Distribution and ecology of *Allanblackia* spp. (Clusiaceae) in African rain forests

with special attention to the development of a wild picking system of the fruits

Photo: Fruit of *Allanblackia kimbiliensis* (Clusiaceae) in Bwindi forest, western Uganda
Source: People and plants Online, Kew, London
(http://www.rbgkew.org.uk/peopleplants/wp/wp4/bwindi.htm)

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Report to Unilever Research Laboratories, Vlaardingen

2nd draft, part West Africa,
and 2nd draft part Central Africa,
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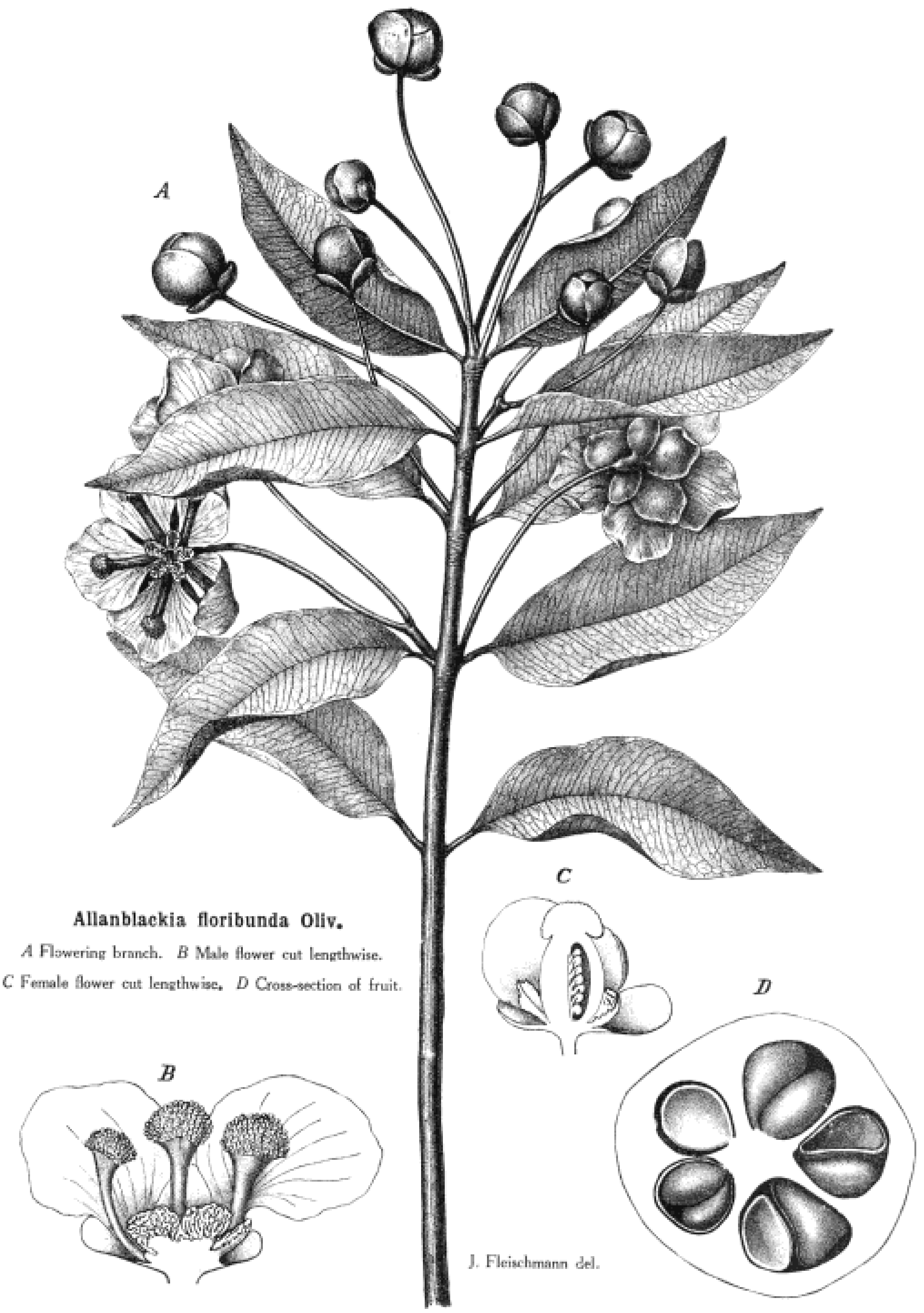

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Abstract
Allanblackia trees have the largest fruits of all plants in the African rain forest. The seeds are known to contain edible fat, but have only scarcely been used on a commercial scale, e.g. in Tanzania. In most parts of Africa, the use of *Allanblackia* has been decreased over the last 50 years to the favour of other, mostly liquid oils. Nevertheless, *Allanblackia* has been identified by amongst others FAO as a crop of high potential interest to the development of rural communities. This work aims to contribute to the development of this idea by quantifying the potential on a district level.
The nine species of *Allanblackia* are mainly distributed in wet evergreen rain forest, lowland from Sierra Leone to Congo, and upland eastwards to Tanzania. In west and central Africa the species become much more abundant in the very wet forest types, reaching densities above 1000 trees per km2. Data from timber inventories were processed to estimate the density of Allanblackia trees. The exponential size class distribution was used to convert density figures from different lower diameter limits. Using GIS, the areas rich in *Allanblackia* (over 500 trees per km2) were overlaid with forest cover maps, forest condition was estimated in these areas and degraded areas excluded, and protected areas were removed from these 'potential development areas'. It is hoped that sustainable use of this natural resource will contribute to the conservation of the rain forest and to the development of the economy of the people living there.

Keywords
Guineo-Congolian forest, non-timber forest product, sustainable use, vegetable oil

Preface

In the summer of 2002 Jon Lovett, York University and part of the WorldMap research group, forwarded me an email from Harrie Hendrickx, Unilever Research Laboratories, with a request of information about *Allanblackia* stem densities in African rain forests. Lovett extracted a map of the distribution of the genus from his WorldMap database, containing 2000 published plant distribution maps for Africa, and published it on internet (see 5.1).

Harrie Hendrickx asked me to carry out a consultancy with the following Terms of Reference:

a. Compile a reader of published information about *Allanblackia spp.* from Wageningen and Brussels libraries
b. Compile detailed quantitative information in table and map form from floristic and forest inventories in: 1) West Africa: Côte d'Ivoire, Liberia with priority
   2) Central Africa: Nigeria, Cameroon with priority
   3) Gabon, Equatorial Guinea and other countries with less priority
c. Have this material reviewed and completed by country experts for Côte d'Ivoire, Ghana, Cameroon, Equatorial Guinea
d. Come up with recommendations based on distribution and ecology concerning the development of a wild picking system for *Allanblackia* fruits

Documents about *Allanblackia* were exchanged in September 2002 (ad a.). The report on West Africa (ad b.1) has been submitted a first draft in October and a second draft in November 2002. The Central Africa report (ad b.2, 3) has been submitted, the Cameroon part in January 2003 and the remaining part in April 2003. Recommendations of potential pickings areas are included in this report (ad d.). Review by country experts is under way. The results of this study will be presented by the author at the AETFAT (Association pour l'Étude Taxonomique de la Flore d'Afrique Tropicale) Conference in Addis-Ababa in September 2003.

Contents

1 Introduction

1.1 The discovery of potential oil crops in Africa

Since the 19th century, European botanists have been intensively exploring the tropics for plants of which oil and fat could be extracted. In this way many plant species have been scientifically described for the first time (Baillon 1862, Pierre 1890, Chevalier 1909). In the mean time, oil palm (*Elaies guineensis)* has become the major vegetable oil producing crop in the tropics.

At that time Prof. Daniel Oliver, Keeper of the Kew Herbarium, London, published in **1869** the genus *Allanblackia* Oliv. ex Benth. in the Guttiferae family. In recent literature this family has been renamed to Clusiaceae - Mangosteen Family, after Lindley (1836). By curiosity I found that in the same volume of the Journal of the Linnean Society, Vol. X. (1869), page 43, Charles Darwin published several articles about plant hybrids.

The same discovery was also published in Benth. & Hook. f (1867). Genera Plantarum 1: 980; and the first species in the genus, *Allanblackia floribunda* Oliv., in Flora of Tropical Africa 1: 163. 1868. The plant was collected by G. Mann, nr. 2193 in January near Cameroons River in the Bight of Biafra (now called 'rivière Wouri' passing through Douala) in former British Cameroon, now Cameroon. Engler (1895) published a second species in another genus, *Stearodendron stuhlmannii*. Engler (1897) has put the genus into synonymy with *Allanblackia*, so this species became *Allanblackia stuhlmannii* (Engl.) Engl. from east Tanzania. Until now, nine species are known and a tenth one is imperfectly known , following the revision of Bamps (1969).

1.2 Sustainable vegetable fat & oil production

Axtell & Fairman (1992) compiled information about minor oil crops in the world. *Allanblackia* is mentioned under the edible oils. The product is called Mkanyi fat or Kagne butter and it has been mainly extracted in Tanzania from *Allanblackia* seeds (Eckey 1954, p. 687).

This list contains only references I came across and is not exhaustive as it was not the objective of this study.

1.3 Medicinal use

Fuller et al. (1999) from the University of Canterbury, Christchurch, New Zealand, tracked the HIV-inhibitory activity in extracts of *Allanblackia stuhlmannii*, related to Guttiferone F, a prenylated benzophenone.
Other Guttiferae are known to contain anti-bacterial substances, like *Garcinia lucida* (Guédjé, 2002), or retrovirus inhibitory substances like *Hypericum perforatum* (internet ref).

1.4 Use for biodiesel production

Some internet references (http://www.cti2000.it/biodiesel.htm, see Appendix 5 and http://www.ata.or.th/info/publications/mu12p_uk.pdf) mention the potential of *Allanblackia* for biodiesel production.

2 Focal region

Allanblackia species grow in the evergreen forests along the Gulf of Guinea in Liberia, Côte d'Ivoire, Ghana, Nigeria, Cameroon, Equatorial Guinea, Gabon, Congo-Brazzaville and Congo-Kinshasa, and in the Congo basin (Figure 1). Some patches of rain forest exist on mountains in Uganda and Tanzania (Figure 9).

