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Characterisation of *Afzelia africana* Sm. habitat in the Lama forest reserve of Benin

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ABSTRACT

A study was carried out in the Lama forest reserve of Benin to characterize the habitat of *Afzelia africana* Sm., an endangered multipurpose tree species (found in African humid, dry forests and woodlands), in order to define a sustainable management strategy for its conservation. An estimation of species density was done on 100 square plots of 1 ha each, while tree height and dbh of all the species were measured on subplots of 50 m × 30 m within the 1 ha plots. The regenerations of *A. africana* (dbh < 10 cm) were counted in the diagonal quadrats of the principal plots. Presence–absence data of the species was subjected to multidimensional scaling and results showed four vegetation communities including: young fallow, old fallow, typical dense forest and degraded dense forest. Significant differences were noted between the four communities with respect to dendrometric parameters of the species. High values of these parameters were noted for the species in typical dense forest (5.2 stems/ha, 66.7 cm, 17.9 m, 7.9 m^2/ha and 38.8% for the tree-density, the mean diameter, the mean height, basal area and basal area contribution of the species, respectively) whereas the lowest values were obtained for the old preforest fallow as far as the mean diameter (59.7 cm), the mean height (15.7 m) and the basal area contribution (27.7%) of the species were concerned. In general, the basal area of *A. africana* in the over vegetation types was less than 3 m^2/ha. No *A. africana* tree was found in the young preforest fallow while more than 80% of *A. africana* trees were found in the typical dense forest community. Stem diameter and height structures of the species in all the four communities showed a left dissymmetric Gaussian shape and were well adjusted to Weibull distribution.

1. Introduction

The world forest cover is a key indicator for the wellbeing of our planet. The world's forest cover approximately 3.9 billion hectares which represents 1/3 of the total area of the planet (FAO, 1999). The most important factor of degradation in species diversity is the loss, fragmentation and modification of natural habitats. At regional level, approximately 76% of all species face extinction risk due to loss and modification of their natural habitats (Hargitt, 1994; McNeely, 1996). From 1990 to 1995, a total of 298,000 ha of Benin's forest cover have been lost (FAO, 1999). There is an average loss of 60,000 ha per year. Benin does not produce a lot of timber because it is a moderately forested country, with savanna as dominating vegetation type. The mean rate of timber exploitation is four cubic meters per ha and is one of the lowest in Africa. However in Benin, the population develops a selective forest harvesting that leads to the scarcity of some species for instance *Milicia excelsa*, *Afzelia africana*, *Khaya senegalensis*, *Mansonia altissima* and *Pterocarpus erinaceus* (Glèlè Kakaï and Sinsin, 2009).

A. africana is one of the most threatened multipurpose forest species in Africa used by local people for animal feeding (Sinsin, 1993; Onana, 1998), traditional medicine (Sinsin et al., 2002) and wood (Ahouangonou and Bris, 1997; Bayer and Waters-Bayer, 1999). Seeds are used as thickening agent (African Regional Workshop, 1996). The species is found in several types of natural forests ranging from the dense forest of the guineo-congolian zone to the woodland forest of the sudanian zone (White, 1983).

The multiple uses of *A. africana* in West Africa led to a permanent pressure on its natural populations. It is frequent to observe adult trees of *A. africana* in savannah as well as in woodland and dense forests but its natural regeneration is rarely observed within the same habitats. This situation was noticed within the species range of distribution in Africa (Sinsin, 1993; Bationo et al., 2000).

The main question in this study is to understand how far the species is facing an extinction risk, since the observed results from some experimental plots established in some zones in West Africa showed a very low density of the species in its habitats (Ahouangonou and Bris, 1997). It was already revealed that

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grazing, uncontroled logging and other factors such as rodents, termites and fungi influence the structure of the species in its habitats (Onana, 1998; Bationo et al., 2000). It is foreseen that the population of *A. africana* in its natural range in Africa will be reduced by a third during the following three generations (Sinsin et al., 2004).

Based on the various types of pressure on the species, it becomes urgent to define a better conservation strategy for its sustainable management, not only by exploring the present status through a structural study of the populations but also by describing the species' habitat. Therefore, the present study aims at characterizing *A. africana* habitat and analysing the present structure of its populations in the Lama forest reserve located in the Guinean zone of Benin.

2. Materials and methods

2.1. Study area

The Lama forest reserve, protected by law since 1946, is located in Southern Benin in the Dahomey Gap between 6°55′ and 7°00′ latitude North and 2°04′ and 2°12′ longitude East (Fig. 1). The total area of the forest is estimated at 16,250 ha.

The rainfall regime is bimodal from April to June and from September to November, with a mean annual rainfall of 1200 mm. The mean temperature varies between 25 and 29 °C and the relative humidity between 69 and 97%. The vegetation in the forest has been strongly affected in the past by various agricultural activities and now forms a mosaic of cultivated lands and small relic forest patches. The original vegetation was dense semi-deciduous forest established on 4777 ha composed of 292 ha of *Tectona grandis* and *Gmelina arborea* plantation, 1900 ha of dense forest, the remaining area being constituted of fallows (Emrich et al., 1999).

2.2. Sampling design and data collection

Transects were designed using the map of the dense forest (*Noyau Central*) of the protected area. Through a random sampling scheme, hundred plots of 1 ha were selected on the map and their geographic coordinates were noted. The total sampled area in the forest is 100 ha representing 2.49% of the total surface covered by the *Noyau Central*.

