Ministry of Environment and Tourism
Directorate of Forestry

FOREST INVENTORY REPORT
OF
UUKWALUDHI COMMUNITY FOREST

Namibia Finland Forestry Programme
National Forest Inventory Sub-component

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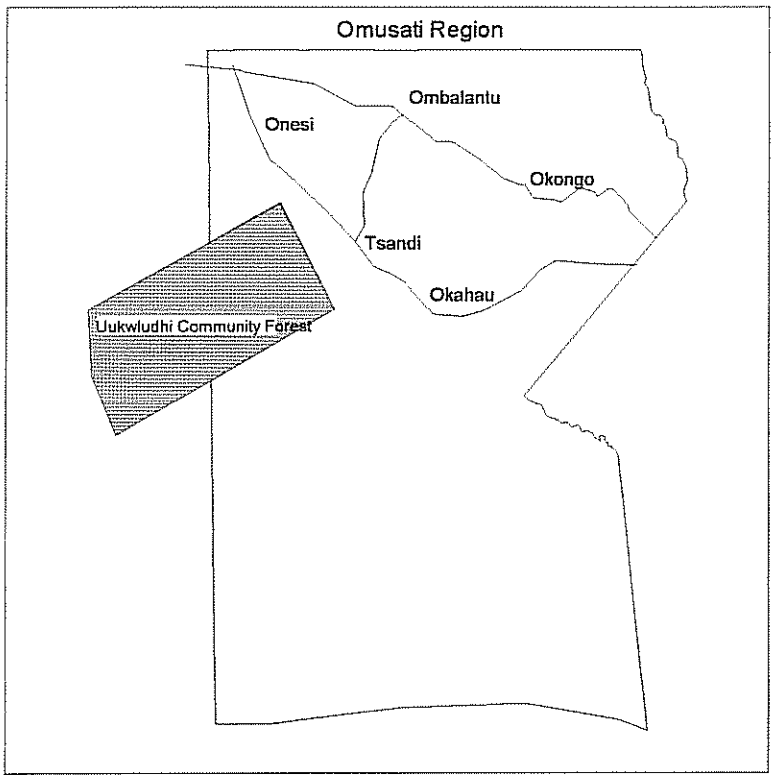
1. INTRODUCTION

Uukwaludhi Community Forest was set up in early 1994 when the communities in the area approached the Ongwediva District Forestry Office to have the area proclaimed as a Forest Reserve in order to protect the vegetation from indiscriminate cutting and thereby conserve the area mainly for grazing and harvesting of construction materials. The area was surveyed and mapped in late 1994 (See map 1).



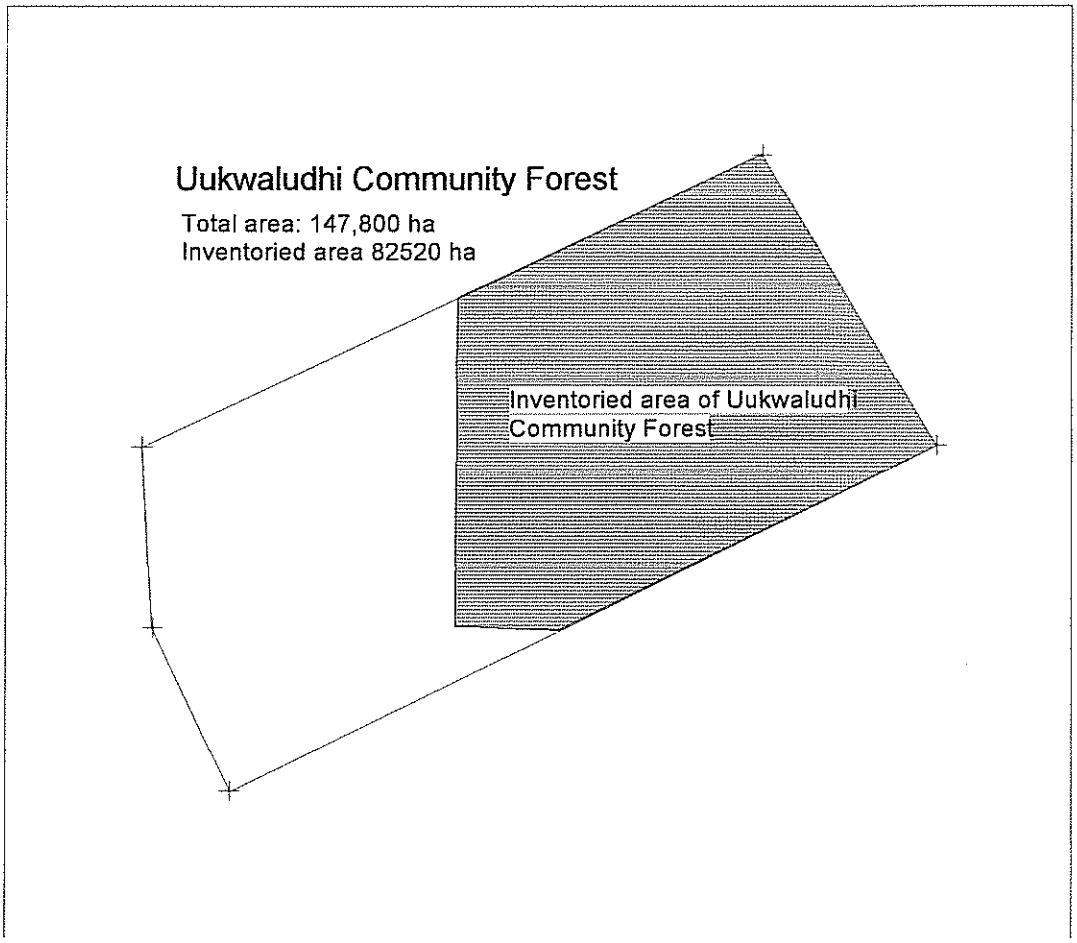
Map 1. Uukwaludhi Community Forest and Omusati region.

The Directorate of Forestry in cooperation with FINNIDA started a National Forest Inventory Project in 1995 aimed at producing forest data and information on the woodlands in Northern Namibia. In 1997 the Directorate began a comprehensive implementation of the Forest Strategic Plan of 1996 by launching the Namibia-Finland Forestry Programme in April of 1997. The overall programme objective is to ensure an increased role of forestry in the socio-economic development of Namibia through continuous implementation and development of sustainable forest management practices. The National Forest Inventory Project was incorporated, as a sub-component, into the Namibia-Finland Forestry Programme.

The Community Level Forest Management Component of the NFFP based at the Outapi Forestry District Office has part of its operations in the Uukwaludhi Community Forest. One of its activities is to prepare a Community Level Forest Management Plan for a pilot area within the Uukwaludhi Community Forest.

One of the aims of the Forest Inventory Sub-Component is to produce forest resource data on selected forest areas for operational management planning. A forest inventory was carried out in Uukwaludhi Community Forest between January and March 1998. The inventory covered all tree and shrub species. Uukwaludhi Community Forest is 147,800 ha. The whole area could not be inventoried due to the appearance of explosives (originationg from the liberation war) in the area. Therefore 82,520 ha of the community forest (56% of the area) was inventoried. The results

presented in this report do not therefore cover the whole community forest, but the area that was covered by the inventory. The inventoried part of the Uukwaludhi Community Forest is on map sheet 1714D. (see map 2)



Map 2. Area covered by the inventory.

