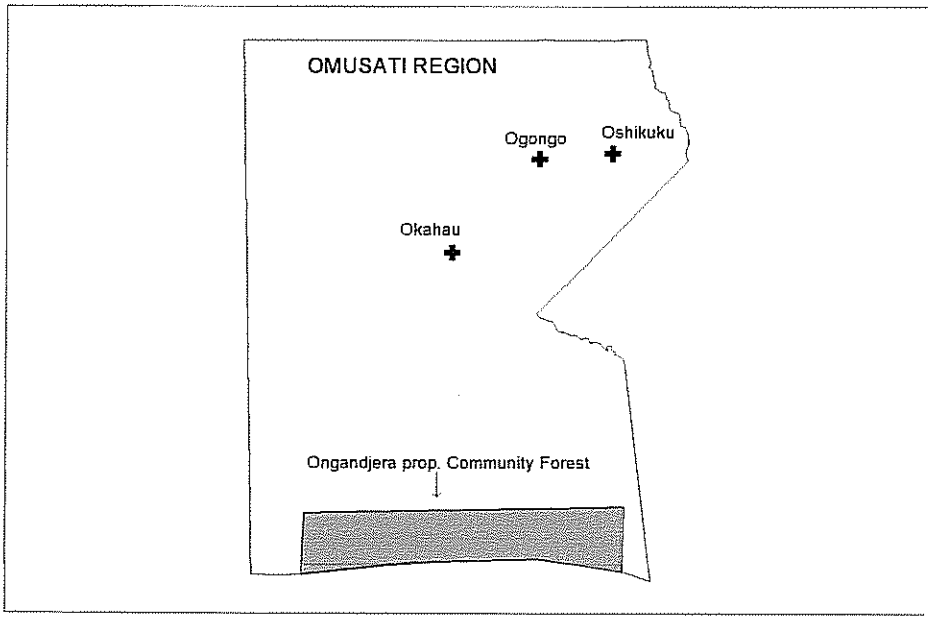
Ministry of Environment and Tourism
Directorate of Forestry

FOREST INVENTORY REPORT
OF
Ongandjera Community Forest



Namibia Finland Forestry Programme
National Forest Inventory Sub-component

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Tables

1. BACKGROUND

The forest inventory area covers the Ongandjera Community Forest, 128 200 hectares, in Uutapi district, Oshana Region.

The woody resources were estimated using systematic plot sampling. A systematic grid was laid on the Vegetation Maps produced by the Directorate of Forestry. The plots were 5 Km apart in the east-west direction and 2 Km apart in the north-south direction. A total of 96 plots were on the grid. The Ongandjera Community Forest is on the two adjacent map sheets 1814C and 1814D at 1:100 000 scale.

All trees, with at least 5 cm DBH, inside the circular plot were measured. The plot consisted of three circles. The size of the plot depended on the size of the tree so that the radius of the plot is 30 m for trees with breast height diameter (DBH) more than 45 cm; 20 m for trees with $20 < DBH < 45$ cm; and 10 m for trees with $5 < DBH < 20$ cm. Diameter, location, species, crown class, quality, length and quality of possible saw log were measured. Height, diameter of canopy, crown height, damages and phenology were recorded for each tree in the plot.

In addition, shrubs and regeneration were measured using two 3.99 m radius circular plots. Woody plants with diameter at breast height less than 5 cm were recorded on the shrub and regeneration field form and bigger woody plants on the sample tree field forms. Several variables describing the site, soil and tree cover were observed for each plot. Coverage of grasses and herbs were measured, also. All the measurements are described in more detail in the field instructions (Field Instructions Western Bushmanland 1996).

For estimation of tree volume, volume functions of West Tsumkwe were used. No trees were felled in Ongandjera Community Forest for stem analysis to determine tree volume.

2. GENERAL DESCRIPTION OF THE AREA

The area belongs to the Mopane Savanna vegetation zone in the classification of Giess (National Atlas of South West Africa). Soil is always sandy. The following land forms are present: oshanas and dry river beds. Annual rainfall is 52 - 978 mm. Elevation is 1100 - 1300 m over sea level.

3. INVENTORY RESULTS

3.1 Measured data

A total of 96 plots were measured. According to the vegetation maps, all the 96 plots were on the Savanna/Bushland stratum. Each plot in this Savanna/Bushland stratum represents 1335.42 ha. A total of 42 trees with diameter at least 5 cm were measured on the plots. Table 1 shows the total

number of measured trees by species.