Within each 1 ha square plot, rectangular subplots of 50 m × 30 m were designed to record ecological data relating to all the species having at least 10 cm dbh. Moreover, adjacent diagonal 10 m × 10 m plots were established within each 1 ha plot for the natural regeneration study of *A. africana* (Fig. 2).

Within each of the 1 ha plots, all individuals of *A. africana* were counted. In addition, the diameter of all tree species (dbh ≥ 10 cm) was measured within the rectangular plot of 50 m × 30 m as well as the total height of *A. africana* individuals. Moreover for the regeneration study, all individuals of *A. africana* having less than 10 cm dbh were counted within the diagonal 10 m × 10 m plots.

2.3. Data analyses

2.3.1. Description of vegetation

The presence–absence data of all inventoried species within the 100 plots of 50 m × 30 m were grouped in a binary matrix and submitted to multidimensional scaling for mapping the plots according to their species composition. The ALSCAL procedure of SPSS software was used to build a bidimensional geometric structure based on the observed similarity or dissimilarity among plots.

2.3.2. Ecological and dendrometric parameters

The following dendrometric parameters were used:

The tree-density of the stands (N), i.e. the average number of trees per plot expressed in trees/ha:

$$N = \frac{n}{s} \tag{1}$$

n is the overall number of trees in the plot, and s the area (s = 0.15 ha).

To analyse the spatial distribution of *A. africana*, the index of Green (IG) was used (Jayaraman, 1999):

$$\mathrm{IG} = \frac{(\mathrm{IB} - 1)}{n - 1} \quad \text{and} \quad \mathrm{IB} = \frac{s_N^2}{N} \tag{2}$$

with, IB representing the Blackman Index (IB); N and s_N^2 are, respectively, the mean and variance of the *A. africana* tree-density of the stands. The IG value may range from 0 (random distribution) to 1 (maximal aggregative distribution of trees).

The mean diameter of the trees (D_g, in cm), i.e. the diameter of the tree with the mean basal area in the stand:

$$D_g = \left(\frac{1}{n}\sum_{i=1}^{n} d_i^2\right)^{1/2} \tag{3}$$

where n is the number of trees found on the plot, and d_i the diameter of the i-th tree in cm.

The basal area of the stand (G), i.e. the sum of the cross-sectional area at 1.3 m above the ground level of all trees on a plot, expressed in m^2/ha:

$$G = \frac{\pi}{4s}\sum_{i=1}^{n} 0.0001\, d_i^2 \tag{4}$$

d_i is the diameter (in cm) of the i-th tree of the plot; s = 0.15 ha.

Basal area contribution (Cs, in percent), i.e. part of *A. africana* trees in the overall basal area of trees in the plot and was computed for *A. africana* trees as follows:

$$Cs = 100\frac{Gp}{G} \tag{5}$$

Gp is the basal area of the *A. africana* trees, and G is the basal area for the whole plot.

The Lorey's mean height (H_L, in meters), i.e. the average height of all trees found in the plot, weighted by their basal area (Philip, 2002), was computed as follows:

$$H_L = \frac{\sum_{i=1}^{n} g_i h_i}{\sum_{i=1}^{n} g_i} \quad \text{with} \quad g_i = \frac{\pi}{4} d_i^2, \tag{6}$$

g_i and h_i are the basal area (in m^2/ha) and the total height (in m) of tree i.

The following ecological parameters were assessed:

The species richness (S) is the number of species recorded in the whole stand.

The Shannon's Diversity Index (H, in bits) is computed using the following formula:

$$H = -\sum_{i=1}^{s}\left(\frac{n_i}{n}\right)\mathrm{Log}_2\left(\frac{n_i}{n}\right) \tag{7}$$

n_i is the number of individuals of species i, n is the overall number of trees inventoried in the plot.

The Pielou's evenness (Eq) measures the diversity degree of a stand compared with the possible maximum and is computed as