The presentation of results in this report is one out of the many possibilities in which the data can be analysed to provide different overviews of the status of the forest resources in Uukwaludhi Community Forest. The database created from the collected field data in Uukwaludhi Community Forest provides possibilities for further studies on the woodland ecosystems within the area. Information on the species composition on different sites as well as on the species diversity may be obtained by further analysis of the data. The database can be accessed at the Directorate of Forestry, Ministry of Environment and Tourism.

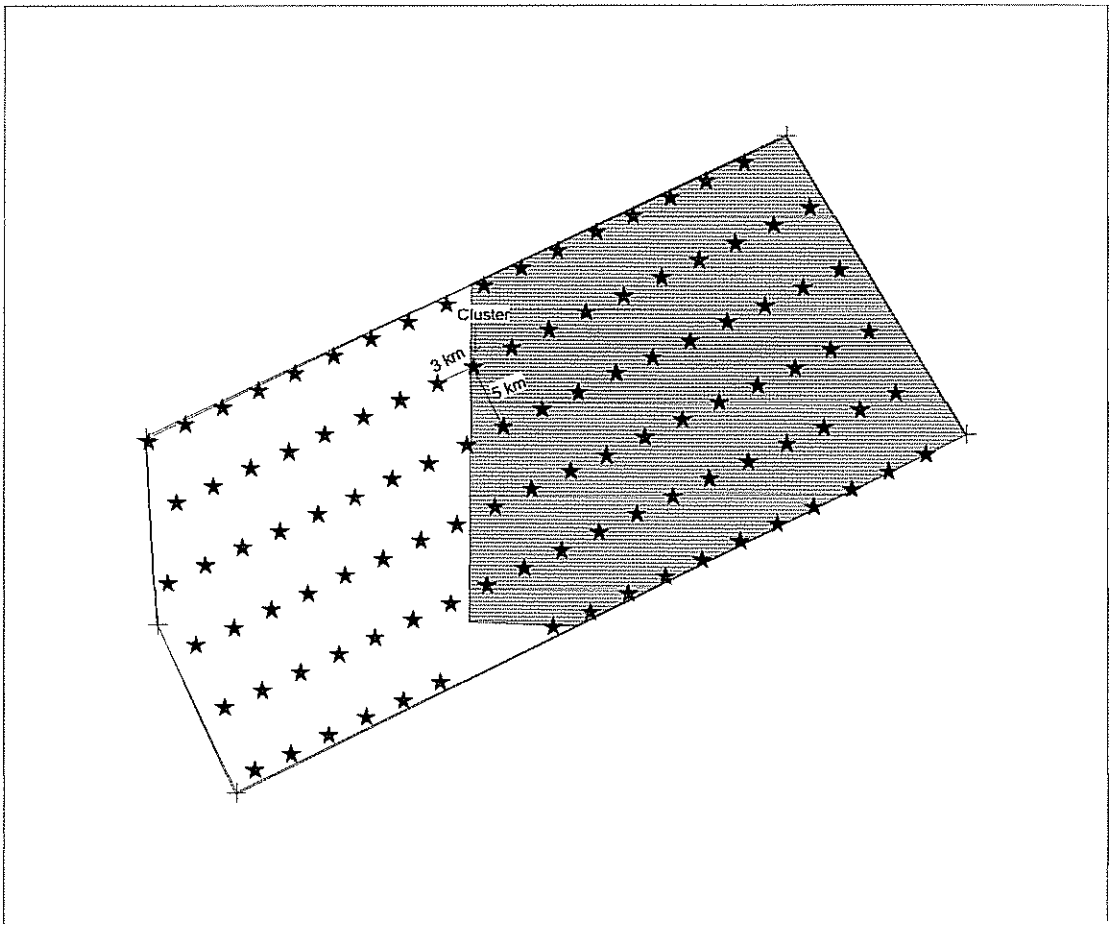
This report is related to a series of other inventories carried out in various parts of Namibia. The previous reports are "Woody Resources of Western Tsumkwe", "Woody Resources of East and South Tsumkwe, Otjinene and Okakarara Districts", "Forest Inventory Report of Ongadjera Community Forest" and "Forest Inventory Report of Caprivi Region" available at the Directorate of Forestry.

Uukwaludhi Community Forest is in an area that belongs to the Mopane Savanna vegetation zone in the classification of Giess (National Atlas of South West Africa). Mopane Savanna covers about 16% of Namibia's land area.

2. INVENTORY DESIGN

2.1 Sampling method

The forest resources were estimated using systematic plot sampling. Uukwaludhi Community Forest is covered by 3 Namibian Series 1:100 000 scale map sheets (1814A, 1714C, 1714D). Vegetation Maps at the Directorate of Forestry were used to lay a systematic grid over Uukwaludhi Community Forest. The distance between these lines was 5 km in Southwest -



Northeast direction. The distance between clusters in a line was 3 km.

Figure 1. Systematic grid in Uukwaludhi Community Forest inventory

The total number of sample clusters was 109. Each cluster consisted of 2 plots at a distance of 100 m apart in north-south direction. Hence, a total of 218 sample plots were to be measured in Uukwaludhi Community Forest.

The map coordinates and reference ellipsoid used when locating the cluster coordinates are:

- Datum: Scwarzeck
- Ellipsoid: Modified Bessel 1841
- Compass declination: 13.3° west of true north

2.2 Cluster coordinates

The clusters plotted on the Vegetation Maps were digitized using MapInfo to obtain coordinates for each cluster. The coordinates and GPS were used for the location of the clusters in the field.

All sample plots in each cluster are regarded as permanent measurement plots. They can be re-located for re-measurements in future. The coordinates are shown in Appendix 1 for other users who may wish to locate the plots in the field. The coordinates are the locations of the first plot (the plot most to the south) in the cluster. To locate the other plot a compass and measurement tape are used.

2.3 Field measurements

A plot consisted of three concentric circles with 10 m, 20 m and 30 m radii respectively (see figure 2). All trees with DBH equal to or larger than 5 cm inside the circular plot were measured. The size of the plot depended on the size of the tree to be measured so that the radius of the plot was 30 m for trees with breast height diameter (DBH) more than 45 cm; 20 m for trees with $20 < DBH \leq 45$ cm; and 10 m for trees with $5 < DBH \leq 20$ cm. Diameter, location, species, crown

class, quality, length and quality of possible saw log were measured and recorded for each tree (called enumeration trees). Height, diameter of canopy, crown height, damages and phenology were recorded for all the trees on the first plot of each cluster (i.e. for one third of all the trees). These trees are called sample trees.

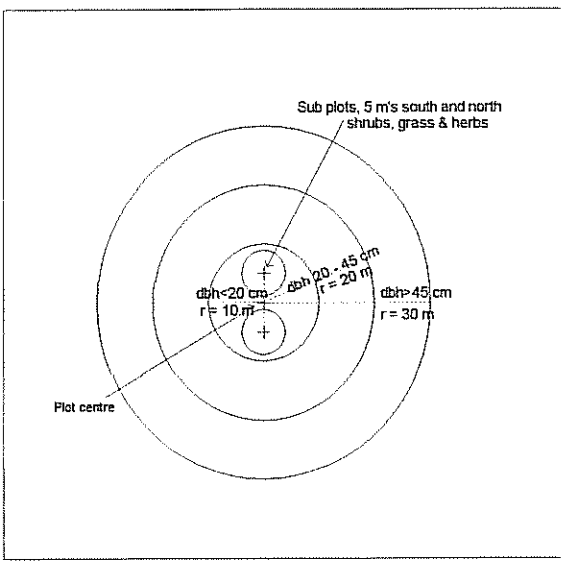
In addition, shrubs, regeneration, coverage of grasses and herbs, were measured using two 3.99 m radii circular plots located in the first plot of each cluster (see figure 2). Woody plants with diameter at breast height less than 5 cm were recorded on the shrub and regeneration field form and bigger woody plants on the sample and enumeration tree field forms. Several variables describing the site, soil and tree cover were observed for each plot and recorded on the stand description field form. All the measurements are described in more detail in the field instructions (Field Instructions Western Bushmanland 1996).