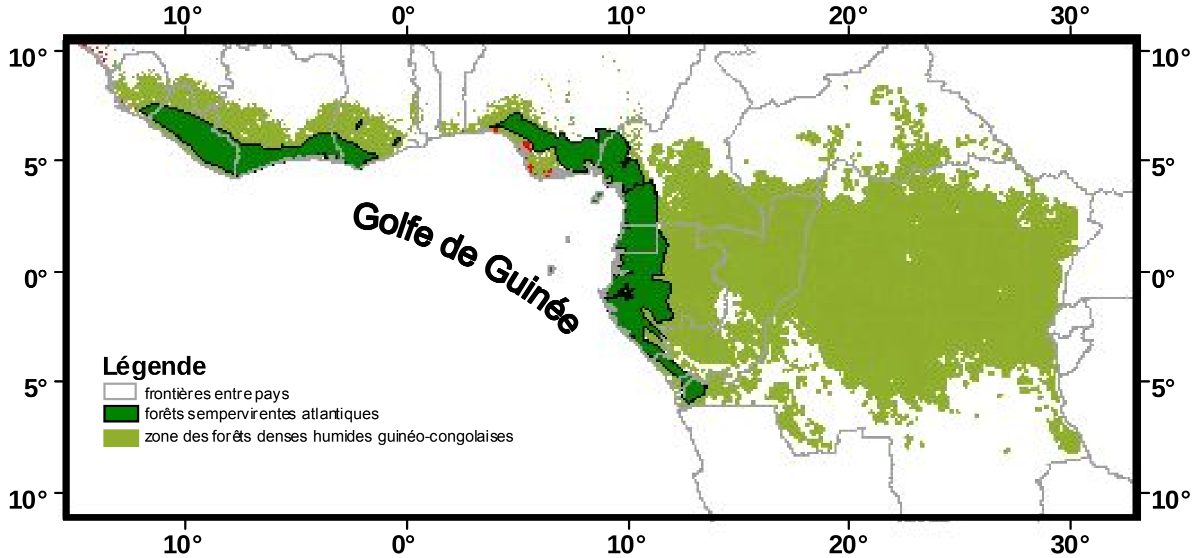

Figure 1: The Guineo-Congolian forest zone, original forest cover in light green, and the strip of evergreen forests along the Gulf of Guinea in dark green, believed to be the habitat of *Allanblackia* spp. In the Congos continental rain forests exists, also inhabited by *Allanblackia* spp. (see Fig. 2). On some mountains in Tanzania (Figure 9) forests remained resembling the Guineo-Congolian forest, but with 20 % endemic species (Lovett & Wasser 1993). Amongst them are two *Allanblackia* species.

3 The nine species of *Allanblackia*

After taxonomic revision of the genus, Bamps (1969) accepted 9 species in the genus *Allanblackia*, plus probably a tenth imperfectly known species from Fernando Po. His view was followed by Lebrun & Stork (1991-1997). Below these accepted species names are listed and numbered. The protologue (=first publication of the name) is given, as well as notes on distribution as given by Index Kewensis (www.ipni.org). Another very useful website is W3 Tropicos, Missouri Botanical Garden, http://mobot.mobot.org/cgi-bin/search_vast. After each accepted name synonyms are given. These synonyms are also included in non-bold font in the alphabetical list.

For certain names Bamps (1969) has found that there has been confusion in the literature. This is indicated by synonym names followed by Auct. (Latin: auctor=author) non (http://wwwcjb.unige.ch/cjb/code/art_50.html). This should be read: not according to the (original) author, but according to the second, confused author. Further in the text no author names will be given. For example, the West African species, ***Allanblackia parviflora,*** has been published in the two major botanical publications for West Africa (Hutchinson & Dalziel 1958, Aubréville 1958) under the name ***Allanblackia floribunda,*** so many botanists used and still use this wrong name for West African *Allanblackia*s.

3.1 Endemism

2 species are endemic to Congo-Kinshasa.
2 to Tanzania.
1 species occurs only in West Africa.
The remaining 4 species occur in several countries of Central Africa.

3.2 Names and synonyms

I follow Bamps (1969), which was also followed by Lebrun & Stork (1992-1997). Names in bold italic are accepted, good names. The others are synonyms. The 'See…' refers to the good name.

1. *Allanblackia floribunda* Oliver (**1869**) in Journ. Linn. Soc. X: 43.
Distrib.: **Nigeria to Congo-Kinshasa.** All plants from Sierra Leone to Ghana are ***A. parviflora*!**
Syn. : *A. klainei*, *A. stanerana* Auct. non Exell & Mendonca, Spirlet (1966)

A. floribunda var. *gabonensis*. See *A. gabonensis*
A. floribunda var. *kisonghi* (Vermoesen) Pieraerts. See *A. kisonghi*.

2. *A. gabonensis* (Pellegr.) Bamps (**1969**) in Bull. Jard. Bot. Nat. Belg. xxxix: 356.
Distrib.: **Cameroon (**in upland forest between 500 and 1750 m, Letouzey et al. 1978) and **Gabon**.
Syn. : *A. floribunda* var. *gabonensis*

3. *A. kimbiliensis* Spirl. (**1959**) in Bull. Jard. Bot. Brux. Xxix: 357.
Distrib: **Congo-Kinshasa (Kivu), Uganda,** between 1250 and 1800 m asl. (Bamps 1970).

4. *A. kisonghi* Vermoesen (**1923**) in Man. Ess. Forest. 11.
Distrib. : **Congo-Kinshasa** (Cuvette, gallery forest of Kasai and bas-Congo),
Syn: *A. floribunda* var. *kisonghi* (Vermoesen) Pieraerts, A. *monticola* Auct. non Mildbr.ex Engl.; Staner (1934), Spirlet (1966)

A. klainei Pierre ex A.Chev. (1917) in Veg. Ut. Afr. Trop. Franc., Fasc. 9, 62. See : *A. floribunda*

5. *A. marienii* Staner (**1934**) in Bull. Jard. Bot. Brux. xiii. 110.
Distrib: **Congo-Kinshasa (**Cuvette centrale, in gallery and swamp forests**)**

A. monticola Mildbr.ex Engl. (**1921**), in Engl. Pflanzenw. Afr. iii. II. (Engl. & Drude, Veg. der Erde, ix.) 509.
Distr.: **Fernando Po**. Nomen non validum. **Imperfectly known species.**

A. monticola Auct. non Mildbr.ex Engl.; Staner (1934), Spirlet (1966). See *A. kisonghi*

A. oleifera. This name was found in http://www.ata.or.th/info/publications/mu12p_uk.pdf, related to Kagne-butter (*A. stuhlmannii*). In taxonomic literature no reference to this name has been found.

6. *A. parviflora* A.Chevalier (**1909**) in Veg. Ut. Afr. Trop. Franc. 5: 163.
Distrib.: The only species in West Africa, **Sierra Leone to Ghana**.
Syn. : *A. floribunda* Auct. non Oliver, Keay (1954) in Hutchinson & Dalziel, Flora West Tropical Africa, ed. 2, 1: 291 p.p.; Aubréville (1959), Flore Forestière Cote d'Ivoire, ed. 2, 2:330; Irvine (1961), Woody plants of Ghana.
Further refs: Sattler et al. (2000) contains nice colour photos.

A. sacleuxii Hua in Bull. Mus. Hist. Nat. Par. ii. 155. See *A. stuhlmannii*

7. *A. stanerana* Exell & Mendonça (**1936**) in Journ. Bot., Lond., lxxiv. Suppl., 20.
Distrib.: **SW-Cameroon** (Bamps 1969, Letouzey et al 1978)**, Congo-Kinshasa** (Mayumbe, Tailfer 1989), **Angola**

8. *A. stuhlmannii* Engl. (**1897**) in Engl. & Prantl, Die Natürlichen Pflanzenfamilien. Nachtr. I. 249.
Distrib.: **Tanzania**, (540-1600 m asl, FAO 1983). Syn.: *Stearodendron stuhlmannii* Engl. (1895).

9. *A. ulugurensis* Engl. (**1900**) in Engl. Jahrb. xxviii. 435.
Distr: **Tanzania** (700-2050 m asl., FAO 1983)

3.3 Dioecy (male and female trees)

Dioecy exists in the genus *Allanblackia*. Renner's (2002) dioecy database on Internet http://www.umsl.edu/~biosrenn/dioecy.pdf includes one of the ten species as dioecious (Renner & Ricklefs 1995), but this is based on Yampolsky & Yampolsky (1922), who list one *Allanblackia* species being dioecious. As in 1922 only four species were known, it is likely that *A. stuhlmannii* was meant.
FAO (1983) stated that *A. stuhlmannii* and *A. ulugurensis* are dioecious, and Lovett (1983) said *A. stuhlmannii* was. Bamps et al. (1978) is the first taxonomic reference to confirm dioecy in *A. stuhlmannii*. Bamps does not mention it for *A. ulugurensis*, but for this species there is no description of female flowers either. May be, the female flowers are still unknown.

Chevalier (1909) started his description of Allanblackia *parviflora* with 'Plante dioïque', so this species is also dioecious. Oliver (1869) started his description of *A. floribunda* with the Latin 'Flores dioici', meaning also this species is dioecious.

4 Methods

4.1 Where is the species present?

The distribution of the species in derived from three kinds of data:
- **Collected herbarium specimens**, kept in herbaria and used for taxonomic research (typically referenced to as: Collector, number)
- **Botanical survey records**: (complete) species lists within one habitat made by botanists-ecologists while studying the vegetation for various purposes. Sometimes sample are collected to check the identification in the herbarium. For a given protected area, these species lists can be compiled into a checklist of all species known for the area. If the area has been sufficiently visited, also the absence from the checklist becomes reliable.
- **Forest inventory data** (see below) and forest research plots

4.2 How abundant is the species in a given forest?

Which sampling intensity of a forest inventory is needed to give sufficiently precise results?
To answer these kind of questions, a forest inventory has to be undertaken. On usually long strips in the forest, trees are identified and their diameter measured to assess the available timber volume and species composition.

Important for the precision of the results, is the **sampling intensity**, expressed as the percentage in area of the forest on which trees are identified and measured. Typically forest inventory have the objective to estimate the available commercial timber reserve (all commercial species together) with a precision of 10%. For this, typically 1% of the forest in inventoried.

Estimates of densities of individual species, like here *Allanblackia,* are less precise, and the rarer the species, the lower the precision. It is clear that given the error of 20 to 50 % when using inventory results from a 1% sampling intensity inventory, these estimates should be drastically rounded to one significant digit.

The Ghana Forest Inventory, carried out 1986-1992 (Wong 1989), had a sampling intensity of:
- 0.25% for trees above 30 cm diameter,
- 0.025% for trees 10-30 cm diameter, and
- 0.0125% for trees 5-10 cm diameter.

Wong (1989) claimed that this allowed estimates of regional standing volume (d>70cm) of class I timber species, with a sampling error of less than 20%. Results presented by Ghartey (1989) are the lower figure of the 95% confidence interval. With region, the 5 administrative regions covering the high forest zone of Ghana are meant.

- **Forest inventory data and precision of tree density estimates of individual species**:

This provides reliable quantitative estimates of the density of the (larger) species, e.g. number of trees with diameter>10 cm per km2 of forest. Typically forest inventory have the objective to estimate the available commercial timber reserve (all commercial species together) with a precision of 10%. For this, typically 1% of the forest in inventoried.

Estimates of individual species, like here *Allanblackia,* are less precise, and the rarer the species, the lower the precision. It is clear that given an error of 20 to 50 %, these estimates should be drastically rounded to one significant digit.

- How to convert tree density estimates to 10 cm lower diameter limit using the exponential distribution?

The observation that of many tropical tree species many small trees and only a few bigger ones are found in the forest, indicates that tree diameter has an exponential distribution. Each forest inventory has defined a minimum diameter to survey, often 60 cm for mature timber trees and 20 cm for regeneration surveys. To study the dynamics of tropical forest, many permanent sample plots have been established, typically 1 ha in size with all trees above 10 cm diameter monitored.

