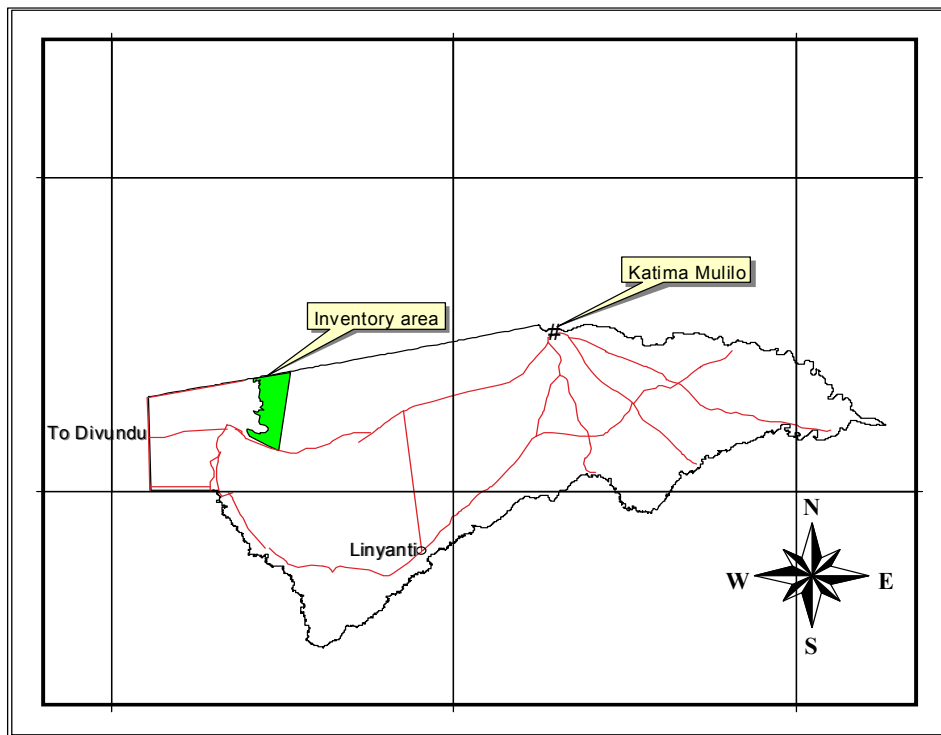


MINISTRY OF ENVIRONMENT AND TOURISM

Directorate of forestry



Woody Resources Report of Kwando Community Forest



**Namibia Finland Forestry Programme
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1. INTRODUCTION

The Directorate of Forestry (DoF) under the Ministry of Environment and Tourism in Namibia has a mission to carry out forest resource assessments in Namibia. In this task the Government of Finland has supported it since 1995. Initially the aim of the support was to build up the capacity of the Directorate to carry out regional forest inventories of large areas (National Forest Inventory component, NFI). During the years, an increasing number of local level inventories have also been carried out to fulfill specific requests by projects and forest managers. The support from the Government of Finland today through Namibia-Finland Forestry Programme Phase II aims now more at strengthening the capacity of DoF to serve the needs for local level forest management planning.

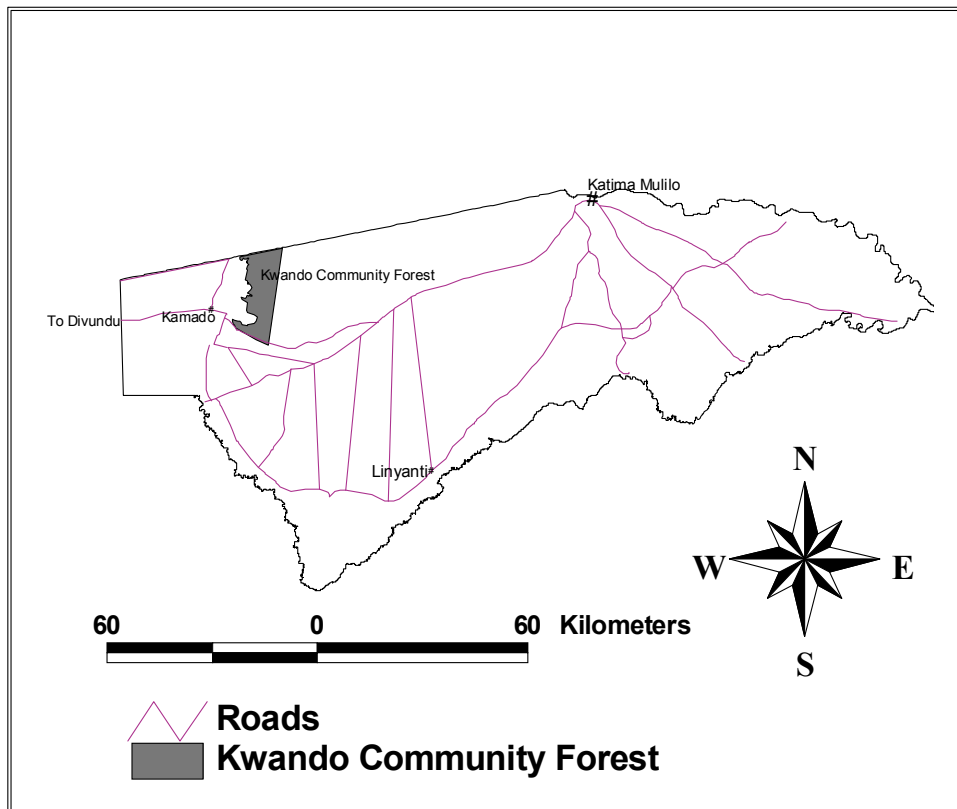
Inventory of Kwando forest is an example of a local level inventory. These local level inventories make it possible to produce forest management plans. The data in this case can be used to enhance the Conservancy management decisions.

The inventory in Kwando Forest was carried out by the National Forest Inventory team (NFI) between the 6th and 30th of May 2003. The forest inventory area covers the Kwando Conservancy that is an area of 19,888 hectares, in Katima Mulilo district, Caprivi Region.

Another component of NFFP, which is the Participatory Integrated Forest Management (PIFM), is directly working with the community of Kwando. They deemed it necessary to find out the amount of resources available in the area in order to compile a sound management plan. With regard to community forestry, the component is encouraging community participation in the management of their forest and forest products. More income generating actions for sustainable development are thought of in the near future, as the community will be habituated with the concept of community forestry.

2. General description of the area

The Kalahari sands outweigh in the eastern parts of the country including Kwando forest. The land is rather uniform. The average annual temperature is usually more than 22°C. The annual rainfall is 600-1,000 mm. The average elevation is about 1,100 m above sea level. The inventory area is about 100 Kilometers to west of Katima Mulilo (see Map 1).

