Table of contents:

List of tables:

List of Appendices:

EXECUTIVE SUMMARY

The woody species
A total of 48 woody species were found in the Omusati region, 29 species as trees and 40 species in the shrub layer. This is less than the number of species recorded both in Tsumkwe district in Otjozondjupa region and in Caprivi region.

Colophospermum mopane is very dominating both in the tree layer and in the shrub layer. In fact, the species is found either as a tree or a shrub in most of the areas with woody vegetation in the region. Few of the woody species in the region are common. 33 of the species were found in less than 10 of the 238 measured clusters. 7 species were found in only one cluster.

The structure of the woody vegetation
There are no areas in the region with a tree layer dense enough to be called forest. Only on one tenth of the region is there some kind of a tree layer, and also here the woody vegetation is very low, generally below 5 m. The dominating vegetation types in the region are dense shrub land and areas with virtually no vegetation.

The reason why there is no forests or woodlands varies. In parts of the region the tree layer has disappeared due to over-cutting, resulting in a shrub layer. These shrub lands will develop into woodlands and even forests if properly managed. In other parts of the region, mainly in the south, poor soil conditions prevent the woody species from growing into tree size. Here the shrub lands will probably never develop into woodland or forest even with proper management.

The forest resource
The tree volumes in the Omusati region are extremely low. The region has the lowest mean tree volume (3.2 m^3/ha) of all the regions so far measured. The mean tree volume in Otjozondjupa region was 4.2 m^3/ha, in Caprivi region 17.8 m^3/ha. The woody vegetation is quite homogenous when it comes to volumes in the region.

The bulk of the trees in the region are small. 2/3 of the trees have a dbh between 5 cm and 15 cm. More than 90% of the trees have a dbh below 25 cm.

The potential for even small-scale timber industries in the region are very limited. The volume of the only timber species found in the region (*Baikea plurijuga*) is too small. Also the option to create a small-scale timber industry by utilising other species (e.g. *Terminalia prunoides*) is not viable. One area of interest is the *Baikea plurijuga* stands in Uukolankadhi proposed community forest. This area should be looked into as a part of the management planning of that community forest.

The economic importance of the wooded areas in the region lies at present in the utilisation of the wood for fuel and poles, and the non-wood forest products including fodder. There are strong indications that the utilisation of the woody resources for poles and fuel wood is not sustainable at the moment. This means that there is no potential to increase the economic utilisation of the woody resources for this purpose. On the contrary, for the resource base not to vanish in the long run, the utilisation has to be decreased.

The woody resources on the farms
Although the whole Omusati region formally is communal land, a considerble part of the region is fenced off into private farms. According to the inventory, 28 % of the region is fenced off into private farm land. 35 % of the total tree volume and 17% of the total number of stems in the Omusati region is inside fenced off areas, i.e. on private farms. The trees growing on the farms are on average bigger than in the whole region in general. There are fewer species on the farms than in the region as a whole. *Sclerocarya birrea, Combretum*

collinum, Hyphaene petersiana, Berchemia discolor, Baikea plurijuga are profoundly more common inside the farms than in the region in general.

The regeneration
There is on average 1897 shrubs/saplings per hectare in the shrub layer. Saplings dominate the shrub layer, i.e. small specimen of species that are growing into trees in the region. However, the soil conditions in the area where the woody species is growing will affect whether the sapling of a certain species will develop into a tree or if it will remain as a shrub.

Although the number of species found in the shrub layer is rather high, 86.1 % of the woody vegetation is coming from the 5 most common species in the layer. These species are *Colophospermum mopane, Catophractes alexandri, Bauhia petersiana, Baphia massaiensis* and *Commiphora angolensis*. *Colophospermum mopane* is by far the most common species in the shrub layer, ¾ of all the saplings/shrubs found in the shrub layer comes from that species. For the other species the regeneration is poor. No saplings were observed for *Baikea plurijuga* or *Sclerocarya birrea*. Hence, the domination of *Colophospermum mopane* in the region will even increase in the future.

Non timber forest products (NTFPs)
Trees for fodder is one of the most important products from the wooded areas in the region. A substantial part of the region consists of shrubland, where the main species are suitable as fodder. Mopane worms are another important NTFP in the region. The environment for the mopane worm is favourable and it can be assumed that the supply of this NTFP is going to be secured also in the future.

Fruits from *Sclerocarya birea* (Marula), *Berhcemia discolor (*Eembe), *Hyphaene petersiana, Ficus sycomorica, Diospyros mespiliformis* and *Adanonsia digitata* (Baobab) are used for various purposes in the region. At the moment there is a scarcity of fruit trees in the region, and the situation is not likely to improve due to poor regeneration. On the contrary, without managment inputs, the supply of the fruits from these species will decrease and in the end eventually stop. To get more detailed information on the indigenous fruit tree resources, an assessment would have to be carried out focusing on farms.

The DoF is in the process of starting a project to promote the use of indigenous fruit trees, "Improvement and Promotion of Selected Indigenous Fruit Trees in Namibia". This project could carry out the following important activities in Omusati region:

- Establishment of monitoring sites to determine the fruit production of various species of various sizes.
- Implement management activities to ensure the continuity of the indigenous fruit tree species.
- Carry out an on-farm inventory of the indigenous fruit tree resources to get more detailed information. In this inventory the farms should be the sampling unit.

The future of the woody resources in Omusati region
The population density in the region, 13.9 persons per km^2, is among the highest in Namibia. The woody resources are very important for the well being of the rural population in the region. The majority of the population depends on the woody resources for fuel-wood and poles for house construction. Various non- timber forest products are of significant economic importance to the people in the region. But the use of the resource base is not sustainable at the moment. Therefore, the introduction of sustainable woody resource management practises is of crucial importance to the future well-being of the population in the region.

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 cooperation 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 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 region 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. Therefore, the aims of the NFI are both to produce resource information on different levels and to build Namibian capacity for woody resource assessments.

The utility of information from different levels 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, hence the information on very small units cannot be derived, and the results cannot be used for operational management planning. To get detailed information for operational management, local level inventories has to be carried out. Basically the information substance is the same in the local level inventories as in the higher 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 taken at the start of the NFI in 1995. The logical sequence in developing forestry in a region is to first carry out a region inventory to determine the resource potential for different uses in the region. If the region inventory indicates potential for forestry development, e.g. timber utilization, the next step is to identify smaller areas for forestry development and to carry out local level inventories in those smaller areas. The inventories on sub-region areas (e.g. Caprivi State Forest) carried out within the NFI have a higher sampling intensity than the region inventories and provide site-specific information to a certain extent. Hence, they can be classified as something between region level and local level inventories.

This report presents the results from the region level inventory of the Omusati region. The results are presented for the region as one unit and are therefore not site-specific on sub-region level. However, it is possible to produce more site-specific information for particular sub-region areas by analysing only the clusters measured in that particular area (see chapter 3, p. 7). Data for each cluster is available in the Directorate of Forestry Headquarters in Windhoek.

Below is listed the 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
- Woody Resources of Western Tsumkwe
- Woody Resources of East and South Tsumkwe, Otjinene and Okakarara Districts
- Forest Inventory Report of Ongadjera Community Forest
- Forest Inventory Report on Uukwaludhi Community Forest
- Forest Inventory Report of Caprivi State Forest
- Inventory of the Directorate of Forestry Eucalyptus Plantations in Kavango Region
- Forest Inventory Report on Nkurenkuru Concession Area

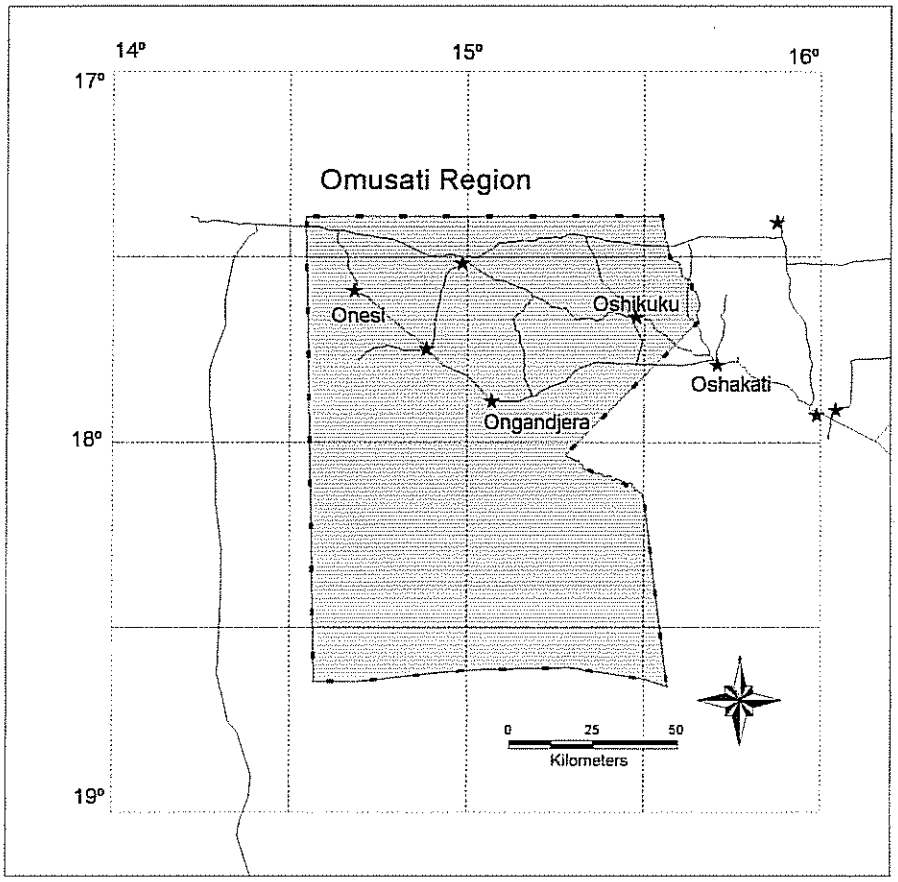
2. GENERAL DESCRIPTION OF THE AREA.

The Omusati Region forms the western part of the former Ovamboland. According to the Vegetation Mapping Project (Directorate of Forestry) the size of the region is 1.39 million hectares. Note that the size of the region and the region boundaries used in this report are the ones existing before the constituency and regional boundary changes in late 1998.

The topography in the region is characterised by an extremely flat plain, which forms a part of the Etosha depression. The only exceptions to the flat topography are found to the west, where the land rises gently to the foothills of the Kaokoland mountain ranges (Namibia Regional Resources Manual 1993). Annual rainfall in the region is 350 – 500 mm.

According to The Namibia Regional Resources Manual, the vegetation in the region can broadly be classified into four zones; (1) The Etaka-Cuvelai Drainage Basin in the north mainly covered by palm savanna, (2) The Western Sandveld with bush savanna of mainly Mopane, (3) The Ekuma Grassveld towards southeast with seasonally flooded grasslands and patches of Mopane and Acacia and (4) The Kalkveld in the extreme southeast and northwest with open shrub savanna of Mopane and Acacias. During the rainy season a considerable part of the Etaka-Cuvelai Drainage Basin and Ekuma Grassveld are covered with water.

The population density in the region is among the highest in Namibia, 13.9 persons per km^2 , with the majority of the population in the northern and central parts of the region. The total population for the region in 1991 was 189,919, which represented 13% of the national total. Although the land in the region is communal, a considerable part of the region is fenced off into private farming areas.



