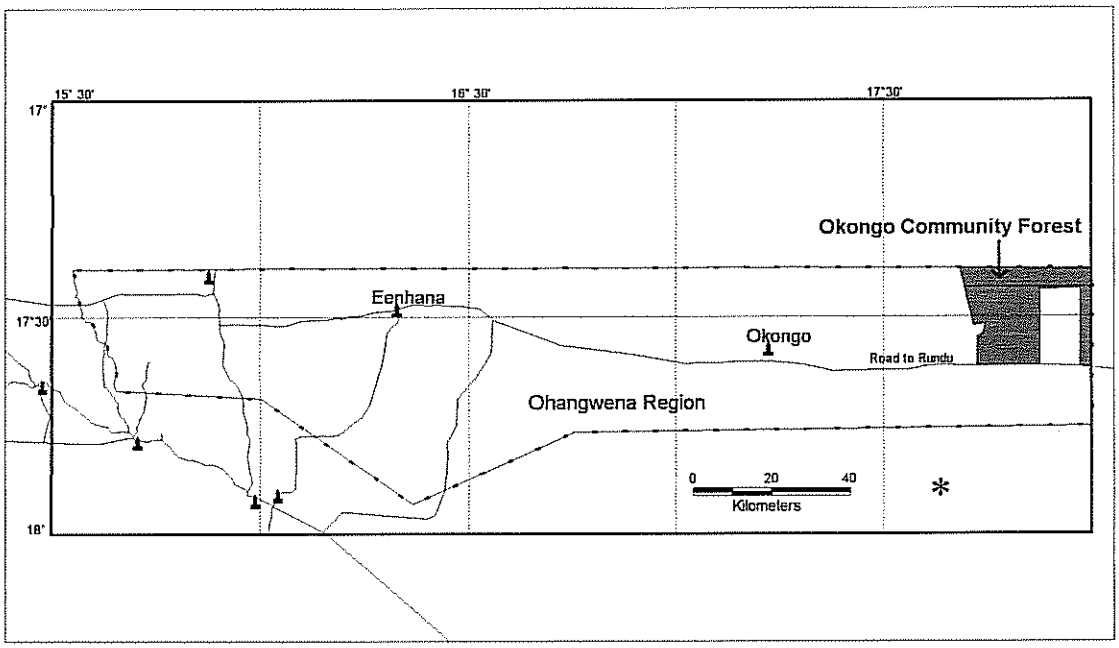
MINISTRY OF ENVIRONMENT AND TOURISM
Directorate of Forestry

Inventory Report on the Woody Resources in the Okongo Community Forest



Namibia Finland Forestry Programme
National Forest Inventory Sub-Component

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EXECUTIVE SUMMARY

The woody species
A total of 56 woody species were recorded in the Okongo Community Forest. 29 species were recorded as trees and 55 species were found in the shrub layer. 28 species were occurring both as trees and in the shrub layer. The species diversity in the Community Forest is high for Namibian conditions.

The most common species found in the tree layer were *Baikiaea plurijuga, Pterocarpus angolensis, Burkea africana, Combretum collinum and Terminalia sericea.* The most common species in the shrub layer were *Bauhia petersiana, Baphia massaiensis, Croton gratissimus, Combretum collinum, Ochna pulchra* and *Terminaria sericea.*

The vegetation types
There is a distinct tree layer on a considerable part of the Community Forest. Although only 2.3% of the area is classified as forest according to Edwards classification, most of the Community Forest (76%) would be classified as forest if the FAO classification would be used.

The woody vegetation is concentrated in the tree layer. But there are also considerable parts of the Community Forest were there is a shrub layer. However most of the shrub vegetation is growing under a tree layer. There are few areas in the Community Forest, where the woody vegetation is found only in the shrub layer. Only 5% of the Community Forest has no woody vegetation, i.e. areas classified as grassland or bare land

The forest resource
The total live tree volume in the Community Forest is 2.4 million m^3. The mean tree volume and the mean number of trees for the whole area are 43.2 m^3/ha and 209.8 stems/ha. There is quite a high amount of dead trees (deadwood) in the area. The total deadwood volume in the Community Forest is 310,800 m^3 or on average 5.6 m^3/ha. Hence, the mean tree volume including deadwood is 48.8 m^3/ha. The volumes and numbers of stems in the Community Forest are the highest found in any area inventoried in Namibia so far.

Almost 2/3 of the total tree volume in the area is from *Baikiaea plurijuga, Pterocarpus angolensus* and *Burkea africana.* The biggest volumes of deadwood are found among *Baikea plurijuga, Burkea africana, Guibourtia coleosperma, Combretum collinum* and *Erythrophleum africanum.*

The tree species in the Okongo Community Forest show a well-balanced diameter distribution, i.e. the bulk of the stems for most species are found in the small diameter classes.

Regeneration
There is on average 4603 shrubs and tree sapling per hectare in the shrub layer. Half of this amount is from species also occurring as trees in the Community Forest. Hence the regeneration of the tree species is quite good in the area. Of the 6 species most commonly found in the tree layer at the moment, only *Combretum collinum* and *Terminalia sericea* are among the most commonly found as saplings. *Baikiaea plurijuga* and *Burkea africana* saplings are found to some extent, while regeneration of *Pterocarpus angolensis* and *Schinziophyton rautanenii* is scarce.

This indicates that *Terminalia sericea* and *Combretum collinum* are going to be more dominating in the tree layer in the future than at present and that *Pterocarpus angolensis* is going to be scarce.

Okongo Community Forest and Caprivi State Forest are parts of the *Baikiaea plurijuga* woodland ecosystem in southern Africa. In both areas *Combretum collinum* and *Terminalia sericea* are very common among the regeneration. This might indicate a gradual change of the species composition in the tree layer of the *Baikiaea plurijuga* woodland ecosytem towards a more abundant occurrence of those species.

Damage to the woody vegetation

Fire is the most common cause of damage in the Community Forest. There were signs of fire damage on practically the whole area. However, most of the fire damages are mild, i.e. the damage is not affecting the vitality of the trees. Hence, the fire is not as big problem as in e.g. the Caprivi State Forest. Very little human activities in form of cutting were observed in the Community Forest.

Potential for economic utilization now and in the future

It is recognized that the woody resource can derive economic benefits from a number of products. But only the economic utilization for construction, carpentry and furniture is discussed here, and only two species, *Pterocarpus angolensis* and *Baikiaea plurijuga* are included.

The tree volume in the *Baikiaea plurijuga* trees with dbh > 45 cm is at the moment 67,100 m^3. Of this tree volume 10,500 m^3 is saw-log volume. The tree volume in the *Pterocarpus angolensis* trees with dbh > 45 cm is at the moment 48,100m3. Of this tree volume 15,340m^3 is saw-log volume. Branch wood and deadwood is not included in the saw-log figures presented above. There are relatively high concentrations of both *Baikiaea plurijuga* and *Pterocarpus angolensis* in the northern and eastern part of the Community Forest.

There is a potential for small-scale utilization of both *Baikiaea plurijuga* and *Pterocarpus angolensis* at the moment. The diameter distribution and the regeneration indicate that there is a potential for small-scale sustainable utilization of *Baikiaea plurijuga* also on long-term basis. Without management to enhance the poor regeneration of *Pterocarpus angolensis*, sustainable long-term utilization of this species looks bleak.

Some management proposals

Proper management is crucial for the utilization of the woody resources in the Community Forest to be sustainable. The management of the woody resources in the Community Forest should include at least the following:

- Management of the mature trees in form of calculation of Annual Allowable Cut to ensure a sustainable utilization.
- Management of the smaller trees for them to grow into mature trees.
- Management of the regeneration in form of both the management of existing seedlings and the management to enhance regeneration.
- Fire management.
- Integration of grazing, other farming activities and the utilization of Non Timber Forest Products into the planning.

1. INTRODUCTION

The information on Namibian forest resources has been limited on all levels (local, regional and national). Therefore, in 1995 the Directorate of Forestry in co-operation with FINNIDA started a National Forest Inventory (NFI) with the main aim to produce region level information on the woody vegetation in the communal lands of northern Namibia. In April 1997 the Directorate of Forestry began a comprehensive implementation of the Namibia Forestry Strategic Plan of 1996 by launching the Namibia-Finland Forestry programme. The NFI was incorporated as a sub-component, into this programme. The main objectives of the NFI are: (1) To produce regional level forest resource data on northern Namibia for strategic planning; (2) To produce more detailed forest resource data for strategic or operational management planning on sub region areas, and (3) To build Namibian capacity to carry out the inventories.

The utilization of information from different level of inventories is different. The region level inventories provide information on the forest resource for the entire region for region level planning. The sampling intensity is low, therefore information on very small units cannot be derived, and the results cannot be used for operational management. To get detailed information for operational management, local level inventories have to be carried out. Basically the information substance is similar for both region level and local level inventories. The sampling intensity in the local level inventories is high compared to the region level inventories, and the information is site specific to small units in the area inventoried.

The decision to prioritise the region level inventories in the Directorate of Forestry was decided at the initiation of the NFI in 1995. The logical sequence in developing forestry in the region is to first carry out a region inventory to determine the resource information for different uses in the region. If potential is determined, e.g. timber utilization, then the next step is to identify small areas for forest development and to carry out local level inventories in those local level areas identified.

This report presents the results from the inventory of Okongo Proposed Community Forest. The woody resource inventory was carried out on the request of the Community Forest. The data collected and the information presented in this report reflects the information need stated by the project manager at the time of the inventory design and fieldwork.

The results are presented for the Community Forest as one unit and are therefore not site-specific for certain smaller areas within the Community Forest. However, the spot maps in the Appendices provide site-specific information on vegetation types and volumes. It is possible to produce more site-specific information for certain areas within the Community Forest by analysing only clusters measured in that smaller area. Data for each sample plot is available in the Directorate of Forestry Headquarter in Windhoek.

Below is the listed resource reports so far produced within the NFI. The reports are all available at the Directorate of Forestry. The previous reports are:

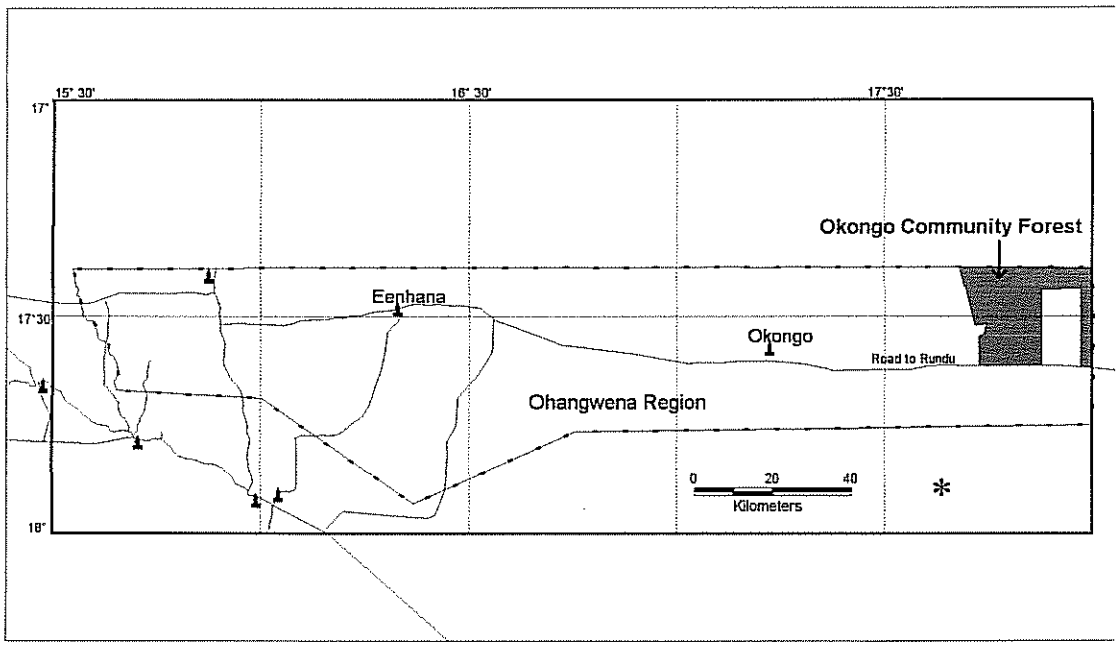
- Forest Inventory Report of Caprivi Region
- Inventory Report on the Woody Resources in the Omusati Region
- Inventory Report on the Woody Resources in the Oshana Region
- Woody Resources of Western Tsumkwe
- Woody Resources of East and South Tsumkwe, Otjinene and Okakarara Districts
- Forest Inventory Report on Uukwaludhi Community Forest

- Forest Inventory Report on Ongandjera Community Forest
- Forest Inventory Report on Caprivi State Forestry
- Inventory of the Directorate of Forestry Eucalyptus Plantations in Kavango Region
- Forest Inventory Report on Nkurenkuru Concession Area

2. GENERAL DESCRIPTION OF THE AREA

The Okongo Community Forest is located in the northeastern parts of the Ohangwena region, 49 km east of the Okongo settlement. The size of the Community Forest is 55,918 ha. The Community Forest is bordered to the north by the Angolan border and to the east by the Kavango region.

The Community Forest forms a part of the unique *Baikea plurijuga* woodlands found in Southern Africa. The woodlands are characterized by thick deposit of Kalahari sand.
Common tree species found are *Baikea plurijuga, Burkea africana, Pterocarpus angolensis, Combretum collinum* and *Terminalia sericea.*



Map 1. Location of the Okongo Community Forest

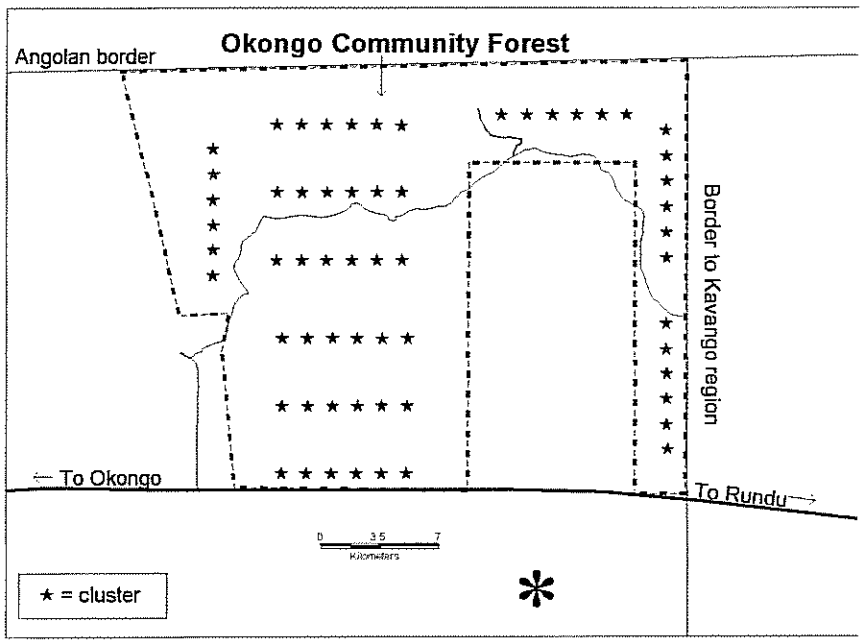
Namibia is one of the four SADC member states implementing the GTZ (German Agency for Technical Cooperation) sponsored project "Sustainable Management of Indigenous Forests". The project is a part of the SADC FSTCU Programme of Action. In Namibia the project started in 1 April 1998. The first phase of the project was completed in 31 March 2000. The Directorate of Forestry is the implementing agency, and the project is implemented in the Okongo Community Forest. The objectives of the project are to 1) improve the living standards of the communities in the area through sustainable management of the natural resources by the communities, and 2) to conserve the biodiversity in the area.