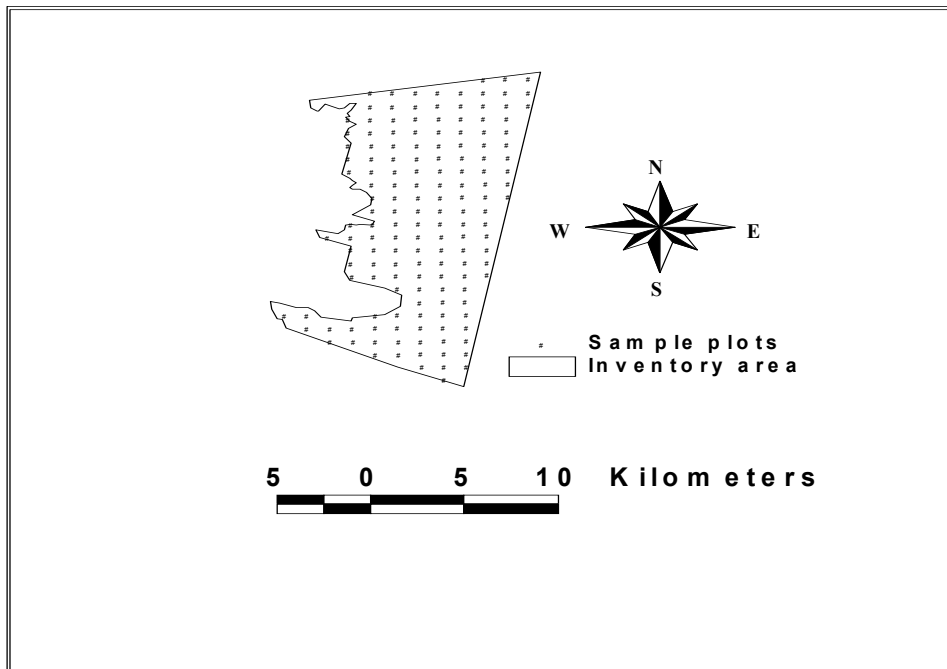


Map 1. Location of Kwando Community Forest.

3. INVENTORY DESIGN

3.1 Sampling method

The woody resources were estimated using a systematic sampling of field plots. A total of 153 sample plots were measured in Kwando Community Forest. This was much dictated by the given number of working days available for the inventory. Also experience showed that satisfactory inventory accuracy should be possible to achieve with that number of plots. The aim was to reach an accuracy of 10 % (standard error) for mean volume per hectare and number of stems per hectare.



Map 2. Location of sample plots.

All trees, with at least 5 cm DBH, inside the circular plot were measured. The plot consisted of three concentric circles. The size of the plot depended on the size of the tree so that the radius of the plot is 30 m for trees with a breast height diameter (DBH) more than or equal to 45 cm; 20 m for trees with $20 \leq \text{DBH} < 45$ cm; and 10 m for trees with $5 \leq \text{DBH} < 20$ cm. Diameter, location, species, crown class, quality, length and quality of possible saw log were measured. Height, canopy diameter, crown height and phenology were recorded for each tree in the plot (see figure 1). Damages were recorded for the stand in the sample plot.

In addition, shrubs and regeneration were measured using two circular sub plots of 3.99 m radius. Woody plants with a diameter at breast height less than 5 cm were recorded on the shrub and regeneration field form.

Several variables describing the site, soil and tree cover were observed for each plot. All measurements are described in more detail in the field instructions (Selanniemi and Chakanga, 2001).

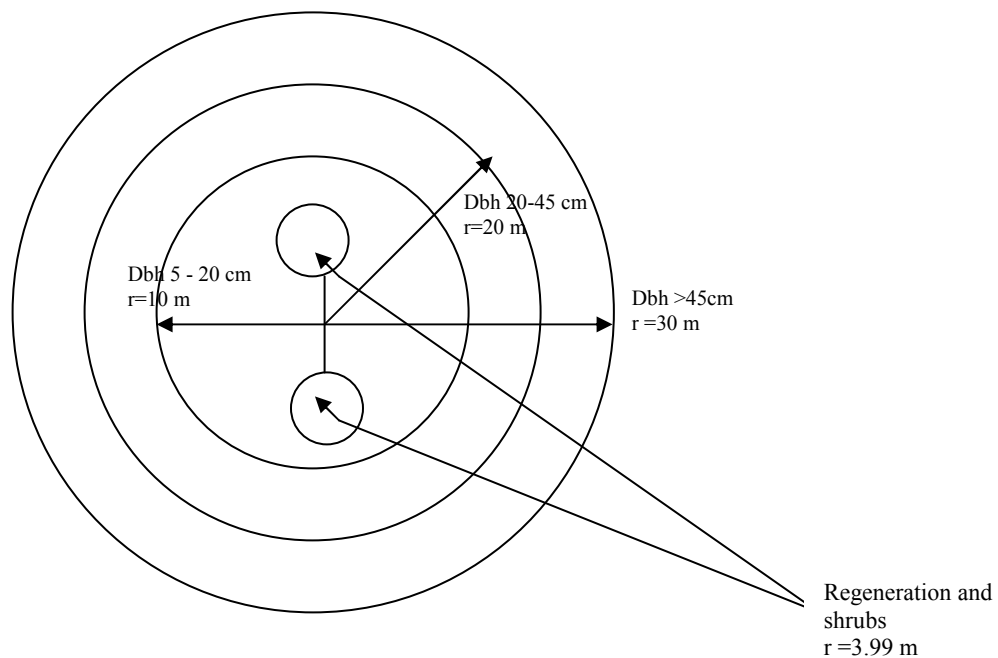


Figure 1: Plot design.

The inventory did not collect information specifically on the non-timber forest products (NTFPs) in the sense that it did not for example try to estimate the availability of fruits from different species or collect information on roots tubers etc. However, a considerable part of the NTFPs used in the region are related to trees. Therefore, the information on trees can be used to indicate the abundance or scarcity of some of the NTFPs.

4. INVENTORY RESULTS

4.1 Measured data

A total of 153 plots were measured on an area of 19,888 hectares. Each plot represents an area of 130 ha. A total of 954 trees with a diameter of at least 5 cm were measured on the plots. Table 1 shows the total number of measured trees by species.

| Species | Total No. of measured trees | % of measured trees |
|--|-----------------------------|---------------------|
| <i>Acacia ataxacantha</i> | 4 | 0.4 |
| <i>Acacia erioloba</i> | 35 | 3.7 |
| <i>Acacia fleckii</i> | 40 | 4.2 |
| <i>Acacia nebrownii</i> | 4 | 0.4 |
| <i>Acacia nilotica</i> | 1 | 0.1 |
| <i>Acacia tortillis</i> | 2 | 0.2 |
| <i>Baikiaea plurijuga</i> | 364 | 38.2 |
| <i>Bauhinia petersiana</i> | 2 | 0.2 |
| <i>Berchimia discolor</i> | 1 | 0.1 |
| <i>Boscia albitrunca</i> | 10 | 1.0 |
| <i>Burkea africana</i> | 40 | 4.2 |
| <i>Combretum collinum</i> | 178 | 18.7 |
| <i>Combretum imberbe</i> | 2 | 0.2 |
| <i>Combretum molle</i> | 3 | 0.3 |
| <i>Combretum psidioides (psidioides)</i> | 10 | 1.0 |
| <i>Combretum zeyheri</i> | 2 | 0.2 |
| <i>Commiphora angolensis</i> | 7 | 0.7 |
| <i>Croton gratissimus</i> | 7 | 0.7 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 86 | 9.0 |
| <i>Erythrophleum africanum</i> | 16 | 1.7 |
| <i>Guibourtia coleosperma</i> | 11 | 1.2 |
| <i>Lonchocarpus capassa</i> | 6 | 0.6 |
| <i>Lonchocarpus nelsii</i> | 67 | 7.0 |
| <i>Ochna pulchra</i> | 1 | 0.1 |
| <i>Peltoporum africanum</i> | 3 | 0.3 |
| <i>Pterocarpus angolensis</i> | 24 | 2.5 |
| <i>Terminalia sericea</i> | 27 | 2.8 |
| <i>Ziziphus mucronata</i> | 1 | 0.1 |
| Total | 954 | 100.0 |

Table 1. Number of measured trees by species.