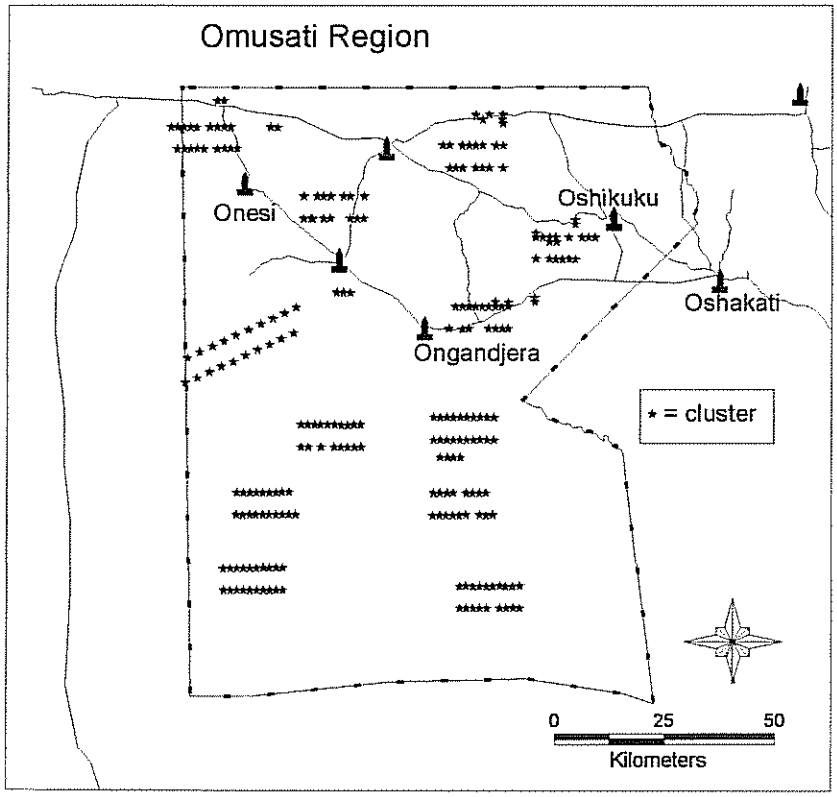
Map 1: Omusati Region

3. INVENTORY DESIGN

3.1 Sampling method

Stratified systematic plot sampling was used to estimate the quantity and quality of the woody resources in the Omusati region. Vegetation Maps at the Directorate of Forestry were used to stratify the region into 9 sampling strata. The density and structure of the woody vegetation was used as criteria for the stratification. The sampling intensity was higher for dense wooded areas than for areas with less woody vegetation.

The total number of clusters located in the region was 240. Each cluster consisted of 2 sample plots at a distance of 100 m apart in the north-south direction. Hence, a total of 480 sample plots were located in the region. The clusters were located in groups, with 20 clusters per group. The clusters in one group were located in 2 parallel lines in east-west direction. The line distance being 5 km and the cluster distance in one line 1.5 km. The groups of clusters were located evenly over the region. Map 2 shows the final location of the clusters after corrections to fulfil demands from the stratification.



Map 2: Location of the clusters in Omusati region.

The clusters plotted on the Vegatation Maps were digitised using Mapinfo software to obtain coordinates for each cluster. The coordinates and GPS were used for locating the clusters in the field. The map coordinates, reference ellipsoid and compass declination used when locating the cluster coordinates were:

- Datum: Schwarzeck
- 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 coordinates and are marked in the field with an aluminium pole and 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 second plot a compass and measurement tape are 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 ≥ 5cm, 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 1).

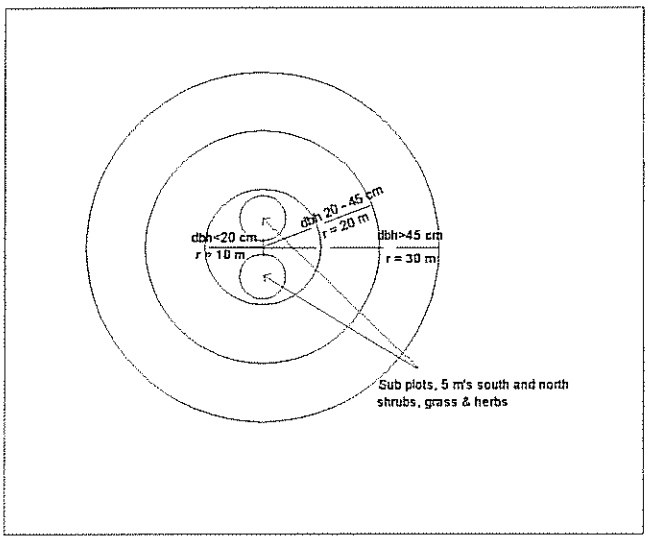


Figure 1: Plot Design

Information 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 Bushmanland 1996).

3.3 Stem analysis and volume functions.

33 trees of different sizes were felled and measured in the Omusati region for the development of volume function for *Colophospermum mopane, Combretum collinum, Lonchocarpus nelsii* and *Terminalia sericea.*

The data on 53 trees (from 5 species) felled and measured in West Tsumkwe and 95 trees (from 7 species) felled and measured in Caprivi region were added to the trees felled in the Omusati region for the development of the volume functions. The estimated volume functions are in Appendix 4.

Volume functions were developed only for the most common species. For the other non-common species the volume function were applied to estimate the volumes of those species. For other users who may wish to use the models, Appendix 4 shows also which models that were applied to the species where no functions were developed.

4. INVENTORY RESULTS

4.1 Measured data

The inventory field work in Omusati region was carried out in January, February, March and July 1999. A total of 476 sample plots (238 clusters) were measured in the inventory. Although the land in the region is supposed to be communal, a considerable part of the area is fenced off into private farms. Hence a considerable part of the sample plots were inside private farms (see chapter 4.13).

A total of 724 trees with DBH ≥ 5 cm were measured in the sample plots (see Table 1 p. 11), which is on average 1.5 trees per sample plot. This is very few trees and indicates the scarcity of trees in the region. Out of the 724 trees 339 were sample trees, i.e. trees where additional variables were measured (see chapter 3.2 p. 8).

A total of 48 woody species were recorded in Omusati region. 29 of the species were recorded as trees, while 40 of the species were found as shrubs. The most frequent species in the data were as follows:

Species (trees)	**% of measured trees**
Colophospermum mopane	61.1
Combretum collinum	7.7
Terminalia prunoides	7.4
Terminalia sericea	4.1
Acacia erioloba	3.5
Commiphora angolensis	3.5
Total:	**87.3 %**

Colophospermum mopane is by far the most common tree species recorded. More than half of the measured trees are from that species. Together the 3 most common species, *Colophospermum mopane, Combretum collinum* and *Terminalia prunoides* accounts for more than ¾ of all the measured trees. Table 1 (p.11) shows the total number of measured trees per species.

Species (shrubs)	% of measured shrubs
Colophospermum mopane	69.9
Catophractes alexandri	7.4
Bauhia petersiana	3.1
Baphia massaiensis	3.0
Commiphora angolensis	2.9
Combretum apiculatum	1.4
Total:	**87.7 %**

A total of 4514 shrubs were measured (see Appendix 2). *Colophospermum mopane* is also in the shrub layer by far the most commonly measured species. The 6 most common species together accounts for almost 90 % of all the shrubs recorded. 2 of the most common species in the tree layer also occur among the 6 most common species in the shrub layer. Of the 6 most common species in the shrub layer *Catophactes alexandri*, *Bauhia petersiana* and *Baphia massaiensis* 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 total measured trees	Total No. of sample trees	% of sample trees
Colophospermum mopane	435	60.1	207	61.1
Terminalia prunioides	75	10.4	25	7.4
Combretum collinum	34	4.7	26	7.7
Acacia erioloba	26	3.6	12	3.5
Terminalia sericea	23	3.2	14	4.1
Acacia tortilis (heterecantha)	22	3.0	6	1.8
Combretum apiculatum (apiculatum)	16	2.2	6	1.8
Commiphora angolensis	15	2.1	12	3.5
Acacia sieberana	14	1.9	2	0.6
Combretum apiculatum (leutweinii)	8	1.1	4	1.2
Combretum mossambicense	8	1.1	2	0.6
Lonchocarpus nelsii	7	1.0	2	0.6
Baikiaea plurijuga	5	0.7		
Hyphaene petersiana	5	0.7	2	0.6
Sclerocarya birrea	5	0.7	4	1.2
Dichrostachys cinerea (Africana)	4	0.6	2	0.6
Acacia hebeclada (hebeclada)	3	0.4	2	0.6
Albizia anthelmintica	3	0.4	3	0.9
Berchimia discolor	3	0.4	1	0.3
Combretum zeyheri	2	0.3	2	0.6
Commiphora africana	2	0.3	1	0.3
Diospyros mespiliformis	2	0.3	1	0.3
Peltophorum africanum	2	0.3		
Acacia aranaria	1	0.1		
Acacia reficiens	1	0.1		
Acacia schweinfurthii	1	0.1	1	0.3

Boscia albitrunca	1	0.1	1	0.3
Ziziphus mucronata	1	0.1	1	0.3
Total	724	100.0	339	100.0

4.2 Structure of the woody vegetation

4.2.1 The vegetation type classification used in this report

Edwards Vegetation Structural Types (Edwards 1983) is used for describing the structure of the woody vegetation (Appendix 3). This classification is based on the crown cover of the tree, shrub and grass layer and the height of the tree and shrub layer. There are 6 main vegetation types determined by the layer in which the woody vegetation is, namely; forest, woodland, thicket, bushland, shrubland and grassland. Each main vegetation type is further divided into sub-types depending on the height and density of the woody vegetation. E.g. short closed woodland, tall closed woodland, short open woodland and short closed woodland. The main vegetation types can briefly be described as follows:

Vegetation type	Description
Forest	Dense tree layer. Not much 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 three 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 herbsland	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 the crown coverage and height of the woody vegetation are used as classification criteria and the classification in the vegetation maps is compatible with the Edwards classification.

4.2.2 Structure of the woody vegetation in the Omusati Region

The structure of the woody vegetation is shown in tables 2 and 3 (p. 13). There are no areas in Omusati region with a tree cover dense enough to be classified as forests. Only 11.1% (152,394 ha) of the region is classified as closed woodland or thicket, i.e. on one-tenth of the region there is some kind of a tree layer (trees covering more than 10% of the land area). And here the height of the tree layer is generally below 5 m (see also Table 4 p. 14). The woody vegetation is concentrated to the shrub layer. In a considerable part of the region, 40% (550,000 ha), is the shrub layer rather dense. On the other hand, on 43 % of the region (589,126 ha) there is virtually no woody vegetation.
To sum up:

- There are no forests in Omusati region.
- The dominating vegetation types are areas with a rather dense shrub layer, and areas with virtually no vegetation.
- The areas with a distinct tree layer are few in the region.

Table 2: Area by Vegetation Structural Types

Vegetation structure type	Area, in Ha	% of total area
Short Closed Woodland	41294	3.0
Low Closed Woodland	55062	4.0
Tall Open Woodland	17960	1.3
Short Open Woodland	56374	4.1
Low Open Woodland	74367	5.4
Tall Sparse Woodland	9886	0.7
Low Sparse Woodland	29689	2.1
Short Thicket	20395	1.5
Low Thicket	35643	2.6
Short Bushland	30274	2.2
Low Bushland	72764	5.3
High Closed Shrubland	48945	3.5
Tall Closed Shrubland	281529	20.3
Low Closed Shrubland	60191	4.3
High Open Shrubland	4749	0.3
Tall Open Shrubland	56953	4.1
Low Open Shrubland	70253	5.1
Tall Sparse Shurblad	9498	0.7
Low Sparse Shrubland	5346	0.4
Short Closed Grassland	167337	12.1
Short Open Grassland	5335	0.4
Herbland	5335	0.4
Bare Land	224745	16.2
Total	1383924	100.0

Table 3: Summary of vegetation structure type

Vegetation structure type	Area, in Ha	% of total area
Shrubland	537465	38.8
Woodland	284631	20.6
Bare Land	224745	16.2
Grassland	172671	12.5
Bushland	103039	7.4
Thicket	56038	4.0
Herbland	5335	0.4
Total	1383924	100.0

Table 4 shows the average and maximum height of tree species in the area. The tree layer in the region is very low. The most common species in the region, *Colophospermum mopane*, has an average height of 3.3 m. None of the six most common species has an average height above 5 m. There are only 4 species with an average height above 10 m. The highest tree found in the inventory was a *Sclerocarya birrea* with the height of 19.2 m.