3. INVENTORY DESIGN

3.1 Sampling method

Okongo Community Forest is located on the following 3 quarter degree map sheets: 1717BC, 1717BD and 1717DB. The size of the Community Forest excluding the planned veterinary quarantine camp is 55,918 ha. The veterinary quarantine camp is 19,640 ha. Hence the total area including the veterinary camp is 75,518 ha. The area of the veterinary quarantine camp was excluded from this inventory. Stratified systematic plot sampling was used to estimate the quantity and quality of the woody resources in the Okongo Community Forest. Vegetation maps from DoF were used to stratify the area into 4 sampling strata. The sampling intensity was higher in strata with a more denser tree cover.

The total number of clusters located in the area was 60. Each cluster consists of 2 sample plots at the distance of 100 meters apart in the north-south direction. Therefore, a total of 120-sample plot were located in the area. The clusters were located in parallel lines. The line distance was 4 km and the cluster distance in one line was 1.5 km. The map below shows the locations location of clusters in the area.



Map 2: Location of clusters in Okongo Community Forest.

The clusters plotted on the Vegetation Maps were digitised using MapInfo software to obtain co-ordinates for each cluster. The co-ordinates and GPS were used for locating the clusters in the field. The map co-ordinates, reference ellipsoid and compass declination used when locating the cluster co-ordinates were:

- Datum: Schwartzeck
- Ellipsoid: Modified Bessel 1841
- Compass declination: 13.3 west of true north.

Both sample plots in each cluster are regarded as permanent measurement plots. They have co-ordinates and are marked in the field with an aluminium pole and can be re-located for remeasurements in future.
The co-ordinates are shown in appendix 1 for those who want to locate plots in the field. The co-ordinates are the locations of the first plot (the plot most to the south) in the cluster. To locate the second plot a compass and measurement tape was used.

3.2 Field measurements

The data is collected in circular sample plots. The woody vegetation is classified into trees and shrubs. In this inventory trees are defined as woody plants with dbh>5 cm and shrubs are woody plants with dbh<5 cm.

For tree measurements the size of the circular sample plot depends on the size of the tree (see Figure 2). For small trees (dbh 5 - 20 cm) the radius is 10 m, for medium size trees (dbh 20-45 cm) the radius is 20 m and for big trees (dbh>45 cm) the radius is 30 m.
Diameter, location, species, crown class, quality, length and quality of possible saw log were measured for all trees in all sample plots. The trees in the first plot of each cluster are called sample trees. For them also height, diameter of canopy, crown height, damages and phenology were recorded.

Shrubs, regeneration, coverage of grasses and herbs were measured in two sub-plots (radius 3.99m) located only in the first plot of each cluster (see Figure 2).

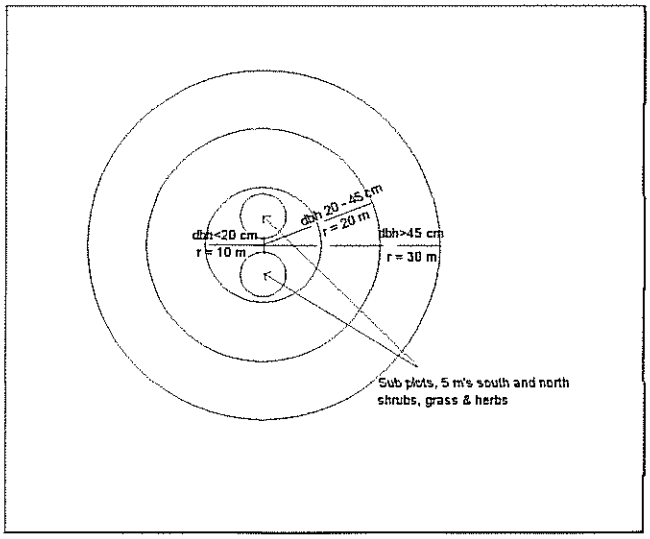


Figure 1: Plot Design

Information's describing the environment surrounding the sample plot ("the stand") was also recorded. This description includes e.g. the soil, the land type, damage to the woody vegetation and human influence. All the measurements are described in more detail in the field instructions (Field Instructions Western Bushman land 1996).

3.3 Stem analysis and volume functions

So far stem analysis for the development of volume functions has been carried out in West Tsunkwe, Caprivi and Omusati region. A total of 181 trees of the most common species have been felled and measured for this purpose. These volume functions were used also in the analysis of the data for Okongo Community Forest.

Volume functions have been developed only for the most common species. For the other species the volume functions were applied to estimate the volumes of those species. For other users who may wish to use the models, Appendix 6 (p. 54) shows which models that were applied to the species where no functions were developed.

4. INVENTORY RESULTS

4.1 Measured data

The inventory fieldwork in Okongo Proposed Community Reserve was carried out in April 1999. A total of 120 sample plots (60 clusters) were measured.

A total of 1489 trees with dbh> 5 cm were measured in the plots (see Table 1 p. 11), which is on average 12.4 trees per sample plot. This is a considerable large number of trees per sample plot compared to the other areas inventoried so far and indicates the comparatively well-developed woodland in the area. Out of the 1489 trees, 744 were sample trees, i.e. trees where additional variables were measured (see Chapter 3.2 "Field measurement" p. 8).

A total of 56 woody species were recorded in Okongo Community Forest. 29 were recorded as trees and 55 woody species were found in shrub layer. The most frequent species in the data were as follows:

Species (trees)	% of measured trees
Baikiaea plurijuga	30
Pterocarpus angolensus	18.1
Burkea Africana	10.6
Combretum collinum	6.8
Terminaria sericea	6
Schinziophyton rautanenii	5.8
Total	**77.3**

Species (shrubs)	% of measured shrubs
Bauhia petersiana	24.7
Baphia massaiensis	11.7
Croton gratissimus	8.3
Combretum collinum	6.7
Terminaria sericea	5.4
Ochna pulchra	3.6
Total	**60.4**

The most common tree species measured in the area was *Baikiaea plurijuga*. The table above indicates that 1/3 of the measured trees are from that species. On most of the areas inventoried in the 4 O's regions, one single species has been dominating, accounting for more than 2/3 of the measured trees. The figure above shows that this is not the case in Okongo Community Forest. The most common species *(Baikiaea plurijuga, Pterocarpus angolensis* and *Burkea africana*) accounts for more than half of the measured trees. Table 1 (p. 11) shows the total number of measured trees per species.

A total of 2924 shrubs were measured (see Appendix 3 "Total number of measured shrubs, p. 51). The 6 most common species represents 60% of the total measured shrubs. The situation is different from most of the other areas measured in the 4 O's, where the shrub layer is dominated by one or few species. Only two of the 6 most common species in the tree layer were found among the 6 most common shrub species. Of the 6 most common species in the shrub layer, two (*Baphia massaiensis* and *Bauhia petersiana*) are typical shrub species, i.e. they do not grow into tree size.

Table 1: Total number of measured trees and sample trees by species

Species	Total No. of measured trees	% of measured trees	Total No. of sample trees	% of sample trees
Baikiaea plurijuga	446	30.0	222	29.8
Pterocarpus angolensis	269	18.1	102	13.7
Burkea africana	158	10.6	85	11.4
Combretum collinum	101	6.8	55	7.4
Terminalia sericea	90	6.0	45	6.0
Schinziophyton rautanenii	86	5.8	61	8.2
Erythrophleum africanum	67	4.5	38	5.1
Guibourtia coleosperma	54	3.6	23	3.1
Lonchocarpus nelsii	48	3.2	22	3.0
Combretum psidioides (psidioides)	27	1.8	14	1.9
Combretum zeyheri	25	1.7	10	1.3
Commiphora angolensis	24	1.6	14	1.9
Ochna pulchra	20	1.3	10	1.3
Dichrostachys cinerea (Africana)	10	0.7	4	0.5
Ozoroa schinzii	10	0.7	7	0.9
Peltophorum africanum	10	0.7	4	0.5
Ozoroa paniculosa	8	0.5	7	0.9
Croton gratissimus	5	0.3	1	0.1
Pavetta zeyheri	5	0.3	5	0.7
Acacia erioloba	4	0.3	2	0.3
Dichrostachys cinerea (Setulosa)	4	0.3	4	0.5
Ozoroa longipes	4	0.3	4	0.5
Strychnos cocculoides	4	0.3	3	0.4
Strychnos pungens	3	0.2	1	0.1
Combretum engleri	2	0.1		0.0
Diplorhynchus condylocarpon	2	0.1		0.0
Boscia albitrunca	1	0.1		0.0
Ochna cinnebarina	1	0.1	1	0.1
Securidaca longepedunculata	1	0.1		0.0
Total	**1489**	**100.0**	**744**	**100.0**

4.2 Structure of the woody vegetation

4.2.1 The classification used

Edwards Vegetation Structural Types (Edwards 1983) is used for describing the structure of the woody vegetation (Appendix 5). This classification is based on the crown cover of the tree, shrub and grass layer and the height of the tree and shrub layer. The classification distinguishes 6 main classes; forest, woodland, thicket, bushland, shrubland and grassland. Each main class is further divided into sub-classes, e.g. short closed woodland, tall closed woodland, short open woodland and short closed woodland. The main classes in the classification of the vegetation structure by Edwards can briefly be described as follows:

Vegetation type	Description
Forest	Dense tree layer with few shrubs.
Woodland	The woody vegetation is in the tree layer. The shrub layer is sparse. Open and sparse woodland implies very little woody vegetation.
Thicket	The woody vegetation is in two layers, i.e. in both the tree layer and the shrub layer. As the name indicates, these areas are thick.
Bushland	The woody vegetation is in the shrub layer. But there is still trees scattered in the area. Hence, there is a scarce tree layer.
Shrubland	The woody vegetation is in the shrub layer. There are virtually no trees in the area. Open and sparse shrubland implies very little woody vegetation in any layer.
Grassland and herbland	The vegetation is in form of grasses and herbs. There is virtually no woody vegetation in the area.

The FAO classification of woody vegetation is commonly used in international reporting. The Edwards classification used in this report is more rigorous when it comes to defining forests than the FAO classification. The vegetation types "Closed Woodland" and "Short Thicket" in Edwards classification would be classified as forests in the FAO classification.

In the vegetation maps produced by the Directorate of Forestry a slightly different classification is used. Here there are 3 main vegetation types; forest, savanna and grassland. The height of the woody vegetation determines if the area is classified as forest or savanna. Forest and savanna are then classified according to their woody cover into "dense", "medium dense" etc. Therefore, also in this classification criteria and the classification in the vegetation maps is compatible with the Edwards classification.

4.2.2 The structure of the woody vegetation in the Okongo Community Forest

The structure of the woody vegetation is shown in tables 2 and 3 (page 13). There is a distinct tree layer on a big part (80%) of the Community Forest. The tree layer is rather dense. In fact on a small part (2.3% of the area) the tree layer is dense enough to be classified as forest according

to Edwards classification. However, in most parts the tree layer is classified as woodlands, i.e. not dense enough to be classified as forest according to Edwards classification.
Almost 2/5 of the area is classified as thicket, which implies dense woody vegetation in both layers, i.e. tree and shrub layer. Hence, by using the FAO classification, a total of 42395 ha will be classified as forest, which represents 76% of area.

The woody vegetation is concentrated in the tree layer. Hence there are few areas in the Community Forest, where the woody vegetation is found only in shrub layer. Less than 10% is classified as bushland or shrubland. Only 5% of the Community Forest has no woody vegetation, i.e. areas classified as grassland or bareland. Map 1 in Appendix 9 "Vegetation types in the Okongo Community Forest" (p. 57) shows the locations of the vegetation types in the Okongo Community Forest according to the clusters measured in the inventory. In Appendix 15 the different vegetation types are visualize by photos taken in the Community Forest.

Table 2: Area by vegetation structural types

Vegetation structure type	Area, in Ha	% of total area
Short Forest	1279	2.3
Tall Closed Woodland	4222	7.6
Short Closed Woodland	18712	33.5
Short Open Woodland	2565	4.6
Low Open Woodland	835	1.5
Short Thicket	18182	32.5
Low Thicket	2114	3.8
Short Bushland	1670	3.0
Low Bushland	1989	3.6
Tall Closed Shrubland	703	1.3
Low Closed Shrubland	835	1.5
Short Closed Grassland	703	1.3
Bare Land	2108	3.8
Total	55918	100.0

Table 3: Summary of vegetation structure types

Vegetation structure type	Area, in Ha	% of total area
Forest	1279	2.3
Woodland	26335	47.1
Thicket	20297	36.3
Bushland	3659	6.5
Shrubland	1538	2.8
Grassland	703	1.3
Bare Land	2108	3.8
Total	**55918**	**100.0**

Table 4 below (p. 14) shows the average, minimum and maximum height by species. The height of the woody vegetation is generally low. Only two species have an average height above 10 meters, namely Pterocarpus angolensus and Schinziophyton rautanenii.

The average height of the most common species (*Baikiaea plurijuga, Burkea africana* and *Pterocarpus angolensus*) is around 10m. The highest trees in the Community Forest were close to 20m and from the species *Pterocarpus angolensus* and *Schinziophyton rautanenii*.