The three most frequent tree species in the data set were *Baikiaea plurijuga* (38.2 %), *Combretum collinum* (18.7 %) and *Dichrostachys cinerea* (9.0 %).

4.2 Average and maximum height by species

| Species | Average height, (m) | Maximum height, (m) |
|--|---------------------|---------------------|
| <i>Acacia ataxacantha</i> | 3.28 | 4 |
| <i>Acacia erioloba</i> | 6.80 | 17.5 |
| <i>Acacia fleckii</i> | 3.92 | 16.3 |
| <i>Acacia nebrownii</i> | 11.90 | 18.9 |
| <i>Acacia nilotica</i> | 7.60 | 7.6 |
| <i>Acacia tortillis</i> | 2.60 | 5.2 |
| <i>Baikiaea plurijuga</i> | 10.64 | 24.1 |
| <i>Bauhinia petersiana</i> | 2.15 | 4.3 |
| <i>Berchimia discolor</i> | 14.70 | 14.7 |
| <i>Boscia albitrunca</i> | 6.33 | 10.5 |
| <i>Burkea africana</i> | 9.54 | 23.6 |
| <i>Combretum collinum</i> | 6.56 | 22.4 |
| <i>Combretum imberbe</i> | 9.75 | 10 |
| <i>Combretum molle</i> | 8.13 | 9 |
| <i>Combretum psidioides (psidioides)</i> | 4.65 | 6.8 |
| <i>Combretum zeyheri</i> | 5.15 | 6.3 |
| <i>Commiphora angolensis</i> | 2.80 | 6.4 |
| <i>Croton gratissimus</i> | 3.39 | 5.5 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 2.09 | 8 |
| <i>Erythrophleum africanum</i> | 3.92 | 13.5 |
| <i>Guibourtia coleosperma</i> | 8.60 | 21.6 |
| <i>Lonchocarpus capassa</i> | 6.85 | 9.1 |
| <i>Lonchocarpus nelsii</i> | 5.64 | 12.6 |
| <i>Ochna pulchra</i> | 13.80 | 13.8 |
| <i>Peltoporum africanum</i> | 7.73 | 18.4 |
| <i>Pterocarpus angolensis</i> | 10.25 | 21.6 |
| <i>Terminalia sericea</i> | 4.52 | 7.5 |
| <i>Ziziphus mucronata</i> | 12.10 | 12.1 |

Table 2. Average and maximum height by species found.

The highest tree that was measured was *Baikiaea plurijuga*, a tree with a height of 24.1 m. The second highest tree species is *Burkea africana* with a height of 23.6 m. The third highest tree species are *Erythrophleum africanum* (13.5 m) and *Pterocarpus angolensis* (21.6 m).

4.3 Species diversity

A simple measure of species diversity is to express the number of species found in the area and the number of plots where each species was found. Table 3 shows the number of plots where each species was found for both trees (≥ 5 cm) and shrubs (<5 cm).

| Species | No. of clusters, Dbh < 5 cm | No. of clusters, Dbh ≥ 5 cm |
|--|-----------------------------|----------------------------------|
| <i>Acacia ataxacantha</i> | 34 | 4 |
| <i>Acacia erioloba</i> | 14 | 12 |
| <i>Acacia fleckii</i> | 36 | 15 |
| <i>Acacia nebrownii</i> | 2 | 3 |
| <i>Acacia nilotica</i> | 3 | 1 |
| <i>Acacia tortillis</i> | | 1 |
| <i>Baikiaea plurijuga</i> | 52 | 97 |
| <i>Baissea wulforthii</i> | 7 | |
| <i>Baphia massaiensis</i> | 124 | |
| <i>Bauhinia petersiana</i> | 101 | 1 |
| <i>Berchimia discolor</i> | | 1 |
| <i>Boscia albitrunca</i> | 8 | 8 |
| <i>Burkea africana</i> | 15 | 19 |
| <i>Combretum apiculatum (apiculatum)</i> | 1 | |
| <i>Combretum apiculatum (leutweinii)</i> | 1 | |
| <i>Combretum collinum</i> | 82 | 80 |
| <i>Combretum elaeagnoides</i> | 1 | |
| <i>Combretum engleri</i> | 31 | |
| <i>Combretum hereroense</i> | 1 | |
| <i>Combretum imberbe</i> | 1 | 1 |
| <i>Combretum molle</i> | 1 | 2 |
| <i>Combretum psidioides (psidioides)</i> | 22 | 2 |
| <i>Combretum zeyheri</i> | 27 | 2 |
| <i>Commiphora angolensis</i> | 17 | 3 |
| <i>Croton gratissimus</i> | 57 | 3 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 56 | 14 |
| <i>Erythrophleum africanum</i> | 9 | 6 |
| <i>Euclea divinorum</i> | 1 | 5 |
| <i>Grewia bicolor</i> | 7 | |
| <i>Grewia flava</i> | 5 | |
| <i>Grewia retinervis</i> | 70 | |
| <i>Guibourtia coleosperma</i> | | 5 |
| <i>Lonchocarpus capassa</i> | 7 | 4 |
| <i>Lonchocarpus nelsii</i> | 57 | 38 |
| <i>Markhamia acuminata</i> | 42 | |
| <i>Ochna cinnebarina</i> | 2 | |
| <i>Ochna pulchra</i> | 14 | 1 |

| | | |
|--|----|----|
| <i>Ozoroa longipes</i> | 8 | |
| <i>Ozoroa paniculosa</i> | 5 | |
| <i>Peltophorum africanum</i> | | 2 |
| <i>Pterocarpus angolensis</i> | 8 | 12 |
| <i>Rhus tenuinervis</i> | 10 | |
| <i>Salacia luebbertii</i> | 5 | |
| <i>Terminalia sericea</i> | 65 | 19 |
| <i>Ximania americana var americana</i> | 2 | |
| <i>Ximania caffra var microphylla</i> | 5 | |
| <i>Ziziphus mucronata</i> | 1 | 1 |

Table 3. Species diversity expressed by the number of plots where each species was found.

A total of 47 woody species were recorded in Kwando community forest. 29 species are occurring as trees while 43 species are found in the shrub layer. 25 species are occurring both as trees and in the shrub layer.