To compare amongst sites, I decided to estimate from the available data Allanblackia tree density as: **Number of *Allanblackia* trees above 10 cm diameter per km2 of forest**.
I suppose, but have no precise information about that, that Allanblackia trees start fruiting when they reach a diameter of 10 cm. In exposed conditions they will be earlier, in shaded forest conditions later.

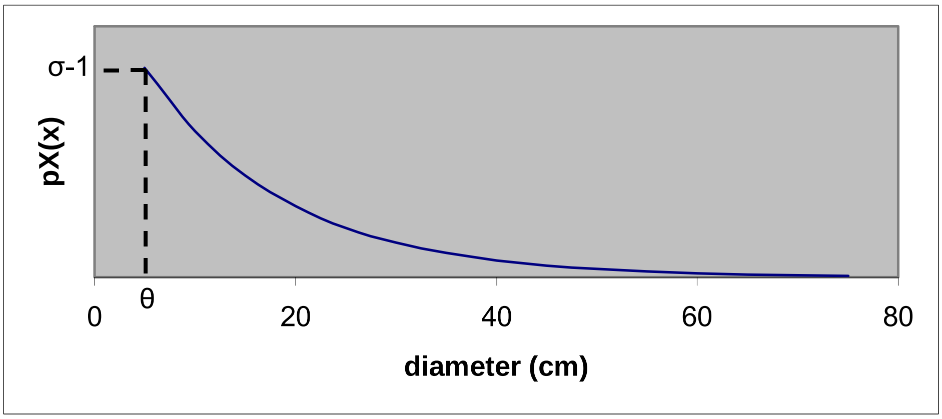

Figure 2 Exponential density function, used to convert tree densities to the standard lower diameter limit of 10 cm

The random variable X has an *exponential* (or *negative exponential) distribution* if it has a probability density function of form (Johnson & Kotz 1970):

(1) $$p_X(x) = \sigma^{-1} \cdot e^{-\frac{x-\theta}{\sigma}} \quad \text{for } x > \theta; \sigma > 0$$

Figure 1 gives a graphical representation of this function, with θ>0. This parameter θ is in our case the lower diameter limit of the forest inventory, d_{lim}, and thus known. The only remaining parameter is σ, which is estimated as follows:

(2) $$\hat{\sigma} = \overline{X} - \theta$$

This means that, if a species shows a exponential diameter distribution, which *Allanblackia* seems to show given that it is a shade-tolerant species, than the average diameter of a population of trees, minus the lower diameter limit, can be put in formula (4) to obtain the tree density above any diameter limit.

The cumulative probability function, giving the percentage of trees smaller than d_{lim}, is:

(3) $$P(d<d_{lim}):\ F(x) = 1 - e^{-\frac{(x-\theta)}{\sigma}}$$

More practical for our purpose is the **survivor function**, giving the percentage trees larger than a diameter limit d_{lim}:

(4) P(d>d_{lim}): $F'(x) = 1 - F(x) = e^{-\frac{(x-\theta)}{\sigma}}$

After transition from relative probabilities to absolute densities, this formula gives by example:
I find in a study that they found 220 Allanblackia trees per km2 above 15 cm diameter.
What is the density above 10 cm diameter?

(5) N(d>10) $= 220 \cdot e^{-\frac{(15-\theta)}{\sigma}}$

I estimated θ and σ from the largest data set with individual *Allanblackia* tree records I have, which is the Ghana Forest inventory data: 2578 trees were found in 787 of a total of 3240 1ha plots inventoried (0.25% sampling intensity). These trees were found in 71 of the 224 Ghanaian Forest Reserves.
Trees between 10 and 30 cm diameter were recorded in a 10% subsample, and trees between 5 and 10 on a 5% subsample. Trees in the subsample have been used resp. 10 and 20 times when calculating the average diameter:

(6) $$\overline{d} = \frac{\sum d}{N} = \frac{\sum d_{30+} + 10 \cdot \sum d_{10-30} + 20 \cdot \sum d_{5-10}}{N_{30+} + 10 \cdot N_{10-30} + 20 \cdot N_{5-10}} = \frac{74068 + 10 \cdot 9544 + 20 \cdot 941}{1912 + 10 \cdot 526 + 20 \cdot 140} = 19$$

This is an average from a forest inventory above 5 cm diameter, thus:

(7) $$\hat{\sigma} = \overline{d} - \theta = 19 - 5 = 14$$

This σ is characteristic for the species, and thanks to the subtraction of θ, the lower inventory limit, also independent of this lower limit. In fact, it is this σ that should be published in inventory reports for species that show an exponential distribution. It is correlated to the maximum size to which a species can grow. In the Ghana inventory, the biggest *Allanblackia parviflora* tree had a diameter of 106 cm. In the Central African inventories, the biggest recorded *Allanblackia floribunda* tree was in the class 150-160 cm. So it seems that *A. floribunda* grows bigger, which would involve a greater σ value.
Given the low precision of the density estimates, between 20 and 50 % (see above), the σ value of Ghana is used as a first approximation to convert tree densities from other lower diameter limits to the standard 10 cm lower diameter limit.

So, equation (5) can be solved:

(8) N(d>10) $= 220 \cdot e^{-\frac{(10-d\,\mathrm{lim})}{\sigma}} = 220 \cdot e^{\frac{-(10-15)}{14}} = 314$

In general terms:

(9) **N(d>10)** $= N(d > d'_{\mathrm{lim}}) \cdot e^{-\frac{(10-d'\mathrm{lim})}{14}}$

Formula (9) allowed us to convert all densities found in literature to **density of trees with diameter above 10 cm, per km2**.

4.3 Methods to assess total population size of a species within a country

The density estimates for an inventory compartment were plotted on the map of the country and interpolated to obtain a country estimate: **number of mature trees per country.** This is done in three steps:
1. First the area where *Allanblackia* grows abundantly has to be estimated.
2. Then the condition of the forest in this area has to be evaluated, both the forest cover as the forest condition. This reduces the area of the picking region to the number of ha where *Allanblackia* grows.
3. And last, the estimated density is multiplied with this area of good forest.

4.4 Which areas are suitable to develop a wild picking system of Allanblackia fruits?

To be suitable as picking area, an area must:
- have no Protected Area status that does not allow use
- be inhabitated or at least accessible
- permission must be obtained from the village authorities (community forest) or Forestry Department (National Forest Reserves) and Concession holders.

5 Results

5.1 Distribution of the genus Allanblackia

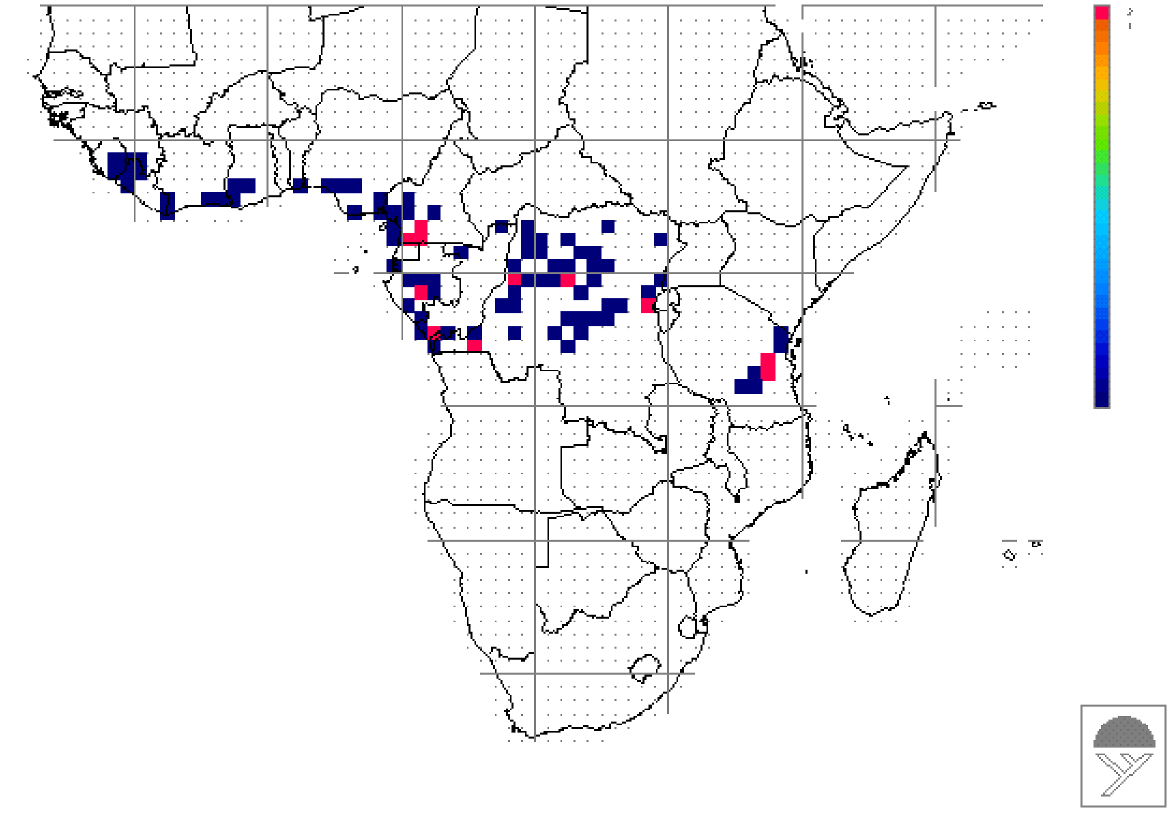

Figure 3: Cumulative map of the localities where 9 *Allanblackia* species in Africa have been collected, as compiled by Bamps (1969). Squares are one square degree large, blue: one species found in the square, red: two species found. These collection locality maps always show gaps. In overlay with the vegetation map of Africa (White 1983) one can hypothesise the full distribution of the species. Source of map: http://www1.york.ac.uk/res/celp/webpages/projects/worldmap/datasets/allanblackia/allanblackia.htm

Allanblackia floribunda	DPA 1:13
Allanblackia gabonensis	DPA 1:20
Allanblackia kimbiliensis	DPA 1:16
Allanblackia kisonghi	DPA 1:15
Allanblackia marienii	DPA 1:18
Allanblackia parviflora	DPA 1:14
Allanblackia stanerana	DPA 1:19
Allanblackia stuhlmannii	J. Taplin Herbarium Data & TROPICOS
Allanblackia ulugurensis	DPA 1:17

DPA=Distributiones Plantarum Africanarum, periodical by National Botanic Gardens, Meise, near Brussels. Volume 1 was published in 1969, using the data of Bamps (1969).