Figure 2. Plot design.

3. INVENTORY RESULTS

3.1 Measured data

A total of 112 plots or 56 clusters were measured out of the total 218 plots or 109 clusters respectively. 53 clusters or 106 plots were not measured because of the mines found in the area. Hence, the field team could not continue for safety reasons.



A total of 260 trees with diameter equal to or greater than 5 cm were measured on the plots. Out of 260 trees, 110 were sample trees, that is trees on which, among other variables, height was measured also. Table 1 shows the total number of measured trees by species. The total number of measured trees includes the sample trees. Sixteen (16)species were enumerated and the most frequent trees in the data were *Colophospermum mopane*, *Terminalia prunioides*, *Commiphora angolensis* and *Terminalia sericea*

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 trees	% of sample trees
Colophospermum mopane	88	33.8	35	31.8
Terminalia prunioides	53	20.4	17	15.5
Commiphora angolensis	47	18.1	23	20.9
Terminalia sericea	18	6.9	13	11.8
Combretum mossambicense	17	6.5	2	1.8
Acacia erioloba	7	2.7	1	0.9
Combretum apiculatum (leutweinii)	7	2.7	5	4.5
Combretum zeyheri	5	1.9	3	2.7
Lonchocarpus capassa	4	1.5		
Lonchocarpus nelsii	3	1.2	3	2.7
Acacia tortilis (heterecantha)	2	0.8	2	1.8
Albizia anthelmintica	2	0.8	2	1.8
Burkea africana	2	0.8	1	0.9
Combretum collinum	2	0.8	2	1.8
Commiphora africana	2	0.8	1	0.9
Combretum molle	1	0.4		
Total	**260**	**100.0**	**110**	**100.0**

3.2 Vegetation Structural Types

Vegetation Structural Types were derived for each vegetation unit from the measured sample plots using criteria of Edwards (1983), Appendix 2.

The derivation of the Vegetation Structural Type is based on the measured tree height, shrub and grass cover and on measured coverage of each of these layers (Edwards 1983). Table 2 shows the average and maximum height of the tree species in the area. The topmost height of over 10 m is for *Acacia erioloba* and *Terminalia prunioides*.

Table 2: Average height by species

Species	Average height, in meters	Maximum height, in m
Acacia erioloba	11.2	11.2
Acacia tortilis (heterecantha)	1.7	3.4
Albizia anthelmintica	3.5	6.9
Burkea africana	9.5	9.5
Colophospermum mopane	4.1	9.8
Combretum apiculatum (leutweinii)	3.7	6.7
Combretum collinum	6.2	6.4
Combretum mossambicense	2.3	4.5
Combretum zeyheri	4.2	6.4
Commiphora africana	7.3	7.3
Commiphora angolensis	3.6	8.7
Lonchocarpus nelsii	7.3	9.6

Terminalia prunioides	5.9	12.3
Terminalia sericea	3.8	8.7

Table 3 shows the area of different Vegetation Structural Types in hectares and percent as a proportion of the total area. There are no areas with tree cover dense enough to be called forest. Overall the area is shrubland, 37.6% followed by woodland, 35.6%, Bushland, 14.2%, Thicket 7.2% and Bareland, 5.4%.

The definition of Shrubland is as follows (Appendix 2): Tree cover < 0.1%. The Shrublands are mostly in the category Tall Closed Shrubland, 17.9% (definition: Tree cover < 0.1%, shrub cover > 10% and shrub height 1-2m).

The definition of Woodlands is as follows (Appendix 2): tree cover > 0.1% and shrub cover < 10% if shrub height is more than 1 m. The woodlands are mostly in the category Short Open Woodland, 10.7% (definition: tree cover 1-10% and tree height 5-10 m).

Table 3: Area by Vegetation Structural Types

Vegetation structure type	Area in Ha	% of total area
Tall Closed Shrubland	14736	17.9
Short Open Woodland	8841	10.7
Low Closed Shrubland	7368	8.9
Short Closed Woodland	7368	8.9
Low Bushland	5894	7.1
Low Closed Woodland	5894	7.1
Low Open Woodland	5894	7.1
Short Bushland	5894	7.1
Bare Land	4421	5.4
Low Open Shrubland	4421	5.4
Short Thicket	4421	5.4
High Closed Shrubland	1474	1.8
Low Sparse Woodland	1474	1.8
Low Thicket	1474	1.8
Tall Open Shrubland	1474	1.8
Tall Sparse Shrubland	1474	1.8
Total	**82520**	**100**

3.3 Dominant species and species composition

The dominant and second dominant species were derived from their crown coverage in the measured clusters. Table 4 shows the areas of dominant species in hectares and percentages. *Colophospermum mopane* is the most common dominant species. *C. mopane* is the dominant species on 22104 ha or 26.8% of the area. Other dominant species are *Commiphora angolensis,* which is the dominant species on 11789 ha or 14.3%; *Terminalia prunioides* on 8841 or 10.7%; and *Terminalia sericea* on 5894 or 7.1%.

Table 4: Area, in ha and %, by dominant species

Dominant Species	Area in Ha	% of total area
Colophospermum mopane	22104	26.8
No dominant trees	20630	25.0
Commiphora angolensis	11789	14.3
Terminalia prunioides	8841	10.7
Terminalia sericea	5894	7.1
Combretum mossambicense	2947	3.6
Lonchocarpus nelsii	2947	3.6
Acacia erioloba	1474	1.8
Burkea africana	1474	1.8
Combretum apiculatum (leutweinii)	1474	1.8
Combretum collinum	1474	1.8
Commiphora africana	1474	1.8
Total	**82520**	**100**

"No dominant trees" in table 4 means that there are no trees (only shrubs, dbh<5 cm) in the area. Therefore, 25 % of the inventoried area is wothout trees.

Table 5 shows the distribution of crown cover of dominant species by crown cover classes. The figures inside the table are percentages of the area of the respective dominant species. From the table it can be concluded that stands where *Colophospermum mopane* dominates are commonly open (93% of the stands in cover classes 0-5, 5-10%). The same conclusion can be drawn for *Commiphora angolensis* (76% of the stands in cover classes 0-5, 5-10%). *Terminalia sericea* and *Terminalia prunoides* on the other hand are occurring as dominate species also in stands with closer canopy (crown cover classes 20-25, 30-35%). The table clearly shows that according to the classifiaction used (Vegetation Structural types by Edwards 1983) there are no areas dense enough to be called forest. The highest crown cover in the area being ion the class 50-55%.