Baikaea plurijuga trees were found on 63 % (97 plots) of the measured plots, while shrubs from the same species were found on 34 % (52 plots) of the measured sub plots. *Baphia massaiensis* was the most frequent species in the shrub layer as it was found in 81% plots (124 plots).

4.4 Tree volumes and number of stems

The tree volumes were divided into dead and live tree volumes.

Live trees

| Species | Total number of stems | Stems per ha | Total tree volume, m ³ | Mean volume, m ³ /ha |
|--|-----------------------|--------------|-----------------------------------|---------------------------------|
| <i>Acacia erioloba</i> | 76,316 | 3.8 | 14,431 | 0.7 |
| <i>Acacia fleckii</i> | 118,956 | 6.0 | 5,378 | 0.3 |
| <i>Acacia nebrownii</i> | 6,091 | 0.3 | 3,859 | 0.2 |
| <i>Acacia nilotica</i> | 4,138 | 0.2 | 515 | 0.0 |
| <i>Baikaea plurijuga</i> | 381,235 | 19.2 | 289,037 | 14.5 |
| <i>Berchimia discolor</i> | 460 | 0.0 | 1,617 | 0.1 |
| <i>Boscia albitrunca</i> | 15,516 | 0.8 | 4,104 | 0.2 |
| <i>Burkea africana</i> | 51,145 | 2.6 | 19,205 | 1.0 |
| <i>Commiphora angolensis</i> | 22,757 | 1.1 | 1,167 | 0.1 |
| <i>Combretum collinum</i> | 505,134 | 25.4 | 55,515 | 2.8 |
| <i>Combretum imberbe</i> | 2,069 | 0.1 | 982 | 0.0 |
| <i>Combretum molle</i> | 6,206 | 0.3 | 696 | 0.0 |
| <i>Combretum psidioides (psidioides)</i> | 37,239 | 1.9 | 917 | 0.0 |

| | | | | |
|---|------------------|---------------|----------------|-------------|
| <i>Combretum zeyheri</i> | 8,275 | 0.4 | 220 | 0.0 |
| <i>Croton gratissimus</i> | 28,963 | 1.5 | 672 | 0.0 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 326,871 | 16.4 | 8,187 | 0.4 |
| <i>Erythrophleum africanum</i> | 38,273 | 1.9 | 1,721 | 0.1 |
| <i>Guibourtia coleosperma</i> | 5,517 | 0.3 | 10,328 | 0.5 |
| <i>Lonchocarpus capassa</i> | 17,585 | 0.9 | 2,727 | 0.1 |
| <i>Lonchocarpus nelsii</i> | 215,156 | 10.8 | 16,905 | 0.9 |
| <i>Ochna pulchra</i> | 1,034 | 0.1 | 574 | 0.0 |
| <i>Peltoporum africanum</i> | 8,735 | 0.4 | 2,299 | 0.1 |
| <i>Pterocarpus angolensis</i> | 27,814 | 1.4 | 14,087 | 0.7 |
| <i>Terminalia sericea</i> | 86,890 | 4.4 | 2,716 | 0.1 |
| <i>Ziziphus mucronata</i> | 1,034 | 0.1 | 1,744 | 0.1 |
| Total | 1,993,410 | 100.23 | 459,604 | 23.1 |

Table 4. Volumes and number of stems for live trees.

Table 4 above shows that there are in 1,993,410 stems, which is 100.2 stems per hectare. The biggest share of stems is of *Baikiaea plurijuga*, *Lonchocarpus nelsii*, *Combretum collinum* and *Acacia erioloba*

The mean volume of all live species is 23.1 m³/ha. The 4 most common species represent 83 % of the total volume.

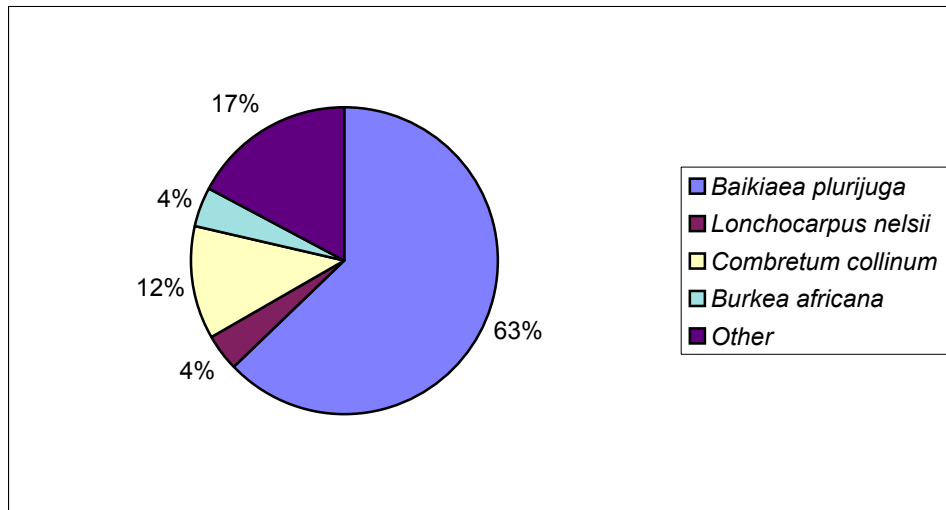


Figure 2: The volumes of the main live species expressed in % of the total volume of all species (459,604 m³).

The total volume of all live trees is 459,604 m³. The total volume of *Baikiaea plurijuga* is 289,037 m³, *Combretum collinum* is 55,515 m³, *Burkea africana* 19,205 m³ and the total volume for *Lonchocarpus nelsii* is 16,905 m³.

Dead trees

The majority of dead trees in Kwando are *Baikaea plurijuga*, *Burkea africana* and *Combretum collinum*. Few dead *Lonchocarpus nelsii* were observed (582 m³). The total volume for *Baikaea plurijuga* is the highest (see table 5). The 4 most common dead species represent 83 % of the total dead wood volume.

| Species | Total number of stems | Stems per ha | Total tree volume, m ³ | Mean volume, m ³ /ha |
|--|-----------------------|--------------|-----------------------------------|---------------------------------|
| <i>Acacia ataxacantha</i> | 16,550 | 0.8 | 373 | 0.0 |
| <i>Acacia erioloba</i> | 15,516 | 0.8 | 3,504 | 0.2 |
| <i>Acacia fleckii</i> | 37,239 | 1.9 | 979 | 0.0 |
| <i>Acacia tortillis</i> | 5,172 | 0.3 | 640 | 0.0 |
| <i>Baikaea plurijuga</i> | 78,615 | 4.0 | 69,518 | 3.5 |
| <i>Bauhinia petersiana</i> | 8,275 | 0.4 | 919 | 0.0 |
| <i>Boscia albitrunca</i> | 1,034 | 0.1 | 579 | 0.0 |
| <i>Burkea africana</i> | 19,654 | 1.0 | 8,244 | 0.4 |
| <i>Combretum collinum</i> | 42,411 | 2.1 | 5,787 | 0.3 |
| <i>Combretum psidioides (psidioides)</i> | 4,138 | 0.2 | 42 | 0.0 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 28,963 | 1.5 | 682 | 0.0 |
| <i>Erythrophleum africanum</i> | 18,619 | 0.9 | 1,783 | 0.1 |
| <i>Guibourtia coleosperma</i> | 2,988 | 0.2 | 4,441 | 0.2 |
| <i>Lonchocarpus capassa</i> | 1,034 | 0.1 | 695 | 0.0 |
| <i>Lonchocarpus nelsii</i> | 8,275 | 0.4 | 582 | 0.0 |
| <i>Pterocarpus angolensis</i> | 4,138 | 0.2 | 1,733 | 0.1 |
| <i>Terminalia sericea</i> | 21,722 | 1.1 | 1,257 | 0.1 |
| Total | 314,344 | 15.8 | 101,760 | 5.1 |

Table 5. Volumes and number of stems for dead trees.