Table 1: Number of measured trees by species

Species	No. of measured trees	% of measured trees
Acacia hebeclada (hebeclada)	4	9.5
Acacia tortilis (heteracantha)	4	9.5
Albizia anthelmintica	16	38.1
Colophospermum mopane	13	31.0
Terminalia prunioides	3	7.1
Terminalia sericea	2	4.8
Total	**42**	**100.0**

The measured trees were found in only 8 clusters out of the 96. The cluster numbers in which the trees were measured are 31, 38, 39, 43, 44, 49, 72, and 82. This is 8.3% of the total clusters.

The most frequent tree species in the data set were Albizia anthelmintica 38.1%, Colophospermum mopane, 31%,. This is followed by Acacia hebeclada (hebeclada) and Acacia tortilis (heteracantha), 9.% each, Terminalia prunioides, 7.1% and Terminalia sericea, 4.8%

3.2 Area estimates

The Vegetation Structural Types were derived for each vegetation unit from the measured sample plots. The derivation of the Vegetation Structural Type is based on the measured tree height, shrub and grass cover and on the measured coverage of each of these layers (Edwards 1983). The criteria are listed in Appendix 3. Table 2 shows the area in hectares and percentage of the different Vegetation Structural Types in Ongandjera Community Forest.

Table 2. Area by Vegetation Structure Types

Vegetation Structure Type	Area in hectares	Area in %
Bare land	17360.42	13.54
High Closed Shrubland	4006.25	3.13
High Open Shrubland	1335.42	1.04
Low Closed Shrubland	12018.75	9.38
Low Open Shrubland	40062.50	31.25
Low Open Woodland	2670.83	2.08
Low Sparse Shrubland	10683.33	8.33
Short Closed Grassland	1335.42	1.04
Short Closed Woodland	1335.42	1.04
Short Open Woodland	5341.67	4.17
Tall Closed Shrubland	21366.67	16.67
Tall Closed Woodland	1335.42	1.04
Tall Open Shrubland	8012.50	6.25
Tall Sparse Shurblad	1335.42	1.04

Total	**128200.00**	**100.00**

Table 2 shows that Low Open Shrubland (definition: Tree cover <0.1%, shrub cover >0.1%, shrub cover 1-10%, shrub height <1 m) covers 31.25% of Ongandjera Community Forest. Tall Closed Shrubland (definition: Tree cover < 0.1% and shrub cover > 0.1% and Shrub height 1-2 m) covers 16.67%.

The entire area can therefore be summarised as consisting of the following proportions of grassland, bare land, shrubland and woodland:

Vegetation structure	**Area in ha**	**%**
Short Closed Grassland	1335.42	1.04
Bare land	17360.42	13.54
Shrubland	98820.83	77.08
Woodland	10683.33	8.33
Total	**128200.00**	**100.00**

Most of the area, about 77.08% is shrubland, that is, trees less than 5 meters in height.

The crown coverage of each species was calculated for each plot. The dominant and second dominant species were derived from these crown coverage estimates. Table 3 shows the areas in hectares and percentages of dominant species. Colophospermum mopane is the most common dominant tree species found on 4006.25 ha or 3.13% of the area.

Table 3: Area (in ha and %) by dominant species

Species	Area in hectares	Area in %
Acacia hebeclada (hebeclada)	1335.42	1.04
Acacia tortilis (heteracantha)	1335.42	1.04
Albizia anthelmintica	1335.42	1.04
Colophospermum mopane	4006.25	3.13
No trees	117516.67	91.67
Terminalia prunioides	1335.42	1.04
Terminalia sericea	1335.42	1.04
Total	**128200.00**	**100.00**

The 91.67% of the area with no trees consists (from Table 2 above) of shrubland 77.08%, grassland 1.04% and bareland 13.54%. This shows and means that 91.67% of Ongandjera Community Forest has no trees greater than 5 meters in height. In other words, the area is shrubland and consists of the species with DBH < 5 cm shown in Table 8.

Table 4 shows the distribution of crown cover classes by dominant species. *Acacia hebeclada (hebeclada)*, *Albizia anthelmintica* and *Terminalia prunioides* dominated areas are most often in the cover classes 5-10%. Most of the *Acacia tortilis (heteracantha)* dominated areas are in cover classes 10-15%. For *Terminalia sericea* and *No trees* dominated areas the crown cover is in most cases 0-5%. *Colophospermum mopane* dominated areas are most often in the cover class 5-10% and 10-15%.

Table 4: Percentage of crown cover by DBH class and by dominant species. Values in the table are percentages of the area of the dominant species.