5.2 *Distribution and abundance of* A. parviflora *in West-Africa (Sierra Leone to Ghana)*

5.2.1 Where has the species been found?

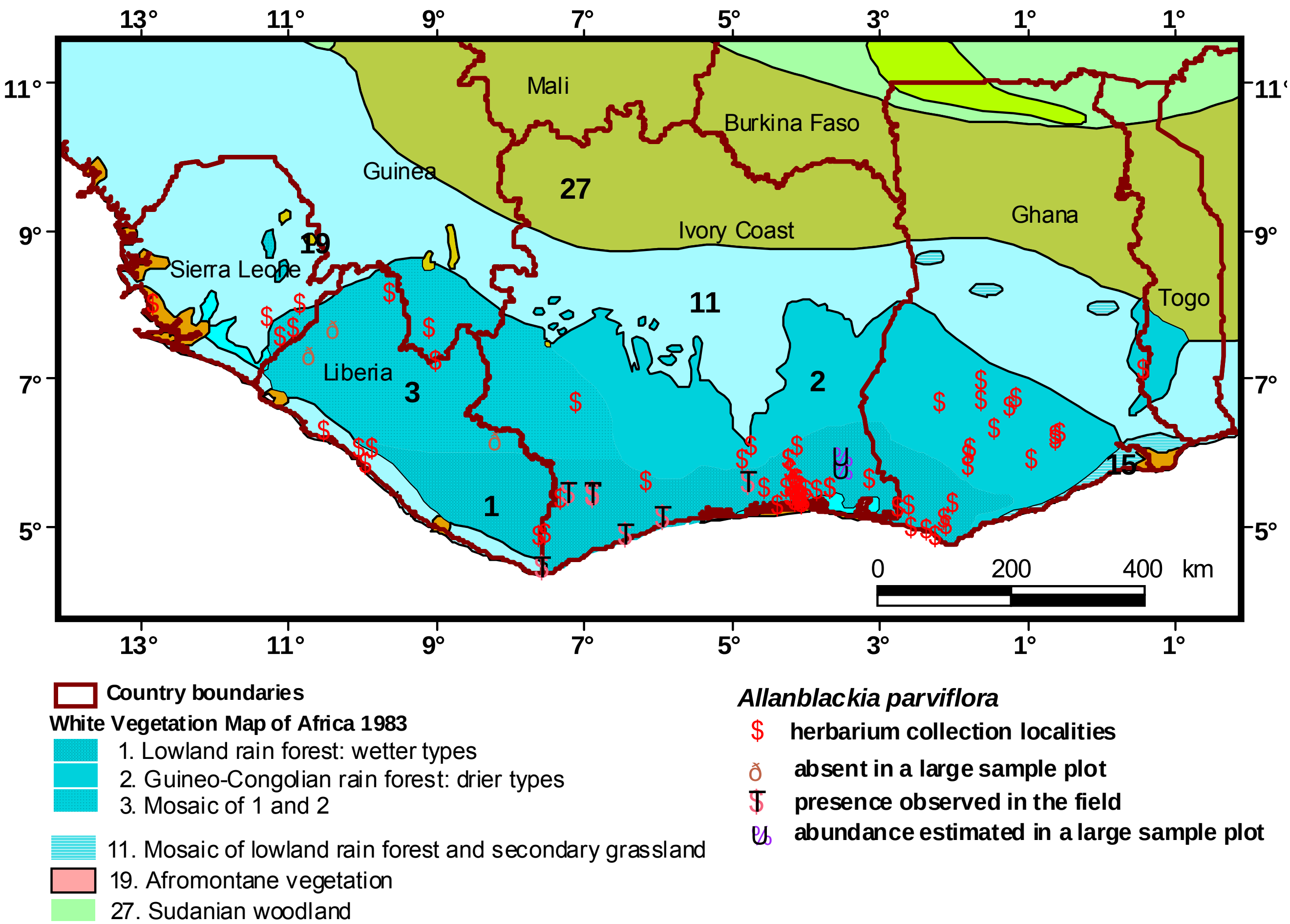

Figure 4: Localities in West Africa (Sierra Leone to Ghana) where *Allanblackia parviflora* has been collected or observed. For Ghana only herbarium records known to me are shown. Sample plot data and field observations are being processed by FORIG. For Liberia and Côte d'Ivoire also other data sources are shown.

<u>**Herbarium records**</u>

- **103 herbarium records** have been found for this species (FWTA 1958, Bamps 1969, Aké Assi 2001, and from several databases). Most of them are lying in the herbaria of Wageningen WAG, Kew-London K, Paris P, and Brussels-Meise BR.
- These records refer to **66 different localities in five countries** (Guinée, Sierra Leone, Liberia, Côte d'Ivoire, Ghana). Records from Ghana have been included here. Botanical survey and forest inventory data from Ghana have not been analysed, because FORIG prepares a report on this.

<u>**Botanical survey records**</u>

Besides herbarium records, botanists have also published observations in the field. Although the identification can no longer be verified because no sample has been collected, these observations provide additional information, especially for species that are easy to recognise, like *Allanblackia parviflora* being the only species in its genus in West Africa.

Ghana

For Ghana an extensive database of over 700 botanical survey records exists (Hall & Swaine 1981, Hawthorne & Abu Juam 1995). The density of *Allanblackia* per forest type can best be answered from this data set. FORIG prepared a report on *Allanblackia* in Ghana.

Southwest Côte d'Ivoire

In Côte d'Ivoire, Guillaumet (1967) found the species west of Tabou. Aké Assi & Pfeffer (1975) has included the species in the checklist of Taï National Park, but without a precise indication where within this 500.000 ha large reserve. Van Rompaey et al. (2001) found the species south of the Hana River, east of Guiroutou and west of Djapadji. Botanists from Cocody-Abidjan University working in the ECOSYN project have found the species inside the Haute Dodo Forest Reserve. I have no information about its presence in Haut Cavally Forest Reserve. Cyrille Châtelain from the Geneva Botanic Garden could have data about this area.

Coastal forests in south Côte d'Ivoire

Aké Assi (2000) found the species in Monogaga and in Dassioko Forest Reserve. Bertault (1986) has recorded the species in the Irobo Research Plot. Aubréville (1959) characterised the species as belonging to the wet coastal forests, there sometimes very common, as for example in Banco National Park, next to Abidjan. De Koning (1983) remarks that the seeds are much appreciated by monkeys and rodents, and that he seldom found a mature fruit on the forest floor; rodents always already ate the seeds. Bamps (pers. comm. 2002) thinks that these rodents also disperse the seeds, and this is why *Allanblackia* often grows in clumps.

Another tree species with a 'coastal' type of distribution is *Cynometra ananta* (Caesalpiniaceae), also common in Banco. The coastal forests also receive the most rainfall, and in the very wet forests gregariousness or even single dominance of tree species has been reported (Voorhoeve 1964, 1965 in Liberia; Hart 1990 in Congo-Kinshasa, Newbery et al. 1988). It seems that *Allanblackia* also shows this behaviour in Côte d'Ivoire.

Southeast Côte d'Ivoire

Kouadio Kouassi (2000) found the species in the Yaya and Mabi Forest Reserves.

Conclusion

Hall & Swaine 1981 stated the it is an Upper Guinean rainforest species, **more abundant in evergreen forest types, especially on slopes and away from disturbed areas** (Hawthorne 1995), but not absent from semi-deciduous forest types. Hall & Swaine (1981) mentioned that the species was significantly associated with soils low in calcium, potassium, magnesium, base saturation and pH; over half records on soil with pH 3.8-4.1, none >5.3. Such soils are found under evergreen forest.

The species is clearly more abundant in the **wet evergreen forest zone** (type 1 on Figure 3). Hawthorne (1995) recorded densities of 900 trees per km2 in the diameter class 5-30 cm, and 200 trees per km2 in the class 30 cm and above. For mixed natural rain forest these are quite high densities.

5.2.2 How many trees there are growing in individual reserves?

Allanblackia parviflora is not on the 'Main timber species' list in Côte d'Ivoire. As this list was used during most of the timber inventories, only few data exist of this kind. The best data are available for Ghana where a national forest inventory of all tree species above 5 cm diameter exists.

For the Forest Reserves in east-Côte d'Ivoire, a different technique was used. In eastern Cote d'Ivoire the Sodefor-GTZ forest inventory (Birkenhaeger & Fickinger 1994) found **150 trees per km2 for the class above 10 cm diameter in Forêt Classée de Mabi**, and **600 trees per km2 for**

the same class in the Forêt Classée de Yaya. Yaya is known to be botanically amongst the wettest forests in southeast Cote d'Ivoire.

In Liberia Wöll (1981) & Poker (1992) counted trees above 10 cm diameter in four research plots, and found:
- 3 trees on 20 ha **Grebo** plot = **15 trees d>10cm per km2**
- 0 trees on 12 ha Cavalla plot, 6 ha Gola plot, 4 ha Kpelle plot

Given the size of these plots, these records can be considered as 'absence' records ('0' on Fig. 3)

5.2.3 Estimation of the number of fruiting trees growing in each country

__Diameter of maturity__

The diameter above which *Allanblackia* trees start fruiting is being studied by FORIG. I standardised abundance figures to Number of trees per km2 above 10 cm diameter. Using Formula 9 these can always be converted later to densities above a larger diameter of maturity, e.g. 20 cm.

For the evergreen forest zone in West Africa (blue to purple on Figure 5 and Figure 6, index >180**)** I estimated the **number of trees above 10 cm diameter** using the estimate of Hawthorne (1995) for the wet forest type in Ghana:
- 870 trees/km2 in class 5-30 cm,
- 215 trees in class 30-60 cm,
- 5 trees in class 60cm+

This is all together 1090 trees per km2 above 5 cm diameter. Using Formula (9) this is **800 trees per km2 above 10 cm, 8 trees per ha**.

__Sex ratio__

If we assume that the sex ratio of mature trees is 50-50, half of the mature trees will be fruiting given the dioecy.

__Area of *Allanblackia* rich forest and its protection status__

In Cote d'Ivoire, an estimated **300.000 ha of this evergreen forest** type is left (Figure 4) having the status of 'Forêt Classée', where sustainable use is possible. On Figure 4 the remaining forests based on 1992 NOAA satellite images (Olesen 1994) are shown and coloured using Van Rompaey's (2000) index of wetness of forest type, blue wet to yellow dry.
In black lines the existing forest reserves are indicated. The Forest Service manages these, and a sustainable management system is their management target. Centred on big forest reserves that may provide the bulk of the seeds, but avoiding National Parks, and complemented by smaller quantities harvested off reserve, the picking areas have been delimited.

__Condition of the forest__

We estimate that half of these forest reserves are **in good condition, around 150,000 ha**. An update of the National Forest Map, the 'Bilan forestier 1990', should be made using recent Landsat TM images.
This leaves us with a final estimate of **1.100.000 *Allanblackia* trees above 10 cm diameter in Côte d'Ivoire that** can be used in a wild picking system.