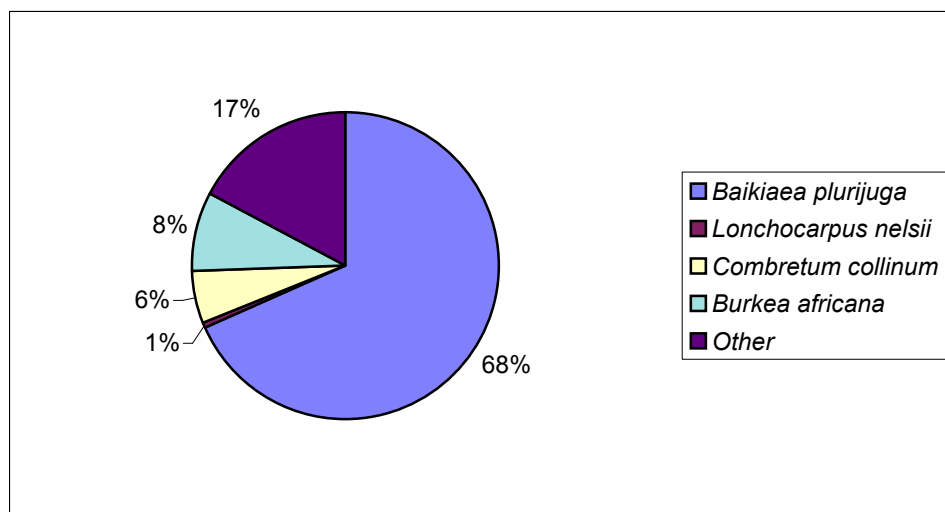


Figure 3: The volumes of the common dead species expressed in % of the total volume of all species (101729 m³).

4.5 Diameter distribution

Live trees

Appendix 1 shows the diameter distribution of live trees. The bulk of the trees in Kwando community forest are in the small and medium sized diameter classes. The distribution also gives indications on which tree species have a potential to grow into big size trees in the area. The biggest live trees in Kwando community forest are *Combretum collinum* and *Baikiaea plurijuga*-trees. Their diameter distribution is also good in the sense that the majority of the stems are in lower diameter classes. These trees, if managed properly, will grow into bigger trees and provide poles also in the future.

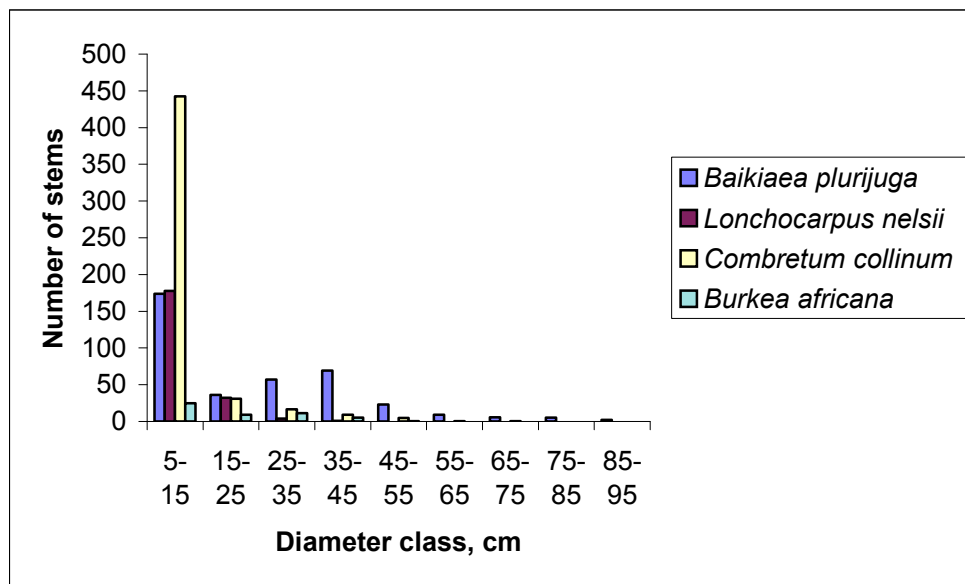


Figure 4. Live wood diameter distribution for the main species.

The number of small size *Combretum collinum* stems is very high, 443 stems with dbh between 5 and 15 cm (see Appendix 1).

Dead trees

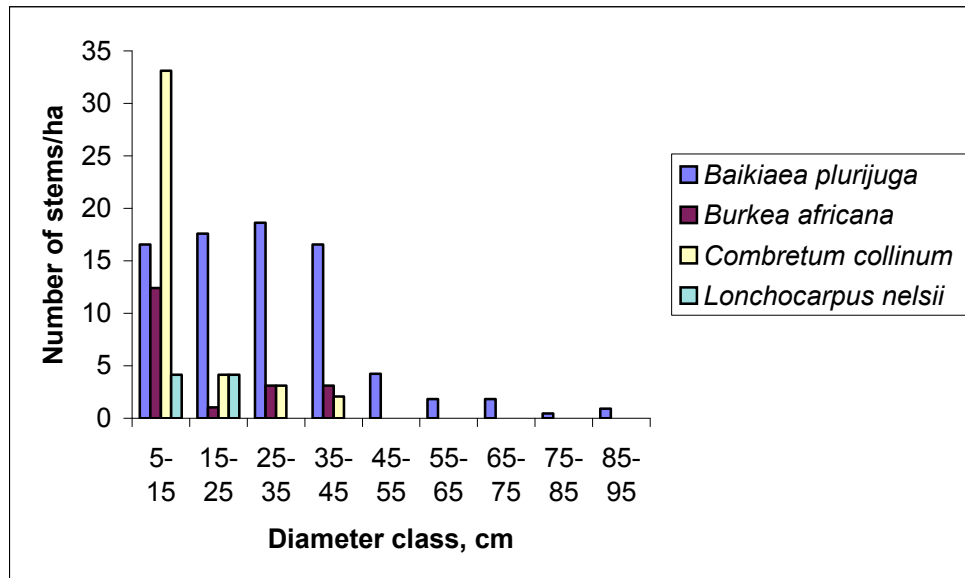


Figure 5. Dead wood diameter distribution for the main species.

Figure 5 and Appendix 2 show that most of dead stems are of *Combretum collinum*. They are mainly small size trees, less than 25 cm at breast height. The biggest dead trees shown in fig.5 are *Baikiaea plurijuga* trees within 65-75 cm and 85-95 cm diameter classes.