	Crown cover class in %		
Species	**0-5**	**5-10**	**10-15**
Acacia hebeclada (hebeclada)		100	
Acacia tortilis (heteracantha)			100
Albizia anthelmintica		100	
Colophospermum mopane		67	33
No trees	100		
Terminalia prunioides		100	
Terminalia sericea	100		

3.3 Tree Volume and number of stems

Total tree volume, mean tree volume, total number of stems and average number of stems per hectare by species and for the whole area are shown in Table 5. Only living trees are included in the table. The most common tree species is *Colophospermum mopane* with an average of 4.31 trees per ha followed by *Albizia anthelmintica* with 2.36 trees per ha. However, *Albizia anthelmintica* has the highest mean volume of 0.36 m3/ha and total volume of 45 630 m3. The second highest mean volume is for *Terminalia sericea* (0.25 m3/ha) followed by *Colophospermum mopane* (0.20 m3/ha). Ongandjera Community Forest has about 1 311 830 total number of trees.

Table 5: Number of stems and volume per hectare by species and for the whole area

Species	**Total tree volume (1000 m3)**	**Mean tree volume (m3/ha)**	**No. of trees (1000)**	**No. of trees/ha**
Acacia hebeclada (hebeclada)	6.86	0.05	170.03	1.33
Acacia tortilis (heteracantha)	18.34	0.14	170.03	1.33
Albizia anthelmintica	45.63	0.36	302.28	2.36
Colophospermum mopane	25.22	0.20	552.60	4.31
Terminalia prunioides	7.87	0.06	31.88	0.25
Terminalia sericea	32.60	0.25	85.02	0.66
Total	**136.53**	**1.06**	**1311.83**	**10.23**

Table 6 shows the maximum diameter measured for each tree species. The biggest tree diameters occurred in *Terminalia sericea, Albizia anthelmintica, Terminalia prunioides,Acacia tortilis(heteracantha), Colophospermum mopane* and *Acacia hebeclada (hebeclada)* respectively. However, the number of trees per hectare (from Table 6) for each one of these species is 0.66, 2.36, 0.25, 1.33, 4.31, and 1.33 respectively. It must, hovwever, be noted that there are very few large trees of these species in Ongandjera Community Forest.

Table 6: Maximum diameter by species

Species	Maximum DBH, cm
Acacia hebeclada (hebeclada)	12.9
Acacia tortilis (heteracantha)	19.5
Albizia anthelmintica	65.0
Colophospermum mopane	17.5
Terminalia prunioides	27.3
Terminalia sericea	73.1

3.4 Damages

Damages were recorded both at stand level and at tree level (for the measured sample trees). There was no damage recorded on the trees.

3.5. Species diversity

Table 3 above described the occurrence of dominant species in the area. Table 6 gave a figure on the frequency of the different tree species in the inventory area.

Another measure for species diversity is the frequency of plots where each species was found. Table 7 shows this result for both trees less than 5 cm in diameter, including shrubs, and trees larger than 5 cm. A total of 6 different species were recorded on the tree field form and 24 species on the regeneration and shrub field form.

For trees greater than 5 m in height, *Colophospermum mopane* was recorded on 4 plots out of the 96 plots. The other species, *Acacia hebeclada (hebeclada)*, *Acacia tortilis (heteracantha)*, *Albizia anthelmintica*, *Terminalia prunioides*, and *Terminalia sericea*, were recorded on only 1 plot each.

On the other hand for trees less than 5 m *height*, *Commiphora angolensis*, *Colophospermum mopane* and *Peltophorum africanum*, were recorded on 51, 39,and 38 plots respectively out of the total 96 plots.

Table 7 shows the number of plots in which a species was recorded. The number of species recorded was 26.

Table 7: Number of plots in which a species was found

Species	*DBH < 5 cm*	*DBH > 5 cm*
Acacia erioloba	5	
Acacia fleckii	4	
Acacia hebeclada (hebeclada)	7	1
Acacia mellifera	3	
Acacia tortilis (heteracantha)		1
Acacia reficiens (reficiens)	2	
Albizia anthelmintica	2	1
Baphia massaiensis	3	
Boscia albitrunca	2	
Catophractes alexandri	15	
Colophospermum mopane	39	4
Commiphora angolensis	51	
Croton gratissimus	15	
Dichrostachys cinerea	14	
Grewia avellana	1	
Grewia bicolor	3	
Grewia retinervis	3	
Mundulea sericea	1	
Ozoroa paniculosa	1	
Peltophorum africanum	38	
Rhigoszum brevispinosum	9	
Rhus marlothii	2	
Rhus tenuinervis	1	
Terminalia prunioides		1
Terminalia sericea	11	1
Unknown	1	

3.6 Standard error and confidence limits

Table 8 shows the sampling error and 68% confidence limits for total tree volume. For the average tree volume the sampling error was 0.48 m^3/ha (i.e. 45% of the average tree volume). This means the true average total tree volume for all species is between 0.58 and 1.54 m^3/ha with 68% probabilty. Since no sampling error is related to the area estimates of the two sampling strata, the total volume estimate has the relative sampling error of 45% for the total tree volume of all species. It must be noted that the sampling error is high because only 8 clusters out of the total 96 had trees with DBH at least 5 cm.