Table 5: Distribution of crown cover of dominant species by crown cover classes

	Crown cover class, in %								
Species	0-5	5-10	10-15	15-20	20-25	25-30	30-35	50-55	% Total
Acacia erioloba	100								100
Burkea africana			100						100
Colophospermum mopane	80	13						7	100
Combretum apiculatum (leutweinii)	100								100
Combretum collinum			100						100
Commiphora africana	100								100
Commiphora angolensis	63	13	13			13			100
Lonchocarpus nelsii	50			50					100
Terminalia prunioides	50		17		17		17		100
Terminalia sericea		50	25				25		100

Table 6 shows species composition by dominant species. The data are reliable only for the most frequent species like *Colophospermum mopane*, *Terminalia prunioides*, *Commiphora angolensis* and *Terminalia sericea*.

Colophospermum mopane most often occurs in pure stands, i.e. no second dominant species are found (87% of the *C. mopane* dominated area). If there is a second species, then this species is *Terminalia prunioides* (13% of the *Colophospermum mopane* dominated area).

When *Terminalia prunioides* is the dominant species it is associated with *Colophospermum mopane*.

Commiphora angolensis dominated stands are associated with *Colophospermum mopane* (25%), *Combretum apiculatum* (13%), *Lonchocarpus nelsii* (13%) and Terminalia sericea (13%). *Commiphora angolensis* occurs as pure stands on 38% of *Commiphora angolensis* dominated area.

Terminalia sericea dominated areas are most frequently associated with *Acacia erioloba* (50%), *Combretrum zeyheri* (25%) and *Commiphora angolensis* (25%).

Table 6: Occurrence, in %, of a second dominant species for each dominant species

	Second dominant species										
Dominant Species	**A. erioloba**	**C. mopane**	**C. apiculatum (leutweinii)**	**C. zeyheri**	**C. angolensis**	**L. capassa**	**L. nelsii**	**No second dominant species**	**T. prunioides**	**T. sericea**	**% Total**
Acacia erioloba								100			100
Burkea africana	100										100
Colophospermum mopane								87	13		100
Combretum apiculatum (leutweinii)								100			100
Combretum collinum					100						100
Combretum mossambicense		50				50					100
Commiphora africana		100									100
Commiphora angolensis		25	13				13	38		13	100
Lonchocarpus nelsii					50			50			100
No dominant species								100			100
Terminalia prunioides		100									100
Terminalia sericea	50			25	25						100

3.4 Species diversity

Tables 1 and 13 show the frequency of different species in Uukwaludhi Community Forest. Tables 4 and 6 described the occurrence of dominant species and also gave an idea about the mixture of species. Another measure of species diversity is the number of clusters where each species was found.

Table 7 shows the number of clusters where each species was found for both trees less than 5 cm in diameter including shrubs, and trees larger than 5 cm. A total of 16 different species were recorded on the tree field form and 27 species on the regeneration and shrub field form.

Table 7: Species diversity indicated by the frequency of clusters where each species was found

Species	No. of clusters, Dbh < 5 cm	No. of clusters, Dbh > 5 cm
Acacia aranaria	1	
Acacia erioloba	2	4
Acacia fleckii	3	
Acacia hebeclada (hebeclada)	1	
Acacia reficiens	1	
Acacia tortilis (heterecantha)	1	1
Albizia anthelmintica		1
Baphia massaiensis	1	
Bauhinia petersiana	13	
Berchimia discolor	1	
Burkea africana		1
Colophospermum mopane	42	28
Combretum apiculatum (leutweinii)	15	4
Combretum collinum	11	1
Combretum molle		1
Combretum mossambicense	2	2
Combretum zeyheri	7	4
Commiphora africana	3	1
Commiphora angolensis	14	18
Croton gratissimus	4	
Dichrostachys cinerea	8	
Grewia bicolor	5	
Grewia retinervis	2	
Lonchocarpus capassa		1
Lonchocarpus nelsii		3
Ochna pulchra	2	
Ozoroa longipes	1	
Peltophorum africanum	7	
Rhigoszum brevispinosum	6	
Rhus marlothii	2	
Terminalia prunioides	13	10
Terminalia sericea	14	8

Colophospermum mopane, DBH ≥ 5 cm, was found on 28 clusters, i.e. almost in every 2nd cluster, while *Colophospermum mopane* shrub/regeneration, DBH < 5 cm, was found on 42 clusters. *Commiphora angolensis*, DBH ≥ 5 cm, was found on 18 clusters while *Commiphora Angolensis* shrub/regeneration, DBH < 5 cm, was found on 14 clusters. There is more *C. Mopane* regeneration compared to all other species.

Other important tree species were found on the following number of clusters: *Terminalia prunioides, 10;* and *Terminalia sericea*,8.

Tree species, like *Lonchocarpus capassa*, *Commiphora africana*, *Combretum molle*, *Combretum collinum*, and *Burkea africana*, were found only on 1 cluster each.

Other important shrub species which will enventually grow into trees were found on the following number of clusters: *Terminalia prunioides, 13; Terminalia sericea*, 14; *Combretum apiculatum*, 15; and *Combretum collinum*, 11.

3.5 Regeneration

Regeneration is important for the renewing and perpetuation of forest/woodland ecosystems.

Table 8 shows the estimated area covered by regeneration. About 93% of the area has regeneration of which 63% has seedlings or sprouts lower that 1.5 m and 30% has seedlings or sprouts higher that 1.5 m. Only about 7% of the area has no regeneration.

Table 8: Extent of regeneration, in Ha

Regeneration	Area, in Ha	% of total area
No regeneration observed	5894	7
Seedlings or sprouts are present but only lower that 1.5 m	51575	63
Vital seedlings or sprouts higher than 1.5 m are present	25051	30
Total	**82520**	**100**

Table 9 shows the number of shrubs and seedlings by height classes and species in Uukwaludhi Community Forest. It should be noted that Table 9 includes only shrubs and seedlings less than 5 cm in diameter since larger stems (DBH ≥ 5 cm) were measured as trees.

The most frequent species, seedlings per hectare, in the shrub and seedling layer for the whole area are *Colophospermum mopane*, 1348; *Cartophractes alexandri*, 350; *Combretum apiculatum*, 163; *Bauhinia petersiana*, 109; *Combretum collinum*, 86; *Combretum zeyheri*, 73; *Terminalia sericea*, 71; and *Terminalia prunioides*, 70.

It seems that *C. Mopane* is regenerating reasonably well. This is because about 26.8% of the area is dominated by mopane.

Table 9: Number of shrubs and 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
Colophospermum mopane	125	129	454	330	196	39	54	21	1348
Catophractes alexandri	39	84	104	84	38		2		350
Combretum apiculatum (leutweinii)	9	13	16	25	21	5	7	66	163
Bauhia petersiana	13	82	9	2	4				109
Combretum collinum		11	30	16	7	4	18		86
Combretum zeyheri		11	5	18	16	2	21		73
Terminalia sericea	2	5	38	20	0		7		71
Terminalia prunioides	23	9	7	4	16	2	5	4	70
Commiphora angolensis	2	30	11	9	11				63
Peltophorum africanum		18	23	13	2				55
Rhigoszum brevispinosum	11	7	11	2					30
Dichrostachys cinerea		4	9	7	2	2	4		27
Rhus marlothii			18		4				21

Ochna pulchra	18	2		2					21
Combretum mossambicense		16			2				18
Baphia massaiensis	9	7							16
Elephantorrhiza elephantina			9	2	2				13
Acacia fleckii	2	2	2	4	2				11
Croton gratissimus	2	5	2		2				11
Grewia bicolor		4	5						9
Commiphora africana		2	4					2	7
Ozoroa longipes		4	2						5
Acacia erioloba		2					2		4
Acacia hebeclada (hebeclada)		2						2	4
Grewia retinervis			2	2					4
Acacia aranaria				2					2
Acacia reficiens			2						2
Acacia tortilis (heterecantha)				2					2
Berchimia discolor			2						2
Elephantorrhiza suffruticosa	2								2

3.6 Damage to trees

Damages to trees were recorded both at cluster level (for the sampled vegetation unit) and at tree level (for the measured sample trees). Table 10 shows the area in hectares of damaging agent by severity of damage. The most common damage is Human, covering about 16.07% of the area. Other damage is due to Domestic mammals, 5.36%; Forest fire, 3.57% and Wild mammmals, 1.79%. Most of the damages were moderate, 14.29%, that is, damages are decreasing the vitality of trees.