Table 4: Average and maximum height by species

Species	Average height, in meters	Maximum height, in meters
Berchimia discolor	18.1	18.1
Sclerocarya birrea	15.6	19.2
Hyphaene petersiana	12.3	14.8
Diospyros mespiliformis	11.1	11.1
Commiphora africana	7.3	7.3
Ziziphus mucronata	5.0	5.0
Terminalia prunioides	4.8	9.6
Acacia hebeclada (hebeclada)	4.3	5.1
Acacia sieberana	3.8	5.0
Acacia erioloba	3.6	5.9
Combretum apiculatum (apiculatum)	3.6	8.8
Colophospermum mopane	3.3	10.5
Terminalia sericea	3.2	9.0
Commiphora angolensis	3.1	7.3
Combretum zeyheri	3.1	3.2
Acacia schweinfurthii	2.9	2.9
Albizia anthelmintica	2.9	6.9
Combretum apiculatum (leutweinii)	2.6	6.3
Dichrostachys cinerea (Africana)	2.6	3.1
Acacia tortilis (heterecantha)	2.5	7.3
Boscia albitrunca	2.5	2.5
Combretum mossambicense	2.3	4.5
Combretum collinum	2.1	6.8

Lonchocarpus nelsii	1.6	3.1
Unknown2	1.5	4.6

4.2.3 Description of the woody vegetation in the DEA Environmental Profile

The Environmental Profiles Project within the Directorate of Environmental Affairs (DEA) has in 1998 - 2000 been carrying out mapping of the environment in north central Namibia (the 4 O's Regions). The mapping carried out by the DEA and the NFI carried out by the DoF have been separate activities. Both of them however collected data on the vegetation, and therefore it is of interest to present shortly in this report also the results from the DEA mapping of the Omusati Region. Appendix 7 shows both in thematic map format and in text format a description of the vegetation in the region. This information is extracted from "A profile of North Central Namibia" (to be published in 2000), the environmental mapping carried out by the Environmental Profiles Project within the DEA.

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 measures of species diversity are 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 cm
Acacia aranaria	1	4	Combretum mossambicense	1	2
Acacia ataxacantha		7	Combretum zeyheri	2	2
Acacia erioloba	10	10	Commiphora africana	1	9
Acacia fleckii		6	Commiphora angolensis	7	49
Acacia hebeclada (hebeclada)	3	4	Croton gratissimus		3
Acacia luederitzii		1	Dichapetalum cymosum		1
Acacia mellifera		6	Dichrostachys cinerea (Africana)	3	14
Acacia nigrescens		6	Dichrostachys cinerea (Setulosa)		8
Acacia reficiens	1	2	Diospyros mespiliformis	2	
Acacia schweinfurthii	1	2	Elephentorrhiza elephantina		12
Acacia sieberana	4		Grewia bicolor		14
Acacia tortilis (heterecantha)	6	2	Grewia retinervis		4
Acacia Tortilis (spirocarpa)		2	Hyphaene petersiana	1	1
Albizia anthelmintica	2	8	Lonchocarpus nelsii	4	
Baikiaea plurijuga	1		Maytenus senegalensis		1
Baphia massaiensis		5	Ozoroa longipes		1
Bauhinia petersiana		15	Pavetta zeyheri		6
Berchimia discolor	2		Peltophorum africanum	1	1

Boscia albitrunca	1	9	Rhigoszum brevispinosum		7
Catophractes alexandri		23	Sclerocarya birrea	3	
Colophospermum mopane	89	137	Terminalia prunioides	21	17
Combretum apiculatum (apiculatum)	5	5	Terminalia sericea	8	17
Combretum apiculatum (leutweinii)	3	7	Unknown2	1	
Combretum collinum	5	2	Ziziphus mucronata	1	

A total of 48 woody species were recorded in the region. 29 species are occurring as trees, while 40 species are found in the shrub layer. Hence, the species diversity in the shrub layer is bigger than in the tree layer. 21 species occurred both as trees and in the shrub layer.

Colophospermum mopane trees were found on 37% (89 clusters) of the measured clusters, while shrubs from the same species were found in more than half (137 clusters) of the measured clusters. Taking into consideration the considerable area without woody vegetation, *Colophospermum mopane* seems to occur either as a tree or a shrub in most of the areas with woody vegetation in the region. *Commiphora angolensis* and *Terminalia prunoides* are other woody species to some extent common in the region. *Commiphora angolensis* is mostly appearing as a shrub, while *Terminalia prunoides* is appearing both as trees and shrubs. 13 different *Acacia* species were found in the region.
Most of the woody species in the region are scarce. 33 of the species (69 % of the species) were found in less than 10 clusters. 7 species were found in only one cluster. Hence, the number of common species is rather low in the region. Therefore, although a comprehensive number of species can be found in the region, the species diversity on local level is not very high.

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 Omusati region. Note that this is the dominant species in the tree layer, not in the shrub layer. The table includes only areas with trees, hence only 48 % (664,865 ha) of the region is included in the table. More than half of the region is not included in the table since there are no trees on those areas and hence no dominant species.

On more than half of the area where there is a tree layer, the dominant species is *Colophospermum mopane*. On 2/3 of the area with a tree layer the dominant species is either *Colophospermum mopane* or *Terminalia prunoides*. Therefore, the impression of the tree layer in the region is very much affected by these two species and above all *Colophospermum mopane*. On the rest of the area with a tree layer the dominating species is one of the 20 other species listed in Table 6.

Table 6: Areas of dominant species

Species	Area, in Ha	% of total area
Colophospermum mopane	368554	55.4
Terminalia prunioides	80209	12.1
Acacia erioloba	43936	6.6
Acacia tortilis (heterecantha)	20736	3.1

Commiphora angolensis	20179	3.0
Combretum collinum	19970	3.0
Combretum apiculatum (apiculatum)	15624	2.3
Terminalia sericea	14867	2.2
Hyphaene petersiana	13016	2.0
Lonchocarpus nelsii	10692	1.6
Albizia anthelmintica	5346	0.8
Peltophorum africanum	5346	0.8
Acacia hebeclada (hebeclada)	5335	0.8
Diospyros mespiliformis	5335	0.8
Berchimia discolor	4943	0.7
Sclerocarya birrea	4943	0.7
Combretum apiculatum (leutweinii)	4749	0.7
Combretum mossambicense	4749	0.7
Commiphora africana	4749	0.7
Dichrostachys cinerea (Africana)	4749	0.7
Unknown2	4749	0.7
Baikiaea plurijuga	2087	0.2
Total	664865	100

Most of the areas with a tree layer in the region are open, therefore it is logical that most of the species occur as dominant in areas with an open tree layer. Table 7 shows the dominant species in closed and open woodlands, thickets and bushland. Hence, the table shows which species that are likely to be found as dominant in tree vegetation of various densities. Note that the table shows only the 9 species most commonly occurring as dominant (see Table 6).

The table shows that *Colophospermum mopane* is the species most commonly found as dominating species regardless of density of the tree layer. When the tree layer is dense (closed woodland) the dominating species are either *Colophospermum mopane* or*Combretum collinum*. *Terminalia prunoides* is occurring as dominant in open areas or areas with a significant shrub layer.

Table 7: Area (Ha) and % of dominant species in open and closed woodlands, thickets and bushland.

	Woodland				Thicket		Bushland	
	Closed		Open					
Species	Area	%	Area	%	Area	%	Area	%
Acacia erioloba			15441.6	10	9498.3	21	4749	5.1
Acacia tortilis	1142	1			5346.2	11		
Colophospermum mopane	55628	61	90408.7	58	20981	38	53746	57
Combretum apiculatum			4943.17	3	5346.2	11		
Commiphora angolensis			5334.59	3			10095	11
Combretum collinum	19970	22						
Hypeane petersiana			13016.4	8				
Terminalia prunioides	4749	5	20798.3	13	10118	20	24950	27
Terminalia sericea	10118	11	4749.14	3				
Total	91607	100	154692	100	51289	100	93541	100

Table 8 (p. 18) shows the species composition in the region based on which species that typically occurr with a certain dominant 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 most likely to be found toghether and does not give information on the total number of species or which species (more than the 2 most common) that are growing together. The data in the table are reliable only for the most frequent species like *Colophospermum mopane* and *Terminalia prunoides*. Note that this is the species composition for the tree layer only.

The table shows the % occurrence of the second species with a certain dominant species. E.g. in 3.2% of the area where *Colophospermum mopane* is the dominant species is it associated with *Terminalia prunoides*.

The table shows that *Colophospermum mopane* is to a big extent (93.2%) occurring as pure stands, i.e. there are no other species on the site ("No trees" in the table). *Terminalia prunoides* is either occurring with *Colophospermum mopane* or growing in pure stands. Note that "pure stands" should be put in the context of the woody vegetation in the region. Since most of the areas with a tree layer are open, "pure stands" mean trees of the species in question sparsely scattered over the area.

Table 8: Species composition based on which species that is associated with the dominant species

	Second domiant species											
Dominant Species	Acacia erioloba	Acacia hebeclada (hebeclada)	Colophospermum mopane	Combretum apiculatum (leutweinii)	Combretum collinum	Combretum zeyheri	Diospyros mespiliformis	Lonchocarpus nelsii	No trees	Terminalia prunioides	Terminalia sericea	Total area of dominat species, in %
Acacia erioloba			24.8						25.5		49.7	100
Acacia hebeclada (hebeclada)					100.0							100
Acacia tortilis (heterecantha)			4.5						95.5			100
Baikiaea plurijuga								100.0				100
Berchimia discolor											100.0	100
Colophospermum mopane		1.5					0.3	1.7	93.2	3.2		100
Combretum apiculatum (apiculatum)			100.0									100
Combretum apiculatum (leutweinii)									100.0			100
Combretum collinum			49.0	26.4					24.7			100
Combretum mossambicense			100.0									100
Commiphora africana			100.0									100
Commiphora angolensis			25.3						74.7			100
Dichrostachys cinerea (Africana)									100.0			100
Hyphaene petersiana									100.0			100
Lonchocarpus nelsii									100.0			100
Peltophorum africanum									100.0			100
Sclerocarya birrea									100.0			100
Terminalia prunioides		7.4	63.0						29.6			100
Terminalia sericea	34.7		34.7			30.6						100.0

4.5 Tree volumes and number of stems

Volume functions: An important activity within the NFI region inventories is to develop volume functions for the most common tree species in each region. This is done by stem- analysis on a representative number of stems for the most common species in each region. Stem analysis has so far been carried out in Otjozondjupa, Caprivi and Omusati regions. The volume functions used to calculate the volumes in Omusati region are presented in Appendix 4. Volume functions are developed for the most common species only, but the functions are also applied on the other species without own volume functions. For other users who may wish to use the models, Appendix 5 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. The number of trees and volumes for the whole Omusati region are as follows:

Total number of trees	45,075,000
Mean number of trees per hectare	32.6
Total tree volume, m^3	4,449,500
Mean volume per hectare, m^3	3.2

The tree volumes in the Omusati region are extremely low, both when it comes to total volumes and mean volumes per hectare. In fact, Omusati region has the lowest mean tree volume of all the regions so far measured. The mean tree volume in Otjozondjupa region was 4.2 m^3/ha, in Caprivi region 17.8 m^3/ha.