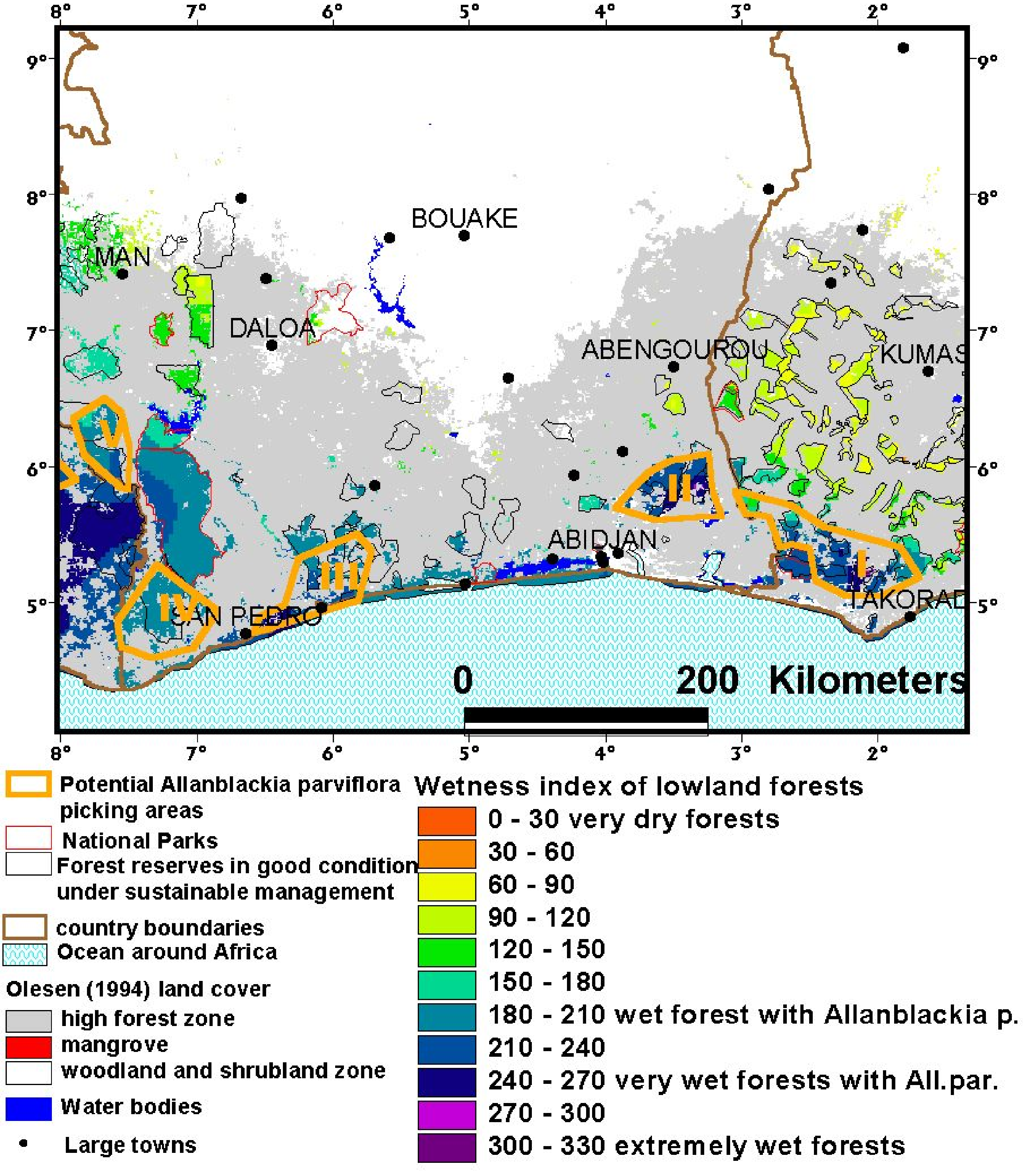

Figure 5: Potential picking areas of *Allanblackia parviflora* fruits in Cote d'Ivoire and Ghana. In grey the forest zone, the remaining forests (Olesen 1994) are coloured according to the wetness of the forest type. *Allanblackia parviflora* prefers the wetter forests: blue and purple.

Liberia has about **500.000 ha of wet evergreen and 1.500.000 ha extremely wet evergreen forest** left (Figure 5) in reasonable condition. In the former I expect **4.000.000 trees above 10 cm** to be growing in the forest. During a field visit to Sapo National Park, southeast Liberia, in November 2002, no *Allanblackia* trees have been encountered, and the local tree finder, David Kwiwon, said it was present but not common. Kwiwon also assisted Voorhoeve (1965) and Kunkel (1965) during their field trips. Voorhoeve mentioned *A. parviflora* briefly and called it a **rare**, large, evergreen forest tree up to 30 m high and cited Aubréville (1959) 'locally the tree may be very abundant'.

Future inventory work should clarify the abundance of *Allanblackia* in the extremely evergreen forest of Liberia (purple on Figure 5 and 6).
An update of the condition of Liberian Forest Resources is about to be published by Conservation Intl, Washington and Fauna & Flora International, Cambridge. This area estimates above are derived from the wetness of the forest type, not confirmed yet by field surveys.

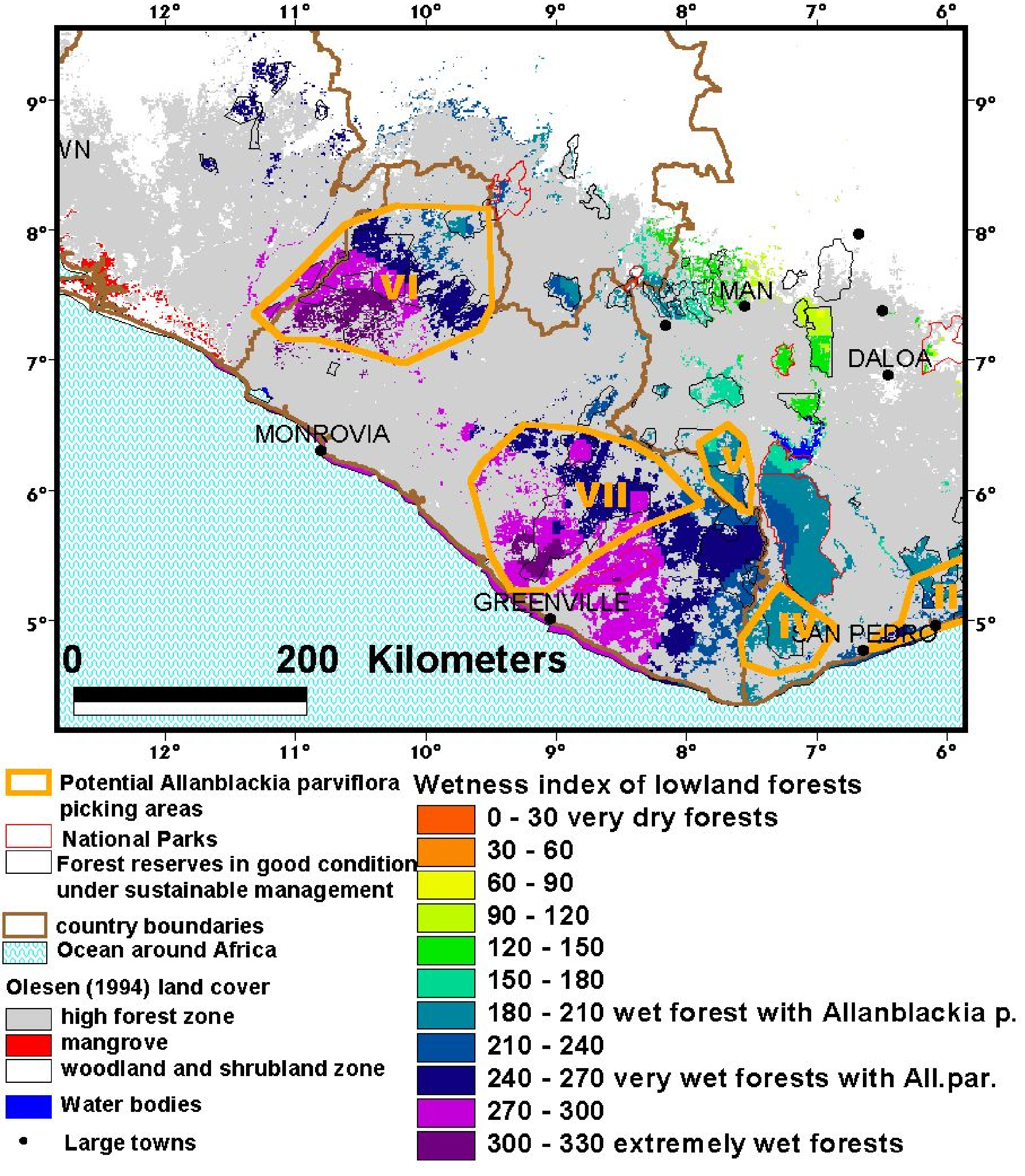

Figure 6 Potential *Allanblackia* picking areas in western Cote d'Ivoire and Liberia

5.3 *Distribution and abundance of* A. floribunda *(lowland forest Benin to Congo)*

5.3.1 Where has the species been found?

Allanblackia floribunda is the most widespread *Allanblackia* species in tropical Africa. It occurs from the extreme southeast of Benin through Nigeria, Cameroon, and Gabon to Congo. It is a lowland forest species growing up to 800 m altitude, typically the altitude where the clouds hit the hills). Above that, *A. gabonensis* occurs, see 5.1.3.

Bamps (1969) published an Africa-wide distribution map, and Letouzey (1978) a detailed one for Cameroon, the latter generalised by Vivien & Faure (1985). The species is most abundant in the Atlantic forests in the west, less abundant in the Congolese forests in the south, and rare or absent from the semi deciduous forests (Letouzey 1978).