Table 10: Damaging agent by severity of damage at cluster level, in Ha

	Severity of damage					
Damaging agent	**Mild**	**Moderate**	**Serious**	**No damage**	**Total area**	**% of total area**
Human	1474	8841	2947		13262	**16.07**
Mammals, domestic	2947	1474			4421	**5.36**
Forest fire	2947				2947	**3.57**
Mammals, wild		1474			1474	**1.79**
No damage				60416	60416	**73.21**
Total area	7368	11789	2947	60416	82520	
% of total area	**8.93**	**14.29**	**3.57**	**73.21**		**100.00**

Table 11 shows damage to individual trees. About 4% of *C. mopane* has Human damage and 13% Unkown damage. The rest of the sample tree species did not exhibit any damages.

Table 11: Damaging agent and degree of damage to individual trees by species, in %

		Species													
Damaging	**Degree of**	A.	A.	A.	B.	C.	C.	C.	C.	C.	C.	C.	L.	T.	T.

agent	Damage	erioloba	tortilis	anthelmintica	africana	mopane	apiculatum	collinum	mossambicense	zeyheri	africana	angolensis	nelsii	prunioides	sericea
Human	Serious, vitality seriously reduced					4									
No damage		100	100	100	100	83	100	100	100	100	100	100	100	100	100
Unknown						13									

3.7 Grazing

At cluster level, in every first plot, signs of grazing were observed in the lower vegetation and on branches of trees and bushes, and the intensity of grazing noted. Table 12 shows the intensity of grazing. About 52% of the area shows signs of grazing of which 43% is moderate and 9% is intensive with vitality of vegetation clearly threatened.

Table 12: Intensity of grazing, in Ha

Intensity of grazing	Area, in Ha	% of total area
No signs of grazing observed	39786	48
Moderate signs of grazing are visible, vegetation is still alive	35366	43
Signs of intensive grazing visible, vitality of vegetation clearly threatened	7368	9
Total area	**82520**	**100**

3.8 Tree volume and number of stems

Volume functions: Volume functions from Caprivi Inventory for *Burkea africana*, *Combretum collinum*, *Lonchocarpus nelsii*, *Pterocarpus angolensis*, *Baikiaea plurijuga*, *Colophospermum mopane* and *Terminalia sericea* were used to calculate tree volume in Uukwaludhi. The volume functions are in Appendix 3. For other species without a volume function one of these functions was applied to estimate the volume of such species. For other users who may wish to use the models, Appendix 3 shows which models were applied to the species without volume functions.

Unless specified otherwise, ***Tree volume*** means the volume of the entire tree comprising of the main tree trunk and branch wood. Table 13 shows total number of stems, stems per hectare, tree volume and mean tree volume per hectare by species and for the whole area. This is for trees with DBH $\geq$ 5 cm. And, only living trees are included in the table.

The area has an estimated total number of 4 404 530 trees, the average number of trees per hectare is 53.38 and, the average total tree volume per hectare is 6.31 m^3 for the whole surveyed area.

The most common species is *C. Mopane*, on average 16.93 stems per ha, followed by *Commiphora angolensis* 11.19 stems per ha, *T. Prunioides* 9.51 stems per ha, *Combretum mossambicense 4.62 stems per hectare* and *Terminalia sericea* 4.01 stems per hectare.

Commiphora angolensis has the highest mean and total tree volume 1.59 m^3/ha and 130 810 m^3 followed by *C. Mopane* 1.49 m^3/ha and 123 050, *T. Prunioides* 1.26 m^3/ha, *Combretum mossambicense 0.38* and *T. sericea* 0.34 m^3/ha.

Table 13: Number of stems, stems/Ha, tree volume, and mean volume by species and for the whole area

Species	Total No. of stems, 1000	Stems/Ha	Total tree volume, 1000 m3	Average volume, m3/ha
Colophospermum mopane	1396.73	16.93	123.05	1.49
Commiphora angolensis	923.12	11.19	130.81	1.59
Terminalia prunioides	785.01	9.51	103.86	1.26
Combretum mossambicense	381.11	4.62	31.34	0.38
Terminalia sericea	330.94	4.01	28.11	0.34
Combretum apiculatum (leutweinii)	146.58	1.78	9.64	0.12
Combretum zeyheri	117.26	1.42	2.11	0.03
Lonchocarpus capassa	93.81	1.14	1.91	0.02
Lonchocarpus nelsii	52.77	0.64	12.71	0.15
Combretum collinum	46.91	0.57	0.64	0.01
Commiphora africana	46.91	0.57	4.12	0.05
Acacia erioloba	37.78	0.46	16.11	0.20
Combretum molle	23.45	0.28	0.83	0.01
Burkea africana	11.73	0.14	5.53	0.07
Acacia tortilis (heterecantha)	5.21	0.06	22.67	0.27
Albizia anthelmintica	5.21	0.06	26.94	0.33
Total	**4404.53**	**53.38**	**520.38**	**6.31**

For the mean tree volume of all species the standard error was 1.27m^3/ha or 20% of the mean tree volume per hectare. This means that the true mean tree volume per hectare is between 5.04 and 7.57 m^3/ha with the probability of 68%. See Table 16.

Table 14 shows the distribution of total tree volume for the area by species and diameter classes. About 50-60% of the total tree volume of the area is in the diameter class between 5-10 and 20-25.

Table 15 shows the distribution of total number of stems for the area by species and diameter classes. About 52.7% of all the stems in the area are in the class 5-10 cm, while 43.8% are in the classes 10-15%, 15-20% and 20-25%. Therefore, most of the trees are small.

Table 14: Distribution of total tree volume by species and diameter classes

	Diameter class, cm																		
Species	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	**30-35**	**35-40**	**45-50**	**55-60**	**60-65**	**65-70**	**70-75**	**75-80**	**80-85**	**85-90**	**95-100**	**105-110**	Total	% of total volume
Acacia erioloba				4.19	4.10	3.61		4.21										16.11	3.1
Acacia tortilis (heterecantha)													11.04	11.63				22.67	4.4
Albizia anthelmintica															12.05		14.89	26.94	5.2
Burkea africana				2.27	3.26													5.53	1.1
Colophospermum mopane	15.33	22.11	16.88	23.22	13.58	4.52		3.87	10.37	6.26	6.90							123.05	23.6
Combretum apiculatum (leutweinii)	3.64						6.00											9.64	1.9
Combretum collinum	0.64																	0.64	0.1
Combretum molle	0.83																	0.83	0.2
Combretum mossambicense	7.47	10.56		6.16			7.16											31.34	6.0
Combretum zeyheri	2.11																	2.11	0.4
Commiphora africana	0.87		3.25															4.12	0.8
Commiphora angolensis	8.12	24.25	47.67	29.64	5.94	4.90				10.30								130.81	25.1
Lonchocarpus capassa	1.91																	1.91	0.4
Lonchocarpus nelsii			10.46	2.25														12.71	2.4
Terminalia prunioides	20.07	7.84	21.53	15.27	7.57	7.23						10.88				13.47		103.86	20.0
Terminalia sericea	8.34	5.00	6.11							8.66								28.11	5.4
Total	69.32	69.75	105.90	82.99	34.45	20.26	13.16	8.08	10.37	25.23	6.90	10.88	11.04	11.63	12.05	13.47	14.89	520.38	
% of total volume	13.3	13.4	20.3	15.95	6.62	3.89	2.53	1.55	1.99	4.85	1.33	2.09	2.12	2.23	2.32	2.589	2.861		100.0