The mean tree volumes in the two proposed community forest areas in the Omusati region were the following; Ongandjera 1.06 m^3/ha and Uukwaluudhi 6.3 m^3/ha. This indicates that the woody resources south in the region are lower than in the western parts of the region.

The figures above include the whole region, i.e. all different vegetation types inclusive bare land. Table 9 shows the volumes and number of trees for the main vegetation types. The table shows that the mean volumes and number of trees even in areas with the densest tree layer in the region, i.e. closed woodland and thicket, is very low.

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

	Vegetation type					
	Woodland		Shrubland			
	Closed	Open	Closed	Open	Thicket	Bushland
Total No. of stems, 1000s	9904.8	8477.4	6926.5	658.9	6154.8	6017.3
Stems per Ha	102.8	45.0	17.5	4.6	109.8	58.4
Total tree volume, 1000s	667.0	1599.5	210.8	755.0	412.4	372.7
Average tree volume, m3/ha	6.9	8.5	0.5	5.3	7.4	3.6

238 clusters (consisting of 2 sample plots) were measured in the region. The highest volume measured in a cluster was 131 m^3/ha. In only 1 cluster (0.4% of the measured clusters) was the volume above 100 m^3/ha. In only 5 clusters (2 % of the measured clusters) was the volume

above 30 m^3/ha. The main reason behind the higher volumes in these clusters was that big trees of e.g. *Peltophorum africanum, Acacia erioloba* or *Sclerocarya birrea* were found in the clusters. Therefore the higher volumes in those clusters do not come from concentrations of species valuable for timber or poles. In only 26 clusters (11% of the measured clusters) was the volume above 10 m^3/ha. 199 clusters (84% of the measured clusters) had a volume below 6 m^3/ha. This means that the variation in the volumes between the 238 measured clusters in the region is quite small, and consequently the woody vegetation is quite homogenous when it comes to volumes in the region.

There are no forest industries in the region. The economic importance of the wooded areas in the region lies at present in the utilisation of the wood for fuelwood and poles, and the non-wood forest products including fodder. The most preferred species for poles are *Colophespermum mopane* and *Dichrostachys cinerera* (Salinas 1998). Other species used for poles are *Terminalia prunoides*, *Terminalia sericea* and different *Combretum* species. According to a study in Ontanda village in the region (Ojanen-Jarlind 1998), the annual consumption of poles per farm is 3.5 m^3, with 95% of the consumption being *Colophespermum mopane* and *Terminalia prunoides.* The above figure does not include firewood.

Table 10 (p. 21) shows the number of stems and tree volumes per species for the whole region. The total number of stems and total volumes might for some species seem high. However, the Omusati region covers a large area (1.38 million hectares), the mean number of stems and mean tree volumes per hectare are modest even for the most common species in the region. The total amount of *Colophespermum mopane* and *Terminalia prunoides* is 2.3 millionm^3. Considering the annual subsistence consumption of poles per farm (3.5 m^3) and that 13% of Namibia's population lives in the region, the total volume of the two preferred species is not big. Furthermore, the 2.3 million m^3 include trees of all sizes while trees only up to a certain diameter is used as poles. Therefore the volumes available for poles are even smaller than the above mentioned figure. A survey on the management of the woody resources in the Omusati region in fact indicates that there is already a shortage of poles in parts of the region due to over-cutting (Salinas 1998).

The most valuable timber tree species in Namibia is *Pterocarpus angolensis.* Other species utilised by the timber industry in the country are *Baikea plurijuga, Guibourtia coleosperma* and *Burkea africana.* There are no *Pterocarpus angolensis*, *Guibourtia coleosperma* or *Burkea africana* in the region. Table 10 shows that there are some *Baikea plurijuga* in the region, but the amounts are very small.

The figures presented above indicate that:
- The potential for even small-scale forest industries in the region are very limited.
- The use of wood in the region is not sustainable.

Table 10: Total number of stems, stems/Ha, total tree volume, and average volume by species and for the whole area

Species	Total No. of stems, 1000s	Stems per Ha	Total tree volume, 1000, m3	Average tree volume, m3/ha
Colophospermum mopane	27561.2	19.9	1694.8	1.225
Terminalia prunioides	3288.2	2.4	420.9	0.304
Combretum collinum	2304.7	1.7	81.4	0.059
Acacia erioloba	2012.7	1.5	29.4	0.021
Acacia sieberana	1885.7	1.4	30.3	0.022
Terminalia sericea	1475.5	1.1	37.6	0.027
Acacia tortilis (heterecantha)	1418.8	1.0	120.2	0.087
Combretum apiculatum (apiculatum)	1154.5	0.8	43.4	0.031
Commiphora angolensis	796.9	0.6	122.2	0.088
Combretum mossambicense	604.7	0.4	46.5	0.034
Combretum apiculatum (leutweinii)	501.2	0.4	44.6	0.032
Lonchocarpus nelsii	322.8	0.2	56.7	0.041
Dichrostachys cinerea (Africana)	302.3	0.2	2.4	0.002
Hyphaene petersiana	230.2	0.2	230.5	0.167
Unknown2	226.8	0.2	14.9	0.011
Acacia hebeclada (hebeclada)	175.5	0.1	29.6	0.021
Combretum zeyheri	170.9	0.1	1.7	0.001
Commiphora africana	151.2	0.1	10.7	0.008
Albizia anthelmintica	101.9	0.1	86.3	0.062
Acacia reficiens	84.9	0.1	2.5	0.002
Boscia albitrunca	75.6	0.1	2.8	0.002
Acacia schweinfurthii	51.8	0.0	15.8	0.011
Berchimia discolor	48.1	0.0	104.3	0.075
Sclerocarya birrea	43.7	0.0	325.8	0.235
Baikiaea plurijuga	36.9	0.0	56.7	0.041
Peltophorum africanum	18.9	0.0	700.7	0.506
Acacia aranaria	18.2	0.0	0.2	0.000
Diospyros mespiliformis	11.5	0.0	136.6	0.099
Total	45075.0	32.6	4449.5	3.215

4.6 Diameter distribution

A desired diameter distribution from management and utilisation point of view is one with the bulk of the stems 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 or 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 11 shows the diamter distribution of the tree species in Omusati region. The bulk of the trees in the region are small. 2/3 of the trees have a dbh between 5 cm and 15 cm. More than 90% of the trees have a dbh below 25 cm.

Table 11: Diameter distribution of stems by species

	Diameter class, in cm; No. of stems in 1000s														
Species	**5-15**	**15-25**	**25-35**	**35-45**	**45-55**	**55-65**	**65-75**	**75-85**	**85-95**	**95-105**	**105-115**	**135-145**	**215 - 225**	**Total**	**% of total**
Colophospermum mopane	18180	7224	1612	343	64	58	36	18	18	9				27561	61.15
Terminalia prunioides	1231	1523	422	104						8				3288	7.30
Combretum collinum	1987	233	64	21										2305	5.11
Acacia erioloba	2013													2013	4.47
Acacia sieberana	1603	283												1886	4.18
Terminalia sericea	1219	237	20											1475	3.27
Acacia tortilis (heterecantha)	1313	76	5				8	8	8					1419	3.15
Combretum apiculatum (apiculatum)	740	393	21											1155	2.56
Commiphora angolensis	492	171	104	21			9							797	1.77
Combretum mossambicense	76	454	76											605	1.34
Combretum apiculatum (leutweinii)	237	246	19											501	1.11
Lonchocarpus nelsii	170		149				4							323	0.72
Dichrostachys cinerea (Africana)	302													302	0.67
Hyphaene petersiana			52	155		23								230	0.51
Unknown2	151	76												227	0.50
Acacia hebeclada (hebeclada)	76	79		21										175	0.39
Combretum zeyheri	171													171	0.38
Commiphora africana	76	76												151	0.34
Albizia anthelmintica	85								8		8			102	0.23
Acacia reficiens	85													85	0.19
Boscia albitrunca	76													76	0.17
Acacia schweinfurthii			52											52	0.11
Berchimia discolor				20	20				9					48	0.11
Sclerocarya birrea								9		17	17			44	0.10
Baikiaea plurijuga				17	20									37	0.08
Acacia aranaria	18													18	0.04
Diospyros mespiliformis							2					9		11	0.03
Peltophorum africanum													18.9	19	0.04
Total	30299	11067	2593	702	104	81	59	35	43	35	26	9	19	45075	
% of total	67.22	24.55	5.75	1.6	0.2	0.2	0.1	0.1	0.1	0.08	0.1	0.02	0.04		100

The table also gives indications on which tree species that have a potential to grow into big size trees in the region. The biggest trees in the region are *Pelthophorum africanum, Diospyros mespiliformis, Sclerocarya birrea* (Marula tree), *Albizia anthelmintica, Terminalia prunoides* and *Colophospermum mopane.*

The diameter distribution for most of the species is good in the sence that the bulk of the stems are in the lower dbh classes. These trees if properly managed will grow into bigger trees and provide poles also in the future. However, the diamater distribution for *Baikea plurijuga, Sclerocarya birrea* and *Hyphaene petersiana* is skewed to the right with no trees in the smaller classes. This will affect the utilisation of those trees species for timber or fruits in the future in the region.

The Namibian timber industry utilises a number of indigenous species, but only one of them, *Baikea plurijuga*, is found in the Omusati region. Table 11 and 12 shows that there are some *Baikea plurijuga* in the region that can be harvested, but the amounts are very small. Furthermore, there are no *Baikea plurijuga* in the smaller dbh classes. *Baikea plurijuga* is found in the northwestern parts of the region, in the Uukolankadhi proposed community forest.

Table 12: Total tree volume and number of stems by diameter classes; *Baikiaea plurijuga*

Dbh class, cm	Total tree volume, 1000, m3	Total No. of stems, 1000s	% of total stems
35-45	16.6	16.6	45.0
45-55	40.2	20.3	55.0
Total	56.7	37	100.0

Poles are used for homestead construction and fencing. The most preferred species for poles are *Colophespermum mopane* and *Dichrostachys cinerera* . Other species used for poles are *Terminalia prunoides*, *Terminalia sericea* and *Combretum* species. The most preferred pole size is a diameter of 20 cm and length between 2 –3 m. But also smaller sizes are used. The survey in Ontanda village (Jarlind 1998) showed that pole diameters down to 5 cm and lengths down to 1.5 m were used.

Table 13 (p. 24) shows that 2/3 of the *Colophespermum mopane* volumes and ¾ of the *Terminalia prunoides* volumes are in the dbh classes below 35 cm, and therefore suitable for pole production. The rest of the volumes are in the bigger trees, too big to be utilised for pole production.

Table 11 (p. 22) shows that the bulk of the stems for *Terminalia sericea* and *Combretum* species are in the desired diameter classes from pole utilisation point of view. *Dichrostachys cinerera* was found only as a very small tree (dbh 5 – 15 cm) and its importance as a construction pole is therefore at the moment limited. The reason for not finding bigger trees of this species is most probably over-cutting.

Hence, the sizes of most of the tree species used as poles in the region are good. The problem is that the amounts of growing trees are much smaller than what would be needed for the present utilisation of the woody vegetation in the region to be sustainable.

Table 13: The stems and tree volumes per diameter class for *Colophespermum mopane* and *Terminalia prunoides*.