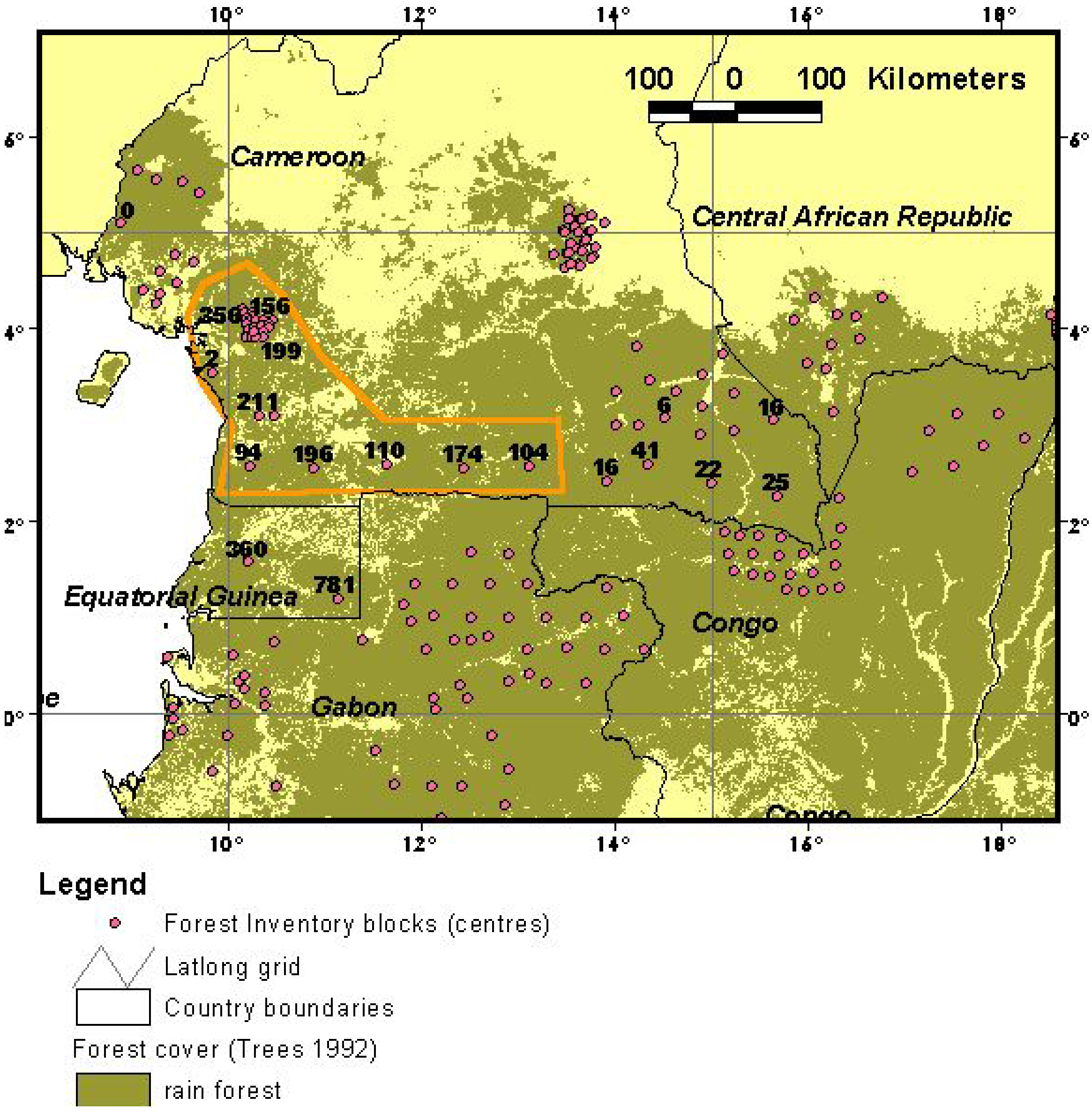

Figure 7: *Allanblackia floribunda* densities (trees above 10 cm diameter per km2) as found in forest inventories in Central Africa (Borry & Goossens 1995). Forest cover from the TREES (1992) map. Plots without label have no *Allanblackia* in the inventory report, because not recorded or because absent. Orange line indicates the most interesting 'wild picking area' of Cameroon. For NW-Cameroon more data are needed.

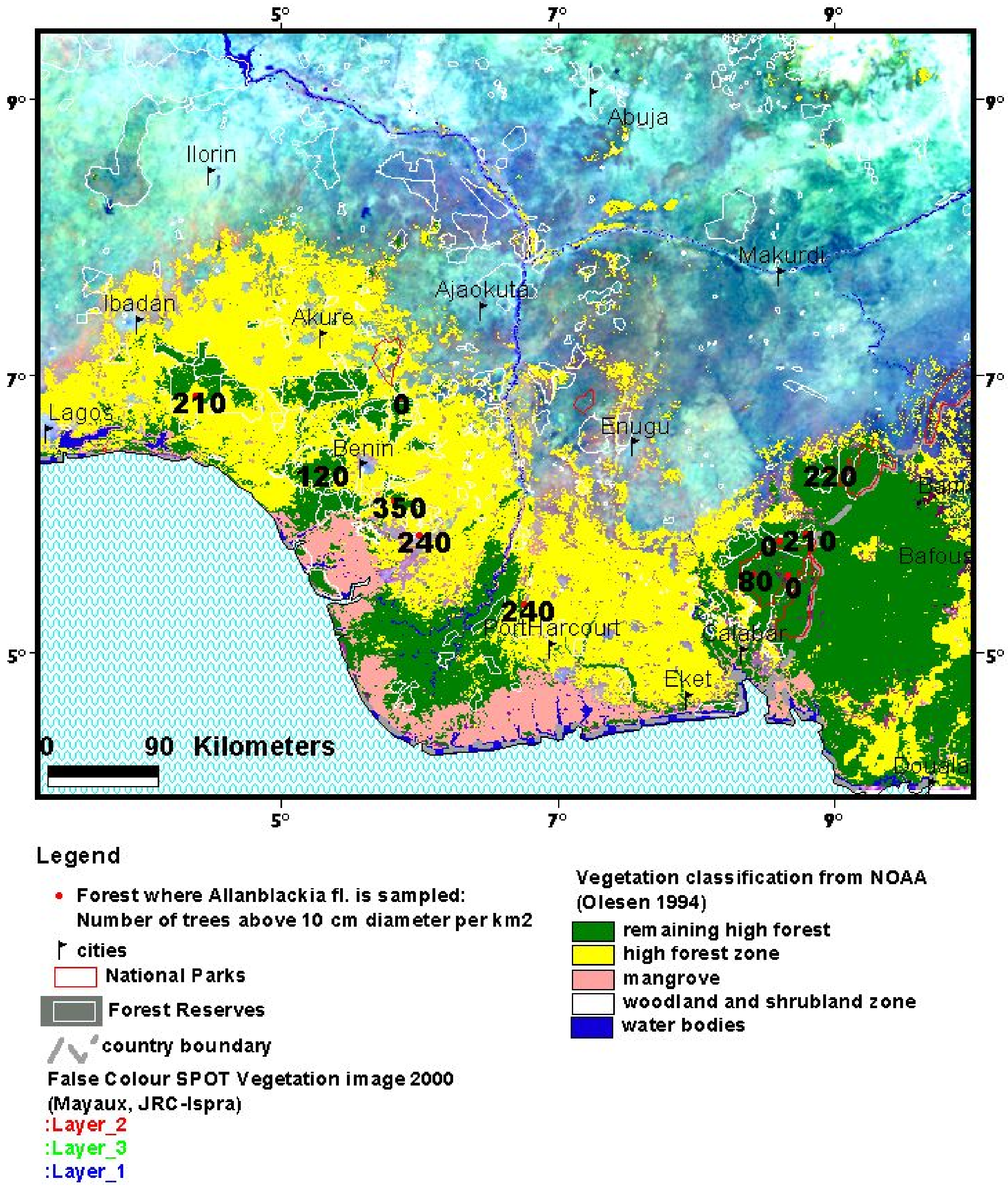

Figure 8: Recorded densities as number of trees above 10 cm diameter per km2 of *Allanblackia floribunda* in Nigeria (data from Hall 1977 and Lowe 1997). The few remaining forests around Benin City are rich in *Allanblackia*, related to the Tertiary sands there (Hall 1977). Forests in SE-Nigeria on basement complex and with high rainfall are poor in *Allanblackia*. Background in the savanna zone is the SPOT Vegetation satellite image 2000 by Mayaux Ph., JRS-Ispra.

5.3.2 What is the species' abundance in the different forest areas where it occurs?

Borry & Goossens (1995) compiled forest inventory data for 5 Central African countries (Cameroon, Gabon, Congo-Brazzaville, Congo-Kinshasa and Central African Republic). In 32 inventory blocks and in research plots *Allanblackia floribunda* has been found.

Newbery, Gartlan et al. (1986), Parren MPE (pers. comm. 2003), Sonké (1998) established research plots in the Cameroonian forest in which they identified trees above 10 cm diameter. Van Reeth (1998) and Senterre (1999) did the same in Equatorial Guinea.

The density of *Allanblackia floribunda* found by these authors was converted to **Number of trees with diameter exceeding 10 cm per km2**, and is shown in Figure 7.

Cameroon:

In NW-Cameroon no signs of presence were found. Tchouto et al. (1999) found *A. gabonensis* on Mt Cameroon in the mountain forest.

The highest densities were found in **West- and Southwest Cameroon**, where I delimited a potential picking area of 5.5 million ha (Figure 7). Suppose that half of its area is in good condition, then 2.7 million ha are available for picking. I estimate the *Allanblackia* density at 150 trees, d>10 cm, per km2, resulting in around **4 million trees**.

Along the south boundary, a Canadian company carried out an important forest inventory (Borry & Goossens 1995). In the eastern half of this boundary, the Congolian type of forest, *Allanblackia* is definitely rarer.
It seems that *A. floribunda* densities are lower than *A. parviflora* densities in Ghana. On the other hand, *A. floribunda* grows thicker than *A. parviflora*, so may produce more fruits.

Equatorial Guinea and Gabon

In Equatorial Guinea, where rainfall is even higher, also *Allanblackia* density is more important. For Gabon, the inventory results do not mention *Allanblackia*. I suppose this is because it is not considered a commercial timber species. Extrapolating the findings for SW-Cameroon and Equatorial Guinea, *Allanblackia* should be abundant, especially in the western part, but given the experience in SE-Nigeria and Liberia, also very wet regions, this should be checked in the field. Recently Lee White and Chris Wilkes, WCS, carried out extensive botanic surveys. Their results could confirm this statement.

Nigeria:

Figure 8 shows the results of forest inventories in Nigeria. Hall (1977) reported pre-exploitation data in 46 samples. His Table 3 shows that *Allanblackia floribunda* has been found in all of the 17 samples on Ferralitic soils. Especially on Cenozoic sands (the same Tertiary sands as in Banco national Park near Abidjan), the abundance can be pretty high: up to 700 trees, d>10 per km2 in one part of Sapoba Forest Reserve. These sandy soils may correspond with the significant association Hall & Swaine (1981) found for *Allanblackia parviflora* with 'soils low in Ca, K, Mg, base saturation and pH (over half records on soil with pH 3.8-4.1, none >5.3).
The very wet forests in SE-Nigeria have none or low *Allanblackia* density. This confirm the low abundance in Korup, NW-Cameroon, and in SE-Liberia.

Lowe (1997) analysed data from 95 1ha plots in 5 forest areas in Nigeria. Two of them have been analysed by Hall also, and, as for the double sampled Ghanaian forests, differences are important:
Sapoba forest: 350 (Hall) vs. 550 (Lowe)
Oban group forest: 40 (Hall) vs. Oban west 80, Oban east 0 (Lowe).
As discussed above, precision of individual species abundance from forest inventory data is limited.