Table 15: Distribution of number of stems by species and diameter classes

	Diameter class, in cm																	
Species	**5-10**	**10-15**	**15-20**	**20-25**	**25-30**	**30-35**	**35-40**	**45-50**	**55-60**	**60-65**	**65-70**	**70-75**	**75-80**	**80-85**	**85-90**	**95-100**	**105-110**	**Total stems**	**% of total stems**
Colophospermum mopane	773.9	369.4	123.1	82.1	29.3	5.9		2.6	5.2	2.6	2.6							1396.7	31.7
Commiphora angolensis	234.5	281.4	281.4	105.5	11.7	5.9				2.6								923.1	21.0
Terminalia prunioides	445.6	93.8	146.6	64.5	17.6	11.7						2.6				2.6		785.0	17.8
Combretum mossambicense	211.1	140.7		23.5			5.9											381.1	8.7
Terminalia sericea	211.1	70.4	46.9							2.6								330.9	7.5
Combretum apiculatum (leutweinii)	140.7						5.9											146.6	3.3
Combretum zeyheri	117.3																	117.3	2.7
Lonchocarpus capassa	93.8																	93.8	2.1
Lonchocarpus nelsii			46.9	5.9														52.8	1.2
Combretum collinum	46.9																	46.9	1.1
Commiphora africana	23.5		23.5															46.9	1.1
Acacia erioloba				17.6	11.7	5.9		2.6										37.8	0.9
Combretum molle	23.5																	23.5	0.5
Burkea africana				5.9	5.9													11.7	0.3
Acacia tortilis (heterecantha)													2.6	2.6				5.2	0.1
Albizia anthelmintica															2.6		2.6	5.2	0.1
Total stems	2321.8	955.7	668.4	304.9	76.2	29.3	11.7	5.2	5.2	7.8	2.6	2.6	2.6	2.6	2.6	2.6	2.6	4404.5	
% of total stems	**52.7**	**21.7**	**15.2**	**6.9**	**1.7**	**0.7**	**0.3**	**0.1**	**0.1**	**0.2**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**	**0.1**		**100.0**

4. RELIABILITY OF THE RESULTS

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.

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 undertook a re-fresher course in Tree Identification at the national Botanical Research Institute. 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 applied volume functions are propably the main source of errors. The functions used are from data collected in the Caprivi and West Tsumkwe Inventory. The tree trunk (or saw log) volumes were estimated simply by multiplying the timber log height with the timber log basal area at breast height because it was felt that the cylindrical volume more or less estimated the log volume. These error sources have an effect on the volume estimates but not, for example, on the estimates of stem or tree numbers and size class distributions.

The magnitude of sampling error, Table 14, was estimated with the formula of stratified random sampling using clusters, 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.

4.1 Sampling error and confidence limits for volume

Table 16 shows the sampling error. For the estimate of mean tree volume per hectare of all species the sampling error was 1.27 m^3/ha (i.e. 20% of the mean). Hence, the true mean tree volume is between 5.04 and 7.57 m^3/ha with the probability of 68%. The total volume estimates for the whole area have the relative sampling errors of 20%.

Table 16: Sampling error for tree volume for the whole area

Item	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	1.61	1.27	6.31	20.09	5.04	7.57	68

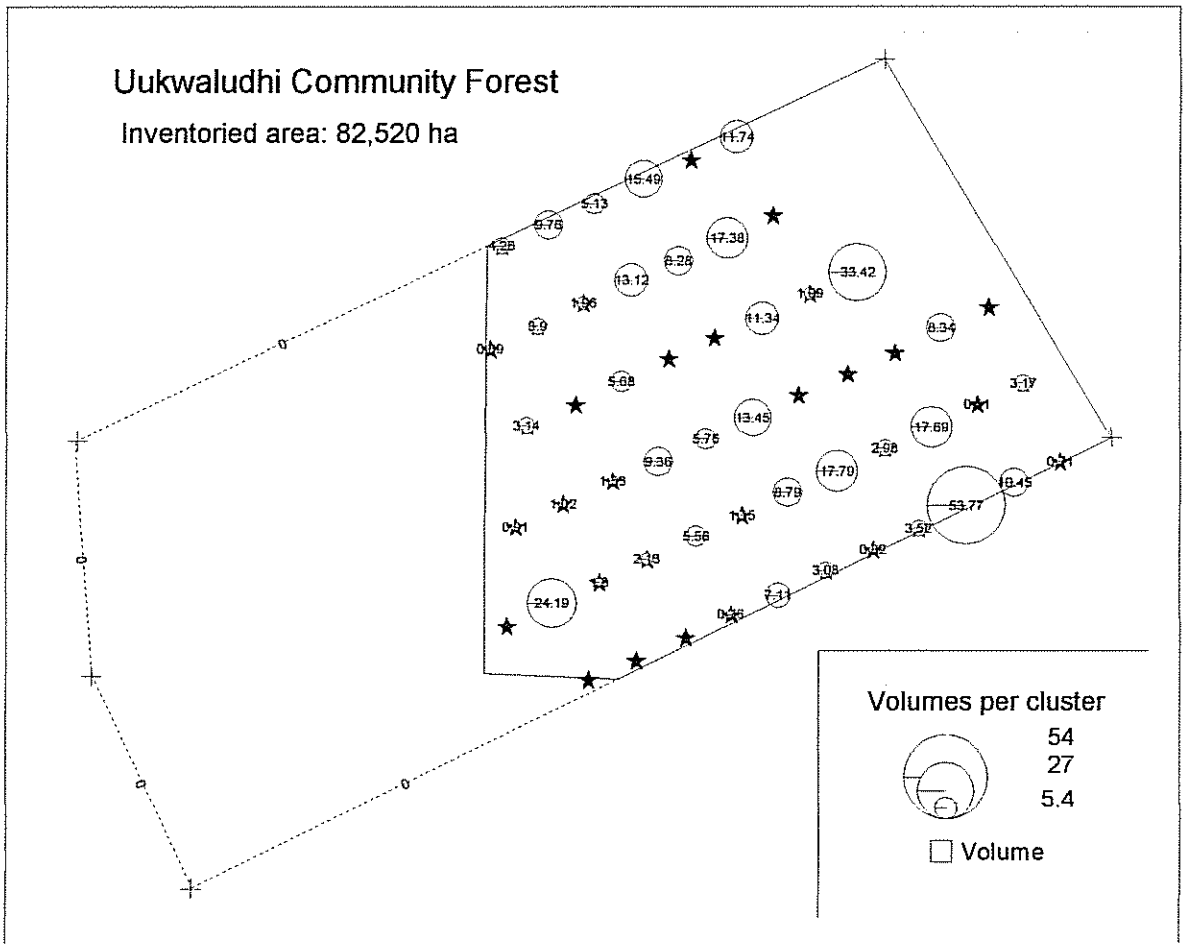
The 20% sampling error for all species is high. As shown in Table 17 there is a lot of variability in volume per hectare between clusters. The volume ranges between 0 and 53.8 m^3/ha for an average of 6.31 m^3/ha.