4.5.1 Regeneration and shrubs

Table 6 and 7 below shows the number of tree seedlings and shrubs by height classes in Kwando community forest. It should be noted that regeneration deals only with diameters less than 5 cm.

Tree seedlings

| SpeciesName | Height class, in cm | | | | | | | | Total |
|--|---------------------|------------|------------|------------|------------|-----------|-----------|-----------|--------------|
| | 0-25 | 26-50 | 51-100 | 101-150 | 151-200 | 201-250 | 251-300 | 300+ | |
| <i>Acacia erioloba</i> | 1 | 12 | 8 | 2 | 1 | 2 | 1 | 0 | 27 |
| <i>Baikiaea plurijuga</i> | 12 | 58 | 99 | 33 | 28 | 1 | 0 | 1 | 232 |
| <i>Boscia albitrunca</i> | 1 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 7 |
| <i>Burkea africana</i> | 1 | 14 | 15 | 3 | 11 | 6 | 1 | 6 | 58 |
| <i>Combretum collinum</i> | 12 | 38 | 54 | 63 | 30 | 19 | 9 | 11 | 236 |
| <i>Combretum engleri</i> | 4 | 8 | 13 | 5 | 4 | 3 | 1 | 0 | 36 |
| <i>Combretum psidioides (psidioides)</i> | 3 | 21 | 18 | 6 | 16 | 1 | 1 | 1 | 67 |
| <i>Combretum zeyheri</i> | 0 | 8 | 34 | 17 | 7 | 4 | 0 | 0 | 71 |
| <i>Commiphora angolensis</i> | 0 | 5 | 3 | 3 | 6 | 1 | 0 | 4 | 21 |
| <i>Croton grattissimus</i> | 13 | 60 | 36 | 28 | 10 | 2 | 1 | 3 | 152 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 18 | 59 | 23 | 15 | 25 | 5 | 3 | 6 | 154 |
| <i>Erythrophleum africanum</i> | 1 | 8 | 8 | 5 | 3 | 0 | 0 | 0 | 25 |
| <i>Lonchocarpus nelsii</i> | 7 | 22 | 34 | 13 | 13 | 9 | 1 | 3 | 101 |
| <i>Ochna pulchra</i> | 10 | 5 | 1 | 0 | 4 | 1 | 0 | 0 | 21 |
| <i>Ozoroa longipes</i> | 0 | 0 | 1 | 5 | 3 | 0 | 0 | 0 | 9 |
| <i>Ozoroa paniculosa</i> | 0 | 0 | 1 | 0 | 5 | 0 | 0 | 1 | 7 |
| <i>Pterocarpus angolensis</i> | 0 | 2 | 0 | 0 | 3 | 3 | 0 | 0 | 7 |
| <i>Terminalia sericea</i> | 19 | 45 | 72 | 20 | 28 | 21 | 7 | 10 | 223 |
| Total | 103 | 365 | 420 | 219 | 197 | 79 | 26 | 46 | 1,454 |

Table 6. Number of tree seedlings per hectare.

On average, there are 236 *Combretum collinum*, 232 *Baikiaea plurijuga* and 223 *Terminalia sericea* tree seedlings. It seems that *Combretum collinum* and *Baikiaea plurijuga* are regenerating reasonably well, (Figure 4). There are 1,454 tree seedlings in Kwando.

Shrubs

| Species | Height class, in cm | | | | | | | Total | |
|--|---------------------|------------|------------|------------|------------|-----------|-----------|-----------|--------------|
| | 0-25 | 26-50 | 51-100 | 101-150 | 151-200 | 201-250 | 251-300 | | 300+ |
| <i>Acacia ataxacantha</i> | 1 | 9 | 14 | 7 | 7 | 3 | 1 | 4 | 46 |
| <i>Acacia fleckii</i> | 1 | 1 | 12 | 10 | 12 | 5 | 3 | 11 | 54 |
| <i>Baissea wulfhorstii</i> | 42 | 5 | 0 | 3 | 1 | 0 | 0 | 0 | 50 |
| <i>Baphia massaiensis</i> | 182 | 393 | 526 | 225 | 51 | 17 | 2 | 1 | 1,398 |
| <i>Bauhinia petersiana</i> | 101 | 139 | 149 | 44 | 18 | 5 | 2 | 3 | 461 |
| <i>Combretum apiculatum</i> (<i>apiculatum</i>) | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 |
| <i>Combretum elaeagnoides</i> | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 |
| <i>Grewia bicolor</i> | 0 | 0 | 5 | 6 | 1 | 0 | 0 | 0 | 13 |
| <i>Grewia flava</i> | 1 | 0 | 0 | 1 | 2 | 0 | 1 | 0 | 5 |
| <i>Grewia retinervis</i> | 6 | 56 | 53 | 26 | 13 | 1 | 3 | 2 | 160 |
| <i>Markhamia acuminata</i> | 6 | 44 | 108 | 79 | 25 | 3 | 0 | 1 | 266 |
| <i>Rhus tenuinervis</i> | 0 | 1 | 4 | 2 | 3 | 2 | 0 | 0 | 11 |
| Total | 339 | 648 | 872 | 403 | 132 | 37 | 13 | 21 | 2,466 |

Table 7. Number of shrub per hectare.

On average, there are 1,398 *Baphia massaiensis*, 461 *Bauhinia petersiana*, 266 *Markhamia acuminata* and 160 *Grewia retinervis* shrubs. There are 2,466 shrubs in Kwando.

4.6 Timber Quality

The quality classification used in the inventory is the following:

- Expected good quality: There is at least 2 m long straight stem without damages
- Expected medium quality: The stem is slightly curving or sweeping or having other damages but still having at least 2 m sawable log.
- Expected poor quality: It is possible to find only 1.2-2 m long meeting the minimum timber quality requirement.
- Not sawable: The log is not sawable and will probably never develop sawable quality.

The above classification was applied to all species. However, only the main species are discussed in this report. Table 8 below shows the timber quality of the main species with dbh \geq 45 cm. There is a considerable 12,450 stems of *Baikaea plurijuga* with good expected timber quality, 630 stems for *Combretum collinum*, 420 stems for *Pterocarpus angolensis* and 210 stems for *Burkea africana*.

| Species | Quality | Stems per ha | Total number of stems, 1000s | Total log volume, 1000 m ³ | Average log volume, m ³ /ha |
|-------------------------------|-------------------------|--------------|------------------------------|---------------------------------------|--|
| <i>Baikea plurijuga</i> | No code | 0.01 | 0.21 | 0.20 | 0.01 |
| | Expected good quality | 0.63 | 12.45 | 14.38 | 0.72 |
| | Expected medium quality | 0.17 | 3.38 | 1.95 | 0.10 |
| | Poor quality | 0.02 | 0.42 | 0.44 | 0.02 |
| | Not sawable | 0.21 | 4.22 | 0.00 | 0.00 |
| <i>Combretum collinum</i> | Expected good quality | 0.03 | 0.63 | 0.32 | 0.02 |
| | Expected medium quality | 0.03 | 0.63 | 0.51 | 0.03 |
| | Poor quality | 0.02 | 0.42 | 0.34 | 0.02 |
| | Not sawable | 0.04 | 0.84 | 0.00 | 0.00 |
| <i>Burkea africana</i> | Expected good quality | 0.01 | 0.21 | 0.12 | 0.01 |
| <i>Pterocarpus angolensis</i> | Expected good quality | 0.02 | 0.42 | 0.45 | 0.02 |
| | Total | 1.20 | 23.84 | 18.71 | 0.94 |