We conclude on **Nigeria** that there are **two potential picking areas**, **one** in the **southwest**, the wetter forests on Tertiary sands, of which less than 100.000 ha remains, i.e. with an average density of 250 per km2 **250.000 trees**. A second picking area is in **SE-Nigeria**, but away from the coast, from Cross River North Forest Reserve to Afi River Forest Reserve, where up to 500.000 ha of forest is still remaining, i.e. **1.250.000 trees**. Also adjacent areas in NW-Cameroon are likely to carry the same kind of forest, but I have no data from that area. I would suggest to contact:
Limbe Botanic Garden

Dr Nouhou NDAM, Conservator / Head of the Institution,
The Limbe Botanical and Zoological Gardens (LBZG), www.mcbcclimbe.org
P O.Box 437 Limbe
Cameroon
Tel (237) 999 89 13 or (237) 333 26 20, (237) 333 28 31/2
Fax (237) 333 28 34 or (237) 333 20 25 or (237) 333 0 91

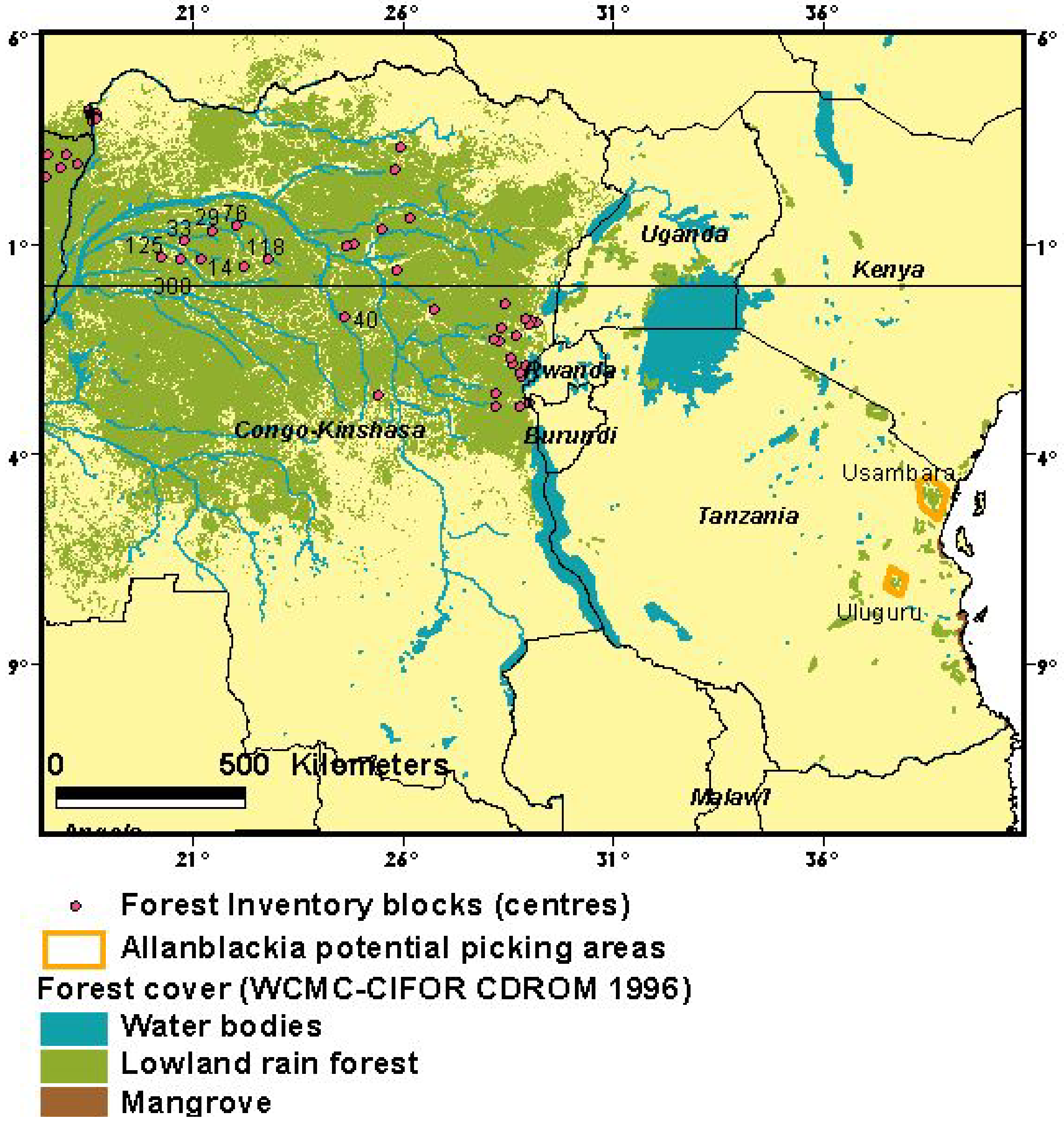

Figure 9: Abundance of *Allanblackia* in Central- and East-Africa. In the 'Cuvette centrale' of Congo Kinshasa populations of *A. floribunda* exist. In east-Tanzania the species *A. ulugurensis* and *A. stuhlmannii* exist in small very wet relic forests. No abundance data were found for the Kivu endemic *A. kimbiliensis* and the twoCuvette endemics *A. kisonghi* and *A. marienii.*

<u>**Central and East Africa**</u>

Abundance data for Central Africa are scarce. Figure 9 shows the results of an inventory in the 'Cuvette centrale', and of one research plot. In the Congo basin forest cover is still huge, more than 50 million ha. With an average abundance of 50 trees d>10cm, per km2, this represents the largest resource of Africa, ca. 25 million trees. Uncertainties are however large, and accessibility of the area is difficult.

5.4 *Distribution and abundance of other* Allanblackia *species in Central and East Africa*

5.4.1 *A. gabonensis* (submontane forest Cameroon to Gabon)

This is a submontane species, occurring above 500 m altitude. As these areas are less accessible, it is less likely that its fruits can be used in a wild pickings system.

5.4.2 *A. stanerana* (coastal forests Cameroon to Angola)

Letouzey et al. (1978) showed the distribution map of this third species for Cameroon, found in 7 grid cells in the Atlantic forest type. Given the smaller fruits (7 cm, Letouzey), probably not an interesting species for a wild picking system.

5.4.3 *A. kisonghi* and *A. marienii* (Congo basin)

In the Congo basin also two other endemic *Allanblackia* species exist: *A. kisonghi* and *A. marienii*. No information about these was found in the data.

5.4.4 *A. ulugurensis* and *A. stuhlmannii* (east Tanzania)

In east Tanzania the species *A. ulugurensis* and *A. stuhlmannii* exist in small very wet relic forests of Usumbara and Uluguru mountains. Economic use of the fruits existed in the 1950s, but forest cover is small, and under high pressure.

6 Conclusions

In total 7 areas have been identified in West Africa as potential *Allanblackia parviflora* picking areas:

- 1 in Ghana: **SW-Ghana** forest reserves
- 4 in **Cote d'Ivoire**: Songan-Mabi-Yaya-Tamin forest reserves in the east, Forêts côtières in the south, and Haut Cavally (presence of *Allanblackia* still to be verified) and Haute Dodo forest reserves in the west
- 2 in **Liberia**: west-Liberia and southeast Liberia. Inventory work is needed.

More than 5 million fruiting trees are believed to grow in these forests at the moment. Most of these are expected to grow in Liberia, but this needs further investigation, especially in the wettest forest types there.

In Cameroon, one area with *Allanblackia floribunda* has been identified as potential picking area:

- **SW-Cameroon.** I estimated the number of trees, d>10cm, in this area around 4 million.

Possibly important Allanblackia resources exist also in Equatorial Guinea and Gabon. Further study is needed.

In Nigeria two areas with *Allanblackia floribunda* have potential:

- SW-Nigeria: wet forests on Tertiary sands: 0,25 million trees
- SE-Nigeria away from the coast: 1,25 million trees

In the Congo basin *Allanblackia* is present. It may consist the largest resource on the continent, 25 million trees. More detailed information is needed.

The other *Allanblackia* species do not represent an important resource.

As a final remark, I would like to distinguish between potential picking areas with confirmed resources and areas where the *Allanblackia* resource still has to be assessed, like the wetter part of Liberia, Haut Cavally in Côte d'Ivoire, NW Cameroon, Gabon, Congo.

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Appendix 1: Minor oil crops (Axtell & Fairman 1992)

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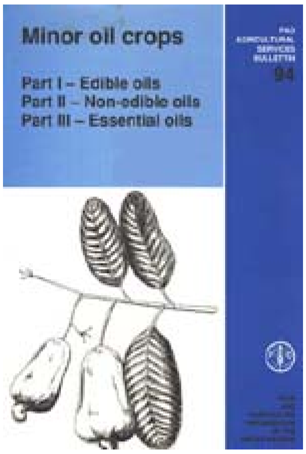
See: http://www.fao.org/inpho/vlibrary/x0043e/X0043E00.htm



Minor oil crops

Part I - Edible oils
Part II - Non-edible oils
Part III - Essential oils

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FOOD AND AGRICULTURE ORGANIZATION OF THE UNITED NATIONS

Rome, 1992

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Extract of the webpage:

Individual monographs

Allanblackia

<u>I. GENERAL</u>

COMMON NAME OF THE OIL
Allanblackia

BOTANICAL NAME
Allanblackia stuhlmannii, A.floribunda

FAMILY
Guttiferae

OTHER NAMES OF THE OIL
Mkanyi fat, Kagne butter,

HABITAT
Tropical

MAJOR PRODUCING COUNTRIES
E. Africa, Congo, Cameroons

YIELD AND DESCRIPTION
Trees of the genus bear large fruits, up to 12 inches long which may contain 40-50 seeds. The seed kernels amount to 60-80% of the whole seed weight. A hard white fat can be extracted from the kernels. Allanblackia fats are unusual in that they consist almost entirely of stearic and oleic acids,

and even more unusual in that the stearic acid proportion is very high, above 50%. Allanblackia has thus had considerable attention, based on its unusual fat composition, rather than its commercial importance (Ecky).
In 1958 E.Tanganyika was reported to have produced 68 tons of Kagne butter (Tang).

MAIN USES

The use of the fat in soap has been suggested (Foma). The timber is suitable for use under damp conditions and finds use in Ghana for bridge piers and pit props. The pounded bark is used for medicinal purposes, in Ghana for example as a pain reliever, for tooth ache, and to treat diarrhoea (Abbiw).

II. AGRICULTURAL ASPECTS

CULTIVATION

No information identified

HARVESTING PERIOD

No information identified

HARVESTING METHODS

No information identified

III. POST HARVEST PRE-TREATMENT, PROCESSING, STORAGE

PRE-TREATMENT

No information identified

IV. PROCESSING

OIL EXTRACTION

No information identified

MAJOR FATTY ACID COMPOSITION OF OIL

Palmitic acid 2-3%
Stearic acid 52-58%
Oleic acid 39-45%
(Hilditch)

EQUIPMENT

No information identified

NOMENCLATURE OF PRODUCTS

No information identified

There is a lack of identifiable information for the following areas: GENERAL, production, uses: AGRICULTURAL ASPECTS, cultivation, harvesting periods and methods; PROCESSING, primary processing, oil extraction, by products.