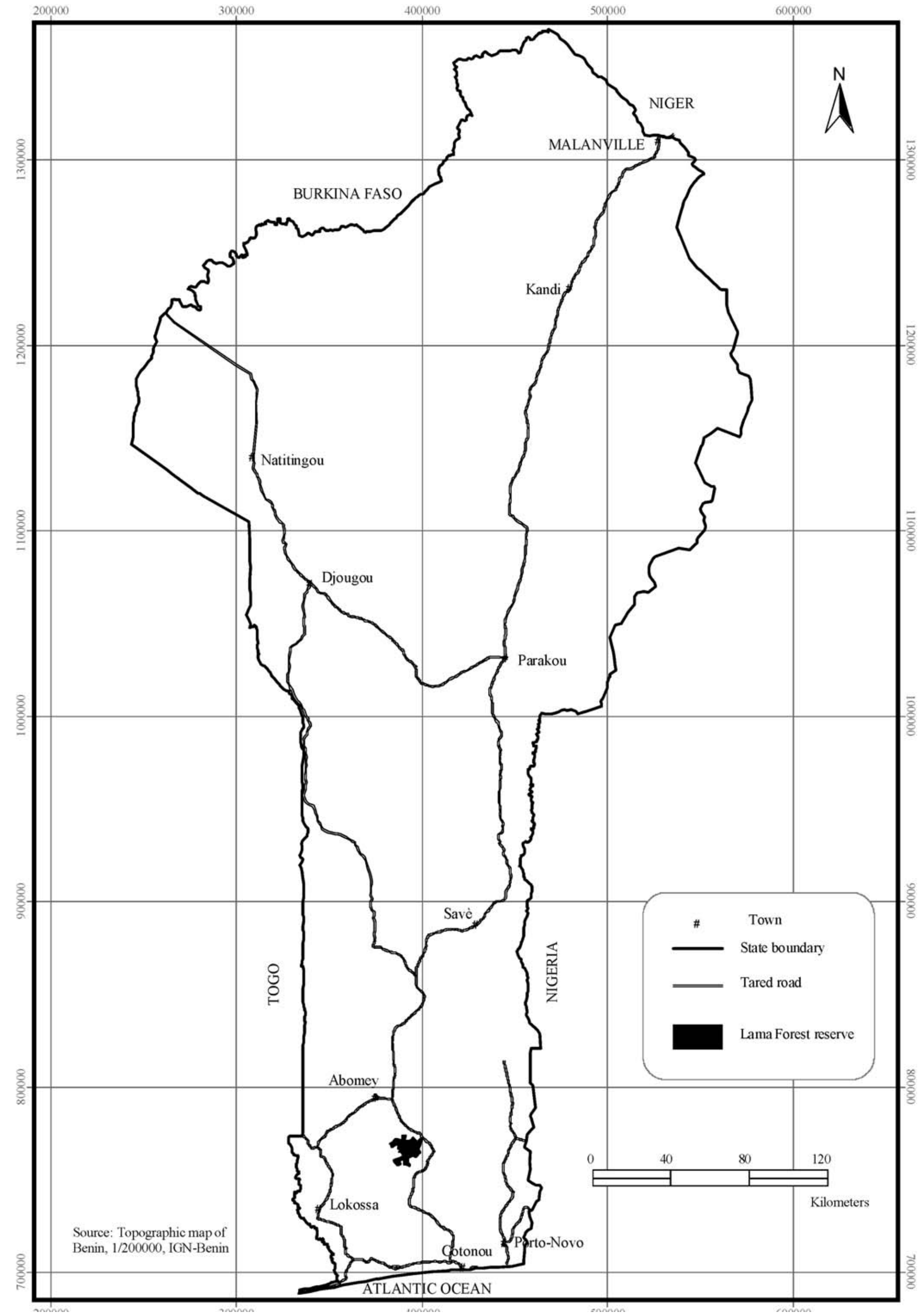

Fig. 1. Location of Lama forest reserve in Benin map.

follows:

$$Eq = \frac{H}{H_{\max}} \quad \text{with}\, H_{\max} = \text{Log}_2 S. \tag{8}$$

$H_{\max}$ is the maximum value of the Shannon's diversity index of the stand, and S is the number of tree-species recorded in the considered plot.

The dendrometric parameters N, G, D_g were computed for the whole *Noyau Central* and for each group of vegetation identified from the multidimensional scaling. The parameters H_L, Cs and IG were calculated for *A. africana* both for the whole *Noyau Central* and separately for each identified group of vegetation.

Since the structural parameters computed for the identified vegetation groups were not normally distributed (Ryan–Joiner test of normality; Ryan and Joiner, 1976), the non-parametric test of Kruskal–Wallis was applied.

2.3.3. Characterizing natural regeneration of A. africana

For the characterisation of the natural regeneration density of *A. africana*, the four identified vegetation groups were assimilated to strata. The regeneration density of the *A. africana* population, $\hat{\bar{N}}_r$,

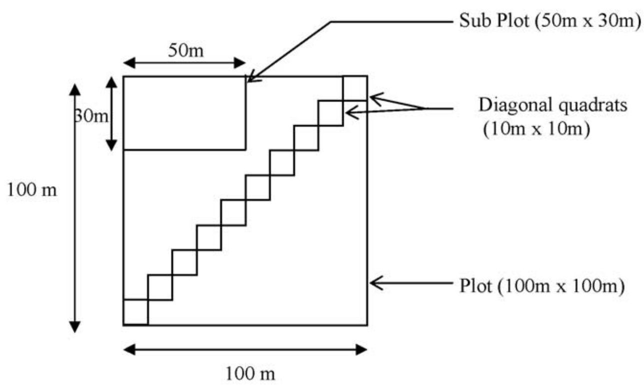

Fig. 2. Sample unit of forest inventory.

was computed as indicated below (Dessard and Bar-Hen, 2004):

$$\hat{N}_r = \frac{\sum_{l=1}^{k} N_l \bar{N}_{rl}}{N}; \qquad \bar{N}_{rl} = \left(\frac{1}{n_l}\right)\sum_{i=1}^{n_l} y_{li}, \tag{9}$$

$\bar{N}_{rl}$ = mean density of *A. africana* regeneration within group l (l = 1, 2, 3, 4); N = total number of plots within the global sampling; y_{li} = regeneration density of *A. africana* within the ith plot of group l of the stand.

2.3.4. Structuring diameters and heights of A. africana trees

To establish the stem diameter structure of *A. africana* stands, all individuals of the species were grouped into diameter classes of 10 cm in order to obtain enough diameter classes (at least 10). This allows the adjustment of Weibull theoretical distribution to the observed shape. The tree densities were assessed for diameter classes. As far as the height structure is concerned, classes with 2 m amplitude were considered.