Table 17: Distribution by cluster of total tree volume per Hectare

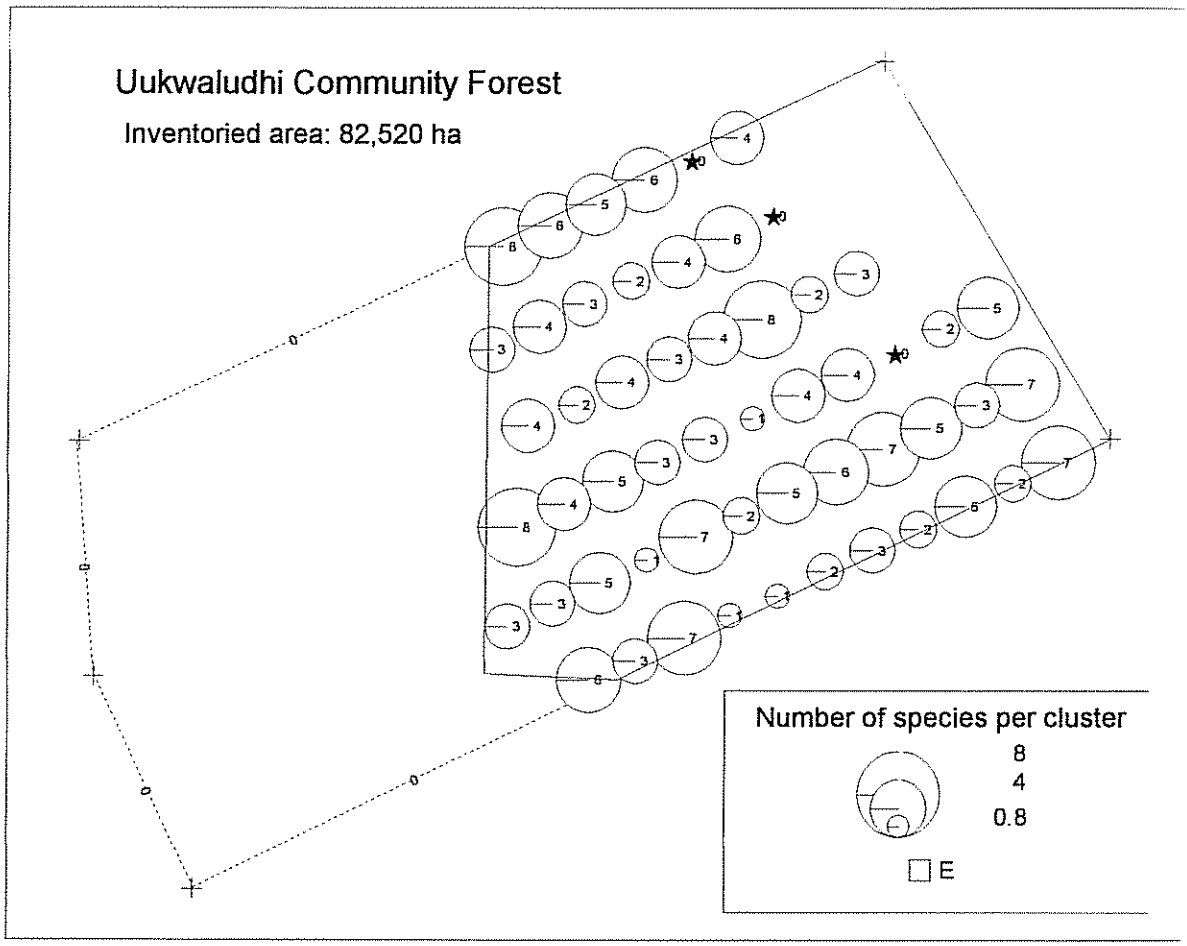
Cluster	Volume per Ha, m3	Cluster	Volume per Ha, m3
1	4.3	37	0.0
2	9.8	38	0.0

3	5.1	39	8.3
4	15.5	40	0.0
5	0.0	41	0.0
6	11.7	42	24.2
9	0.7	43	1.3
10	3.9	44	2.1
11	2.0	45	5.6
12	13.1	46	1.1
13	8.3	47	8.8
14	17.4	48	17.8
15	0.0	49	3.0
19	3.1	50	17.7
20	0.0	51	0.5
21	5.7	52	3.2
22	0.0	53	0.0
23	0.0	54	0.0
24	11.3	55	0.0
25	2.0	56	0.8
26	33.4	57	7.1
29	0.9	58	3.1
30	1.0	59	0.8
31	1.5	60	3.5
33	9.4	61	53.8
34	5.8	62	10.5
35	13.5	96	0.7
36	0.0	97	0.0

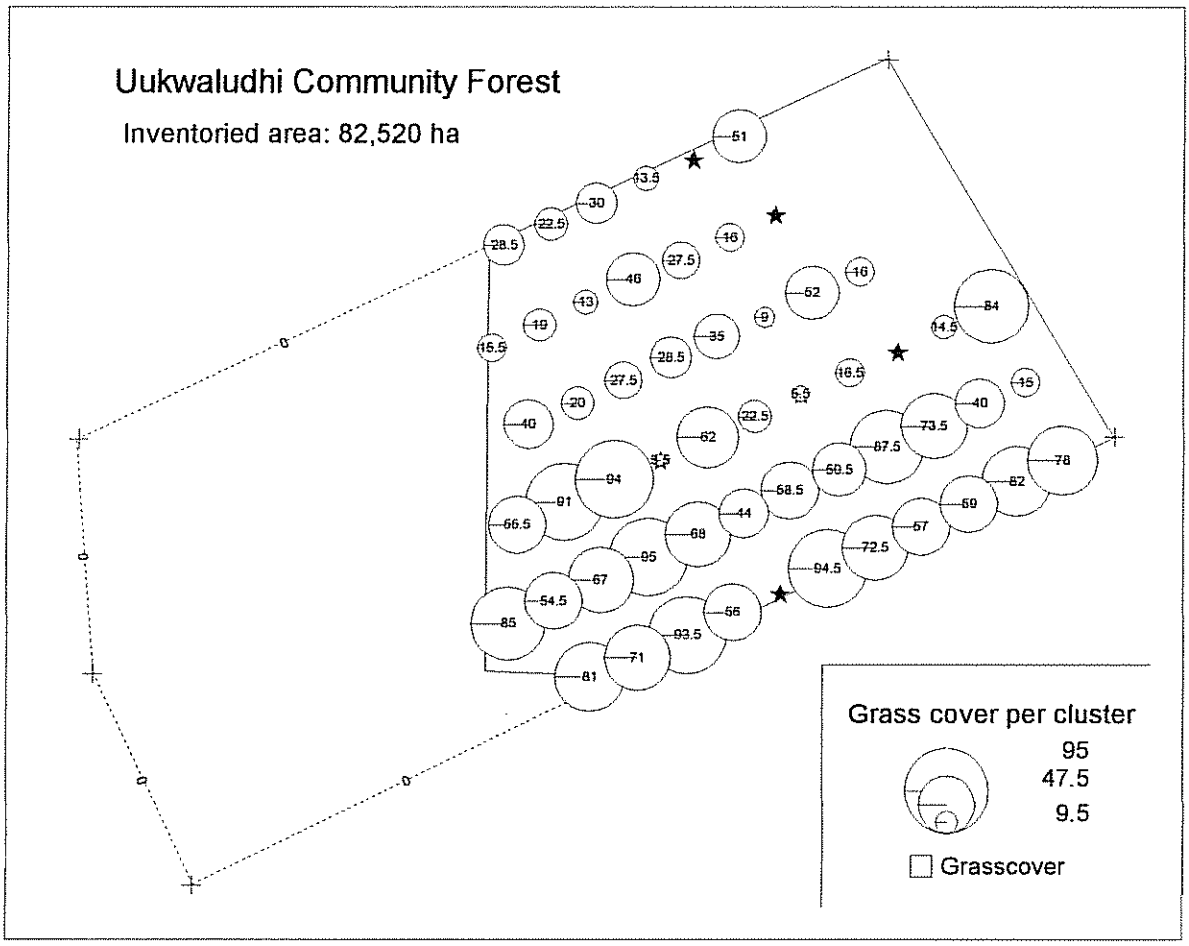
The distribution of volume per hectare for each cluster (Table 17) is plotted on Map 3. Map 4 and Map 5 the distribution per cluster of number of species and the grass cover in percent respectively.