Colophospermum mopane			
Dbh class, cm	**Total tree volume, 1000, m3**	**Total No. of stems, 1000s**	**% of total stems**
5-15	206.1	18180	66.0
15-25	538.7	7224	26.2
25-35	387.7	1612	5.8
35-45	190.7	343	1.2
45-55	64.9	64	0.2
55-65	94.3	58	0.2
65-75	82.2	36	0.1
75-85	45.7	18	0.1
85-95	50.7	18	0.1
95-105	33.7	9	0.0
Total	1694.8	27561	100.00

Terminalia prunioides			
Dbh class, cm	**Total tree volume, 1000, m3**	**Total No. of stems, 1000s**	**% of total stems**
5-15	27.5	1231	37.4
15-25	160.6	1523	46.3
25-35	124.2	422	12.8
35-45	64.4	104	3.2
45-55	0	0	0.0
55-65	0	0	0.0
65-75	0	0	0.0
75-85	0	0	0.0
85-95	0	0	0.0
95-105	44.1	8	0.3
Total	420.9	3288	100.0

The following can be concluded on the potential for forestry in the region:

- The potential for even small-scale timber industries in the region are very limited. The volume of the only timber species found in the region (*Baikea plurijuga*) is too small. Also the option to create a small-scale timber industry by utilising other species (e.g. *Terminalia prunoides*) is not viable due to few trees found in the region.
- The *Baikea plurijuga* stands in the northwestern parts of the region should be looked into as a part of the management planning of the Uukolankadhi proposed community forest. There might be potential to economically utilise the species on a long term basis.
- The economic importance of the wood in the region lies at present in the utilisation for fuel wood and poles. There are strong indications that the wood use for poles and fuel wood is unsustainable in the region.
- The non-wood forest products including fodder are economically important in the region. These products are described in chapter 4.11 "Non-wood forest products".

4.7 Damage to the woody vegetation

Damages to the woody vegetation were recorded both at stand level, for the sampled vegetation unit (Table 14), and at tree level (Table 15), for the measured sample trees. In the damage assessment 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 14: Damaging agent by severity of damage at cluster level, in ha

Damaging agent	Mild (ha)	Moderate (ha)	Serious (ha)	Total (ha)	% of total damaged area	% of total area
Forest fire	23709	0	0	23709	4	2
Human	63051	261032	97133	421216	69	30
Mammals domestic	57257	64925	0	122182	20	9
Mammals wild	4175	28495	0	32669	5	2
Unknown	0	13016	0	13016	2	1
Total	148192	367468	97133	612793	100	44
% of total	24	60	16	100		
Area without damages				771131		56

The table shows that more than half of the woody vegetation in the region does not show any signs of damage. Where damage is visible it is in most cases mild or moderate, i.e. the damages is to some extent decreasing the vitality of the woody vegetation.

The most common cause for damage is human, 2/3 of the damages are caused by human activities. Human activities here means cutting. All damages classified as serious are caused by human activities. This gives some indications on the degree of over-cutting in the region. The damages caused by fires are very few. Hence, the situation is completely different from the one in Caprivi region, where the most common cause for damage on the woody vegetation was fire.

Table 15 shows the damage to the individual trees for the 7 most common species. Very few damages were recorded on the trees in the sample plots. The reasons why the damage assessment of stand level indicates damages, but the assessment on tree level shows very few damages are the following:

- The stand level classification also inludes damages on shrubs into the classification.
- When the stand level classification indicates damages caused by humans, it means that tree cutting are visible in the stand. Trees that have been removed by cutting can obviously not be measured, and are therefore not included in the tree level classification.

Table 15: Cause and degree of damage to individual trees for 7 most common species

Damaging agent	Degree of Damage	Acacia erioloba	Acacia sieberana	Acacia tortilis	Colophosper mum mopane	Combretum apiculatum	Combretum collinum	Commiphora angolensis	Hyphaene petersiana	Terminalia prunioides	Terminalia sericea
Forest fire	Mild, no harm for the tree				0.2						
	Moderate, degrades the vitality of the tree				0.2						
Human	Moderate, degrades the vitality of the tree						18				
	Serious, vitality seriously reduced				0.2						
No Damage	No Damage	100	100	100	98.6	100	82	100	100	100	100
Unknown	No Damage				0.7						
Total		100	100	100	100.00	100	100	100	100	100	100

4.8 Regeneration of the tree - saplings

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 utilisation 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) will not decrease as the old trees are dying. If the regeneration is weak, it is going to affect the desired diameter distribution mentioned in chapter 4.6 (p. 22) and hence also affect short or long-term management decisions.

Table 16 shows the estimated area covered by regeneration. Note that the table includes all woody vegetation with dbh < 5 cm. Hence the table includes both saplings and shrubs. Saplings are small specimen of species that are known to become trees, while shrubs are specimen that do not grow into trees in the region. Table 16 shows that there is regeneration visible in a major part (80%) of the region.

Table 16: Extent of regeneration, in Ha

Regeneration	Area, in Ha	% of total area
Vital seedlings or sprouts higher than 1.5 m are present	652033	47
Seedlings or sprouts are present but only lower than 1.5 m	459625	33
No regeneration can be observed	272266	20
Total	1383924	100

Table 17 (p. 27) shows the amount of saplings per species in the region. Comparing this table and Table 18 (p. 28) which shows the whole shrub layer, gives information on how big a proportion of the regeneration presented in Table 16 that are saplings.

Table 17: Number of tree saplings 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**
Colophospermum mopane	58.8	97.9	383.2	356.3	200.4	132.4	51.7	45.8	1326.5	91.5
Terminalia prunioides	4.6	3.8	3.4	2.5	3.4	1.3	2.1	1.7	22.7	1.6
Terminalia sericea		0.8	2.9	7.6	2.9	2.5	0.4	2.1	19.3	1.3
Acacia erioloba		1.3	2.1	3.8	0.4	3.8	0.0	5.9	17.2	1.2
Dichrostachys cinerea (Setulosa)		4.2	8.0	1.7	0.8			0.8	15.5	1.1
Albizia anthelmintica		0.8	2.9	0.8	0.4	0.4	0.4	3.4	9.2	0.6
Dichrostachys cinerea (Africana)	0.4	0.8	3.4	1.3	1.3	1.3	0.4	0.4	9.2	0.6
Acacia fleckii	0.4		1.3	2.1	1.7	0.0			5.5	0.4
Combretum zeyheri		1.3			0.8	0.4	2.5		5.0	0.3
Acacia nigrescens			1.3	0.4	0.8	0.8	0.4		3.8	0.3
Boscia albitrunca	0.4	1.3	1.3	0.4		0.4			3.8	0.3
Acacia tortilis (heterecantha)			1.7		0.4	0.8			2.9	0.2
Acacia Tortilis (spirocarpa)		0.4	0.4	0.8		0.8			2.5	0.2
Hyphaene petersiana	0.4	1.3		0.0	0.4		0.4		2.5	0.2
Croton gratissimus	0.4	0.4		1.3					2.1	0.1
Combretum collinum	0.8	0.0	0.4						1.3	0.1
Peltophorum africanum		0.8							0.8	0.1
Total	66.4	115.1	412.2	379.0	213.9	145.0	58.4	60.1	1450.0	
% of total	5	8	28	26	15	10	4	4	100	100

Table 17 should be interpreted with caution. The reason why there is no tree layer varies in different parts of the region. There used to be thick forests in parts of the region (Salinas 1998). This tree layer has now disappeared due to over-cutting, remaining is a shrub layer that will develop into trees if properly managed. On the other hand, the *Colophospermum mopane* shrub land in e.g. Ongandjera proposed community forest in southern Omusati will probably never develop into woodland or forest even with proper management due to the soil conditions in the area. Hence, although Table 17 shows that the regeneration of *Colophospermum mopane* is rather good, the area where it is growing will determine whether the sapling will develop into a tree or if it will remain as a shrub.

Most of the saplings found in the region are between ½ - 2 ½ m in height. *Colophospermum mopane* is the most common sapling, with 92 % of all saplings coming from that species. For the other species the regeneration is poor. No saplings were observed for *Baikea plurijuga* or *Sclerocarya birrea*. Hence, from this perspective the domination of *Colophospermum mopane* in the region will even increase in the future. The poor regeneration for the other species will affect the extraction of both poles and non-timber forest products in the future. Which in turn will have an impact on the economic importance of the wooded areas in the region.

4.9 The shrub layer

As described in chapter 4.2 ("The structure of the woody vegetation"), one of the dominating vegetation types in the region is shrub land. I.e. there are no trees, only shrubs in the area. It is however important to note, that the woody vegetation in the shrub layer consists of both shrubs and saplings. To get a clear picture of the regeneration of the tree species, Table 17 (p. 27) showed the saplings in the shrub layer, which means only the species in the shrub layer that also occur as trees in the region. Table 18 shows all the species in the shrub layer including also the saplings.

Table 18: Shrubs/saplings per hectare by height classes and species in the shrub layer

	Height class, in cm									
Species	**0-25**	**26-50**	**51-100**	**101-150**	**151-200**	**201-250**	**251-300**	**300+**	**Total**	**% of total**
Colophospermum mopane	58.8	97.9	383.2	356.3	200.4	132.4	51.7	45.8	1326.5	69.9
Catopractes alexandri	4.6	18.1	39.5	47.5	23.1	4.2	0.4		137.4	7.2
Bauhinia petersiana	26.47	15.97	11.76	1.26	0.42		2.10		58.0	3.1
Baphia massaiensis	10.92	32.77	12.61						56.3	3.0
Commiphora angolensis	0.84	10.50	23.11	10.50	7.14	1.68	0.84		54.6	2.9
Combretum apiculatum (leutweinii)	2.10	2.52	2.10	1.26	2.52	1.26	0.84	14.71	27.3	1.4
Pavetta zeyheri	6.30	5.46	10.08	2.52	1.26	0.84	0.00	0.00	26.5	1.4
Terminalia prunioides	4.6	3.8	3.4	2.5	3.4	1.3	2.1	1.7	22.7	1.2
Elephentorrhiza elephantina		1.26	12.18	6.30	1.26				21.0	1.1
Terminalia sericea		0.8	2.9	7.6	2.9	2.5	0.4	2.1	19.3	1.0
Acacia erioloba		1.3	2.1	3.8	0.4	3.8	0.0	5.9	17.2	0.9
Dichrostachys cinerea (Setulosa)		4.2	8.0	1.7	0.8			0.8	15.5	0.8
Albizia anthelmintica		0.8	2.9	0.8	0.4	0.4	0.4	3.4	9.2	0.5
Dichrostachys cinerea (Africana)	0.4	0.8	3.4	1.3	1.3	1.3	0.4	0.4	9.2	0.5
Rhigoszum brevispinosum	3.36	0.84	2.10	2.52		0.42			9.2	0.5
Grewia bicolor	0.42	1.68	3.36	1.68	0.84				8.0	0.4
Acacia aranaria			0.42	6.30	0.42	0.42			7.6	0.4
Maytenus senegalensis	0.84	1.68	5.04						7.6	0.4
Commiphora africana	0.84	0.84	2.94	1.26					5.9	0.3
Acacia ataxacantha	0.42	0.42	0.84	3.36			0.42		5.5	0.3
Acacia fleckii	0.4		1.3	2.1	1.7	0.0			5.5	0.3
Combretum zeyheri		1.3			0.8	0.4	2.5		5.0	0.3
Combretum apiculatum (apiculatum)		1.26	1.68	0.42		0.84			4.2	0.2
Combretum mossambicense		3.78			0.42				4.2	0.2
Acacia hebeclada (hebeclada)		0.42	0.42	0.42	2.10			0.42	3.8	0.2
Acacia nigrescens			1.3	0.4	0.8	0.8	0.4		3.8	0.2
Boscia albitrunca	0.4	1.3	1.3	0.4		0.4			3.8	0.2
Acacia tortilis (heterecantha)			1.7		0.4	0.8			2.9	0.2
Acacia mellifera		0.42	1.26	0.42		0.42	0.42		2.9	0.2
Grewia retinervis			2.52		0.42				2.9	0.2
Acacia tortilis (spirocarpa)		0.4	0.4	0.8		0.8			2.5	0.1
Hyphaene petersiana	0.4	1.3		0.0	0.4		0.4		2.5	0.1
Croton gratissimus	0.4	0.4		1.3					2.1	0.1
Acacia schweinfurthii	0.0	0.0	0.8	0.0	0.4	0.0	0.0	0.0	1.3	0.1
Combretum collinum	0.8	0.0	0.4						1.3	0.1
Ozoroa longipes		0.84	0.42						1.3	0.1
Acacia luederitzii			0.84						0.8	0.0
Acacia reficiens			0.42	0.00	0.42	0.00			0.8	0.0
Peltophorum africanum		0.8							0.8	0.0
Dichapetalum cymosum	0.00	0.00	0.00	0.42	0.00	0.00	0.00	0.00	0.4	0.0
Total	123.53	213.87	546.64	464.71	254.62	155.04	63.45	75.21	1897.49	100.0
% of total	6.5	11.3	28.8	24.5	13.4	8.2	3.3	4.0	100.0	

The table shows that the general height of the shrub layer in the region is ½ - 2 m. A total of 40 woody species was found in the shrub layer. 22 of these species only occur as shrubs. There is on average 1897 shrubs/saplings per hectare in the shrub layer, which is quite a considerable amount. Considering that there are areas with no or little shrubs in the region (woodlands, grasslands and bareland), other areas are bound to have a rather dense shrub layer to reach up to this average.