The observed different diameter structures were adjusted to the 3-parameter-Weibull distribution because of its flexibility (Johnson and Kotz, 1970), whose density function, f is expressed for a tree-diameter x as follows:

$$f(x) = \frac{c}{b}\left(\frac{x-a}{b}\right)^{c-1} e^{-[x-a/b]^c}, \tag{10}$$

where x = tree diameter; a = 10 cm for the diameter structure and 2 m for the height structure; b = scale parameter linked to the central value of diameters and heights; c = shape parameter of the structure.

For each identified group, diameters of trees were used to estimate the parameters b and c of (10) based on the maximum likelihood method (Johnson and Kotz, 1970). The log-linear analysis (Caswell, 2001) was performed in SAS (SAS Inc., 1999) for each case to test the adequacy of the observed structure to the Weibull distribution. The considered model described by Caswell (2001) is

$$\text{Log Frequency} = F + F_{\text{\_Class}} + F_{\text{\_Adjustment}} + \varepsilon \tag{11}$$

F = mean frequency of the classes; $F_{\text{\_Class}}$ = non-randomly gap linked to the differences in frequency between classes; $F_{\text{\_Adjustment}}$ = non-randomly gap linked to differences between observed and theoretical frequencies; ε is the error of the model. The hypothesis of adequacy between both distributions is accepted if the probability value of the test is higher than 0.05.

3. Results

3.1. Vegetation characterisation in the Noyau central

The multidimensional scaling showed four vegetation groups: G1, G2, G3 and G4 (Fig. 3). The first axis discriminates the open vegetations (G1, G3 and G4) from the closed one (G2). Therefore, there is a structural complexity gradient linked to the species richness of the *Noyau Central* of the Lama forest reserve. The second axis discriminates the plots according to their species richness formed by both the fallow species (G3) and the ones from dense degraded forest (G4).

Group 1 (G1) is composed of 29 plots established in the young fallows. Therefore this vegetation group can be considered as the young preforest fallow. Three dependent variants of the dominant species can be distinguished: population dominated by *Lonchocarpus sericeus*, population of *Anogeissus leiocarpa* or population of both species. In all cases, *A. africana* was lacking in this group. G1 is characterized by the predominance of *Chromolena odorata* (75% of cover). The mean density is estimated at 104.4 trees/ha with a mean tree diameter of 26 cm. The species richness is about 17 species in G1 (Table 1).

Group 2 (G2) is composed of 48 plots established in the typical non-degraded dense forest as noted during the forest inventory and can then be considered as a dense semi-deciduous forest. *A. africana* and *Ceiba pentandra* are the most represented species with the biggest diameter and height, followed by *Diospyros mespiliformis*, *Dialium guineense* and *Mimusops andongensis*. The less represented species are *Drypetes floribunda*, *Celtis brownii*, *Holarrhena floribunda*, *Malacantha alnifolia*, etc. The mean density was estimated at 178.5 trees/ha for the whole stand and at 5.2 trees/ha for *A. africana*. The mean diameter and height of *A. africana* individuals were estimated at 66.7 cm and 17.2 m, respectively, whereas the regeneration density was estimated at 21.5 trees/ha. The estimated Shannon's Diversity Index of G2 was 2.6 bits.

Group 3 is composed of 13 plots mostly established in the open vegetation, more specific in the fallows during the forest inventory. The particularity here is that *L. sericeus* is associated with *Albizia zygia*. The presence of *C. pentandra*, *Ficus sur*, *A. leiocarpa*, etc. was noticed sometimes in a lesser extent. The presence of forest species such as *A. africana*, *D. mespiliformis*, *D. guineense* was also noticed because of the proximity and permanent mix of both types of vegetation, fallow and dense semi-deciduous forest. The *C. odorata* cover is less than in G1 and estimated at about 30% of the overall cover of the vegetation of G3. G3 could be considered as an old preforest fallow. The mean density was estimated at 116.9 trees/ha for the whole stand, whereas the species richness and Shannon's Diversity Index were 21 species and 3.4 bits, respectively. The mean density of *A. africana* and its regeneration were estimated respectively at 1.5 trees/ha and 11.5 plants/ha, while its mean diameter and height were 59.7 cm and 15.7 m, respectively (Table 1).

Group 4 is constituted of 10 plots mostly established in the degraded dense forest and humid semi deciduous forest of *Cynometra megalophylla*. G4 is different from the remaining groups because of the presence of *C. megalophylla*, which is characteristic of permanent humid zones. This vegetation group could then be considered as degraded dense forest. Some forest species such as *A. africana* and *D. guineense* become rare with the important regression of other dense forest species, such as *D. mespiliformis*, *M. andongensis*, *D. floribunda*, *C. brownii*, etc. Within the dense degraded forest, a scattered presence of *C. odorata* was noticed. In G4, the mean density of *A. africana* was estimated at 1.3 trees/ha with a mean diameter and height of 60.6 cm and 21.4 m, respectively (Table 1). The overall density of the stand was estimated at 126 trees/ha whereas the mean density of the regeneration of *A. africana* was 7 plants/ha.

