5 show different features of the *Prunus* specific curve in the two sides of the park. For the Congo side, the specific curve of *Prunus* is characteristic of climax forests, with high number of trees in the medium classes compared to low and high diameter classes. This may be due by the fact that this side of the Kibira national park has been preserved of any kind of exploitation (harvesting). Number of dead trees is high (9%), showing the climax age of that forest. This result also illustrates the light demanding characteristic of *Prunus africana* [2]-[3]-[4]. In fact, as light demanding plant species, young individuals may face problems of regeneration or growth, due to the low quantity of light inherent to the closed canopy caused by adult trees.

The figure obtained for the Nil side (fig. 5) illustrates the high importance of natural regeneration, with high number of trees in small diameter classes. In a situation where the forest has been perturbed (cut), seeds and seedlings of *Prunus* develop well due to the light caused by the perturbation. This results is in accordance with the relative distribution of *Prunus* seedlings in the two sides of the slope. *Prunus* seedlings are more abundant in the Nil side compared to the Congo side. Individuals of diameter classes C40 – C80 are less represented compared to the situation we have in the west side (Congo). This illustrates clearly the degradation of the Nil side. Local populations have harvested *Prunus africana* in this forest. But the fact that we did not recorded any debarked stem, even among the dead trees tends to show that those trees were not harvested for their bark, but for their timber . This confirms the fact that *Prunus africana* is one of the important timber trees for construction in Burundi. The major threats to Burundi's few remaining tropical forests stem from activities such as: land clearing for cultivation, fuelwood harvesting, civil unrest, and timber extraction. For timber_extraction, it is said that_ Burundi's relative lack of forest cover and poor infrastructure limit the profitability of timber extraction. However certain valuable tropical wood species (*Podocarpus milanjianus, Prunus africana,* and *Hagenia abyssinica*) have been targeted and exported illegally from the Kibira National Park [1].

A number of reports [1] highlight dramatic deforestation levels following the 1993 crisis in Burundi. This deforestation is attributed to two causes: the existence of large numbers of refugees, and destruction of property as retribution. As refugees poured into Burundi, large camp populations required massive amounts of wood for cooking, heating, and housing construction. Because the Red Cross was paying good prices for fuelwood, the local population began harvesting whatever they could, including fruit trees.

The few remaining large forest stands in Burundi are under nominal protection—either in Kibira and Ruvumbu National Parks, or in one of the State forest reserves. The primary threat to these forests is the lack of capacity to regulate cutting due to insecurity. Kibira National Park—which is contiguous to the Nyungwe forest in Rwanda—is known to harbor large numbers of rebels and refugees, and is feared to be subjected to extensive harvesting of timber, fuelwood, bamboo, forest products, and bush meat [1].

C. Density of Prunus stems

The average density of living trees obtained is 2.85 stems/ha. This density is comprised between a minimum of 2.64 stems/ha found in the Congo side and a maximum of 3.18 stems/ha found in the Nil side. Inventories carried out with the same method in the mount Cameroon found densities of 3.06 stems/ha [14]. Average density of exploitable living trees in Teza is 2.27 stems/ha, which is high compared to what was assessed in mount Cameroon (1.37 stems/ha). The percentage of wilt or dead trees obtained in Teza (7.6%) quite similar to that (8.1%) obtained in mount Cameroon [14]. All these results tend to show that *Prunus africana* populations have almost been conserved in Burundi than in mount Cameroon. In Cameroon, 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 [4]-[14]-[17].

D. Stock of Prunus trees

The stock expresses the total number of exploitable stems found in a given area. The total number of 6 347 trees of *Prunus africana* can be harvested since they have rich the MED which is 30 cm. The Kibira national park is vast of 40 000 ha, and the production forest can cover more than 30 000 ha. If the density of 2.04 stems of exploitable trees was normally distributed in the park, then the total number of the exploitable *Prunus* trees of the park will be estimated at 61 200, which is almost twice compared to the 32 498 trees obtained in the mount Cameroon national park [14].

V. Conclusion

The "Adaptive Clusters Sampling (ACS)" method used to assess the stock of *Prunus africana* trees in the Teza sector is suitable, due to the scattering feature of *Prunus* trees in the forest. Using that method, we obtained a density of 2.27 of living and exploitable *Prunus* trees/ha and an exploitable stock of 6 347 exploitable trees. Significance differences are observed between trees found in the Congo side, and those situated in the Nil side of the Kibira national park. The next step should consist of estimating the total mass of *Prunus* stem bark that can be sustainably obtained from those stems. Further research should also been done to better appreciate the stock of *Prunus* in the whole park and other protected areas which host that tree species. Future research should also try to better identify environmental parameters which influence the behaviour of *Prunus* trees in each side of the park.

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Author's Profile

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Born in 1966 at Mbeth II, a village locate in the Diang Subdivision, Lom and Djerem division, East region of Cameroon. Engineer in forestry and wildlife obtained in 1994 at the University of Dschang, Cameroon; MSc in management of natural resources and development in tropical countries obtained in 1998 at the faculty of agronomic sciences, Gembloux, Belgium, and Ph.D. in agronomic sciences and biological engineering obtained in 2001 at the Free University of Brussel, Belgium. The main field of study is agronomy, forest and wildlife management, quantitative ethnobotany.

Jean Lagarde worked in the Ministry of Forestry and Wildlife from 1995 to 2007. He worked as consultant for FAO in 2007, 2010 and 2013, for the African Forest Forum (AFF) in 2010. He is currently working as a lecturer at the Department of Botany, Faculty of Sciences, University of Douala, Cameroon. Since January 2008, Jean Lagarde works as a Consultant for the International Tropical Timber Organization (ITTO) and the Convention on International Trade in Endangered Species (CITES) program on sustainable trade in CITES listing II timber species. This Program is a multi-year collaborative project with financial support of the European Commission (EC) together with USA, Japan, Norway and New Zealand, being the EC the primary donor. The program covers

three regions including Asia, Latin America, and Africa. It provides specific assistance to countries throughout the tropics to design forest management plans, forest inventories, provide guidelines and case studies for making NDFs (Non-Detriment Findings), and develop and disseminate tools for timber identification. Jean Lagarde, the lead author is regional coordinator for Africa for that large capacity building programme which seeks to undertake research on and improve management of CITES-listed tropical tree species (http://www.itto.int/cites_programme/); the support and information generated from this programme on *Prunus africana* is gratefully acknowledged. The Program aims to ensure that international trade in CITES-listed tropical tree species is consistent with their sustainable management and conservation. Since July 2010, the program has extended its goal to cover other CITES listed species such as *Prunus africana* in Cameroon and Democratic Republic of Congo.

Dr. BETTI is currently the scientific advisor of the **"GENIE – LEVANT".** This is a local association, which aims to defend property rights of forest population in the East province of Cameroon and enhance community based development through the best utilization of forest resources and improvement of local agriculture. Some recent papers published include:

J.L. Betti, S.J. Belinga and D. Samba, "Stock of *Prunus africana* stems in the Mount Cameroon forests".

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