Table 4: Average and maximum height by species

Species	Average height (m)	Minimum height (m)	Maximum height (m)
Acacia erioloba	5.9	5.5	6.2
Baikiaea plurijuga	9.2	1.3	16.7
Burkea africana	8.8	2.2	15.4
Combretum collinum	5.3	1.7	11.4
Combretum psidioides (psidioides)	5.2	2.6	13.9
Combretum zeyheri	5.0	2.4	7.8
Commiphora angolensis	5.0	1.5	6.6
Croton gratissimus	4.1	4.1	4.1
Dichrostachys cinerea (Africana)	4.7	4.1	6.0
Dichrostachys cinerea (Setulosa)	4.6	1.7	6.5
Erythrophleum africanum	8.2	3.0	13.4
Guibourtia coleosperma	9.5	5.3	16.0
Lonchocarpus nelsii	6.8	4.0	12.7
Ochna cinnebarina	7.0	7.0	7.0
Ochna pulchra	4.7	2.7	10.1
Ozoroa longipes	3.3	2.6	3.9
Ozoroa paniculosa	4.9	3.7	6.3
Ozoroa schinzii	3.4	3.0	3.6
Pavetta zeyheri	9.4	3.5	13.2
Peltophorum africanum	8.2	2.5	11.5
Pterocarpus angolensis	11.0	3.3	19.4
Schinziophyton rautanenii	10.4	4.1	18.5
Strychnos cocculoides	7.6	6.9	8.3
Strychnos pungens	5.1	5.1	5.1
Terminalia sericea	5.4	2.5	9.6

To sum up:

- On a considerable part of the Community Forest, there is a distinct tree layer, (80%). A tree layers dense enough to be classified as forest were found on a small part (2.3%).
- Less than 10% of the area is classified as shrublands or bushlands, i.e woody vegetation in the shrub layer and no tree layer.
- Areas with no woody vegetation are very few.

4.3 Species diversity

There are several measures of species diversity such as Simpson's dominance and Shannon's species diversity index that can be applied on the inventory data. Another simpler measure of species diversity is the number of species found in the area and the number of clusters where each species was found. Table 5 shows the number of clusters where each species was found for both trees (dbh>5 cm) and shrubs (dbh<5 cm).

Table 5: Species diversity by the number of clusters where each species was found

Species	No. of clusters, Dbh < 5 cm	No. of clusters, Dbh > 5 cm	Species	No. of clusters, Dbh < 5 cm	No. of clusters, Dbh > 5
Acacia ataxacantha	2		Grewia avellana	2	
Acacia erioloba	3	4	Grewia bicolor	2	
Acacia fleckii	5		Grewia flava	22	
Acacia polyacantha	1		Grewia retinervis	7	
Acacia schweinfurthii	6		Guibourtia coleosperma	2	18
Ancylanthos baniesii	1		Lonchocarpus nelsii	13	18
Baikiaea plurijuga	15	30	Markhamia acuminata	1	
Baissea wulfhorstii	7		Mundulea sericea	1	
Baphia massaiensis	42		Ochna cinnebarina		1
Bauhia petersiana	39		Ochna pulchra	29	14
Boscia albitrunca	2	1	Ozoroa insignis	2	
Burkea Africana	19	36	Ozoroa longipes	5	1
Combretum apiculatum (apiculatum)	8		Ozoroa paniculosa	11	3
Combretum collinum	34	34	Ozoroa schinzii	8	3
Combretum elaeagnoides	3		Pavetta zeyheri	2	1
Combretum engleri	13	1	Peltophorum africanum	1	3
Combretum psidioides (psidioides)	17	12	Pseudolachnostylis maprouneifolia	1	
Combretum zeyheri	19	15	Pterocarpus angolensis	4	30
Commiphora Africana	3		Rhigoszum brevispinosum	2	
Commiphora angolensis	13	6	Rhus tenuinervis	4	
Croton gratissimus	27	5	Schinziophyton rautanenii	4	22
Dialium engleranum	1		Securidaca longepedunculata	2	1
Dichapetalum cymosum	3		Steganotaenia araliacea	1	
Dichrostachys cinerea (Africana)	13	3	Strychnos cocculoides	4	2
Dichrostachys cinerea (Setulosa)	2	2	Strychnos pungens	5	2
Diplorhynchus condylocarpon	1	2	Terminalia sericea	36	24
Dombeya rotundifolia	2		Unknown2	2	
Erythrophleum africanum	11	16	Vangueria infausta	2	

A total of 56 woody species were recorded in Okongo Community Forest. 29 were recorded as trees and 55 woody species were found in shrub layer. 28 were occurring both as trees and in the shrub layer.

This is considerably large number of woody species recorded within a 55918 ha area. In Caprivi State Forest with an area of 146100 ha, only 45 woody species were recorded.
In Caprivi region: 74 species (2 million ha), Omusati region: 48 species (1.3 milliom ha) and Oshana region: 26 species (0.5 million ha) were recorded. This indicates that the species diversity in the Community Forest is rather high. On the other hand, almost half of the species found (41%) are quiet scarce, i.e. found in less than 5% of the measured clusters.

Baikiaea plurijuga, Burkea africana, Combretum collinum and *Pterocarpus angolensis* trees were found in more than half of the measured clusters. This means that the species are likely to be found in the tree layer in the considerable part of the Community Forest. *Pterocarpus angolensis* is considerably more widespread in Okongo Community Forest than in Caprivi State Forest, where *Pterocarpus angolensis* trees were found in 1/5 of the measured clusters.

Other species rather common in the tree layer are *Guibourtia coleosperma, Lonchocarpus nelsii and Schinziophyton rautanenii.*

Shrubs of *Bauhia petersiana, Baphia massaiensis, Combretum collinum, Ochna pulchra and Terminaria sericea* were found in more than half of the measured clusters. Taking into consideration that the woody vegetation in the Community Forest is concentrated to the tree layer, these species seems to occur in most of the areas with a shrub layer.

Baikiaea plurijuga, Burkea africana, Combretum collinum, Lonchocarpus nelsii and Terminaria sericea are rather common also in the shrub layer. This implies a rather good regeneration of these species. The regeneration is further discussed in Chapter 4.10 "Regeration of the trees".

4.4 Dominant species and species composition in the tree layer

Dominant species means the tree species that is the most common in the tree layer. The dominant species is derived from the crown coverage of each species in the measured sample plots. The species with the largest crown coverage in the sample plot is the dominant species.
Table 6 shows the dominant species in Okongo Proposed Community Forest. The table confirms the information presented in Chapter 4.1 "Measured data" (p. 10) and in Table 5 (p.15) on the species diversity. The species most commonly found in the Okongo Proposed Community Forest are logically also the species dominating the tree layer.

In more than 1/3 of the area, the dominant species is *Baikiaea plurijuga.* More than 2/3 of the area with a tree layer is dominated either by *Baikiaea plurijuga, Burkea africana, Pterocarpus angolensis* or *Combretum collinum.* This gives a clear indication that the tree layer in the Community Forest is mainly composed of the species mentioned above.

In Caprivi State Forest, *Baikiaea plurijuga* was dominating on 2/3 of the area. This means that there is a bigger species variation in the tree layer of Okongo Community Forest than in Caprivi State Forest.

Table 6: Area and %, of dominant species

Species	Area, in ha	% of total area
Baikiaea plurijuga	19772	37.7
Burkea africana	8326	15.9
Pterocarpus angolensis	6417	12.3
Combretum collinum	5382	10.3
Terminalia sericea	3208	6.1
Guibourtia coleosperma	2558	4.9
Schinziophyton rautanenii	1538	2.9
Peltophorum africanum	1286	2.5
Dichrostachys cinerea (Africana)	1279	2.4
Dichrostachys cinerea (Setulosa)	835	1.6
Lonchocarpus nelsii	835	1.6
Ozoroa schinzii	835	1.6
Total	**52272**	**100.0**

Table 7 (p. 18) shows how the species dominance varies in the different vegetation types in Okongo Community Forest. Note that only the six most common species are listed in the table. The table also further gives information on what kind of vegetation a certain species is likely to be found.

The areas with the most dense tree layer are dominated by *Baikiaea plurijuga.* However, *Baikiaea plurijuga* will be found in all vegetation types. *Burkea africana* is dominating in areas with a distinct shrub layer. *Combretum collinum* will be found dominating where there is an open

tree layer. Areas dominated by *Pterocarpus angolensus* will be found where there is a distinct tree layer.

Table 7: Area and % of dominant species in different vegetation types for the six most common species

	Forest		Woodland				Thicket		Closed Shrubland		Bushland	
			Closed		Open							
Species	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Burkea africana			1537.9	8.7			5249.9	36.5			1537.9	42.0
Baikiaea plurijuga	1279.2	100.0	12865.3	72.5			4792.6	33.3			835.2	22.8
Pterocarpus angolensis			3340.9	18.8			3075.8	21.4				
Combretum collinum					2114.4	100.0	1279.2	8.9	702.7	100.0	1286.1	35.1

Table 8 shows the species composition in the Community Forest based on which species that typically occur with a certain species. Two species are noted, i.e. even if there might be more than two species in the cluster, only the second species following the dominant species in crown coverage is noted. Hence, species composition here refers to which two species that are likely to be found together and the table does not give information on the total number of species or which species (more than the two most common) that are growing together. Note that this is the species composition for the tree layer only.

The table shows that no pure stands are to be found, but the species occurs in a mixture. Further, there are no clear patterns on which species that are growing together in the Community Forest.

Table 8: Species composition

Dominant species	Acacia eriolob a	Baiki aea plurij uga	Burk ea afric ana	Comb retum collinu m	Comb retum psidioi des	Comm iphora angole nsis	Erythr ophleu m african um	Lonch ocarpu s nelsii	No secon d domi nant	Ochna pulchr a	Pavett a zeyher i	Pteroc arpus angole nsis	Schinzio phyton rautane nii	Stryc hnos pung ens	Ter min alia seri cea	Total area of dominant species, in %
Baikiaea plurijuga				10	4	10		23		4		12	27		11	100
Burkea africana				32	15			25			8	10		8		100
Combretum collinum	16	24						24	13						24	100
Guibourtia coleosperma			50									50				100
Pterocarpus angolensis		50	13		11		26									100

Table 9 below shows the volumes and number of trees for the main vegetation types. The table further shows that the mean volume is high compared to other areas.

Table 9: Volumes and number of trees in the main vegetation types

	Forest	Woodland		Thicket	Closed Shrubland	Bushland
		Closed	Open			
Total No. of stems, 1000s	345.5	6320.1	255.5	4475.9	11.2	323.9
Stems per Ha	270	276	75	221	7	89
Total tree volume, 1000s	121.2	1418.8	26.5	798.8	0.3	49.8
Average tree volume, m3/ha	94.7	61.9	7.8	39.4	0.2	13.6

The volume in forest is close to 100 m^3/ha, which is very high and is twice as high as in the whole area. Even the volume for closed woodland is very high, 61.9 m^3/ha. The forest and closed woodlands together represent an area of 43% of the whole Community Forest. In other words, on almost half of the Community Forest there is a very high tree volume. Also the tree volume in thicket is quite high. Almost 80% of the area is classified either as forest, closed woodland or thicket. Therefore there is quite a high volume on a very big part of the Community Forest. The lowest tree volume is found in closed shrublands, where there are practically no trees. On the other hand, only 2.8% of the area in the Community Forest is closed shrublands.

Since the number of trees per hectare is more or less similar in forest, closed woodland and thicket, it is the size of the trees that are making the volumes to differ, i.e. bigger trees in forest and closed woodland than in thicket. A figure that describes the high amount of volumes in the Community Forest is the average volume in the open woodlands (7.8 m^3/ha). This volume is very low compared to the tree volumes in most of the Community Forest (forest, closed woodland and thicket), but it is more or less similar to the highest tree volumes found in both Omusati and Oshana regions.

In 1/3 of the measured clusters (20 clusters) the tree volume was greater than 60 m^3/ha. In more than half of the measured clusters (35 clusters) the tree volume was bigger than 30 m^3/ha. In 1/5 of the measured clusters (13 clusters) the volume was less than 10 m^3/ha. Therefore, although a considerable part of the Community Forest has high tree volumes, there is also quite big variation in the volumes in the area. Map 2 in Appendix 10 (p. 58) shows the distribution of the tree volumes in the Community Forest according to the locations of the measured plots. The map shows that the tree volumes are generally higher on the northern parts of the Community Forest.

Table 10 (p. 22) shows the number of stems and tree volumes by species for the whole Okongo Community Forest. Table 11 (p. 23) breaks down the information for the six most common tree species into stems and volumes for the main vegetation types in the area. Only living trees are

included in the tables. More information on volume distribution can be found in Appendix 4 (p. 52) "Diameter distribution of volumes by species".

The 5 most common species (*Baikiaea plurijuga, Pterocarpus angolensus, Burkea africana, Combretum collinum* and *Terminalia sericea*) count for 2/3 of the total number of stems in the Community Forest.
Combretum collinum and *Terminalia sericea* have high number of stems, but small volumes, because the bulk of the trees were found in small diameter classes. The species mostly utilised by the timber industry in Namibia are *Baikiaea plurijuga* and *Pterocarpus angolensis*. Half of the total tree volumes in the Community Forest are from the species mentioned above. Therefore there is a potential for timber utilisation in the Community Forest.

Table 10: Volumes and number of stems by species, totally and per ha

Species	Total No. of stems, 1000s	Stems per Ha	Total tree volume (1000 m^3)	Average tree volume, m3/ha
Baikiaea plurijuga	2790.2	49.9	847.7	15.2
Pterocarpus angolensis	1773.9	31.7	457.4	8.2
Burkea Africana	1217.7	21.8	228.0	4.1
Combretum collinum	1135.2	20.3	75.8	1.4
Terminalia sericea	1101.1	19.7	51.5	0.9
Lonchocarpus nelsii	551.0	9.9	67.7	1.2
Schinziophyton rautanenii	462.7	8.3	376.5	6.7
Erythrophleum africanum	461.4	8.3	59.2	1.1
Combretum psidioides (psidioides)	352.2	6.3	22.5	0.4
Combretum zeyheri	303.3	5.4	12.4	0.2
Commiphora angolensis	282.7	5.1	23.9	0.4
Ochna pulchra	245.9	4.4	16.0	0.3
Guibourtia coleosperma	243.7	4.4	94.3	1.7
Ozoroa schinzii	140.0	2.5	3.8	0.1
Ozoroa paniculosa	93.0	1.7	2.8	0.1
Ozoroa longipes	81.4	1.5	0.8	0.0
Strychnos cocculoides	81.4	1.5	11.1	0.2
Croton gratissimus	74.3	1.3	1.7	0.0
Dichrostachys cinerea (Africana)	71.3	1.3	7.5	0.1
Dichrostachys cinerea (Setulosa)	46.9	0.8	3.6	0.1
Peltophorum africanum	39.5	0.7	19.6	0.4
Strychnos pungens	37.8	0.7	2.6	0.0
Diplorhynchus condylocarpon	33.7	0.6	0.4	0.0
Acacia erioloba	31.6	0.6	8.4	0.1
Combretum engleri	22.4	0.4	1.3	0.0
Securidaca longepedunculata	20.4	0.4	1.2	0.0
Boscia albitrunca	13.3	0.2	1.2	0.0
Ochna cinnebarina	13.3	0.2	1.5	0.0
Pavetta zeyheri	10.9	0.2	14.8	0.3
Total	**11732.1**	**209.8**	**2415.4**	**43.2**

Table 11 shows the number of stems and volumes per vegetation type for the six most common species. Only the main vegetation types are included in the table. *Baikiaea plurijuga* counts for 70.1% of the average tree volume in the forest vegetation type. In closed woodland the bulk of the volumes are from *Baikiaea plurijuga* and *Pterocarpus angolensis*. In thicket 1/3 of the mean tree volume are from *Baikiaea plurijuga*. Thicket seems to have most heterogeneous composition when it comes to volumes.