As shown in the table *Colophospermum mopane* saplings totally dominates the shrub layer. Although the number of species found in the shrub layer is rather high, 86.1 % of the woody vegetation in the shrub layer consists of the 5 most common species in the layer. These species are *Colophospermum mopane, Catophractes alexandri, Bauhia petersiana, Baphia massaiensis* and *Commiphora angolensis.*

Of the 1897 shrubs/saplings per hectare only 447 are from typical shrub species. Hence, saplings dominate the shrub layer. However, as stated in the previous page, the area where the woody species are growing will determine whether the sapling will develop into a tree or if it will remain as a shrub.

4.10 The grass and herbs layer

Tables 19 and 20 show the grass cover and herbs cover per different vegetation types in the Omusati region. The tables also show how big the percentage of the region each vegetation type represents. The inventory field work was carried out from January to March 1999 and July 1999, hence the grass and herbs cover reflects the situation during that period.

Table 19: Cover of grasses per vegetation type

	Vegetation type								
	Closed Woodland	Open Woodland	Closed Shrubland	Open Shrubland	Thicket	Bushland	Grassland	Herbland	Bareland
Average % cover of grass	26	35	29	38	33	23	44	5	0
% of land area	7	14	28	11	4	7	12	0.39	16

The highest grass cover is found in the grassland, where grasses cover almost half of the land area. The lowest grass cover is found in areas with dense shrub layer, which is logical since the shrubs and grasses are competing on the same space. The table should be interpreted with caution since the cover of grasses varies with the time of the year. This table represents a situation in the beginning and towards the middle of the rainy season. Table 20 shows that the cover of herbs is generally very low

Table 20: Cover of herbs per vegetation type

	Vegetation type								
	Closed Woodland	Open Woodland	Closed Shrubland	Open Shrubland	Thicket	Bushland	Grassland	Herbland	Bareland
Average % cover of herbs	5	2	4	4	11	4	3	14	0
% of land area	7	14	28	11	4	7	12	0.39	16

4.11 Non-timber forest products

Forests and woodlands supply a number of different products. Timber and poles are one category. Another category are the non-timber forest products (NTFP) such as edible fruits, berries and roots, honey, medicine, fodder etc. The economic value of the non-timber forest products especially for the rural communities might be even higher than that of timber and poles.

The inventory did not collect information specifically on the NTFPs in the sense that it did not for example try to estimate the availability of fruits from different species. However, most of the NTFPs used in the region are related to trees. Therefore, the information on trees can be used to indicate the abundance or scarcity of the NTFPs. Below is presented a number of the NTFPs used in the Omusati region, it does not however include all the NTFPs used in the region.

A substanital part of the fodder for the cattle and goats is leaves from different tree species. According to a study in Oshikoto region trees and shrubs contribute almost 60 % of the feed for cattle and goats (Chacks 1999). It can be assumed that the situation is the same in Omusati region. Important fodder trees are e.g. *Baphia massaiensis, Combretum collinum, Acacia erioloba* and *Colophospermum mopane*. A big part of the wooded areas in the region consist of shrubland. Common woody species in the shrubland are *Colophospermum mopane* and *Baphia massaiensis*. Therefore, although poor in timber and poles, the economic value of the shrublands of Omusati region, is significant to the rural communities in the form of fodder for their animals. According to Salinas (Salinas et al 1998) one of the most important uses of the wooded areas in the Omusati region is fodder for the cattle and goats. The damage classification (p. 25) indicates that there are some visible signs of damage on the woody vegetation caused by animals. It is however not possible with the data collected in this inventory to determine whether the woody vegetation is over-browsed or not. Therefore it is not possible to determine the options to increase the economic value of this NTFP.

Another important NTFP in Omusati region is the mopane worm. These worms are both eaten as relish and sold for income generation (Salinas et al 1998). The mopane worm is most commonly found in younger trees of *Colophospermum mopane*. The dominating species both in the shrublands and the woodlands is *Colophospermum mopane.* Therefore, the environment for the mopane worm is favourable and it can be assumed that the supply of this NTFP is going to be secured also in the future.

Fruits from *Sclerocarya birea* (Marula), *Berhcemia discolor (*Eembe), *Hyphaene petersiana, Ficus sycomorica, Diospyros mespiliformis* and *Adanonsia digitata* (Baobab) are used for various purposes in the region. No *Ficus sycomorica* or *Adanonsia digitata* were recorded in the inventory. The species are however found in the region. But the fact that no tree or sapling of these two species was found inside any of the 478 sample plots in the region is a strong indication of the scarcity of these two species. There are *Sclerocarya birea, Berhcemia discolor, Hyphaene petersiana* and *Diospyros mespiliformis* in the region. According to the inventory *Hyphaene petersiana* is the most common of the species. Acccording to Salinas (Salinas et al 1998) the demand for the fruits from indigenous fruit trees is bigger than the supply. Therefore, at the moment there is a scarcity of indigenous fruit trees in the region. Furthermore, the diameter distribution (p. 22) and the regeneration (p. 27) of the species above raises concern. The inventory found that the only species with trees in the smaller diameter sizes or regeneration is *Hyphaene petersiana*. This means that when the trees which at present are supplying the fruits become too old and start to die, the supply of the fruits from these species will decrease and in the end eventually stop. It also means that without management inputs there are no options to increase the economic importance of these indigenous fruit trees in the region.

However, fruit trees are carefully kept and managed at on-farm level in the region. Hence, the regeneration and younger trees and saplings are mostly to be found on the farms and especially within the homesteads. Therefore, to get more detailed information on the indigenous fruit tree resources, an assessment would have to be carried out focusing on farms and with the farms as the sampling unit.

The DoF is in the process of starting a project to promote the use of indigenous fruit trees, "Improvement and Promotion of Selected Indigenous Fruit Trees in Namibia". Within this project 6 indigenous fruit trees for improvement and promotion have been shortlisted, namely *Sclerocarya birea, Berhcemia discolor, Strychnos cocculoides, Garcinia livingstonei, grewia spp.* and *Syzigium cordatum.* With the above information in mind, it seems that at least in the Omusati region the following activities would be of importance; (1) to carry out an assessment of the on-farm resources of the indigenous fruit trees, (2) to ensure the continuity of these species via proper management inputs and (3) to assess the fruit production of fruit trees of different sizes.

The following conclusion can be made on the NTFPs in the region:

- Trees for fodder is one of the most important products from the wooded areas. A substantial part of the region consist of shrubland, where the main species are suitable as fodder. It is not possible with the information in this inventory to determine the options to increase the utilisation of the woody vegetation for browsing.
- Mopane worms are another important NTFP. The environment for the mopane worm is favourable and it can be assumed that the supply of this NTFP is going to be secured also in the future.
- The demand is bigger than the supply for fruits from the indigenous fruit trees in the region. The inventory did not find any younger trees or saplings for most of the fruit trees, hence without managment inputs the supply of the fruits from these species will decrease and in the end eventually stop.
- The DoF project to promote the use of indigenous fruit trees could carry out the following important activities in Omusati region:
    - ⇒ Establishment of monitoring sites to determine the fruit production of various species of various sizes.
    - ⇒ Implement management activities to ensure the continuity of the indigenous fruit tree species.
    - ⇒ Carry out an on-farm inventory of the indigenous fruit tree resources to get more detailed information. In this inventory the farms should be the sampling unit.

4.12 Human influence

Human influnence in the form of cutting of trees and agriculture was recorded during the inventory. The information 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. Table 21 shows the areas where such influence was visible. Note that the table shows agriculture in form of cultivating the land. Table 22 shows the areas were land utilisation for grazing is visible.

No data on human influence was recorded on a number of clusters, representing 29.6% of the area (the "no code" row). Hence the table is incomplete. However, the data available shows that there was no signs of cuttings or agriculture (cultivation) on half of the region. This is in line with the assessment of the damage on the woody vegetation presented earlier in this report. The big area without signs of human influence might seem surprising taking into consideration the population pressure in the region. However, the population is concentrated to the northern parts of the region, while the southern parts are scarsely populated. The vegetation in the southern parts is mostly low *Colophospermum mopane* shrubland. Fresh water is scarse.

The most common form of human influence is cutting, where almost 1/3 of the area shows signs of this activity. This information corresponds well with the damage assessment presented on page 23 in this report. The areas used for cultivation represents only 2.4 % of the area in the region. Note that this figure includes only cultivation, not cattle farming.

Table 21: Areas of human influence

Accomplished measure	Total	% of total
No accomplished measures observed	693421	50.1
Cultivation	33064	2.4
Cuttings, fuelwood removed	188319	13.6
Cuttings, timber sized trees removed	54981	4.0
Controlled burning	4749	0.3
No code	409391	29.6
Total	1383924	100.0

Table 22"Grazing" (p. 33) and Table 23 "Fenced areas" (p. 33) gives Indications on the area used for cattle farming. 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 are located. Furthermore, the intensity of grazing was noted. No data on grazing was recorded on a number of clusters, representing 33% of the area (the "no code" row). Hence the table is incomplete. However, the

data available shows that a major part of the region is used for grazing. In only 17% of the area was there no signs of grazing. The areas seem not to be over-grazed, since most of the grazing is classifies as "moderate".

Table 22: Grazing

Grazing intensity	Area, in Ha	% of total area
No signs of grazing observed	240023	17
Moderate signs of grazing visible,veg still vital	475656	34
Signs of intesive grazing visible,vegetation vitality threatened	212552	15
No code	455692	33
Total area	1383924	100

To conclude:

- The main human influence on the vegetation in the region comes from using the areas for grazing. The vegetation on a major part of the region shows such signs of grazing.
- A very small portion (2.4%) of the region is used for cultivation.
- On almost 1/5 of the region could signs of cutting be obeserved.

4.13 The woody vegetation on the farms

Although the whole Omusati region is formally communal land, a considerble part of the region is fenced off into private farms. The fenced off areas are mainly of two types; (1) small farms where the main part of the fenced off areas consists of the homestead and the surrounding field for cultivation and (2) big fenced off areas where the main use of the area is grazing. Table 23 shows that almost 1/3 of the region is fenced off into private farm land.

Table 23: Fenced off areas in the Omusati region

Ownership	Area, in Ha	% of total area
Communal area fenced off	387603	28
Communal area open	996321	72
Total	1383924	100

The information on the woody resources presented in this report includes also the woody resources on farms, i.e. inside the fenced off areas. It is however interesting to compare the woody resources in general in the region and the woody resources on the farms. Below this comparison is done for both species and volumes.