As shown in Table 1, only the diameter and basal area contribution of *A. africana* showed the same mean values for the 3 groups (Prob $>$ 0.05). The values obtained for other parameters were significantly different from one group to another (Prob $<$ 0.001). The lowest values obtained for all parameters

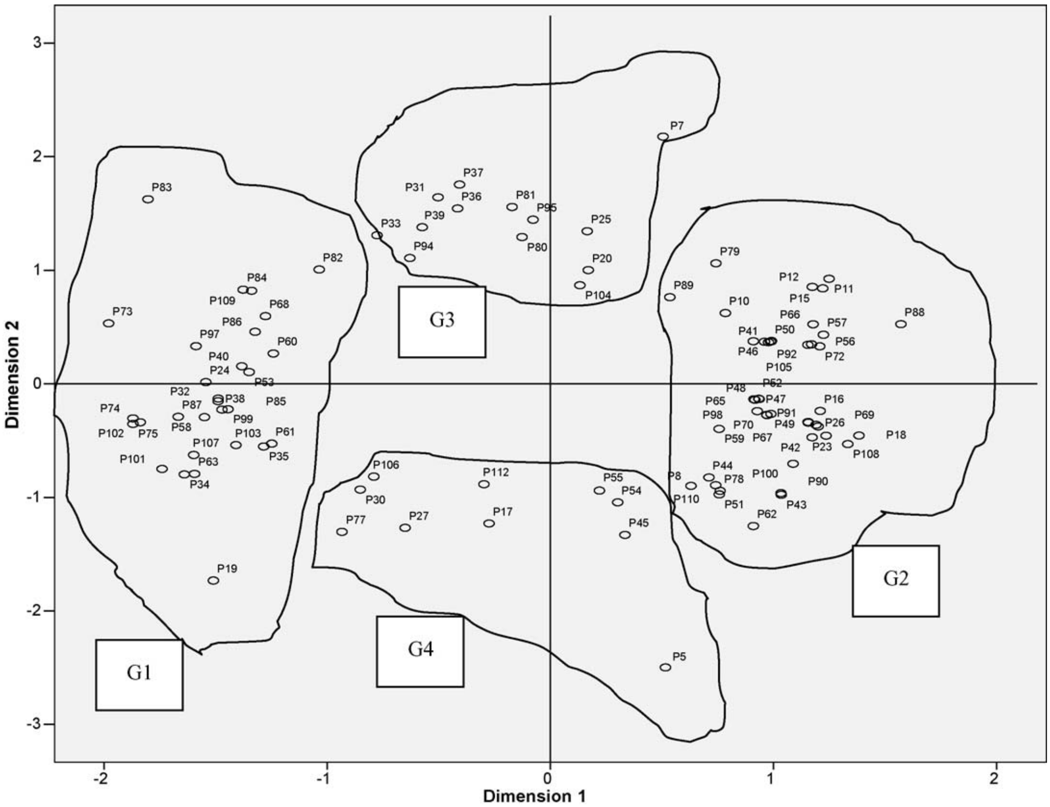

Fig. 3. Projection of the 100 plots of 50 m × 30 m in the system axes 1 and 2, Pi = plot *i*; G1 = young preforest fallow; G2 = typical non-degraded dense forest; G3 = old preforest fallow; G4 = dense degraded forest and humid semi-deciduous forest of *C. megalophylla*.

are recorded by the young fallows while the highest values are observed in the typical non-degraded dense forest of the Lama forest reserve.

The mean diameter and height of the species were estimated at 65.1 cm and 16.9 cm, respectively. The mean regeneration density of the species is 12.6 plants/ha with a Green Index value estimated at 0.1.

3.2. Diameter classes structure

3.2.1. Groups of vegetation

The observed diameter structure for the four identified groups and the overall vegetation shows an inverse "J" shape, characteristic for multispecific populations (Fig. 4) with *c*-value of the Weibull distribution smaller than or close to 1, characteristic of multispecific or uneven-aged populations.

The 10–40 cm dbh classes were the best represented with the majority of trees in the first diameter class. Individuals with dbh of more than 80 cm dbh were scarce in the young preforest fallow and degraded dense forest. We noticed also a good ajustement of the observed distribution to the Weibull theoritical distribution for all identified groups of vegetation as well as for the overall stand ($p > 0.05$).

3.2.2. Populations of A. africana

Apart from the diameter distribution of G3, Fig. 5 shows a bell-shape distribution for G2, G4 and the overall *Noyau Central*, characteristic for monospecific stands.

Table 1
Dendrometric characteristics of groups: mean, coefficient of variation and probability values.

Parameters	Group 1 (n = 29)		Group 2 (n = 48)		Group 3 (n = 13)		Group 4 (n = 10)		p
	m	cv (%)	m	cv (%)	m	cv (%)	m	cv (%)	
A. africana									
Density (N, stems/ha)	–	–	5.2	96.3	1.5	131.5	1.3	124.3	0.000
Diameter (D_g, cm)	–	–	66.7	21.4	59.7	44.3	60.6	26.9	0.406
Basal area (G, m^2/ha)	–	–	7.9	78.2	2.8	129.9	2.2	151.8	0.000
Height (H_L, m)	–	–	17.9	23.3	15.7	30.5	21.4	22.3	0.003
Basal area contribution (Cs, %)	–	–	38.8	48.5	27.7	70.3	33.3	48	0.228
Regeneration density (N_r, plants/ha)	–	–	21.5	112.1	11.5	182.5	7.0	128.6	0.000
Global									
Density (N, stems/ha)	104.4	38.6	178.5	40.6	116.9	32.6	126	21.5	0.000
Diameter (D_g, cm)	26	31.6	36.9	18.7	33.9	31.9	30.1	23.3	0.000
Basal area (G, m^2/ha)	5.6	57.7	19.4	50.6	11.1	57.3	9.5	51.5	0.000
Species richness (S, species)	17	–	17	–	21	–	16	–	–
Shannon's diversity (H, bits)	2.4	–	2.6	–	3.4	–	3.0	–	–
Pielou's evenness, Eq	0.6	–	0.7	–	0.8	–	0.8	–	–