Table 11: Volumes and number of stems for the dominant species in the main vegetation types

Main vegetation type	Dominat species	Total No. of stems, 1000s	Stems per Ha	Total tree volume, 1000s	Average tree volume, m3/ha
Forest	Baikiaea plurijuga	305.4	238.7	85.9	67.1
Closed Woodland	Baikiaea plurijuga	1760.2	76.7	494.5	21.6
	Pterocarpus angolensis	1273.4	55.5	292.4	12.7
	Terminalia sericea	609.0	26.6	33.4	1.5
	Burkea africana	458.5	20.0	98.6	4.3
	Combretum collinum	337.7	14.7	33.4	1.5
	Guibourtia coleosperma	187.6	8.2	68.6	3.0
Open Woodland	Combretum collinum	133.8	39.3	3.3	1.0
	Terminalia sericea	20.4	6.0	1.0	0.3
	Burkea africana	13.3	3.9	0.7	0.2
Thicket	Baikiaea plurijuga	718.0	35.4	260.7	12.8
	Burkea africana	640.1	31.5	116.3	5.7
	Combretum collinum	593.6	29.2	36.3	1.8
	Pterocarpus angolensis	480.5	23.7	158.6	7.8
	Terminalia sericea	471.8	23.2	17.1	0.8
	Guibourtia coleosperma	49.4	2.4	23.3	1.1

To sum up:

- There is a very high tree volume on a considerable part of the Community Forest. Okongo Community Forest is one of the few areas inventoried with a high tree volume in Namibia. It's by far the highest found in any inventory in the 4 O's regions.
- Almost half of the total tree volumes in the area are from *Baikiaea plurijuga* and *Pterocarpus angolensis.*
- Utilisation and management of the tree volumes found in the Community Forest are further discussed in Chapters 4.6 and 4.7.

4.6 Diameter distribution

A desired diameter distribution from management point of view is one were the bulk of the stems are in the lower diameter classes, and the number of stems gradually decreasing as the diameter gets bigger. With this kind of distribution there is continuously going to be trees entering into mature stage and a continuous harvesting of timber and poles will be possible. If the actual diameter distribution deviates from the desired one, it is bound to affect short or long term management decisions.

Table 12 (p. 25) shows the distribution of stems into diameter classes for the different species. Except providing information on the diameter distribution, Table 12 also gives indications on which tree species that have a potential to grow into big size trees in the area. Table 13 (p. 26) shows in more detail the diameter distribution of stems and volumes for 3 species, namely *Baikiaea plurijuga*, *Burkea africana* and *Pterocarpus angolensis* in the Okongo Community Forest. Note that the diameter distribution presented in this chapter includes only live trees. The diameter distribution of dead trees is presented in chapter 4.8 "Deadwood" (p. 32).

The tree species in the Okongo Community Forest show a well-balanced diameter distribution, i.e. the bulk of the stems for most species are found in the small diameter classes. Even for *Pterocarpus angolensis* the bulk of the stems were found in the small diameter classes. The situation for this species is different from other areas, e.g. Caprivi State Forest, where there was few trees found in the smaller diameter classes.

The biggest trees in the Community Forest are *Guibourtia coleosperma* and *Schinziophyton rautanenii*. This is similar to Caprivi State Forest. *Schinziophyton rautanenii* was found in all diameter classes, furthermore a considerable number of the trees were in small diameter classes. With proper management there is continuously going to be *Schinziophyton rautanenii* tree entering into mature stage. Therefore there is potential for fruit harvest of *Schinziophyton rautanenii* also in the future.

Baikiaea plurijuga, and *Pterocarpus angolensis* count for more than half of the total tree volume in the Community Forest. Since stem species are utilized by the timber industry, it's of importance to further analyze how the volume is distributed in the different diameter classes for those species. Table 13 (p. 26) shows this distribution. *Burkea africana* is included for comparison purposes.

Table 12: Diameter distribution of stems by species (1000s)

	Diameter class, in cm									
Species	5-15	15-25	25-35	35-45	45-55	55-65	65-85	85-125	Total	% of total
Baikiaea plurijuga	1091.6	1080.7	510.4	78.5	24.0	2.7	2.3		2790.2	23.8
Pterocarpus angolensis	914.6	482.1	266.1	92.5	12.9	4.2	1.5		1773.9	15.1
Burkea africana	641.3	471.5	87.1	16.3		1.5			1217.7	10.4
Combretum collinum	960.5	151.5	20.9		2.3				1135.2	9.7
Terminalia sericea	952.4	145.4	3.3						1101.1	9.4
Lonchocarpus nelsii	378.1	132.4	37.7	2.8					551.0	4.7
Schinziophyton rautanenii	237.2	101.6	36.7	24.4	19.2	9.8	15.2	18.7	462.7	3.9
Erythrophleum africanum	359.5	68.9	30.1	2.8					461.4	3.9
Combretum psidioides (psidioides)	317.9	31.5		2.8					352.2	3.0
Combretum zeyheri	287.1	16.3							303.3	2.6
Commiphora angolensis	217.6	57.2	7.9						282.7	2.4
Ochna pulchra	227.6	18.4							245.9	2.1
Guibourtia coleosperma	87.4	79.4	47.4	21.9	5.0	1.2		1.2	243.7	2.1
Ozoroa schinzii	140.0								140.0	1.2
Ozoroa paniculosa	93.0								93.0	0.8
Ozoroa longipes	81.4								81.4	0.7
Strychnos cocculoides	40.7	20.4	20.4						81.4	0.7
Croton gratissimus	74.3								74.3	0.6
Dichrostachys cinerea (Africana)	61.1	5.1		5.1					71.3	0.6
Dichrostachys cinerea (Setulosa)	33.7	13.3							46.9	0.4
Peltophorum africanum	11.2	7.9	18.1		2.3				39.5	0.3
Strychnos pungens	26.6	11.2							37.8	0.3
Diplorhynchus condylocarpon	33.7								33.7	0.3
Acacia erioloba	13.3	13.3		2.8	2.3				31.6	0.3
Combretum engleri	22.4								22.4	0.2
Securidaca longepedunculata	20.4								20.4	0.2
Boscia albitrunca	13.3								13.3	0.1
Ochna cinnebarina	13.3								13.3	0.1
Pavetta zeyheri			5.6	2.8		1.2		1.2	10.9	0.1
Total	7350.9	2908.1	1091.7	252.7	67.8	20.7	19.0	21.2	11732.1	
% of total	62.7	24.8	9.3	2.2	0.6	0.2	0.2	0.2		100

Table 13: Total tree volume and number of stems by diameter classes for *Baikiaea plurijuga*, *Burkea africana* and *Pterocarpus angolensis*

	Baikiaea plurijuga			Burkea africana			Pterocarpus angolensus		
Dbh class, cm	Total tree volume, 1000 m3	Total number of stems, 1000s	% of total stems	Total tree volume, 1000 m3	Total number of stems, 1000s	% of total stems	Total tree volume, 1000 m3	Total number of stems, 1000s	% of total stems
5-15	62.8	1091.6	39.1	38.0	641.3	52.7	69.3	914.6	51.6
15-25	266.0	1080.7	38.7	109.9	471.5	38.7	93.9	482.1	27.2
25-35	347.3	510.4	18.3	57.1	87.1	7.2	139.0	266.1	15.0
35-45	104.5	78.5	2.8	18.9	16.3	1.3	107.0	92.5	5.2
45-55	49.2	24.0	0.9			0.0	26.9	12.9	0.7
55-65	8.8	2.7	0.1	4.2	1.5	0.1	14.0	4.2	0.2
65-75	9.1	2.3	0.1			0.0	7.2	1.5	0.1
Total	847.7	2790.2	100.0	228.0	1217.7	100.0	457.4	1773.9	100.0

Table 13 shows that *Pterocarpus angolensis* is represented in all diameter classes. The bulk of the stems are in small sizes. *Baikiaea plurijuga* is represented in all classes up to 75 cm. Also of this species, the bulk of the stems are in small sizes. The table shows that *Burkea africana* is generaly smaller than both *Baikiaea plurijuga* and *Pterocarpus angolensis*. This is logical because *Burkea africana* generally never grow as big as *Baikiaea plurijuga* or *Pterocarpus angolensis*.

The limit for timber harvesting is 45 cm dbh. At the moment there is 67 100 m^3 or 1.2 m^3 /ha of *Baikiaea plurijuga*, 48 100m^3 or 0.86 m^3 /ha of *Pterocarpus angolensis* and 4 200m^3 or 0.08 m^3 /ha.of *Burkea africana* in the diameter classes that can be harvested. Note the figures above are the tree volume, not timber (saw-log) volume. The saw-log volumes of *Baikiaea plurijuga* and *Pterocarpus angolensis* are presented in Chapter 4.7 "Timber volumes and qualities". The figures in Chapter 4.7 show that 15% and 30% of the volume mentioned above for *Baikiaea plurijuga* and *Pterocarpus angolensis* respectively, are sawlog volumes.

The figures above of volume for harvestable trees per hectare are very small. However the maps in the appendices show that there is concentration of relatively high volumes of both *Baikiaea plurijuga* and *Pterocarpus angolensis* in the northern parts of the Community Forest.
With proper management there will be a considerable number of *Baikiaea plurijuga*, *Pterocarpus angolensis* and *Burkea africana* in the bigger diameter classes in the future. Hence the figures show potential for small-scale timber utilisation both on short term and long-term basis. This will be further discussed in Chapter 4.7 " Timber volumes and qualities".

Map 3 in Appendix 11 (p. 59) shows the distribution of *Baikiaea plurijuga* volumes according to plots measured in the inventory. The map further shows that *Baikiaea plurijuga* is concentrated on the eastern part of the Community Forest.

Map 4 in appendix 12 (p. 60) shows the distribution of *Pterocarpus angolensis* tree volumes according to the plots measured in the inventory. The map shows that *Pterocarpus angolensis* is concentrated to the northern and eastern part of the Community Forest.

To sum up:

- There is a well-balanced diameter distribution among the tree species found in Okongo Community Forest. Therefore with proper management, there will be mature trees to be utilised also in the future.
- The diameter distribution of the species utilised by the timber industry (*Baikiaea plurijuga* and *Pterocarpus angolensis*) is well balanced with the bulk of the stems in the lower diameter classes.
- The potential for small-scale utilisation of *Baikiaea plurijuga* and *Pterocarpus angolensis* at the moment is feasible.
- With proper management, there is going to be a potential for harvesting of *Baikiaea plurijuga* and *Pterocarpus angolensis* also in the future. In other words, if the woody resources of the Community Forest are managed properly, there is a potential for a steady flow of *Baikiaea plurijuga* and *Pterocarpus angolensis* timber now and in the future. Proper management means, sustainable utilisation of the *Baikiaea plurijuga* and *Pterocarpus angolensis* resources in the Community Forest.
- There is considerable number of *Schinziophyton rautanenii* in the small diameter classes. Therefore the potential for fruit tree harvest also in the future is possible.

4.7 Timber volumes and quality classification

The objectives of community based resource management are that, 1) the well being of the communities is improved and 2) the utilisation of the natural resource is sustainable. The woody resource supplies a number of products ranging from timber and poles to various non-timber products. Therefore, the well being of the local communities can be improved by the utilisation of different products. One of the income generating activities for the communities by managing the Okongo Community Forest might be the processing of standing trees into logs and sawn timber. It is recognised that the woody resource can derive economic benefits from a number of other purposes than sawn timber, e.g. pole production, fruits or woodcarving. This chapter however focuses on the potential for sawn timber production and does not try to estimate wood utilisation for other purposes.

To be able to determine the tree potential for utilisation of the woody resources for sawn timber production, the quantities of saw logs needs to be known. Since mainly *Pterocarpus angolensis* and *Baikiaea plurijuga* are utilised for this purpose, this chapter focuses on these species. However, it is important to note that there are also other species that can be utilised by the timber industry.

Timber volume or saw log volume means the volume of the part of the main trunk that has been regarded saw able. In the field, the dbh and length of the saw able trunk was recorded. The saw log volume was estimated assuming the log has a cylindrical form. The log lengths presented in the tables exclude deformed bases. To get the volume of sawn timber, the volume of residues has to be subtracted from the saw log volume.

It is recognised that, some of the big trees has thick branches that to a certain extent can be utilised as saw logs. But for simplicity in the classification in the field, it was decided not to include any branch wood into the timber volumes.

The quality classifications used in the inventory are as follows:

Good quality	There is at least 2m long straight stems without damages.
Medium quality	The stem is slightly curving or sweeping or having other damages but still having at least 2 m saw-able log.
Poor quality	It is possible to find only 1.2 - 2 m long log meeting the minimum timber quality requirement.
Not saw-able	The log is not saw-able and will probably never develop saw-able quality.

The timber volumes and qualities are presented in Tables 14 and 15 for *Baikiaea plurijuga* and *Pterocarpus angolensis*. The table includes only trees with dbh>45 cm, i.e. trees that can be harvested. Note that the tables also include dead trees. The volumes in Tables 14 and 15 are log volumes, not tree volumes. Hence the volumes are smaller than in Table 13, which shows the tree volumes.

Table 14: Status and quality of *Baikiaea plurijuga* trees with dbh>45 cm

Baikiaea plurijuga					
Status	**Quality**	**Stems per Ha**	**Total No. of stems, 1000s**	**Total log volume, 1000 m3**	**Average log volume, m3/ha**
Live tree	Good quality	0.11	6.00	1.94	0.03
Live tree	Poor quality	0.21	11.49	4.51	0.08
Live tree	Medium quality	0.14	7.70	4.05	0.07
Live tree	Not sawable	0.07	3.74		
Standing dead tree	No code	0.11	6.22		
Standing dead tree	Not sawable	0.02	1.24		
Total		**0.65**	**36.40**	**10.50**	**0.19**

There is 10 500 m^3 of *Baikiaea plurijuga* saw logs in the Community Forest. In this volume, only sawable tree volume is included. I.e. volumes from trees that are not regarded to be sawable due to defect like crooked or dead trees are not included. More than half of the above mentioned volume (6000 m^3) is classified to be of good or medium quality. I.e. logs of more than 2m can be cut and they are rather straight. More than every 10^{th} (13%) living tree can not be utilised as sawn timber due to poor quality (class, not sawable). Every fifth tree with a dbh>45 cm is dead.