	The whole region	On the farms only
Total number of trees	45,075,000	7,677,000
Mean number of trees per hectare	32.6	19.8

Total tree volume, m^3	4,449,500	1,574,200
Mean volume per hectare, m^3	3.2	4.0

The table on the previous page shows that 35 % of the total tree volume and 17% of the total number of stems in the Omusati region is on private farms, i.e. inside fenced off areas. The table also shows that the trees growing on the farms are on average bigger than in general for the whole region.

Comparing Table 10 (p. 21) and Table 24 reveals some interesting differences between the species on the farms and the species found in general in the region:

- There are fewer species on the farms than in the region in general.
- *Colophospermum mopane* is still the most common species. But it is not as dominating inside the farms as in the region in general.
- The following species are profoundly more common inside the farms than in the region in general; *Sclerocarya birrea, Combretum collinum, Hyphaene petersiana, Berchemia discolor, Baikea plurijuga.*

Most of the species mentioned above are species that provide important NTFP's for the rural population in the region (see chapter 4.11, p. 30). The information above confirms that the farmers favour these species in their managment of the woody resources on their farms.

Although a considerable number of the measured sample plots were on farms, no young trees or saplings were found for most of the fruit trees (Table 11, p. 22 and Table 17 p. 27). However, to get more detailed information on fruit trees on the farms including saplings, an inventory focusing on farms would have to be carried out with a farm as the sampling unit.

Table 24: Tree volumes and stems inside the fenced off areas

Species	Total No. of stems, 1000s	Stems per Ha	Total tree volume, 1000, m3	Average tree volume, m3/ha
Colophospermum mopane	4436	11.446	478.7	1.235
Combretum apiculatum (apiculatum)	1323	3.413	49.3	0.127
Terminalia prunioides	869	2.242	87.4	0.226
Combretum collinum	316	0.815	28.0	0.072
Hyphaene petersiana	230	0.594	230.5	0.595
Acacia hebeclada (hebeclada)	113	0.291	30.2	0.078
Commiphora angolensis	112	0.288	54.0	0.139
Acacia reficiens	89	0.230	2.6	0.007
Baikiaea plurijuga	55	0.143	85.1	0.220
Berchimia discolor	55	0.143	119.9	0.309
Sclerocarya birrea	50	0.130	374.7	0.967
Terminalia sericea	23	0.058	8.3	0.022
Lonchocarpus nelsii	6	0.014	25.3	0.065
Total	7677	19.807	1574.2	4.061

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. 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.

Sampling error estimator
The magnitude of sampling error, Table 25, 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.

4.14.2 Sampling error and confidence limits for tree volume

Table 24 shows the sampling error and confidence limits for tree volume for all species and individually for the most common species. For the estimate of average tree volume per hectare of all species the sampling error was 20.09 %. Therefore, the true average tree volume for all species is between 1.95 m^3/ha and 4.48 m^3/ha with the probability of 95%.

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	0.41762	0.65	3.22	20.09	1.95	4.48	95
C. mopane	0.03871	0.20	1.22	16.06	0.84	1.61	95
C. collinum	0.00087	0.03	0.06	50.08	0.00	0.12	95
T. prunioides	0.00693	0.08	0.30	27.37	0.14	0.47	95
T. sericea	0.00014	0.01	0.03	44.11	0.00	0.05	95

5. CONCLUSION

The woody species
A total of 48 woody species were found in the Omusati region, 29 species as trees and 40 species in the shrub layer. This is less than the number of species recorded both in Tsumkwe district in Otjozondjupa region (56 species) and in Caprivi region (74 species). This indicates that the species diversity is less in Omusati region than in the regions in the north-east of the country.

Colophospermum mopane is dominating both in the tree layer and in the shrub layer. In fact, the species is to be found either as a tree or a shrub in most of the areas with woody vegetation in the region. Most of the woody species in the region are scarce. 33 of the species (70% of the species) were found in less than 10 of the 238 measured clusters. 7 species were found in only one cluster. Hence, the species diversity on local level in the region is rather low.

The vegetation types
Edwards classification was used for the classification of the woody vegetation into vegetation types. There are no areas in the region with a tree layer dense enough to be called forest. Only on one tenth of the region is there some kind of a tree layer, and also here the woody vegetation is very low, generally below 5 m.

The dominating vegetation types in the region are dense shrub land and areas with virtually no vegetation. In 40 % of the region there is a fairly dense shrub layer. In 40 % of the region there is virtually no woody vegetation.

The reason why there is no forests or woodlands varies. In parts of the region the tree layer has disappeared due to over-cutting, resulting in a shrub layer. Here the shrub lands will develop into woodlands and even forests if properly managed. In other parts of the region, mainly in the south, poor soil conditions prevent the woody species from growing into tree size. Here the shrub lands will probably never develop into woodland or forest even with proper management.

The forest resource
The tree volumes in the Omusati region are extremely low, both when it comes to total volumes and mean volumes per hectare. In fact, Omusati region has the lowest mean tree volume (3.2 m^3/ha) of all the regions so far measured. The mean tree volume in Otjozondjupa region was 4.2 m^3/ha, in Caprivi region 17.8 m^3/ha.

In 84% of the measured clusters was the volume below 6 m^3/ha, which indicates that the variation in the volumes in the region is quite small, and consequently the woody vegetation is quite homogenous when it comes to volumes in the region. The mean tree volumes in the two proposed community forest areas in the Omusati region were the following; Ongandjera 1.06 m^3/ha and Uukwaluudhi 6.3 m^3/ha. This indicates that the woody resources south in the region are lower than in the western parts of the region.

The bulk of the trees in the region are small. 2/3 of the trees have a dbh between 5 cm and 15 cm. More than 90% of the trees have a dbh below 25 cm. The diameter distribution for *Baikea plurijuga, Sclerocarya birrea* and *Hyphaene petersiana* is skewed to the right with no trees in the smaller classes.

There are no forest industries in the region. The economic importance of the wooded areas in the region lies at present in the utilisation of the wood for fuel wood and poles, and non-wood forest products including fodder. The most preferred species for poles are *Colophespermum mopane* and *Dichrostachys cinerera*. Other species used for poles are *Terminalia prunoides*, *Terminalia sericea* and different *Combretum* species.

The following can be concluded on the potential for economic utilisation of the woody resources in the region:

- The potential for even small-scale timber industries in the region are very limited. The volume of the only timber species found in the region (*Baikea plurijuga*) is too small. Also the option to create a small-scale timber industry by utilising other species (e.g. *Terminalia prunoides*) is not viable due to the few trees found in the region.
- The *Baikea plurijuga* stands in the northwestern parts of the region should be looked into as a part of the management planning of the Uukolankadhi proposed community forest. There might be some potential to economically utilise the species on a long term basis.
- There are strong indications that the utilisation of the woody resources for poles and fuel wood is not sustainable at the moment. This means that there is no potential to increase the economic utilisation of the woody resources for this purpose. On the contrary, for the resource base not to vanish in the long run, the utilisation has to be decreased.

The woody resources on the farms

Although the whole Omusati region is communal land, a considerble part of the region is fenced off into private farms. The fenced off areas are mainly of two types; (1) small farms where the main part of the fenced off area consists of the homestead and the surrounding field for cultivation and (2) big fenced off areas where the main use of the area is grazing. According to the inventory, 28 % of the region is fenced off into private farm land.

35 % of the total tree volume and 17% of the total number of stems in the Omusati region is inside fenced off areas, i.e. on private farms. The trees growing on the farms are on average bigger that in general for the whole region.

Other differences between the species on the farms and the species found in general in the region are:

- There are fewer species on the farms than in the region in general.
- *Colophospermum mopane* is still the most common species. But it is not as dominating inside the farms as in the region in general.
- The following species are profoundly more common inside the farms than in the region in general; *Sclerocarya birrea, Combretum collinum, Hyphaene petersiana, Berchemia discolor, Baikea plurijuga.*

Regeneration

One of the dominating vegetation types in the region is shrub land. The woody vegetation in the shrub layer consists of both shrubs and saplings. Saplings are small specimen of species that are known to become trees, while shrubs are specimen that do not grow into trees in the region. The area where the woody species are growing will determine whether the sapling of a certain species will develop into a tree or if it will remain as a shrub.

There is on average 1896 shrubs/saplings per hectare in the shrub layer, which is quite a considerable amount. Of the above figure only 447 are from typical shrub species. Hence, saplings dominate the shrub layer. Although the number of species found in the shrub layer is rather high, 86.1 % of the woody vegetation is coming from the 5 most common species in the layer. These species are *Colophospermum mopane, Catophractes alexandri, Bauhia petersiana, Baphia massaiensis* and *Commiphora angolensis*.

Colophospermum mopane is by far most common species in the shrub layer, 2/3 of all the saplings/shrubs found the shrub layer comes from that species. For the other species the regeneration is poor. No saplings were observed for *Baikea plurijuga* or *Sclerocarya birrea*. Hence, the domination of *Colophospermum mopane* in the region will even increase in the future. The poor regeneration for the other species will affect the extraction of both poles and non-timber forest products in the future. This in turn will have an impact on the economic importance of the wooded areas in the region.

Non timber forest products

The economic value of the non-timber forest products especially for the rural communities might be even higher than that of timber and poles. The inventory did not collect information specifically on the NTFPs in the sense that it did not for example try to estimate the availability of fruits from different species. However, most of the NTFP's used in the region are related to trees. Therefore, the information on trees can be used to indicate the abundance or scarcity of the NTFPs.

Trees for fodder is one of the most important products from the wooded areas in the region. A substantial part of the region consist of shrubland, where the main species are suitable as fodder. It is not possible with the information in this inventory to determine the options to increase the utilisation of the woody vegetation for grasing.

Mopane worms are another important NTFP. The environment for the mopane worm is favourable and it can be assumed that the supply of this NTFP is going to be secured also in the future.

Fruits from *Sclerocarya birea* (Marula), *Berhcemia discolor (*Eembe), *Hyphaene petersiana, Ficus sycomorica, Diospyros mespiliformis* and *Adanonsia digitata* (Baobab) are used for various purposes in the region. A study (Salinas et al 1998) indicate that the demand for fruits from the indigenous fruit trees is bigger than the supply in the region. The inventory did not find any younger trees or saplings for most of the fruit trees. Therefore, at the moment there is a scarcity of fruit trees in the region, and the situation is not likely to improve. On the contrary, without managment inputs, the supply of the fruits from these species will decrease and in the end eventually stop.

However, fruit trees are kept and managed at on-farm level in the region. If regeneration and younger trees of the above species are to be found, it is on the farms and especially within the homesteads. A number of the sample plots in the inventory were located on farms, but to get more detailed information on the indigenous fruit tree resources, an assessment would have to be carried out focusing on farms and with the farms as the sampling unit.

The DoF is in the process of starting a project to promote the use of indigenous fruit trees, "Improvement and Promotion of Selected Indigenous Fruit Trees in Namibia". This project could carry out the following important activities in Omusati region:

- Establishment of monitoring sites to determine the fruit production of various species of various sizes.
- Implement management activities to ensure the continuity of the indigenous fruit tree species.
- Carry out an on-farm inventory of the indigenous fruit tree resources to get more detailed

information. In this inventory the farms should be the sampling unit.

The future of the woody resources in Omusati region
The population density in the region is among the highest in Namibia, 13.9 persons per km^2, with the majority of the population in the northern and central parts of the region. The woody resources are very important for the well being of the rural population in the region. The majority of the population depends on the woody resources for fuel-wood and poles for house construction. Various non- timber forest products are of significant economic importance. But the use of the resource base is not sustainable at the moment. Therefore, the introduction of sustainable woody resource management practises is of crucial importance to the future well-being of the population in the region.