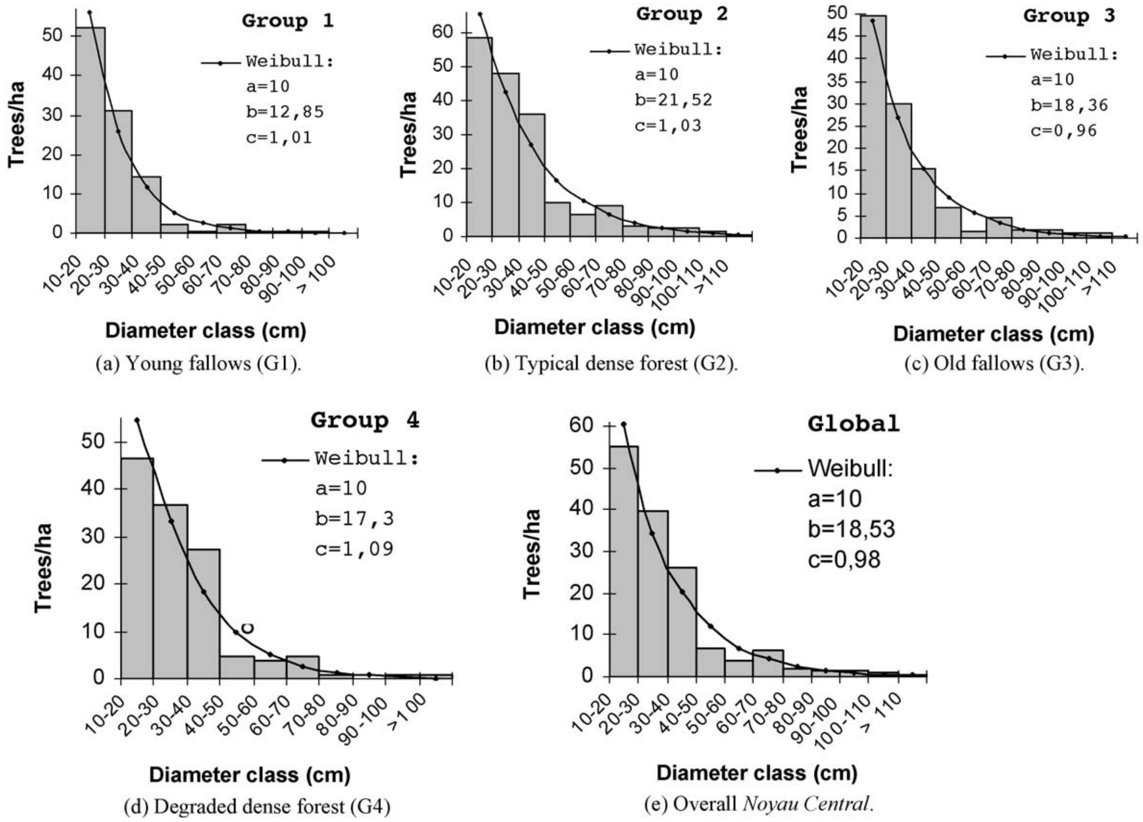

Fig. 4. Diameter structure of the identified groups of vegetation.