BIBLIOGRAPHY

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ECKEY, E.W. Vegetable Fats and Oils, Reinhold Publishing Corp. 1954. p 687
FOMA, M.; ABDALA, T.; "Kernel oils of seven plant species of Zaire", Journal of the American Oil Chemists' Society, 1985, Vol 62, No.:5, pp 910-911.
HILDITCH, Chemical Contribution of Natural Fats. pp 264-5 TANG. Tr. Bull., 1958, Part I, p.13

Appendix 2: Evaluation of tree species using the new CITES Listing Criteria

See http://www.unep-wcmc.org/species/tree_study/africa/1-5.html

Annex 2. Profiles of Tree Species: Africa

25 ***Allanblackia stuhlmannii*** Guttiferae

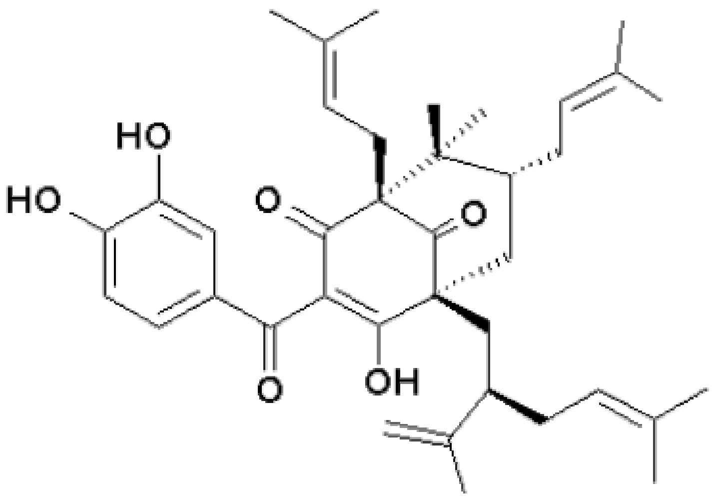
Distribution Tanzania **Habitat** A species of moist closed forest up to 1600m. **Population status and trends** This tall tree may be found in some abundance in remaining areas of moist upland forest only in eastern Tanzania, such as the Usambara Mts. **Role of species in the ecosystem Threats Utilisation** The seeds produce an edible oil, mkani fat. The timber is also used. **Trade** The oil is used locally and traded. **IUCN Conservation category** VU B1+2c according to Lovett, J. & P. Clarke (Lovett, 1996). **Conservation measures Forest management and silviculture** The forests on the Usambaras are under a degree of protection as catchment forests. **References** Knox, Eric B. 1995. The List of East African Plants (LEAP): An electronic database (Draft). 72pp. Lovett, Jon. 1996. Completed data collection forms of restricted range trees of Tanzania. Prospect. 1995. Species listing from the PROSPECT database. WWF & IUCN. 1994. Centres of plant diversity. A guide and strategy for their conservation. 3 volumes. Cambridge: IUCN Publications Unit

Appendix 3: Guttiferone F, the first prenylated benzophenone from *Allanblackia stuhlmannii*

Richard W. Fuller, John W. Blunt, Jamie L. Boswell, John H. Cardellina II, and Michael R. Boyd:
J.Nat.Prod. 62: 130-132, 1999.

Abstract:
The HIV-inhibitory activity in extracts of *Allanblackia stuhlmannii* was tracked, via bioassay-guided fractionation, to a new member of the camboginol/guttiferone class of prenylated benzophenones, guttiferone F (**1**). The structure was solved by extensive NMR analyses and by acid-catalyzed conversion to 30-*epi*-cambogin (**4**). This is the first report of this compound type in the genus *Allanblackia*. link to Medline

Natural Product with Anti-HIV Activity

<table>
<tr><td rowspan="5"></td><td>Name
Guttiferone F</td><td>NSC
709866</td></tr>
<tr><td>Molecular Formula
$C_{38}H_{50}O_6$</td><td>Reference</td></tr>
<tr><td colspan="2">Source:
Allanblackia stuhlmannii
[N31207, Q65T701]</td></tr>
<tr><td>HIV EC_{50} 23 µg/ml</td><td>HIV IC_{50} 82 µg/ml</td></tr>
<tr><td>Chemical Class
Benzophenone</td><td>Discovery Type
New Compound</td></tr>
</table>

Molecular Targets Discovery Program, CCR, NCI

Appendix 4: *Allanblackia stuhlmannii* in ICRAF Wood density database

See:
http://www.worldagroforestrycentre.org/sea/AgroModels/DBases/WD/asps/DisplayDetail.asp?SpecID=177

6. Allanblackia stuhlmannii

Main Page
New Search

Species Identity

Taxonomy
Current Name: Allanblackia stuhlmannii
Authority: Engl.
Family/Genus: Guttiferae - Allanblackia

Synonym(s)

Common Names
allanblackia,

Wood Density **(in Kg/m3)**

Low	Medium	High	Moisture Content (%)	Notes	References
600	-	839	12-15	-	Prospect: The Wood Database Version 2.1

Note: If the **Moisture Content** column is undefined, you may assumed the value of **15%**

Appendix 5: Piante oleaginose ordinate per genere

See: http://www.cti2000.it/biodiesel/piante%20oleose.htm

Tabella B

Piante oleaginose ordinate per genere

Nome Scientifico	Nome comune - Inglese/Italiano	Famglia
Allanblackia floribunda	Bouandjo	Guttiferace
Allanblackia oleif era	Kagne	Guttiferace
Allanblackia parviflora	--	Guttiferace
Allanblackia stuhlmannii	Mkanyi	Guttiferace

Etc….

Appendix 6: People and plants Online, Kew, London

x

See: http://www.rbgkew.org.uk/peopleplants/wp/wp4/bwindi.htm

People and plants Online

Bwindi Impenetrable Forest: conservation importance and vegetation change

Conservation importance

The importance of conserving Bwindi and other forests in western Uganda has been explained by Butynski (1984) and Struhsaker (1987). Detailed comment here is limited to aspects relating to forest plants.

Photo 1. An unidentified *Memecylon* (Melastomataceae) species.

Although tree species diversity of Bwindi Impenetrable Forest is low compared with high diversity rain forest, it is important not only as a representative of the Afromontane centre of endemism for plants (Photo 1), but also for animals restricted to this habitat (Butynski, 1984; Howard, 1991) (Tables 1 and 2). A 1ha plot surveyed for trees >10 cm dbh (diameter at breast height) in Amazonian rain forest in Peru, for example, contained 275 species, representing 50 families (Peters et al., 1989), compared to only 45-50 tree species >10 cm dbh in 1 ha of Bwindi Impenetrable Forest at 2000-2200 m asl, and only 20 tree species per ha in forest at 2400 m asl (Howard, 1991).

Bwindi Impenetrable Forest contains tree genera endemic to Afromontane forest, and many tree species that typify Afromontane rain forest are also represented.

Although Lovoa swynnertonii (Meliaceae) is the only tree species listed as endangered, Bwindi Forest contains a number of tree species not found elsewhere in Uganda, or represented in Uganda only in Kabale-Rukungiri.

Photo 2. Fruit of *Allanblackia kimbiliensis* (Clusiaceae).

(Although Allanblackia kimbiliensis (Photo 2), Brazzeia longipedicellata, Grewia mildbraedii, Strombosiopsis tetrandra, Maesobotrya floribunda (plus Chrysophyllum pruniforme, which Howard (1991) has since recorded from Budongo and Itwara forests) were thought to be confined to Ishasha Gorge (Hamilton, 1991), this is collecting surveys. Allanblackia probably an artefact of previous plant ...

Bwindi Forest is a Pleistocene refugium containing not only plants typical of Afromontane forest but also representatives of the Guineo-Congolian flora, such as the secondary forest tree Musanga leo-errerae (Cecropiaceaea), the shrub Agelaea pentagyna (Connaraceae), herbs such as Ataenidia and Marantochloa (Marantaceae) and parasitic plants such as Thonningia sanguinea (Balanophoraceae).

Appendix 6: Preliminary list of Late Quaternary Pollen Taxa

See: http://medias.obs-mip.fr/apd/maquette/program/taxons.html

A. Vincens, in progress (06/99)
The list includes all the pollen taxa recognized in the 110 firts pollen sequences collected in the database (original name). The name of each taxa is discussed and a new name is assigned (proposed name) after study of the reference pollen slides.A type is added to the genus or to the species when several genera (in the same family) or several species (in the same genus) present a the same pollen morphology (same type). The number of species refers to the botanical diversity in Africa.The nomenclature uses Lebrun and Stork (1991-1997) "Enumération des Plantes à fleurs d'Afrique Tropicale" (Genève, Conservatoire et Jardins botaniques de la ville de Genève)
!!! Please, contact Annie Vincens for improvements, discussions and explanations either directly at avincens@cerege.fr or through the forum at apd@medias.cnes.fr!!!

Allanblackia	Allanblackia ou Allanblackia-type ?	9 sp.	
Allanblackia-type	Allanblackia ou Allanblackia-type ?		
Garcinia	Garcinia	29 sp.	
Garcinia epunctata	Garcinia epunctata-type		
Garcinia epunctata-type	Garcinia epunctata-type		
Garcinia gnetoides-type	Garcinia gnetoides-type		
Garcinia volkensii-type	Garcinia volkensii-type		
Guttiferae	Clusiaceae		genres très différents

Appendix 7: National Tree Seed Programme in Tanzania

Seeds can be bought from the National Tree Seed Programme in Tanzania, see: http://home.twiga.com/ntsp/seedprg.htm

Kiswahili Name	Scientific name	seed accession number	provenance locality	altitude (m asl)	rainfall	No. of seeds/kg
Msambu, Mkani	**Allanblackia** stuhlmanii	ABST001I	Kwamkoro F.R	1000	2000	14,400
Msambu, Mkani	**Allanblackia** ulugurensis	ALUL089I	Uluguru mountains	1200	1200	14,400

Appendix 8: Dioecy database

Dioecy database, Feb. 2002. This is a subset of the data used in :
Renner, S. S., and R. E. Ricklefs. 1995. Dioecy and its correlates in the flowering plants. Am. J. Bot. 82(5): 596-606,
except that family circumscriptions have been up-dated follwing the APG classification (see http://www.mobot.org/MOBOT/Research/APweb/orders/).
For details about sources and coding see R. & R. 1995. References are also available from renner@umsl.edu.
Yampolsky, C., and H. Yampolsky 1922. Distribution of sex forms in the phanerogamic flora. Bibliotheca Genetica 3: 1-62 is abbreviated as Y.
This includes 994 genera that together contain 15000 dioecious species, or 7.4% out of 13,479 accepted angiosperm genera (Brummitt et al., 1992) and 3.6% out of 421,200 known species (Govaerts, 2001).
From Table:

Fam.	Genus	Order	No_species	No_dioecious	dispersal	conti.
Clusia.	Allanblackia	Malpighiales	10	1	animals insects	trop. Afr.

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RESEARCH INTERESTS

I work on the systematics and evolution of flowering plants, especially the evolution of their sexual systems and their biogeography. Sexual systems being studied are dioecy, heterodichogamy, and sex change. Most work focuses on tropical groups, such as Melastomataceae and relatives, and families in the Laurales, especially Hernandiaceae, Monimiaceae, and Siparunaceae. Recently started projects deal with the evolution of environmental sex determination and habitat diversity in Cucurbitaceae and Areae/Colocasieae, especially *Arisaema*.

SEXUAL SYSTEMS AND POLLINATION

- Renner, S. S. 2001. Heterodichogamy, how common is it? Trends Ecol. Evol. 16(11): 595-597.
- Renner, S..S., and H. Won 2001. Repeated evolution of dioecy from monoecy in Siparunaceae (Laurales). Syst. Biol. 50(5): 700-712.This cites a database of angiosperm genera with dioecious species. For more on this database see:
- Renner, S. S., and R. E. Ricklefs. 1995. Dioecy and its correlates in the flowering plants. Am. J. Bot. 82(5): 596-606 (abstract).