10 500 m^3 might seen as a big volume. However, one should remember that Okongo Community Forest is a big area with *Baikiaea plurijuga* occurring on a considerable part of it. Map 5 in Appendix 13 (p. 61) shows the distribution of the sawlog volumes of *Baikiaea plurijuga* according to the plots measured in the inventory. The map shows that there are spots of rather high sawlog volumes in the northern and eastern parts of the Community Forest.

Comparing log volumes with tree volumes in Table 13 (p. 26) shows that 16% of the tree volume of *Baikiaea plurijuga* in the Okongo Community Forest is as sawable log volume. When sawn timber is produced, approximately 40% of the sawlog volume becomes sawn timber the rest is residues. Therefore there is approximatery 4 200 m^3 of sawn timber of *Baikiaea plurijuga* in the Community Forest at the moment. Considering the size of the area this is not much. In fact the concentration of *Baikiaea plurijuga* is smaller in Okongo Community Forest than in Caprivi State Forest, where average saw log volume was 2.69 m^3/ha.

There is a potential for a small-scale utilisation of the *Baikiaea plurijuga* resources in the Community Forest. Almost every third (30%) of *Baikiaea plurijuga* tree is not included in the utilisable volume due to either too bad quality or the fact that the tree is dead. Hence, the volumes to be utilised might be bigger. The dead wood is further discussed in Chapter 4.8 "Deadwood" (p. 32).

Table 15 (p. 30) shows timber volumes and quality of *Pterocarpus angolensis*. Note that the table shows only log volumes for harvestable trees, i.e. trees with dbh>45 cm.

Table 15: Status and quality of *Pterocarpus angolensis* trees with dbh>45 cm

Pterocarpus angolensis					
Status	**Quality**	**Stems/ha**	**Total No. of stems, 1000s**	**Total log volume, 1000 m3**	**Average log volume, m3/ha**
Live tree	Good quality	0.19	10.42	8.93	0.16
Live tree	Medium quality	0.10	5.67	5.13	0.09
Live tree	Poor quality	0.04	2.49	1.28	0.02
Total		**0.33**	**18.58**	**15.34**	**0.27**

There is a total of 15,340m^3 saw-log volume of *Pterocarpus angolensis* in the Okongo Community Forest. All living trees with dbh>45 cm were classified as good enough to be utilised for the timber industry (saw-able). Furthermore almost the whole volume (91% of the volume) is classified to be good or medium quality, i.e. logs of more than 2m can be cut from the trees and the logs are rather straight. There is in fact a bigger log volume of *Pterocarpus angolensis* than of *Baikiaea plurijuga* in the Community Forest.

Comparing log volumes with tree volumes in Table 13 (p. 26) shows that 32% of *Pterocarpus angolensis* tree volume is sawable log volume, i.e. volume that can be utilised by the timber industry. Therefore, the part of the tree volume that can be utilised by the timber industry (i.e. sawlog volume) is twice as high for *Pterocarpus angolensis* compared to *Baikiaea plurijuga.* When sawn timber is produced, approximately 40% of the sawlog volume becomes sawn timber the rest is residues. Therefore there is approximatery 6 100 m^3 of sawn timber of *Pterocarpus angolensis* in the Community Forest at the moment.

15 340 m^3 of logs seems like a high volume. But put on an average per hectare, the figure is rather small, 0.27 m^3/ha. Map 6 in Appendix 14 shows the distribution of the *Pterocarpus angolensis* sawlog volumes according to the plots measured in the inventory. The map shows that the sawlog volumes are concentrated to the northern and eastern parts of the area. Hence, although the average per hectare figure seems small (0.27 m^3/ha), there is concentration of relatively high volumes of *Pterocarpus angolensis* timber in the Community Forest.

Looking at the total volumes and the concentration of the volumes to the northern and eastern parts of the Community Forest, one can conclude that there is a potential for small-scale utilisation of the *Pterocarpus angolensis* resources for sawn timber in the Community Forest.

To sum up:

- The tree volume of *Baikiaea plurijuga* for trees with dbh>45 cm is bigger than for *Pterocarpus angolensis*, but the log volume for *Pterocarpus angolensis* is higher. The following are some reasons: 1) a bigger part of *Pterocarpus angolensis* trees can be utilised and 2) all *Pterocarpus angolensis* trees with dbh>45 cm are good enough to be utilised for timber.
- Almost every 3rd *Baikiaea plurijuga* tree is not included in the log volume due to either too bad quality or the fact that the tree is dead.
- Total log volumes of both species seems big. On the other hand, when put on per hectare basis the figures are small. However the maps in the appendices shows that the log volumes are concentrated to the northern and eastern part of the area.
- The bulk of the *Baikiaea plurijuga* and *Pterocarpus angolensis* trees are in the smaller diameter classes (<45 cm). Therefore there is continuously going to be trees entering into mature stage (dbh>45 cm).
- Therefore, there is potential for small-scale utilisation of *Pterocarpus angolensis* and *Baikiaea plurijuga* trees for sawntimber. But for this utilisation to be sustainable, proper management of the woody resources is of crucial importance.

  Proper management implies:

  a) Management of the harvest in form of e.g. calculates of Annual Allowable Cut (AAC).
  b) Management of the smaller trees for them to grow into mature trees.
  c) Management of the regeneration to get mature trees also in the future.

4.8 Deadwood.

In the presentation on volumes and diameter distributions in the previous chapters only living trees were included. The information on deadwood was excluded. "Dead wood" refers to trees that are dead. There is a considerable amount of dead trees in the Community Forest. In fact, 10 % of the measured trees in the inventory were found to be dead trees. Most of the dead trees (42 %) were from *Baikea plurijuga.* 3/4 of the dead trees found in the inventory were from *Baikea plurijuga, Burkea Africana, Erythrophleum africanum* or *Combretum collinum* (see also Appendix 2: "Status of Measured Trees", p. 50).

The table below shows the proportion of the measured trees that were dead among the most common species in the Community Forest. It shows that the proportion of dead trees among *Baikea plurijuga, Burkea africana, Combretum collinum, Erythrophleum africanum* and *Guibourtia coleosperma* is guite high. On the other hand, a very small proportion of the *Pterocarpus angolensis* trees were found to be dead. This is an interesting result, since there have been observations on dieback of *Pterocarpus angolensis* in the Oshikoto region.

Species	% of dead trees among the measured trees
Baikea plurijuga	15 %
Pterocarpus angolensis	2 %
Burkea africana	15 %
Combretum collinum	13 %
Terminalia sericea	10 %
Schinziophyton rautanenii	1 %
Erythrophleum africanum	22 %
Guibourtia coleosperma	17 %

Table 16 (p. 33) shows that the deadwood volume in the Community Forest is considerable, 318,000 m^3. Note that the volume functions for living trees were used to calculate the deadwood volumes. These volume functions are assuming a certain amount of branchwood, and therefore the wood volumes might be overestimated.

Also the number of dead stems is high in the area, on average 26 stems/ha. The biggest volumes of deadwood are found among *Baikea plurijuga, Burkea africana, Guibourtia coleosperma, Combretum collinum* and *Erythrophleum africanum.* Table 17 (p. 33) shows that the dead trees are small. 95% of the dead trees have a dbh smaller than 35 cm.

The German Development Service (DED) is as a part of their development co-operation programme "Community Forestry in Northeastern Namibia" doing research on the utilization of deadwood for carpentry. The species included in this research at the moment are *Baikea plurijuga, Burkea africana, Pterocarpus angolensis, Guibourtia coleosperma* and *Combretum*

imberbe. The results so far in the research are encouraging. Carpenters in Namibia already utilize deadwood from *Guibourtia coleosperma*.

If deadwood were found to be suitable as raw material for carpentry, this would give the wood a financial value. Considering the big volumes of deadwood in the Community Forest, the utilization of deadwood for carpentry would become an option for income generation by the communities in the area. It is worthwhile for the staff in the Okongo Community Forest to co-operate with the DED in this matter, and utilize the results from their research.

Table 16: Volume and number of stems of dead trees (totally and per ha)

Species	Total No. stems, 1000s	Stems per ha	Total volume (m^3), 1000s	Average tree volume, m^3/ha
Baikiaea plurijuga	429.6	7.7	139.2	2.5
Burkea africana	261.5	4.7	36.7	0.7
Commiphora angolensis	20.4	0.4	0.2	0.0
Combretum collinum	207.8	3.7	15.9	0.3
Combretum psidioides (psidioides)	13.3	0.2	0.5	0.0
Combretum zeyheri	20.4	0.4	0.2	0.0
Dichrostachys cinerea (Africana)	66.2	1.2	7.6	0.1
Dichrostachys cinerea (Setulosa)	13.3	0.2	1.5	0.0
Erythrophleum africanum	174.3	3.1	20.5	0.4
Guibourtia coleosperma	49.9	0.9	51.7	0.9
Lonchocarpus nelsii	5.1	0.1	5.7	0.1
Ochna pulchra	31.5	0.6	2.4	0.0
Ozoroa paniculosa	13.3	0.2	0.2	0.0
Peltophorum africanum	7.9	0.1	4.7	0.1
Pterocarpus angolensis	32.4	0.6	12.2	0.2
Schinziophyton rautanenii	2.3	0.0	6.6	0.1
Terminalia sericea	121.4	2.2	5.1	0.1
Total	**1470.4**	**26.3**	**310.8**	**5.6**

Table 17: Diameter distribution of dead stems by species (1000 stems)

	Diameter class, in cm									
Species	5-15	15-25	25-35	35-45	45-55	55-65	65-85	85-125	Total	% of total
Baikiaea plurijuga	168.2	176.1	57.8	20.1	2.5	5.0			429.6	29.2
Burkea africana	188.9	51.6	20.9						261.5	17.8
Combretum collinum	150.9	56.9							207.8	14.1
Combretum psidioides (psidioides)	13.3								13.3	0.9
Combretum zeyheri	20.4								20.4	1.4
Commiphora angolensis	20.4								20.4	1.4
Dichrostachys cinerea (Africana)	40.7	20.4		5.1					66.2	4.5
Dichrostachys cinerea (Setulosa)		13.3							13.3	0.9
Erythrophleum africanum	129.4	39.8	5.1						174.3	11.9
Guibourtia coleosperma	26.6	5.1	3.3	11.2			1.5	2.3	49.9	3.4
Lonchocarpus nelsii				5.1					5.1	0.3
Ochna pulchra	31.5								31.5	2.1
Ozoroa paniculosa	13.3								13.3	0.9
Peltophorum africanum		2.8	5.1						7.9	0.5
Pterocarpus angolensis	11.2	15.1		6.1					32.4	2.2

Schinziophyton rautanenii						2.3			2.3	0.2
Terminalia sericea	105.3	16.1							121.4	8.3
Total	920.0	397.1	92.2	47.6	2.5	7.2	1.5	2.3	1470	
% of total	62.6	27.0	6.3	3.2	0.2	0.5	0.1	0.2		100

4.9 Damage to the woody vegetation

Damages to the woody vegetation were recorded both at stand level, for the sampled vegetation unit (Table 16), and at tree level, for the measured sample trees. In the damage assesment for the stand level the damages were classified into 5 different classes; (1) no damage, (2) mild, (3) moderate, (4) serious and (5) fatal damage.
Table 16 shows the area in hectares of damages. Only two types of damages were observed and two different classes of severity of damage were recorded.

Table 18: Damage classification by severity

	Severity of damage			
Damaging agent	**Mild (ha)**	**Moderate (ha)**	**Total (ha)**	**% Of total area**
Forest fire	51948	1279	53227	**95**
Human	1286	703	1989	**4**
Areas without damage			703	**1**
Total	**53234**	**1982**	**55918**	
% Of total area	**95**	**4**		**100**

Fire is the most common cause of damage. There were signs of fire damage on 95% of the area. Most of the fire damages was however mild, i.e. the damage is not affecting the vitality of the trees. The other cause for damage on tree was human, i.e. cuttings. However cuttings are not very common. Signs of cutting was obseved only on 4% of the area. Furthermore most of the cuttings were not severe.

It is interesting to note that although every 10th of the measured trees in the inventory was found to be dead (see previous chapter), this is not reflected in the damage classification. The obvious reason for this is that the cause of the trees to be dead is not vissible in the form of a damage and hence not included in the damage classification.

To sum up:

- Fires seems to be rather common in the area, but they seem not to be very disastrous.
- Little human activities in form of cutting were observed in the area.
- The effect of fire in the Community Forest were not as serious as in Caprivi State Forest.

4.10 Regeneration of the trees

Regeneration plays a critical role in the renewal and perpetuation of forest/woodland ecosystems. Good regeneration of trees means that there is continuously going to be sufficient number of saplings growing into tree sizes, which in turn means later on trees entering into mature stage. For the utilization of the wooded areas this means that; (1) a continuous harvesting of timber or poles will be possible, (2) the supply of non-wood forest products (e.g. fruits, fodder etc.) will not decrease as the old trees are dying. If the generation is weak, it is going to affect the desired diameter distribution mentioned in Chapter 4.6 (p. 24) and hence also affects short or long-term decisions.

Okongo Community Forest joins Caprivi State Forest as a part of the unique *Baikiaea plurijuga* forest ecosystem in Southern Africa. So, it is extremely important to ensure the survival of the regeneration in order to maintain this important woodland.

Table 19 shows the estimated area covered by regeneration. Note that this table includes all species with dbh<5 cm. Therefore the table includes both saplings and shrubs. Saplings are small specimen of species that known to become trees and shrubs are specimen that do not grow into trees in the area. Hence Table 20 (p. 36) give information for the future timber management while Table 21 (p. 38) gives information for species that occur only as shrubs (dbh<5 cm).

Table 19: Extent of regeneration

Regeneration	Area, in ha	% of total area
No regeneration observed	2811	5.0
Seedlings or sprouts are present but only lower than 1.5 m	32658	58.4
Vital seedlings or sprouts higher than 1.5 m are present	20450	36.6
Total	55918	100.0

The regeneration is visible on almost the whole area. Although there is a distinct tree layer in most of the Community Forest, there is still a shrublayer of saplings and shrub species visible in the whole area.

Table 20 (p. 36) shows the regeneration in terms of number of seedlings by height classes and species. Note that this table includes only woody species that are known to grow into trees in the area.