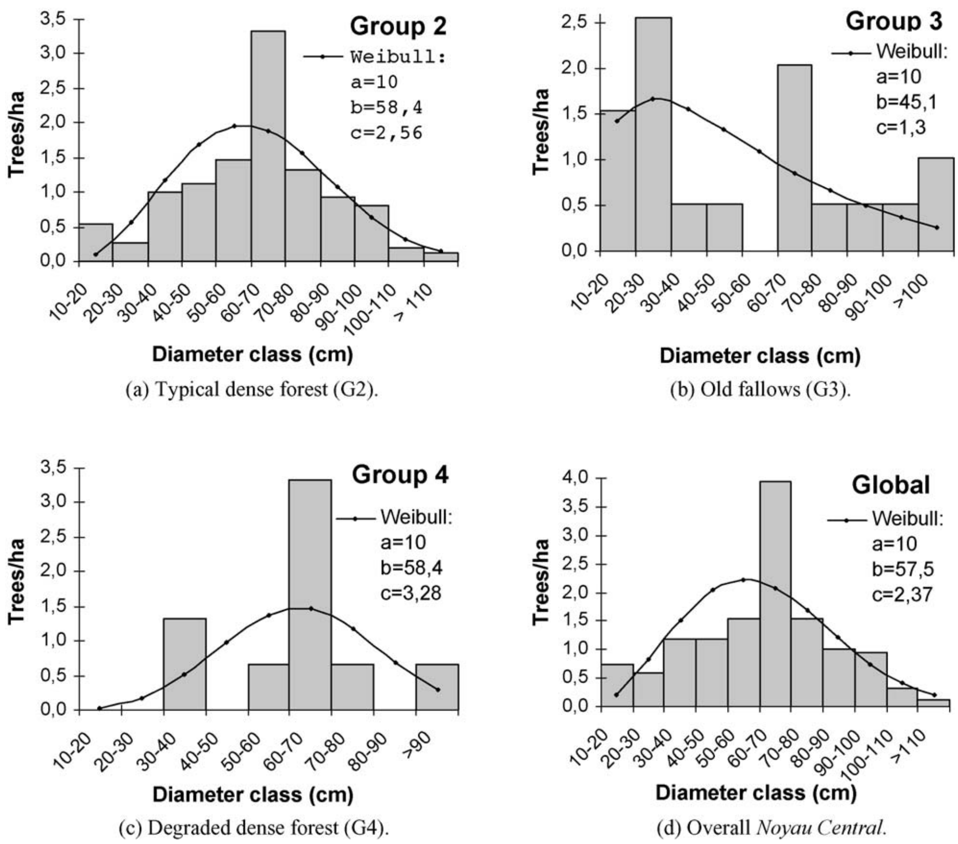

Fig. 5. Diameter structure of *A. africana* population within the identified groups.

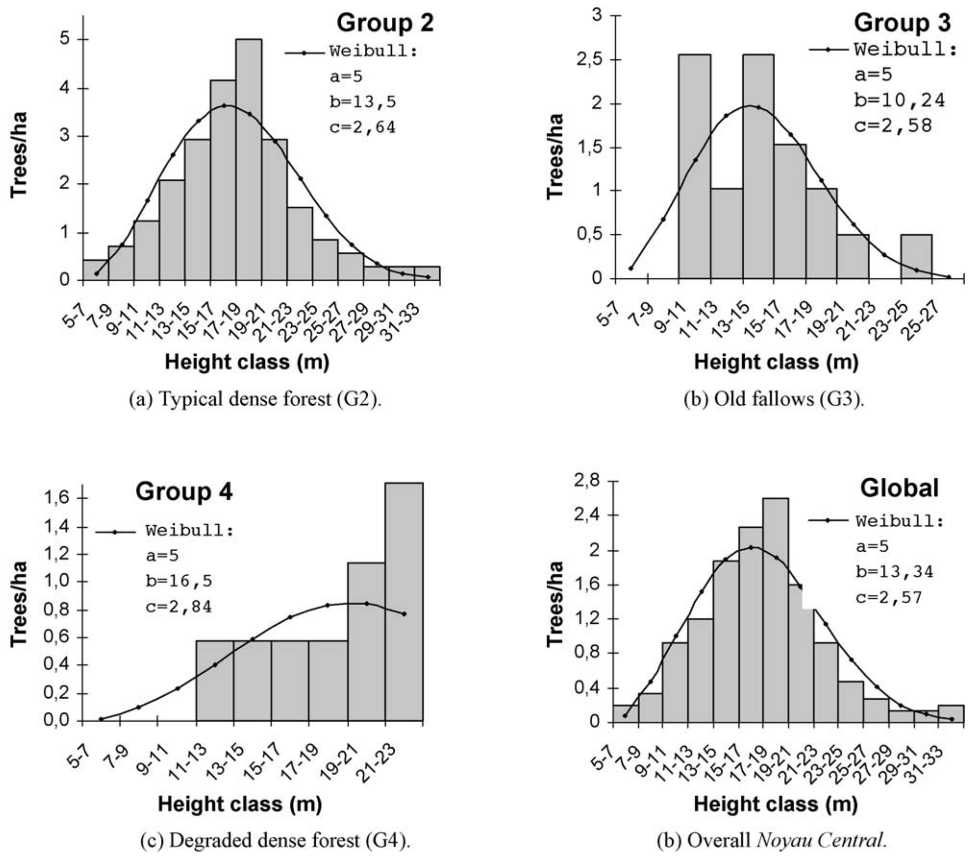

Fig. 6. Height structure of *A. africana* population within the identified groups.

The left dissymetric distribution observed for those groups ($1 < c < 3.6$) meant a predominance of individuals with small diameter (dbh) in the stands (Husch et al., 2003). This distribution is even more characteristic for G3 (old preforest fallow) with the *c*-value of the Weibull distribution estimated at 1.3. The young individuals of *A. africana*, mainly those of 20–30 cm dbh class were the most represented followed by 60–70 cm dbh class. For the overall stand and dense forest, most of the individuals of *A. africana* have a diameter ranging between 60 and 70 cm.

The log-linear analysis (computed for each structure) indicated a good adjustment of the observed distribution to the Weibull distribution ($p > 0.05$).

3.3. Height class structure of A. africana

Fig. 6 shows the height structure of *A. africana* populations according to different identified vegetation groups. The figure exhibits a bell-shaped and a left dissymetric distribution for all groups. Individuals having a height ranging from 13 to 21 m were the most represented in the typical dense forest (G2) and for the overall *Noyau Central*, while, in the old fallows (G3), the most represented individuals were the ones having heights ranging from 9 to 15 m. The height of the most represented individuals in the old degraded forest ranged between 19 and 23 m. The log-linear analysis (computed for each structure) indicated a good adjustment of the observed distribution to Weibull distribution ($p > 0.05$).