Table 8: Sampling error and 68% confidence limits

Item	Sampling variance	Standard error, m3/ha	Average volume, m3/ha	Lower confidence limit, m3/ha	Upper confidence limit, m3/ha	Confidence level, %
Total tree volume, all species	0.23	0.48	1.06	0.58	1.54	68

4. RELIABILITY OF THE RESULTS

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

In this work, specific attention was paid to guarantee good quality of the field data. Field personnel were trained for measurements and plant identification. Several cross checkings were done to find out possible errors and inconsistences in the data. Data processing programs were carefully designed and double checked.

The applied volume functions are probably the main source of errors. The volume functions for West tsumkwe were used (Appendix 1). These error sources affect the volume estimates but not, for example, the estimates of stem numbers and size class distributions.

The magnitude of sampling error was estimated with the formula of stratified random sampling using sample plots as sampling units. The applied sampling method was not random but the formula should be more or less valid. Probably the formula over estimates the sampling error.

5. CONCLUSIONS

The inventory data indicate that there is no commercial timber species such as Pterocarpus angolensis in ongandjera Community Forest. Most of the area, about 91% is shrubland with *Commiphora angolensis, Colophorspermum mopane, Peltophorum africanum, Croton gratissimus Catophractes alexandri and Dichrostachys cinerea* (see Table 8).

Even though in terms of commercial forestry the area does not contain exploitable timber, it would, nevertheless, be wise to conserve the Savanna/bushlands for various purposes such as building materials, animal fodder for both game and domestic animals, carbon sequestration, and prevension of soil erosion.

There are no permanent settlements around Ongandjera Community Forest. The area is used mostly as grazing area. There are a few cattle posts of herdsmen from surrounding villages. Small mopane (Dbh < 5 cm) is potentially useful for fencing poles and droppers.

The data collected provides possibilities for further analysis. Information on the species composition (see Tables 4 and 8) on different sites as well as on the species diversity may be used to update the vegetation maps of the area or for other land use purposes.

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List of appendices

1. Biomass and volume functions
2. Vegetation Structural Types
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Appendix 1. Biomass and volume functions.

Function (1) was found to describe well the relation between volume and diameter for Burkea africana and Terminalia sericea. For Combretum, Lonchocarpus and Pterocarpus, Function 2 was applied.

$$v = e\,(a_0 + a_1/d) \quad (1)$$

$$v/d2 = a_0 + a_1*d + a_2*d^2 \quad (2)$$

where v = volume, dm^3
d = diameter at breast height, cm

The parameter estimates for the volume functions are as follows

Species	a_0	a_1	a_2
Burkea africana	8.607856	-58.71163	-
Combretum collinum	0.131382	0.0180767	-0.0000905
Lonchocarpus nelsii	0.396588	0.0077865	-
Pterocarpus angolensis	0.667061	-0.008408	0.0002143
Terminalia sericea	7.158742	-39.232256	-

The volume is converted to biomass by multiplying with the basic density. The measured basic densities varied according to tree species and stem diameter as follows.

Species	Basic density, kg/dm3	Basic density,kg/dm3
Burkea africana	0.805, if d < 30 cm,	0.770, otherwise
Combretum collinum	0.881, if d < 25 cm,	0.770, otherwise
Lonchocarpus nelsii	0.977, if d < 25 cm,	0.854, otherwise
Pterocarpus angolensis	0.598, if d < 30 cm,	0.525, otherwise
Terminalia sericea	0.754, if d < 20 cm,	0.616, otherwise

The biomass of branches is estimated with Function (3).

$$B5/B = a_0 + a_1/d \quad (3)$$

where B5 = biomass of branches less than 5 cm in diameter
B = total biomass
d = breast height diameter of the tree, cm

The parameter estimates are as follows.

Species	a_0	a_1
B. africana	0.0468932	2.9833058
C. collinum	0.0956231	1.3644359
L. nelsii	0.0713440	3.5334357
P. angolensis	0.0344962	2.9576978
T. sericea	0.1000000	4.5794900

The biomass of branches can be converted to volume by dividing it with following averaged basic densities of branches.

Species	Conversion factor
B. africana	0.7881
C. collinum	0.8366
L. nelsii	0.9229
P. Angolensis	0.6141
T. sericea	0.6627

Appendix 2. Vegetational 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 4: Acknowledgements

The successful completion of the Forest Inventory Exercise in Ongadjera Community Forest was a result of the cooperative efforts of many individuals within the Directorate of Forestry and other institutions. The key personnel directly involved in the forest inventory consisted of Directorate of Forestry and Government of Finland staff.

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