The table shows that there are a considerable number of seedlings in the area. Most of the saplings are in the range of 50-150 cm. This means that there were very few small saplings found, which in turn indicates that the regeneration in the resent years most probably was rather poor. More than 2/3 of the seedlings are from 6 species only, namely (*Croton gratissimus, Combretum collinum, Terminalia sericea, Ochna pulchra, Erythrophleum africanum* and *Combretum zeyheri*). The regeneration among these species is good. The species mentioned above, i.e. species dominating

among the saplings, are not the same as the species at the moment most commonly found in the tree layer.

Table 20: Number of tree saplings per hectare by height classes and species (per ha)

	Height class, in cm									
Species	0-25	26-50	51-100	101-150	151-200	201-250	251-300	300+	Total	% of total
Croton gratissimus	15	28	122	152	47	33	2	8	407	17.6
Combretum collinum	25	48	87	82	65	12	8	2	328	14.2
Terminalia sericea	2	13	83	77	50	17	15	8	265	11.4
Ochna pulchra	22	20	55	48	23	5	5		178	7.7
Erythrophleum africanum		73	83	8	2	2	2	7	177	7.6
Combretum zeyheri	7	28	28	18	27	20	3	2	133	5.8
Ozoroa paniculosa	3	30	52	23	13	3		2	127	5.5
Combretum engleri	2	12	35	27	8	5			88	3.8
Baikiaea plurijuga	2	7	22	27	23	2	2	2	85	3.7
Burkea africana	10	20	28	18	8				85	3.7
Ozoroa longipes			12	35	2	22		7	77	3.3
Combretum psidioides (psidioides)		2	28	15	18	10	2		75	3.2
Ozoroa schinzii			22	32	5				58	2.5
Dichrostachys cinerea (Africana)	25		8	2		8		2	45	1.9
Lonchocarpus nelsii	5	7	13	7	8	2			42	1.8
Commiphora angolensis			15	17					32	1.4
Acacia crioloba		8	12	2					22	0.9
Strychnos pungens	3	5	5	2	2	2			18	0.8
Securidaca longepedunculata			12	3	2				17	0.7
Schinziophyton rautanenii	2		5	3		2		2	13	0.6
Strychnos cocculoides	2	3	2	3	2				12	0.5
Guibourtia coleosperma			5	2			2		8	0.4
Pterocarpus angolensis		2	3	2		2			8	0.4
Dichrostachys cinerea (Setulosa)					5	2			7	0.3
Pavetta zeyheri				2		2			3	0.1
Boscia albitrunca			3						3	0.1
Diplorhynchus condylocarpon			2						2	0.1
Peltophorum africanum				2					2	0.1
Total	123	307	742	607	310	148	40	40	2317	
% of total	5.3	13.2	32.0	26.2	13.4	6.4	1.7	1.7		100.0

Of the 6 species most commonly found in the tree layer at the moment, only *Combretum collinum* and *Terminalia sericea* are also commonly found as saplings. *Baikiaea plurijuga* and *Burkea africana* saplings are found to some extent, while *Pterocarpus angolensis* regeneration is scarce. *Schinziophyton rautanenii* saplings are also scarce.

The regeneration will determine which species that are to be common in the tree layer in the future. *Croton gratissimus* and *Ochna pulchra* are shrub species that occasionally grow into tree size, but they will mostly remain as shrubs. *Terminalia sericea* and *Combretum collinum* do not grow into very big trees in the area. If *Terminalia sericea* and *Combretum collinum* becomes more dominant than at present in the tree layer, it at the same time means a tree layer that is lower

and with less biomass than the present tree layer. Although the *Baikiaea plurijuga* and *Burkea africana* regeneration seems poor when looking a table 20, there are in fact twice as many seedlings of *Baikiaea prulijuga* as there are trees. There are four times as many *Burkea africana* seedlings as there are trees.
There are twice as many *Schinziophyton rautanenii* seedlings as there are trees. The regeneration for *Pterocarpus angolensis* is poor. There are at the moment twice as many trees as there are seedlings of that species.
Hence the following can be concluded on the species composition in the tree layer in the future;

- *Terminalia sericea* and *Combretum collinum* are most probably going to be more dominating in the tree layer than at present.
- *Pterocarpus angolensis* is most probably going to be scarce.
- Much depends on management. With proper management the existing seedling of *Baikiaea plurijuga, Burkea africana, Schinziophyton rautanenii* and *Pterocarpus angolensis* will grow into trees, and secure the existence of these species in the tree layer also in the future. But even with proper management of the existing seedlings, *Pterocarpus angolensis* role in the tree layer is going to decrease.

There are still quite a number of *Pterocarpus angolensis* trees in the smaller diameter classes (see Table 12 "Diameter distribution of stems by species", p. 25). Therefore *Pterocarpus angolensis* is going to be common in the tree layer as long as it takes for those trees to grow into mature trees and disappear from the tree layer (through utilization or dieback).

Okongo Community Forest and Caprivi State Forest are parts of the *Baikiaea plurijuga* woodland ecosystem in southern Africa. In both areas *Combretum collinum* and *Terminalia sericea* are very common among the regeneration. This might indicate a gradual change of the species composition in the tree layer of the *Baikiaea plurijuga* woodland ecosytem towards a more abundant occurrence of those species.

The present regeneration is the future mature trees, i.e. the possibilities in the future to derive benefits from the woody resources. With proper management it is going to be possible to derive benefits from the wooded area in Okongo Community Forest also in the future. But the efficiency of the management will determine how much the community will benefit in the future.
The role of proper management is crucial. The management implies here both 1) the management of existing seedlings and 2) the management to enhance regeneration.

To sum up:

- There is considerable big number of saplings.
- 2/3 of saplings consist of *Croton gratissimus, Combretum collinum, Terminalia sericea, Ochna pulchra, Erythrophleum africanum* and *Combretum zeyheri.*
- There are *Baikiaea prulijuga* and *Burkea Africana* saplings to some extent. *Pterocarpus angolensis* and *Schinziophyton rautanenii* are scarce.
- The species composition in the future depends on how the present seedlings are managed. But the role of *Pterocarpus angolensis* in the tree layer is bound to decrease.
- The role of management is crucial. Efficient management will ensure the possibility to derive benefits from forestry in Okongo Community Forest also in the future.

4.11 The shrub layer

Table 21 shows the number of seedlings for shrub species. Note that the table includes only the woody species, which do not appear as trees in the region. Hence, the combined total number of woody vegetation in the shrub layer is obtained by combining Tables 20 and 21.

There is a total of 55 species appearing in the shrub layer. Of these species, 29 also appear as trees (dbh>5 cm) and are analysed in Chapter 4.10 "Regeneration of trees". 27 species appearing only in the shrub layer are shown in Table 21.

There is on average 2607 shrubs per hectare in the shrub layer. This is a considerable big amount of shrubs. More than 2/3 of the shrubs are from *Bauhia petersiana* and *Baphia massaiensis*. *Bauhia petersiana* and *Baphia massaiensis* is dominating the shrub layer in a considerable part of northern Namibia, i.e in Caprivi and Omusati regions and Twumkwe district. Combining tables 20 and 21 give a total of 4924 shrubs and tree saplings per hectare in the shrub layer in the Community Forest.

Table 21: Number of shrub seedlings per hectare by height classes and species

	Height class, in cm									
Species	0-25	26-50	51-100	101-150	151-200	201-250	251-300	300+	Total	% of total
Bauhia petersiana	218	450	440	182	25	28	2	2	1347	51.7
Baphia massaiensis	32	68	183	197	75	17	2	3	577	22.1
Baissea wulfhorstii	97	22	2						120	4.6
Grewia flava	7	3	23	55	13	10			112	4.3
Combretum apiculatum (apiculatum)		3	25	37	7	7	2		80	3.1
Grewia avellana		62	2						63	2.4
Vangueria infausta		33		3					37	1.4
Combretum elaeagnoides		7	17	5	7				35	1.3
Dichapetalum cymosum	28		7						35	1.3
Grewia retinervis		5	7	17	3	3			35	1.3
Unknown2	3	3	10	8					25	1.0
Commiphora africana	2	5	13	3					23	0.9
Acacia schweinfurthii			2	7	3	7			18	0.7
Acacia fleckii			7	2	2	2	3	3	18	0.7
Dombeya rotandifolia			12	2					13	0.5
Ancylanthos baniesii	5			7					12	0.4
Rhigoszum brevispinosum				3	7	2			12	0.4
Rhus tenuinervis			3	7					10	0.4
Acacia ataxacantha				2			2	3	7	0.3
Grewia bicolor		2	3	2					7	0.3
Dialium engleranum			5						5	0.2
Mundulea sericea				3		2			5	0.2
Ozoroa insignis			2	3					5	0.2
Acacia polyacantha					2				2	0.1
Markhamia acuminata							2		2	0.1
Pseudolachnostylis maprouneifolia			2						2	0.1
Steganotaenia araliacea			2						2	0.1

Total	392	663	765	543	143	77	12	12	2607	
% of total	15.0	25.4	29.3	20.8	5.5	2.9	0.4	0.4		100.0

4.12 The grass and herbs layer

Tables 22 and 23 shows the grass and herb cover in the different vegetation types in the community forest. The inventory field work was carried out in April 1999, hence the grass and herbs cover reflects the situation during that period.

Table 22: Cover of grasses per vegetation type

	Vegetation group						
	Forest	**Closed Woodland**	**Open Woodland**	**Thicket**	**Bushland**	**Closed Shrubland**	**Grassland**
Average % cover of grass	7.0	29.6	22.2	25.7	38.8	17.0	12.0
% of inventory area	2.3	41.0	6.1	36.3	6.5	2.8	1.3

Grass cover is high in bushland and closed woodland. Grass is covering 1/4 of the soil in almost the whole area. This is a moderately high grass cover. This reflects that the inventory was carriied out in the beginning of the dry season.

Table 23: Cover of the herbs per vegetation type

	Vegetation type						
	Forest	**Closed Woodland**	**Open Woodland**	**Thicket**	**Closed Shrubland**	**Bushland**	**Grassland**
Average % cover of herbs	9.0	10.0	6.2	6.4	6.5	8.5	9.0
% of inventory area	2.3	41.0	6.1	36.3	2.8	6.5	1.3

The highest herbs cover can be found in the closed woodland, forest and grassland. In fact, the herbs cover is very low compare to grass cover.

4.13 Human influence

4.13.1 Cutting

The information on the cutting was obtained by observing the area in and surrounding the sample plots. Hence, this information is describing the situation in the stand where the sample plots are located.

No cutting was observed in the area. This implies that there is little utilisation if the woody resources in the area.

4.13.2 Utilisation of land for agricultural purposes

The information on grazing was obtained by observing in the lower vegetation and on branches of trees and bushes in and surrounding the sample plots. Hence, this information is describing the situation in the stand where the sample plots were located. Furthermore the intensity of grazing was noted.

Table 24 shows the intensity of grazing. The table shows that a considerable big part of the Community Forest is utilized for grazing. The grazing is not very intensive. The time of the inventory must be taken into consideration as it has an effect on the results. Therefore, the effects of grazing would most probably be classified as more severe if the inventory would be carried out later on the dry season.

Table 24: Grazing

Grazing intensity	Area, in Ha	% of total area
No signs of grazing observed	9160	16
Moderate signs of grazing visible, vegetation still vital	38426	69
Signs of intensive grazing visible, vegetation vitality threatened	8333	15
Total area	**55918**	**100**

4.13.3 Fencing

5% of the area was found to be fenced off. This is not much, however this is a Community Forest and not supposed to be fenced at all. That means the fenced off areas in the Community Forest are illegal.

To sum up:

- The Community Forest is first and foremost a grazing area.
- The wood in the area is not utilised, not even for poles.

- There is a considerable value in the woody resource in the area. This value is so far untapped and can derive considerable benefits to the communities.
- When planning and imprement the utilisation of the woody resources in the Community Forest, the utilisation of the area for grazing has to be taken into consideration.

4.14 Sampling error and confidence limits

4.14.1 General

Source of error
In sampling based forest inventories the following error sources are always present: sampling error, measurement error including coding error, errors in data processing and errors in models used for e.g. volume estimation.

Training
In this work, specific attention was paid to guarantee good quality field data. Field personnel were continuously trained on-the-job in forest measurements and plant identification. The field team attended a course on species identification at the National Botanical Research Institute during 1998. Field instructions were reviewed both in the office and in the field. Data processing programs were carefully designed and double checked. Several cross checkings were done to find out possible errors and inconsistencies in the data. The data processing and analysis, and reports were double checked.

Volume functions
The applied volume functions are propably the main source of errors. There was no tree felled in Okongo Community Forest. Instead we use the existing volume functions to estimate the volumes. Stem analysis were done only for Caprivi, Omusati and West Tsumkwe.

Sampling error estimator
The magnitude of sampling error, Table 25, was estimated with the formula of stratified random sampling, using clusters but not sample plots, as sampling units. The applied sampling method was systematic, not random, but the formula is more or less valid. However, the formula may over estimate the sampling error.

4.14.2 Sampling error and confidence limits for tree volume

Table 25 (p. 42) shows the sampling error and confidence limits for tree volume for 'all species', *Baikiaea plurijuga, Burkea africana* and *Pterocarpus angolensis.* For the estimate of average tree volume per hectare of "all species" the sampling error was 4.09 m^3/ha, that is, 9.48% of the average. Therefore, the true average tree volume for all species is between 32 and 52 m^3/ha with the probability of 95%.

The sampling error for the average tree volume per hectare of *Baikiaea plurijuga, Burkea africana* and *Pterocarpus angolensis* were as follows: 2.66 m^3/ha (17.52%), 0.77 m^3/ha (18.84%) and 1.57 m^3/ha (19.13%) respectively. Hence, the average trees volume of *Baikiaea plurijuga, Burkea africana* and *Pterocarpus angolensis* were between 9.95 and 20.36; 2.57 and 5.58 and 5.11 and 11.25 m^3/ha with the probability of 95%, respectively.