Uukwaludhi Community Forest
Inventoried area: 82,520 ha
Volumes per cluster
54
27
5.4
Volume

Map 3


Uukwaludhi Community Forest
Inventoried area: 82,520 ha
Number of species per cluster
8
4
0.8
E

Map 4


Uukwaludhi Community Forest
Inventoried area: 82,520 ha
51
43.5
30
22.5
28.5
16
27.5
46
16
62
13
84
19
9
14.5
15.5
35
28.5
16.5
27.5
20
15
40
22.5
40
73.5
62
87.5
94
50.5
78
91
68.5
82
66.5
44
59
68
57
95
72.5
67
94.5
54.5
56
85
93.5
71
81
Grass cover per cluster
95
47.5
9.5
Grasscover

Map 5

5. SUMMARY AND CONCLUSIONS

The whole Uukwaludhi Community Forest could not be inventoried due to the appearance of explosives in the area. 82,520 ha, or 56% of the community forest was inventoried. The result and the conclusions in this report covers the inventoried area only. If the rest of the area looks similar to the inventoried area, it is possible to extrapolate the result from this inventory to cover the whole community forest. Information on the similarity between the inventoried area and the area not inventoried was not available when this report was produced, hence the possibilities for extapolation could not be determined.

This inventory provides quantitative estimates of the present state of part of Uukwaludhi Community Forest. The results can be used for operational forest management planning and in future as a basis for planning inventories, for example, determination of sample size to achieve a desired allowable error. The inventory data indicate that the forest resources in Uukwaludhi Community Forest are not much in comparison to the resources in North eastern Namibia.

Tree species diversity

The area has low tree species diversity, 16 species, compared to Caprivi Region where 57 species were enumerated. In West Tsumkwe 29 species were recorded while in "East and South Tsumkwe, Otjinene and Okakarara" area 24 species were recorded. The area does not have any of the commercial species such as *Pterocarpus angolensis*, and *Baikiaea plurijuga*.

Volume

The average tree volume per hectare is 6.31 m^3 compared to 21.4 m^3 /ha in Caprivi Region, 17.8 m^3/ha in West Tsumkwe and 4.2 m^3/ha for "East and South Tsumkwe, Otjinene and Okakarara" area.

Regeneration

For sustainable forest management regeneration is important for the renewing and perpetuation of forest/woodland ecosystems. The most frequent species, seedlings per hectare, in the shrub and seedling layer for the whole area are *Colophospermum mopane*, 1348; *Cartophractes alexandri*, 350; *Combretum apiculatum*, 163; *Bauhinia petersiana*, 109; *Combretum collinum*, 86; *Combretum zeyheri*, 73; *Terminalia sericea*, 71; and *Terminalia prunioides*, 70.

It seems that *C. Mopane* is regenerating reasonably well compared to other species. This is because about 26.8% of the area is dominated by mopane.

Damage to trees

There is not much extensive damage to the woody resources in Uukwaludhi both at cluster and tree level.

At cluster level the most common damage is Human, covering about 16.07% of the area. Other damage is due to Domestic mammals, 5.36%; Forest fire, 3.57% and Wild mammmals, 1.79%. Most of the damages were moderate, 14.29%, that is, decreasing the vitality of trees.

At individual tree level about 4% of *C. mopane* has Human damage and 13% Unkown damage. The rest of the sample tree species did not exhibit any damages.

Population

There is a considerable amount of people living around Uukwaludhi Community Forest. The majority of the people depend on the forest resources for fuelwood and poles for homestead construction. Other plants are also used for nutrition and medicinal purposes. Domestic animals and game also depend on the forest resources for fodder and shelter. Hence, there is need to manage and maintain the forest bio-diversity of the area.

Sustainable forest management

The Uukwaludhi communities realised the need for sustainable forest management when in early 1994 they approached the Ongwediva District Forestry Office to have the area proclaimed as a Forest Reserve in order to protect the vegetation from indiscriminate cutting and thereby conserve the area mainly for grazing and harvesting of construction materials.

There is therefore need for concerted effort to protect the forest resources from further uncontrolled, especially, human damage. Concerted planning and action in forest management to save the woodlands from further degradation are therefore required. The endeavour should certainly involve local communities to ensure long term success. This is the challenge of the Community Level Forest Management Component. The data generated by the Forest Inventory Sub-Component in Uukwaludhi can also play a role to achieve that end. However, the possibilities for sustainable management of the woodlands needs to be pursued and implemented.

Strategic plan

In 1997 the Directorate of Forestry began a comprehensive implementation of the Namibia Forest Strategic Plan (NFSP) of 1996 through the new Namibia-Finland Forestry Programme which started in April 1997. The Strategic Plan (NFSP) identified the main challenges to sustainable forestry management as: forest *production* (production forestry, environmental forestry, and processing of forest products); *protection* of forest resources; and people's *participation* in forestry development.

Forest policy

The Directorate has revised the National Forest Policy of Namibia and the final document is awaiting approval. The first stated aim of the forest policy is: *"Reconcile rural development with biodiversity conservation by empowering farmers and local communities to manage forest resources on a sustainable basis"*. The potential of Uukwaludhu forest resources, which are mainly on communal lands, can, in the long run, only be effectively conserved through the active participation of the local communities in forest resource management and conservation. Furthermore the completion of the new Forest Bill to replace the Preservation of Trees and Forests Ordinance of 1952 and the Forest Act of 1968, will facilitate people's participation in forestry development.

There is need to work closely with the local communities in Uukwaludhi in the difficult task of conserving the forest resources. In addition to the already on-going pilot Community Level Forest Management exercise, at Outapi District Forest Office, which is working with the communities to manage forest resources in a selecetd pilot area of Uukwaludhi, there is need to work with other institutions involved in natural resource conservation in Northern Namibia to empower the communities to manage and conserve forest resources. This way the survival of the forest

resources will be ensured. Otherwise the forest resource of Uukwaludhi will continue dwindling uncontrollably due to external human pressures, clear cuts for agricultural expansions and other factors.

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