4. Discussion and conclusion

4.1. Characteristics of the identified groups of vegetation

The natural vegetation of the *Noyau Central* of the Lama forest reserve is a mosaic of dense semi-deciduous forest and fallow (Sinsin et al., 2004). Generally, the present study showed that both types of vegetation are equally represented (in the forest). The same observations were reported by Emrich et al. (1999), who observed in the same forest 51% dense forest and 49% fallow. However a floristic relevé in the forest revealed 4 groups of vegetation. The highest density of *A. africana* was observed in the non-degraded dense forest while the lowest one was observed in the preforest fallow. The relatively low density observed for this species in the degraded dense forest may result from the low rate of forest regeneration within stands without new disturbances. The lowest mean diameter observed in the young fallow revealed the first step of the establishment of forest where young individuals predominate while the highest value observed in a typical dense forest underlining the presence of big individuals, especially *A. africana*, *C. pentandra*, *D. guineense*, *D. mespiliformis* and *M. andongensis*. It is quite rare to encounter trees having a diameter more than 50 cm in the young preforest fallow because of the status of this type of vegetation.

4.2. Characteristics of A. africana populations

The timber potential, as indicated by the density of *A. africana* in the *Noyau Central* (2.8 stems/ha), represented about 2% of the inventoried individuals and is remarkably lower than the one observed by Fandohan (2006) in the Wari-Maro forest reserve (142 stems/ha for *A. africana* and 35% for the overall species, in Sudano-Guinean zone of Benin).

Individuals of *A. africana* are scarcely encountered in the young preforest fallow in contrast to the typical non-degraded dense forest where the species is highly represented. In the old fallow, as well as in the degraded dense forest, the species density is less than 2 stems/ha. Within the first stand, a progressive regeneration of the

species was noticed while in the second stand, the species was over-exploited by local people.

The low value of the Index of Green for the overall stand (IG = 0.1) explains a very low gathering of the species. However, some clumped individuals were observed on small areas generally lower than 0.25 ha. Such spatial configuration is similar to the one observed by Fandohan (2006) in the Wari-Maro forest reserve, where a random distribution patterns with a tendency of aggregation of the species individuals for the small radius (30 m) around a random point within the population was seen.

Moreover, *A. africana* constituted 36.6% of the global basal area of the forest despite its low contribution to the mean tree density of the forest, meaning that the majority of individuals are big in diameter compared to other species. The mean height of *A. africana* (16.9 m) is close to the one obtained by Sinsin et al. (2004) in the same forest (17 m). The lowest values of diameter and height were obtained within the old fallow where a progressive emergence of young individuals of the species was noticed. The highest value of height observed in degraded forest is partially explained by the anthropogenic pressure on the species. This leads to the extinction of individuals with small diameter and height against typical dense forest individuals which show a gaussian distribution for the diameter and height structure. Finally, the relatively high frequency of individuals having a diameter ranging from 50 to 80 cm helps to deduce that the population of *A. africana* in the Lama forest reserve is composed of old and big individuals.

The distribution of *A. africana* in all identified groups is unimodal and almost normal. Except for the typical dense forest, all the identified groups showed a left dissymetric distribution, characteristic for young forest stands. This shape is mostly observed in the preforest fallow where a predominancy of individuals with a small diameter was noticed. This can be explained by the disturbance or vulnerability of trees in some stages of their development. The lack of species regeneration implies that the population of *A. africana* is becoming old in the Lama forest reserve. Indeed, Sokpon and Biaou (2003) have qualified the species as disintegrated because of its low rate of recruitement. A similar remark was made for the height structure of the species.

The mean regeneration density (12.6 trees/ha) obtained for the species is severely lower than the one observed by Fandohan (2006) in the Wari-Maro forest reserve (1924 individuals/ha) and by Ouédraogo et al. (2006) in Burkina Faso (4000 individuals/ha). This could be due to different climatic conditions in the study areas. Dryness is more pronounced in Wari-Maro, located in the Sudano Guinean zone, and in Burkina-Faso (Sahelian zone) than in the Lama forest reserve located in the Guinean zone.

4.3. Protective measures and management strategy

The present study on the characterisation of the *A. africana* habitat in the *Noyau Central* of Lama forest reserve helps to describe the present status of the species' populations within this stand.

A large variation in the identified vegetation groups is observed, especially for the dendrometric parameters. Effective conservation strategies are needed for the species in the Lama forest reserve and should be designed based on the specificity of the identified vegetation groups. Therefore, conservation strategies for seeds to protect them against predators as well as for seedlings and saplings should be set up during the first years of their growth through assisted regeneration. Moreover, further studies should target the low level of regeneration observed for the species in its natural habitat. Also, conservation measures should be immediately designed for the species based on scientific research on its genetic diversity and propagation. In addition, permanent plots should be established in this ecosystem in order to follow the dynamics of the species' populations. For example, five zones of 0.5 ha each by vegetation group one by cardinal point and one in the centre or around the centre of the *Noyau Central* can be reserved within the forest where an artificial enrichment will be carried out and followed until the maturity of the trees. To that purpose, various kinds of tests could be done to know the characteristics of the species in this ecosystem. The establishment of such kind of nursery will be used for enriching the 4 vegetation groups. This action could be taken as part of a specific conservation plan of the species, with the agreement and the participation of the rural fringe communities.

Together with the current study, additional studies will help to improve knowledge about the species' habitat according to the climatic zones of Benin and the diversity of vegetations. That action requires the establishment of a programme of forest-threatened species conservation and should be integrated into a global biodiversity conservation programme.

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