Table 25: Sampling error and confidence limits for tree volume for the whole area

Species	Sampling variance	Standard error, m3/ha	Average volume, m3/ha	Sampling error, %	Lower confidence limit, m3/ha	Upper confidence limit, m3/ha	Confidence level, %
All species	16.75	4.09	43.19	9.48	35.17	51.22	95
Baikiaea plurijuga	7.05	2.66	15.16	17.52	9.95	20.36	95
Burkea africana	0.59	0.77	4.08	18.84	2.57	5.58	95
Pterocarpus angolensis	2.45	1.57	8.18	19.13	5.11	11.25	95

4.14.3 Sampling error and confidence limits for sawlog volume

Table 26: Sampling error and confidence limits for saw log timber volume for the whole area

Species	Sampling variance	Standard error, m3/ha	Average volume, m3/ha	Sampling error, %	Lower confidence limit, m3/ha	Upper confidence limit, m3/ha	Confidence level, %
Baikiaea plurijuga	0.26	0.51	2.77	18.54	1.76	3.78	95
Baikea africana	0.02	0.15	0.67	22.07	0.38	0.96	95
Pterocarpus angolensis	0.30	0.54	2.63	20.69	1.56	3.70	95

The sampling error for the average saw log volume per hectare of *Baikiaea plurijuga, Burkea africana* and *Pterocarpus angolensis* were as follows: 0.51 m^3/ha (18.54%), 0.15 m^3/ha (22.07%) and 0.54 m^3/ha (20.69%) respectively. Hence, the average saw log timber volume of *Baikiaea plurijuga, Burkea africana* and *Pterocarpus angolensis* were between 1.76 and 3.78; 0.38 and 0.96 and 1.56 and 3.70 m^3/ha with the probability of 95%, respectively.

5. CONCLUSION

The Okongo Community Forest is located in the northeastern parts of the Ohangwena region. The size of the area is 55,918 ha. The Community Forest forms a part of the unique *Baikea plurijuga* woodlands found in Southern Africa.

The Okongo Community Forest is a part of the GTZ (German Agency for Technical Cooperation) sponsored project "Sustainable Management of Indigenous Forests" currently implemented in four SADC member states. The woody resource inventory was carried out on the request of the Community Forest. The data collected and the information presented in this report reflects the information need stated by the project manager at the time of the inventory design and fieldwork.

The woody species
A total of 56 woody species were recorded in the Okongo Community Forest. 29 species were recorded as trees and 55 species were found in the shrub layer. 28 species were occurring both as trees and in the shrub layer. The number of woody species recorded is higher than in Caprivi State Forest or any of the inventories carried out in the 4 O's regions. Therefore, the species diversity in the Community Forest is high for Namibian conditions.

Furthermore, there is a number of woody species that are rather widespread throughout the Community Forest. Hence the situation is different from most of the areas inventoried in the 4 O's regions, where one single species has been dominating in the tree layer and one or a few species dominating in the shrub layer. The most common species found in the tree layer were *Baikiaea plurijuga, Pterocarpus angolensis, Burkea africana, Combretum collinum* and *Terminalia sericea.* The most common species in the shrub layer were *Bauhia petersiana, Baphia massaiensis, Combretum collinum, Ochna pulchra* and *Terminaria sericea.*

The vegetation types
Edwards classification was used to classify the woody vegetation into structural vegetation types. There is a distinct tree layer on a considerable part of the Community Forest. Although only 2.3% of the area is classified as forest according to Edwards classification, most of the Community Forest (76%) would be classified as forest if the FAO classification would be used.

The woody vegetation is concentrated in the tree layer. But there are also considerable parts of the Community Forest were there is a shrub layer. However most of the shrub vegetation is growing under a tree layer, hence classified as thicket according to the Edwards classification. There are few areas in the Community Forest, where the woody vegetation is found only in the shrub layer. Only 5% of the Community Forest has no woody vegetation, i.e. areas classified as grassland or bare land.

The forest resource
The total tree volume in the Community Forest is 2.4 million m^3. The mean tree volume and the mean number of trees for the whole area are 43.2 m^3/ha and 209.8 stems/ha.

On almost half of the Community Forest (43%) the average tree volume is 63.6 m^3/ha. Note that these figures include only live trees. There is quite a high amount of dead trees (deadwood) in the area. The total deadwood volume in the Community Forest is 310,800 m^3 or on average 5.6 m^3/ha. Hence the mean tree volume including deadwood in the Community Forest is 48.8 m^3/ha. There might be some over-estimation of the deadwood volumes due to the volume functions used.
The volumes and numbers of stems in the Community Forest are very high for Namibian conditions. For example, the mean tree volume and mean number of stems in Caprivi State Forest were 33.3 m^3/ha and 70.6 stems/ha. The figures are even higher than for the concession area inventoried in Nkurenkuru in 1998, where the mean volume was 38 m^3/ha. In fact, the average volumes in the Okongo Community Forest are the highest found in any area inventoried in Namibia so far.

Almost 2/3 of the total tree volumes in the area are from *Baikiaea plurijuga, Pterocarpus angolensus* and *Burkea africana*. The biggest volumes of deadwood are found among *Baikea plurijuga, Burkea africana, Guibourtia coleosperma, Combretum collinum* and *Erythrophleum africanum*. The dead trees are small, more than 90% of them have a dbh smaller than 35 cm.

The tree species in the Okongo Community Forest show a well-balanced diameter distribution, i.e. the bulk of the stems for most species are found in the small diameter classes. In other areas inventoried one worry has been the undesired diameter distribution of *Pterocarpus angolensis*, with few trees found in the smaller diameter classes. This is not the case in the Community Forest, where even for this species the bulk of the stems were found in the small diameter classes.

Regeneration
Regeneration plays a critical role in the renewal and perpetuation of forest/woodland ecosystems. Good regeneration of tree species means that there is continuously going to be sufficient number of saplings growing into tree sizes, which in turn means later on trees entering into mature stage. The regeneration is the factor that is going to determine the species composition in the Okongo Community Forest in the future.

There is on average 4924 shrubs and tree sapling per hectare in the shrub layer. Half of this amount is from species also occurring as trees in the Community Forest. Hence the regeneration of the tree species is quite good in the area. However, the tree species with the best regeneration are not the same species as the species at the moment most common in the tree layer. Of the 6 species most commonly found in the tree layer at the moment, only *Combretum collinum* and *Terminalia sericea* are among the most commonly found as saplings. *Baikiaea plurijuga* and *Burkea africana* saplings are found to some extent, while regeneration of *Pterocarpus angolensis* and *Schinziophyton rautanenii* is scarce.

This indicates that *Terminalia sericea* and *Combretum collinum* are going to be more dominating in the tree layer in the future than at present and that *Pterocarpus angolensis* is going to be scarce. Okongo Community Forest and Caprivi State Forest are parts of the *Baikiaea plurijuga* woodland ecosystem in southern Africa. In both areas *Combretum collinum* and *Terminalia sericea* are very common among the regeneration.

This might indicate a gradual change of the species composition in the tree layer of the *Baikiaea plurijuga* woodland ecosytem towards a more abundant occurrence of those species.

However, the future species composition in the Community Forest depends on the management of the regeneration. There are in fact much more saplings than trees of *Baikiaea plurijuga*, *Burkea africana* and *Schinziophyton rautanenii*. If these saplings are well taken care of, these species are going to be a common sight in the Community Forest also in the future.

Damage to the woody vegetation

Fire is the most common cause of damage in the Community Forest. There were signs of fire damage on practically the whole area. However, most of the fire damages are mild, i.e. the damage is not affecting the vitality of the trees. Hence, the fire is not as big problem as in e.g. the Caprivi State Forest. Very little human activities in form of cutting were observed in the Community Forest.

Although every 10th of the measured trees in the inventory was found to be dead this is not reflected in the damage classification. The obvious reason for this is that the cause of the trees to be dead is not visible in the form of a damage and hence not included in the damage classification.

Potential for economic utilization now and in the future

It is recognized that the woody resource can derive economic benefits from a number of other products than sawn timber, e.g. pole production, fruits or woodcarving. The discussion on economic utilization is here restricted to fulfill the information need stated by the project manager at the time of the inventory design and fieldwork. Therefore, the focus is on the potential for sawn timber production and does not try to estimate the woody resource utilization for other purposes.

The woody species at the moment commonly used in construction, carpentry and furniture making are *Pterocarpus angolensis* and *Baikiaea plurijuga*. The former is by far the most attractive for the industry. Although the economic utilization of only these two species is discussed here, there are also other species used at the moment e.g. *Burkea africana* and *Guibourtia coleosperma*. There might be a potential to use also other species for carpentry and furniture making and to increase the use of deadwood. This would increase the economic value of the woodlands and therefore this should be a research priority within the Directorate of Forestry. The German Development Service (DED) is as a part of their development co-operation program "Community Forestry in Northeastern Namibia" doing research on the utilization of deadwood for carpentry.

The limit for timber harvesting is 45 cm dbh. The tree volume in the *Baikiaea plurijuga* trees with dbh > 45 cm is at the moment 67,100 m^3 in the Community Forest. Of this tree volume 10,500 m^3 is saw-log volume. The tree volume in the *Pterocarpus angolensis* trees with dbh > 45 cm is at the moment 48,100m3. Of this tree volume 15,340m^3 is saw-log volume. The saw-log volume includes only the main trunk. Since some of the big trees have thick branches that to a certain extent can be utilized as saw logs, the saw-log volumes might be underestimated.
On the other hand, non-visible defects inside the trees were not taken into consideration when calculating the saw-log volumes.

The tree volume of *Baikiaea plurijuga* for trees with dbh>45 cm is bigger than for *Pterocarpus angolensis*, but the log volume for *Pterocarpus angolensis* is higher. This is because the *Pterocarpus angolensis* trees are of better quality, i.e. a bigger part of the tree can be utilized, and all *Pterocarpus angolensis* trees with dbh>45 cm are good enough to be utilized for timber which is not the case for *Baikiaea plurijuga.*

When sawn timber is produced, approximately 40% of the saw-log volume becomes sawn timber the rest is residues. Therefore there is approximately 4 200 m^3 of sawn timber of *Baikiaea plurijuga* and 6 100 m^3 of sawn timber of *Pterocarpus angolensis* in the Community Forest at the moment.

A total saw-log volume of both species seems big. On the other hand, when put on per hectare basis the figures are small. However there are relatively high concentrations of both *Baikiaea plurijuga* and *Pterocarpus angolensis* in the northern and eastern part of the Community Forest. Furthermore, branch wood and deadwood is not included in the saw-log figures presented above. There is quite an amount of deadwood of *Baikiaea plurijuga* in the area. This wood is ready for utilization. Therefore there is potential for small-scale utilization of *Pterocarpus angolensis* and *Baikiaea plurijuga* trees for construction, carpentry and furniture making at the moment.

The diameter distribution of both *Baikiaea plurijuga* and *Pterocarpus angolensis* trees are well balanced with the bulk of the stems in the lower diameter classes. With proper management these smaller trees are going to grow into mature trees. Therefore, there is a potential for small-scale utilization of both species also in the future, at least as long as it takes for the trees that at present are small to grow into mature trees.

The present regeneration is the future mature trees. The regeneration of *Baikiaea plurijuga* is reasonable, while the regeneration of *Pterocarpus angolensis* is scarce. Looking at the longterm utilization, there is going to be a potential for utilization of *Baikiaea plurijuga.* Without management to enhance the regeneration of *Pterocarpus angolensis*, the longterm utilization of this species looks bleak.

Therefore:

- There is a potential for small-scale utilization of both *Baikiaea plurijuga* and *Pterocarpus angolensis* at the moment.
- The diameter distribution and the regeneration indicate that there is a potential for small-scale sustainable utilization of *Baikiaea plurijuga* also on long-term basis.
- Without management to enhance the poor regeneration of *Pterocarpus angolensis*, sustainable long-term utilization of this species looks bleak.

Some management proposals

There is a potential for small-scale utilization of *Baikiaea plurijuga* and *Pterocarpus angolensis*. Proper management is crucial for this utilization to be sustainable. This goes also for any other species that is going to be utilized in the Community Forest.

The management of the woody resources in the Community Forest should include at least the following:

- Management of the mature trees in form of calculation of Annual Allowable Cut to ensure a sustainable utilization.
- Management of the smaller trees for them to grow into mature trees.
- Management of the regeneration in form of both the management of existing seedlings and the management to enhance regeneration.
- Fire management.
- Integration of grazing, other farming activities and the utilization of Non Timber Forest Products into the planning.

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Appendix 1: Cluster coordinates for Okongo Community Forest

Note: Coordinates are in decimal degrees.

Map sheet	Cluster	Latitude	Longitude
1717BC	1	-17.4979	17.7348
1717BC	2	-17.4842	17.7348
1717BC	3	-17.471	17.7349
1717BD	4	-17.4575	17.7346
1717BD	5	-17.4436	17.7349
1717BD	6	-17.4299	17.7347
1717BD	7	-17.4886	17.9887
1717BD	8	-17.4749	17.9886
1717DD	9	-17.4612	17.9887
1717BD	10	-17.4475	17.9886
1717BD	11	-17.4338	17.9888
1717BD	12	-17.42	17.9883
1717DD	13	-17.4117	17.8962
1717DD	14	-17.4117	17.9105
1717DD	15	-17.4116	17.9246
1717BD	16	-17.4116	17.9383
1717BD	17	-17.4116	17.9525
1717BD	18	-17.4115	17.9662
1717BC	19	-17.4168	17.7707
1717BC	20	-17.4168	17.7844
1717BC	21	-17.4169	17.7984
1717BD	22	-17.4169	17.8124
1717BD	23	-17.4169	17.8264
1717BD	24	-17.4176	17.8403
1717BD	25	-17.4532	17.7706
1717BD	26	-17.4534	17.7843
1717BD	27	-17.4533	17.7984
1717BC	28	-17.4534	17.8122
1717BC	29	-17.4532	17.8263
1717BC	30	-17.4532	17.8402
1717BD	31	-17.4899	17.7704

Map sheet	Cluster	Latitude	Longitude
1717BD	32	-17.4899	17.7845
1717BD	33	-17.4898	17.7982
1717BC	34	-17.4899	17.8124
1717BC	35	-17.4899	17.8263
1717BC	36	-17.4898	17.8406
1717BC	37	-17.5317	17.7738
1717BC	38	-17.5318	17.7878
1717BC	39	-17.5316	17.8018
1717BD	40	-17.5318	17.8156
1717BD	41	-17.5319	17.8296
1717BD	42	-17.5318	17.8439
1717BD	43	-17.5681	17.7735
1717BD	44	-17.5683	17.7878
1717BD	45	-17.5681	17.8016
1717BC	46	-17.5682	17.8156
1717BC	47	-17.5681	17.8291
1717BC	48	-17.5681	17.8435
1717BD	49	-17.6045	17.7733
1717BD	50	-17.6046	17.7871
1717BD	51	-17.6047	17.8011
1717BC	52	-17.6047	17.8152
1717BC	53	-17.6047	17.8291
1717BC	54	-17.6046	17.8431
1717BC	55	-17.5915	17.9894
1717BC	56	-17.5784	17.9887
1717BC	57	-17.5644	17.9888
1717BD	58	-17.551	17.9887
1717BD	59	-17.5374	17.9886
1717DB	60	-17.5236	17.9886