Table 8. Distribution of volume in timber quality classes (dbh ≥ 45 cm) for main species.

| Species | Quality | Stems per ha | Total number of stems | Total log volume, 1000m ³ | Mean log volume, m ³ /ha |
|-------------------------------|-------------------------|--------------|-----------------------|--------------------------------------|-------------------------------------|
| <i>Baikea plurijuga</i> | No code | 4.13 | 82.11 | 0.33 | 0.02 |
| | Expected good quality | 1.89 | 37.49 | 12.35 | 0.62 |
| | Expected medium quality | 0.88 | 17.56 | 4.22 | 0.21 |
| | Poor quality | 0.07 | 1.42 | 0.86 | 0.04 |
| | Not sawable | 0.79 | 15.66 | 0.00 | 0.00 |
| <i>Combretum collinum</i> | No code | 9.93 | 197.44 | 0.07 | 0.00 |
| | Expected good quality | 0.55 | 10.92 | 1.54 | 0.08 |
| | Expected medium quality | 0.31 | 6.17 | 0.89 | 0.04 |
| | Poor quality | 0.12 | 2.37 | 0.31 | 0.02 |
| | Not sawable | 0.53 | 10.44 | 0.00 | 0.00 |
| <i>Burkea africana</i> | No code | 0.62 | 12.34 | 0.15 | 0.01 |
| | Expected good quality | 0.33 | 6.64 | 0.77 | 0.04 |
| | Expected medium quality | 0.17 | 3.32 | 0.69 | 0.03 |
| | Poor quality | 0.05 | 0.95 | 0.39 | 0.02 |
| <i>Pterocarpus angolensis</i> | No code | 0.19 | 3.80 | 0.00 | 0.00 |
| | Expected good quality | 0.21 | 4.27 | 1.52 | 0.08 |
| | Expected medium quality | 0.05 | 0.95 | 0.16 | 0.01 |
| | Poor quality | 0.12 | 2.37 | 0.22 | 0.01 |
| | Not sawable | 0.05 | 0.95 | 0.00 | 0.00 |
| | Total | 20.98 | 417.19 | 24.47 | 1.23 |

Table 9. Distribution of volume in timber quality classes (dbh < 45 cm) for main species.

Table 9 above indicates that there is a considerable amount of trees with good expected timber qualities that is they are trees which are less than 45 cm at breast height today. *Baikaea plurijuga* has the highest number of stems (37,490) with good expected timber quality. *Combretum collinum* has 10,920 trees with good expected quality.

4.7 Damage to woody vegetation

Damage to the woody vegetation was recorded only at stand level. In the damage assessment the damages were classified into 4 different classes; (1) no damage, (2) mild, (3) moderate, (4) serious and.

| Damaging agent | Severity of damage | | | | Total |
|----------------|--------------------|-------|----------|---------|-------|
| | No damage | Mild | Moderate | Serious | |
| No damage | 1,074 | | | | 1,074 |
| Forest fire | | 2,624 | 119 | 417 | 3,161 |
| Mammals wild | 2,39 | 1,372 | 537 | | 2,147 |
| Human | | 2,445 | 239 | | 2,684 |
| Storm | | | | 60 | 60 |
| Total | ,1312 | 6,441 | 895 | 477 | 9,125 |

Table 10. Damages caused by fire, in hectares.

No damages were observed on 1074 hectares. Fire has damaged most of the area 3161 hectares (see table 10). Damage caused by people is also alarming and currently stands at 2,684 ha already damaged. Mammal damage is on 2,147 ha and storm at 60 ha.

4.8 Reliability of the results

The following error sources are always present in sampling based forest inventories: Sampling error, measurement error including coding error, errors in data processing and errors in models for volume estimation. In this work, specific attention was paid to guarantee good quality of the field data. Several cross checkings were done to find out possible errors and inconsistencies in the data.

The applied volume functions are probably the main source of errors. The size of the material collected for constructing the functions was moderate. A total of 252 trees were felled in West Tsumkwe, Caprivi, Omusati and Oshikoto regions and these were used for modeling.

The sampling error was estimated using the formula for random sampling. The standard error for the mean volume (23.3 m³/ha) was 3.1 m³/ha, which is 15 % of

the mean volume. The true volume with 95 % probability is between 17.2 m³/ha and 29.4 m³/ha. The variation inside the forest was expected.

5. INVENTORY COSTS

All inventories require financial inputs, which are either direct or indirect costs. The design of the inventory determines the financial implications that will be incurred during the inventory activities on the ground. The inventory in Kwando was carried out by the National Forest Inventory team (NFI) between the 6th and the 30th of May 2003. One field trip was undertaken for 24 days. Eleven men did the actual fieldwork. In the calculation, a cost for a man-day includes the salary plus the daily subsistence costs. Four cars (1,200 km one way, from Windhoek to Kwando Community Forest) were used to reach the area from Windhoek. Four ATVs were used for moving from one plot to another. The costs for fuel are more or less real, but the cost for vehicle maintenance is an estimate, which has been derived from annual maintenance costs. This calculation only includes immediate costs of the inventory. It does not include fixed costs and overhead costs like office facilities, computers, supervision etc. The total cost of the inventory is about N\$ 108,135 which is N\$ 5.4 per hectare.

| Cost item | Units | Cost/unit, N\$ | Total cost, N\$ |
|----------------------|--------------|----------------|-----------------|
| Inventory equipment | | | 5,000 |
| Inventory field work | 286 man-days | 224 | 64,135 |
| Fuel | 6,197 litres | 3.55 | 22,000 |
| Vehicle maintenance | | | 15,000 |
| Report printing | | | 2,000 |
| Total | | | 108,135 |

Table 11. Inventory costs.

The inventory cost per hectare in Kwando community forest is N\$ 5.4, Compared to other cost of other areas, this is much higher than the cost to inventory one hectare in Uukolonkadhi (N\$ 1.98), where a stratification was done for a large area (Kanime and Laamanen, 2003) but lower than to inventory an area in Hans Kanyinga. In Sikanjabuka, the cost per hectare was N\$17.40, which is the highest cost analyzed so far (Kamwi and Laamanen, 2002). In Sikanjabuka, a uniform grid with a relatively high number of plots was laid on a small area of 5000 hectares.

6. CONCLUSION

This inventory provides quantitative estimates of the present state of the forest in Kwando Community Forest and indicates that the resources are still remarkable in terms of volume and stems per hectare.

The most common damage (threat) to the woody vegetation is fire. The stand level classification indicates that there are visible signs of damages to trees caused by fires, Human damage and damage caused by mammals. Although the woody vegetation on a big part of the area shows signs of fire damage, surprisingly few trees are damaged, and the damage is usually mild or moderate. Few hectares are seriously damaged.