Appendix 2: Status of measured trees

Species	Dead, lying	Live tree	Standing dead tree	Stump	Total	% of total measured trees
Acacia erioloba		4			4	0.3
Baikiaea plurijuga	1	378	64	3	446	30.0
Boscia albitrunca		1			1	0.1
Burkea africana	1	132	24	1	158	10.6
Combretum collinum		85	13	3	101	6.8
Combretum engleri		2			2	0.1
Combretum psidioides (psidioides)		26	1		27	1.8
Combretum zeyheri		23	1	1	25	1.7
Commiphora angolensis		23	1		24	1.6
Croton gratissimus		5			5	0.3
Dichrostachys cinerea (Africana)		5	4	1	10	0.7
Dichrostachys cinerea (Setulosa)	1	3			4	0.3
Diplorhynchus condylocarpon		2			2	0.1
Erythrophleum africanum		52	15		67	4.5
Guibourtia coleosperma		45	9		54	3.6
Lonchocarpus nelsii		47	1		48	3.2
Ochna cinnebarina		1			1	0.1
Ochna pulchra		18	2		20	1.3
Ozoroa longipes		4			4	0.3
Ozoroa paniculosa		7	1		8	0.5
Ozoroa schinzii		10			10	0.7
Pavetta zeyheri		5			5	0.3
Peltophorum africanum		8	2		10	0.7
Pterocarpus angolensis	1	261	6	1	269	18.1
Schinziophyton rautanenii		85	1		86	5.8
Securidaca longepedunculata		1			1	0.1
Strychnos cocculoides		4			4	0.3
Strychnos pungens		3			3	0.2
Terminalia sericea		81	9		90	6.0
Total	**4**	**1321**	**154**	**10**	**1489**	
% of total measured trees	**0.3**	**88.7**	**10.3**	**0.7**		**100**

Appendix 3: Total number of measured shrubs

Species	No. of measured shrubs	% of measured shrubs
Bauhia petersiana	808	27.4
Baphia massaiensis	346	11.7
Croton gratissimus	244	8.3
Combretum collinum	197	6.7
Terminalia sericea	159	5.4
Ochna pulchra	107	3.6
Erythrophleum africanum	106	3.6
Combretum zeyheri	80	2.7
Ozoroa paniculosa	76	2.6
Baissea wulfhorstii	72	2.4
Grewia flava	67	2.3
Combretum engleri	53	1.8
Baikiaea plurijuga	51	1.7
Burkea africana	51	1.7
Combretum apiculatum (apiculatum)	48	1.6
Ozoroa longipes	46	1.6
Combretum psidioides (psidioides)	45	1.5
Grewia avellana	38	1.3
Ozoroa schinzii	35	1.2
Dichrostachys cinerea (Africana)	27	0.9
Lonchocarpus nelsii	25	0.8
Vangueria infausta	22	0.7
Combretum elacagnoides	21	0.7
Dichapetalum cymosum	21	0.7
Grewia retinervis	21	0.7
Commiphora angolensis	19	0.6
Unknown2	15	0.5
Commiphora africana	14	0.5

Species(.....continue)	No. of measured shrubs	% of measured shrubs
Acacia erioloba	13	0.4
Acacia fleckii	11	0.4
Acacia schweinfurthii	11	0.4
Strychnos pungens	11	0.4
Securidaca longepedunculata	10	0.3
Dombeya rotandifolia	8	0.3
Schinziophyton rautanenii	8	0.3
Ancylanthos baniesii	7	0.2
Rhigoszum brevispinosum	7	0.2
Strychnos cocculoides	7	0.2
Rhus tenuinervis	6	0.2
Guibourtia coleosperma	5	0.2
Pterocarpus angolensis	5	0.2
Acacia ataxacantha	4	0.1
Dichrostachys cinerea (Setulosa)	4	0.1
Grewia bicolor	4	0.1
Dialium engleranum	3	0.1
Mundulea sericea	3	0.1
Ozoroa insignis	3	0.1
Boscia albitrunca	2	0.1
Pavetta zeyheri	2	0.1
Acacia polyacantha	1	0
Diplorhynchus condylocarpon	1	0
Markhamia acuminata	1	0
Peltophorum africanum	1	0
Pseudolachnostylis maprouneifolia	1	0
Steganotaenia araliacea	1	0
Total	**2954**	100

Appendix 4: Volume distribution per diameter class for each species (m^3/ha)

	Diameter class, in cm														
Species	**5-15**	**15-25**	**25-35**	**35-45**	**45-55**	**55-65**	**65-75**	**75-85**	**85-95**	**95-105**	**105-115**	**115-125**	**125-135**	**Total (m^3/ha)**	**% of total**
Baikiaea plurijuga	0.22	3.23	5.49	4.06	1.73	0.17	0.25							15.16	35.09
Pterocarpus angolensis	0.29	1.84	2.09	2.38	1.10	0.26	0.09	0.13						8.18	18.94
Schinziophyton rautanenii	0.08	0.29	0.34	0.65	0.72	0.83	0.56	0.57	0.27	1.41	0.38	0.38	0.25	6.73	15.59
Burkea Africana	0.12	1.42	1.74	0.73		0.08								4.08	9.44
Guibourtia coleosperma	0.02	0.27	0.40	0.56	0.14	0.14				0.16				1.69	3.90
Combretum collinum	0.20	0.57	0.40	0.07		0.11								1.36	3.14
Lonchocarpus nelsii	0.12	0.53	0.52	0.04										1.21	2.80
Erythrophleum africanum	0.07	0.33	0.52	0.13										1.06	2.45
Terminalia sericea	0.16	0.70	0.07											0.92	2.13
Commiphora angolensis	0.05	0.16	0.11	0.11										0.43	0.99
Combretum psidioides (psidioides)	0.05	0.27			0.08									0.40	0.93
Peltophorum africanum		0.01	0.04	0.22	0.08									0.35	0.81
Ochna pulchra	0.14	0.13	0.02											0.29	0.66
Pavetta zeyheri			0.02	0.03	0.05		0.06		0.10					0.27	0.61
Combretum zeyheri	0.06	0.13	0.02											0.22	0.52
Strychnos cocculoides	0.01	0.06	0.12											0.20	0.46
Acacia erioloba		0.05		0.04	0.05									0.15	0.35
Dichrostachys cinerea (Africana)	0.01	0.03	0.02	0.08										0.13	0.31
Ozoroa schinzii	0.02	0.04												0.07	0.16
Dichrostachys cinerea (Setulosa)	0.01	0.06												0.06	0.15
Ozoroa paniculosa	0.02	0.03												0.05	0.12
Strychnos pungens	0.00	0.04												0.05	0.11
Croton gratissimus	0.01	0.02												0.03	0.07
Ochna cinnebarina		0.03												0.03	0.06
Combretum engleri		0.02												0.02	0.05
Securidaca longepedunculata	0.02													0.02	0.05
Boscia albitrunca		0.02												0.02	0.05
Ozoroa longipes	0.01													0.01	0.03
Diplorhynchus condylocarpon	0.01													0.01	0.02
Total	1.71	10.31	11.92	9.10	3.96	1.58	0.96	0.70	0.38	1.57	0.38	0.38	0.25	43.19	
% of total	3.95	23.86	27.61	21.08	9.17	3.65	2.22	1.62	0.87	3.63	0.89	0.87	0.58		100.

Appendix 5: Vegetation Structural Types (Edwards 1983)

1a Tree cover > 0.1%
- 2a shrub cover < 10%, if > 1m high — forest and woodland
  - 3a tree cover > 75% — forest
    - 4a tree height > 20m — high forest
    - 4b tree height 11-20m — tall forest
    - 4c tree height 5-10m — short forest
    - 4d tree height < 5m — low forest
  - 3b tree cover 11 - 75% — closed woodland
    - 5a tree height > 20m — high closed woodland
    - 5b tree height 11-20m — tall closed woodland
    - 5c tree height 5-10m — short closed woodland
    - 5d tree height < 5m — low closed woodland
  - 3c tree cover 1 - 10% — open woodland
    - 6a tree height > 20m — high open woodland
    - 6b tree height 11-20m — tall open woodland
    - 6c tree height 5-10m — short open woodland
    - 6d tree height < 5m — low open woodland
  - 3d tree cover < 1% — sparse woodland
    - 5a tree height > 20m — high sparse woodland
    - 5b tree height 11-20m — tall sparse woodland
    - 5c tree height 5-10m — short sparse woodland
    - 5d tree height < 5m — low sparse woodland
- 2b shrub cover > 10% and > 1 m high — thicket and bushland
  - 8a tree cover > 10% — thicket
    - 9a tree height > 5m — short thicket
    - 9b tree height < 5m — low thicket
  - 8b tree cover < 10% — bushland
    - 10a tree height > 5m — short bushland
    - 10b tree height < 5m — low bushland

1b Tree cover < 0.1%
- 11a shrub cover >0.1% — shrubland
  - 12a shrub cover > 10% — closed shrubland
    - 13a shrub height > 2m — high closed shrubland
    - 13b shrub height 1-2m — tall closed shrubland
    - 13c shrub height < 1m — low closed shrubland
  - 12b shrub cover 1 - 10% — open shrubland
    - 14a shrub height > 2m — high open shrubland
    - 14b shrub height 1-2m — tall open shrubland
    - 14c shrub height < 1m — low open shrubland
  - 12c shrub cover < 1% — open shrubland
    - 15a shrub height > 2m — high sparse shrubland
    - 15b shrub height 1-2m — tall sparse shrubland

15c shrub height < 1m	low sparse shrubland
11b shrub cover < 0.1 %	grassland and herbland

Appendix 6: Volume functions for Okongo Community Forest

For *Terminalia sericea, Pterocarpus angolensis* and *Acacias* use:
$v = e^{\wedge} (a_0 + a_1 * d + a_2 * d^2)$,
where v = tree volume in dm^3
d = tree diameter (dbh) in cm
a_o, a_1 & a_2 = parameters (see table below)

Note: 1. ^ means "to the power of"
2. e = 2.71828
For *Lonchocarpus nelsii, Combretum collinum, Colophospermum mopane, Burkea africana, Baikiaea plurijuga* and *Commiphora angolensis* use:
$v = (a_0 + a_1 * d + a_2 * d^2) * d^2$ or $v = a_0 * d^2 + a_1 * d^3 + a_2 * d^4$
where v = tree volume in dm^3
d = tree diameter (dbh) in cm
a_o, a_1 & a_2 = parameters (see table below)

Parameters:

Species	a_0	a_1	a_2
1 ACACIAS	0.21795109	0.01407904	-0.00010783
2 BAIPL	0.260011	0.02368	-0.00021
3 BURAF	0.151269	0.030485	-0.00029
4 COLMO	0.12798339	0.01580639	-0.00014894
5 COMAN	0.18057025	0.01974331	-0.00010431
6 COMCO	0.18057025	0.01974331	-0.00010431
7 LONNE	0.46735748	0.00342083	0.00008758
8 PTEAN	2.81959700	0.14324800	-0.00090000
9 TERSE	0.21795109	0.01407904	-0.00010783

Example 1: For a *Baikiaea plurijuga* tree with diameter (DBH) = 26.5 cm.
$v = a_0 * d^2 + a_1 * d^3 + a_2 * d^4$
$= (0.260011)*(26.5)^2+(0.02368)*(26.5)^3+(-0.00021)*(26.5)^4$
$= 182.59272+440.67592-103.56256$
$= 519.7\ dm^3$

Example 2: For a *Pterocarpus angolensis* tree with diameter (DBH) = 47 cm.
$v = e^{\wedge} (a_0 + a_1 * d + a_2 * d^2)$
$= e^{\wedge} (2.81959700)+(0.14324800)*(47)+(-0.00090000)*(47)^2$
$= (2.71828)^{\wedge}(2.819597+6.7327-1.9881)$
$= (2.71828)^{\wedge}(7.5641)$

$= 1927.72\ dm^3$

Appendix 7: List of tree/shrub species for Okongo Community Forest

Number = index for the model applied to calculate volume: 1= ACASIAS (v model=TERSE) 2=BAIPL 3=BURAF 4=COLMO 5=COMAN (v model=COMCO) 6=COMCO 7=LONNE 8=PTEAN 9=TERSE (Refer to models in Appendix 5, on page 47 above)

Code	Species	Index to volume model
ACAAT	Acacia ataxacantha	1
ACAER	Acacia erioloba	1
ACAFL	Acacia fleckii	1
ACAPO	Acacia polyacantha	9
ACASC	Acacia schweinfurthii	1
ANCBA	Ancylanthos banicsii	9
BAIPL	Baikiaea plurijuga	2
BAIWU	Baissea wulfhorstii	9
BAPMA	Baphia massaiensis	9
BAUPE	Bauhia petersiana	9
BOSAL	Boscia albitrunca	8
BURAF	Burkea africana	3
COMAA	Combretum apiculatum (apiculatum)	9
COMAF	Commiphora africana	5
COMAN	Commiphora angolensis	5
COMCO	Combretum collinum	6
COMEL	Combretum elaeagnoides	6
COMEN	Combretum engleri	6
COMPS	Combretum psidioides (psidioides)	6
COMZE	Combretum zeyheri	6
CROGG	Croton gratissimus	9
DIAEN	Dialium engleranum	9
DICCA	Dichrostachys cinerea (Africana)	9
DICCS	Dichrostachys cinerea (Setulosa)	9
DICCY	Dichapetalum cymosum	9
DIPCO	Diplorhynchus condylocarpon	9
DOMRO	Dombeya rotandifolia	9
ERYAF	Erythrophleum africanum	3
GREAV	Grewia avellana	9
GREBI	Grewia bicolor	9
GREFL	Grewia flava	9
GRERE	Grewia retinervis	9
GUICO	Guibourtia coleosperma	8
LONNE	Lonchocarpus nelsii	7
MARAC	Markhamia acuminata	3
MUNSE	Mundulea sericea	9
OCHPU	Ochna pulchra	8
OZOIN	Ozoroa insignis	9
OZOLO	Ozoroa longipes	9
OZOPA	Ozoroa paniculosa	9
OZOSC	Ozoroa schinzii	9
PAVZE	Pavetta zeyheri	9
PELAF	Peltophorum africanum	8
PSEMA	Pseudolachnostylis maprouneifolia	9
PTEAN	Pterocarpus angolensis	8
RHIBR	Rhigoszum brevispinosum	9

RHUTE	Rhus tenuinervis	9
SCHRA	Schinziophyton rautanenii	3
SECLO	Securidaca longepedunculata	8
STEAR	Steganotaenia araliacea	8
STRCO	Strychnos coceuloides	9
STRPU	Strychnos pungens	9
TERSE	Terminalia sericea	9
VANIN	Vangueria infausta	8
XXXXX	Unknown2	8

Appendix 8: Acknowledgements

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