The majority of people depend on the forest resources for fuel wood and poles for house construction and grass for thatching. The area inventoried has very good potential for management by the local community.

7. References

Mendelson, J., Jarvis, A., Roberts, C. and Robertson, T., 2002. Atlas of Namibia. A portrait of the Land and its people. Ministry of Environment and Tourism, Namibia.

Selanniemi, T. and Chakanga, M., 2001. Manual for woody resource inventory. Namibia-Finland Forestry Programme. Directorate of Forestry. Windhoek.

Kamwi, J. and Laamanen, R., 2002. Inventory Report on the Woody Resources in Sikanjabuka Community Forest. Namibia-Finland Forestry Programme, Directorate of Forestry, Namibia.

Kanime, N. and Laamanen, R., 2003. Forest Inventory Report of Uukolonkadhi Community Forest. Namibia-Finland Forestry Programme, Directorate of Forestry, Namibia.

Kamwi, J. 2003. Inventory Report on the Woody Resources in Hans Kanyinga Community Forest. Namibia-Finland Forestry Programme, Directorate of Forestry, Namibia.

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Appendix 1. Diameter distribution for live trees in 1000s

| Species | 5-15 | 15-25 | 25-35 | 35-45 | 45-55 | 55-65 | 65-75 | 75-85 | 85-95 | Total | % of total |
|--|--------------|------------|------------|------------|------------|------------|------------|------------|------------|--------------|------------|
| <i>Acacia erioloba</i> | 66 | 1 | 2 | 5 | 1 | | | | 0 | 76 | 3.8 |
| <i>Acacia fleckii</i> | 116 | | 2 | 1 | | | | | | 119 | 6.0 |
| <i>Acacia nebrownii</i> | | 5 | | | 0 | | | | 0 | 6 | 0.3 |
| <i>Acacia nilotica</i> | | 4 | | | | | | | | 4 | 0.2 |
| <i>Baikiaea plurijuga</i> | 174 | 36 | 57 | 69 | 23 | 9 | 6 | 5 | 2 | 381 | 19.1 |
| <i>Berchimia discolor</i> | | | | | | 0 | | | | 0 | 0.0 |
| <i>Boscia albitrunca</i> | 4 | 6 | 5 | | | | | | | 16 | 0.8 |
| <i>Burkea africana</i> | 25 | 9 | 11 | 5 | 0 | | | | | 51 | 2.6 |
| <i>Combretum collinum</i> | 443 | 31 | 17 | 9 | 5 | 0 | 0 | | | 505 | 25.3 |
| <i>Combretum imberbe</i> | | | 2 | | | | | | | 2 | 0.1 |
| <i>Combretum molle</i> | 4 | 2 | | | | | | | | 6 | 0.3 |
| <i>Combretum psidioides (psidioides)</i> | 37 | | | | | | | | | 37 | 1.9 |
| <i>Combretum zeyheri</i> | 8 | | | | | | | | | 8 | 0.4 |
| <i>Commiphora angolensis</i> | 21 | 2 | | | | | | | | 23 | 1.1 |
| <i>Croton gratissimus</i> | 29 | | | | | | | | | 29 | 1.5 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 327 | | | | | | | | | 327 | 16.4 |
| <i>Erythrophleum africanum</i> | 33 | 5 | | | | | | | | 38 | 1.9 |
| <i>Guibourtia coleosperma</i> | | 1 | | 3 | | 1 | | 0 | | 6 | 0.3 |
| <i>Lonchocarpus capassa</i> | 17 | | | 1 | | | | | | 18 | 0.9 |
| <i>Lonchocarpus nelsii</i> | 178 | 32 | 4 | 1 | | | | | | 215 | 10.8 |
| <i>Ochna pulchra</i> | | | 1 | | | | | | | 1 | 0.1 |
| <i>Peltoporum africanum</i> | 8 | | | | | 0 | | | | 9 | 0.4 |
| <i>Pterocarpus angolensis</i> | 8 | 7 | 6 | 5 | 1 | | | | | 28 | 1.4 |
| <i>Terminalia sericea</i> | 83 | 4 | | | | | | | | 87 | 4.4 |
| <i>Ziziphus mucronata</i> | | | | 1 | | | | | | 1 | 0.1 |
| Total | 1,581 | 147 | 108 | 101 | 31 | 11 | 6 | 6 | 3 | 1,993 | |
| % of total | 79.3 | 7.4 | 5.4 | 5.1 | 1.5 | 0.6 | 0.3 | 0.3 | 0.2 | | 100 |

Appendix 2. Diameter distribution for dead trees in 1000s

| Species | 5-15 | 15-25 | 25-35 | 35-45 | 45-55 | 55-65 | 65-75 | 75-85 | 85-95 | Total | % of total |
|--|-------------|-------------|-------------|------------|------------|------------|------------|------------|------------|------------|------------|
| <i>Acacia ataxacantha</i> | 17 | | | | | | | | | 17 | 5.3 |
| <i>Acacia erioloba</i> | 4 | 8 | 1 | 2 | | | | | | 16 | 4.9 |
| <i>Acacia fleckii</i> | 37 | | | | | | | | | 37 | 11.8 |
| <i>Acacia tortillis</i> | 4 | | 1 | | | | | | | 5 | 1.6 |
| <i>Baikiaea plurijuga</i> | 17 | 18 | 19 | 17 | 4 | 2 | 2 | 0 | 1 | 79 | 25.0 |
| <i>Bauhinia petersiana</i> | 4 | 4 | | | | | | | | 8 | 2.6 |
| <i>Boscia albitrunca</i> | | | 1 | | | | | | | 1 | 0.3 |
| <i>Burkea africana</i> | 12 | 1 | 3 | 3 | | | | | | 20 | 6.3 |
| <i>Combretum collinum</i> | 33 | 4 | 3 | 2 | | | | | | 42 | 13.5 |
| <i>Combretum psidioides (psidioides)</i> | 4 | | | | | | | | | 4 | 1.3 |
| <i>Dichrostachys cinerea (Setulosa)</i> | 29 | | | | | | | | | 29 | 9.2 |
| <i>Erythrophleum africanum</i> | 17 | | 2 | | | | | | | 19 | 5.9 |
| <i>Guibourtia coleosperma</i> | | | 1 | | 1 | 0 | | | | 3 | 1.0 |
| <i>Lonchocarpus capassa</i> | | | 1 | | | | | | | 1 | 0.3 |
| <i>Lonchocarpus nelsii</i> | 4 | 4 | | | | | | | | 8 | 2.6 |
| <i>Pterocarpus angolensis</i> | | 2 | 2 | | | | | | | 4 | 1.3 |
| <i>Terminalia sericea</i> | 17 | 5 | | | | | | | | 22 | 6.9 |
| Total | 199 | 47 | 34 | 24 | 6 | 2 | 2 | 0 | 1 | 314 | |
| % of total | 63.2 | 14.8 | 10.9 | 7.6 | 1.8 | 0.7 | 0.6 | 0.1 | 0.3 | | 100 |