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Appendix 1: Cluster coordinates for Omusati Region

Note: coordinates are in decimal degrees

MAP SHEET	CLUSTER	LATITUDE	LONGITUDE	MAP SHEET	CLUSTER	LATITUDE	LONGITUDE
1714D	1	-17.418	14.622	1714D	52	-17.989	14.5812
1714D	2	-17.418	14.636	1714D	53	-17.9769	14.6076
1714D	3	-17.472	14.523	1714D	54	-17.9654	14.6334
1714D	4	-17.472	14.537	1714D	55	-17.9546	14.6587
1714D	5	-17.472	14.551	1714D	56	-17.9423	14.6851
1714D	6	-17.472	14.565	1714D	57	-17.9309	14.7106
1714D	7	-17.473	14.578	1714D	58	-17.9198	14.7359
1714D	8	-17.472	14.607	1714D	59	-17.9082	14.7622
1714D	9	-17.472	14.622	1714D	60	-17.8962	14.7875
1714D	10	-17.472	14.637	1714D	65	-17.456	15.234
1714D	11	-17.472	14.651	1714D	67	-17.509	15.107
1714D	12	-17.472	14.737	1714D	71	-17.51	15.178
1714D	13	-17.473	14.751	1714D	73	-17.51	15.221
1714D	14	-17.517	14.537	1714D	74	-17.509	15.236
1714D	15	-17.517	14.552	1714D	76	-17.555	15.135
1714D	16	-17.517	14.565	1714D	77	-17.556	15.15
1714D	17	-17.516	14.58	1714D	78	-17.555	15.178
1714D	18	-17.517	14.594	1715C	24	-17.615	14.837
1714D	19	-17.517	14.622	1715C	26	-17.615	14.866
1714D	20	-17.516	14.638	1715C	29	-17.615	14.938
1714D	21	-17.516	14.651	1715C	30	-17.661	14.808
1714D	22	-17.516	14.665	1715C	32	-17.661	14.827
1714D	23	-17.615	14.808	1715C	37	-17.66	14.936
1714D	25	-17.615	14.851	1715C	38	-17.813	14.88
1714D	27	-17.615	14.894	1715C	40	-17.814	14.909
1714D	28	-17.615	14.908	1715C	61	-17.447	15.178
1714D	31	-17.66	14.823	1715C	62	-17.456	15.192
1714D	33	-17.661	14.851	1715C	63	-17.446	15.206
1714D	34	-17.66	14.865	1715C	64	-17.446	15.235
1714D	35	-17.66	14.908	1715C	66	-17.464	15.235
1714D	36	-17.661	14.922	1715C	68	-17.509	15.121
1714D	39	-17.813	14.894	1715C	69	-17.51	15.149
1714D	41	-17.948	14.5614	1715C	70	-17.51	15.164

1714D	42	-17.9359	14.5874	1715C	72	-17.509	15.192
1714D	43	-17.9241	14.6137	1715C	75	-17.556	15.122
1714D	44	-17.9126	14.6386	1715C	79	-17.555	15.192
1714D	45	-17.9007	14.6636	1715C	80	-17.555	15.207
1714D	46	-17.8896	14.6906	1715C	81	-17.555	15.236
1714D	47	-17.8777	14.717	1715C	84	-17.69	15.307
1714D	48	-17.8672	14.7426	1715C	85	-17.699	15.307
1714D	49	-17.8555	14.7676	1715C	86	-17.699	15.321
1714D	50	-17.8439	14.7927	1715C	88	-17.699	15.35
1714D	51	-17.9988	14.5553	1715C	89	-17.699	15.378

MAP SHEET	CLUSTER	LATITUDE	LONGITUDE
1715C	90	-17.699	15.407
1715C	91	-17.699	15.421
1715C	93	-17.708	15.336
1715C	96	-17.743	15.336
1715C	97	-17.744	15.35
1715C	98	-17.744	15.364
1715C	99	-17.743	15.378
1715C	100	-17.744	15.392
1715C	101	-17.842	15.135
1715C	102	-17.842	15.15
1715C	103	-17.842	15.164
1715C	104	-17.842	15.178
1715C	105	-17.842	15.192
1715C	106	-17.842	15.206
1715C	107	-17.842	15.22
1715C	108	-17.842	15.234
1715C	109	-17.841	15.248
1715C	110	-17.832	15.22
1715C	111	-17.833	15.248
1715C	112	-17.832	15.306
1715C	114	-17.887	15.121
1715C	115	-17.888	15.15
1715C	116	-17.887	15.164
1715C	117	-17.887	15.206
1715C	120	-17.887	15.248
1815A	121	-18.069	15.089
1815A	122	-18.07	15.103
1815A	123	-18.069	15.117
1815A	124	-18.07	15.131
1814A	125	-18.069	15.146
1815A	126	-18.069	15.16
1815A	127	-18.07	15.174
1815A	128	-18.069	15.188
1815A	129	-18.069	15.203
1815A	130	-18.07	15.217
1815A	131	-18.116	15.089
1815A	132	-18.116	15.103
1815A	133	-18.116	15.117
1815A	134	-18.116	15.13
1815A	135	-18.116	15.145
1815A	136	-18.116	15.159
1815A	137	-18.116	15.174
1815A	138	-18.115	15.188
1815A	139	-18.116	15.203
1815A	140	-18.116	15.217
1815A	141	-18.152	15.103
1815A	142	-18.152	15.118
1815A	143	-18.152	15.131
1815A	144	-18.152	15.146
1814A	145	-18.226	15.089
1814A	146	-18.226	15.103
1814A	147	-18.226	15.118
1814A	148	-18.225	15.131
1814A	149	-18.226	15.16
1814A	150	-18.226	15.173
1814A	151	-18.226	15.187
1814A	152	-18.225	15.201
1814A	153	-18.273	15.088
1814A	154	-18.272	15.103
1814A	155	-18.272	15.116
1814A	156	-18.272	15.131
1815A	157	-18.272	15.145
1815A	158	-18.271	15.159
1815A	159	-18.271	15.188
1815A	160	-18.272	15.202
1815A	161	-18.271	15.216
1815A	162	-18.418	15.146
1815A	163	-18.417	15.159
1815A	164	-18.418	15.174
1815A	165	-18.418	15.188
1815A	166	-18.418	15.203
1815A	167	-18.418	15.216
1815A	168	-18.417	15.231
1815A	169	-18.418	15.244
1815A	170	-18.418	15.259
1815A	171	-18.417	15.274
1815A	172	-18.463	15.146
1815A	173	-18.463	15.16
1815A	174	-18.463	15.174
1815A	175	-18.463	15.188
1815A	176	-18.463	15.203
1815A	177	-18.463	15.231
1815A	178	-18.463	15.245
1815A	179	-18.462	15.26
1815A	180	-18.463	15.274
1814B	181	-18.085	14.804
1814B	182	-18.085	14.818
1814B	183	-18.085	14.833
1814B	184	-18.085	14.846
1814B	185	-18.085	14.861
1814B	186	-18.085	14.876
1814B	187	-18.086	14.89
1814B	188	-18.086	14.904
1814B	189	-18.085	14.917
1814B	190	-18.085	14.931
1814B	191	-18.131	14.804

MAP SHEET	CLUSTER	LATITUDE	LONGITUDE
1814B	192	-18.131	14.819
1814B	194	-18.131	14.847
1814B	196	-18.131	14.875
1814B	197	-18.131	14.889
1814B	198	-18.131	14.904
1814B	199	-18.131	14.918
1814B	200	-18.131	14.932
1814B	201	-18.225	14.667
1814B	202	-18.225	14.681
1814B	203	-18.225	14.695
1814B	204	-18.225	14.709
1814B	205	-18.225	14.723
1814B	206	-18.225	14.737
1814B	207	-18.225	14.751
1814B	208	-18.224	14.764
1814B	209	-18.224	14.779
1814B	210	-18.271	14.793
1814B	211	-18.271	14.666
1814B	212	-18.272	14.68
1814B	213	-18.271	14.695
1814B	214	-18.271	14.708
1814B	215	-18.271	14.723
1814B	216	-18.271	14.736
1814B	217	-18.271	14.751
1814B	218	-18.27	14.765
1814B	219	-18.27	14.779
1814B	220	-18.27	14.793
1814B	221	-18.382	14.638
1814B	222	-18.381	14.653
1814B	223	-18.381	14.667
1814B	224	-18.381	14.681
1814B	225	-18.381	14.695
1814B	226	-18.381	14.709
1814B	227	-18.38	14.724
1814B	228	-18.38	14.737
1814B	229	-18.38	14.752
1814B	230	-18.38	14.765
1814B	231	-18.427	14.639
1814B	232	-18.427	14.653
1814B	233	-18.426	14.667
1814B	234	-18.426	14.681
1814B	235	-18.427	14.695
1814B	236	-18.426	14.71
1814B	237	-18.427	14.724
1814B	238	-18.427	14.738
1814B	239	-18.426	14.752
1814B	240	-18.426	14.766

Appendix 2: Measured shrubs in Omusati Region

Species	No. of measured shrubs	% of measured shrubs
Colophospermum mopane	3157	69.94
Catophractes alexandri	327	7.24
Bauhia petersiana	138	3.06
Baphia massaiensis	134	2.97
Commiphora angolensis	130	2.88
Combretum apiculatum (leutweinii)	65	1.44
Pavetta zeyheri	63	1.40
Terminalia prunioides	54	1.20
Elephentorrhiza elephantina	50	1.11
Terminalia sericea	46	1.02
Acacia erioloba	41	0.91
Dichrostachys cinerea (Setulosa)	36	0.80
Albizia anthelmintica	22	0.49
Dichrostachys cinerea (Africana)	22	0.49
Rhigoszum brevispinosum	22	0.49
Grewia bicolor	19	0.42
Acacia aranaria	18	0.40
Maytenus senegalensis	18	0.40
Commiphora africana	14	0.31
Acacia ataxacantha	13	0.29
Acacia fleckii	13	0.29
Combretum zeyheri	12	0.27
Combretum apiculatum (apiculatum)	10	0.22
Combretum mossambicense	10	0.22
Acacia hebeclada (hebeclada)	9	0.20
Acacia nigrescens	9	0.20
Boscia albitrunca	9	0.20
Acacia mellifera	7	0.16
Acacia tortilis (heterecantha)	7	0.16
Grewia retinervis	7	0.16
Acacia Tortilis (spirocarpa)	6	0.13
Hyphaene petersiana	6	0.13
Croton gratissimus	5	0.11
Combretum collinum	3	0.07
Ozoroa longipes	3	0.07
Acacia luederitzii	2	0.04
Acacia reficiens	2	0.04
Acacia schweinfurthii	2	0.04
Peltophorum africanum	2	0.04
Dichapetalum cymosum	1	0.02
Total	**4514**	**100.00**

Appendix 3: 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 4: Volume functions for Omusati Region

For *Terminalia sericea*, *Pterocarpus angolensis* and *Acacias* use:

$v = e^{\wedge} (a_0 + a_1 * d + a_2 * d^2)$

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 $v = a_0 * d^2 + a_1 * d^3 + a_2 * d^4$

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

Appendix 5: List of tree/shrub species for Omusati Region

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 4)

Code	Species	Index to volume model
ACAAR	Acacia aranaria	1
ACAAT	Acacia ataxacantha	1
ACAER	Acacia erioloba	1
ACAFL	Acacia fleckii	1
ACAHH	Acacia hebeclada (hebeclada)	1
ACAHT	Acacia hebeclada (tristis)	1
ACAKA	Acacia karroo	1
ACALU	Acacia luederitzii	1
ACAME	Acacia mellifera	1
ACANG	Acacia nigrescens	8
ACAPO	Acacia polyacantha	9
ACARE	Acacia reficiens	1
ACASC	Acacia schweinfurthii	1
ACATH	Acacia tortilis (heterecantha)	1
ACATS	Acacia Tortilis (spirocarpa)	1
AFZQU	Afzelia quanzensis	8
ALBAN	Albizia anthelmintica	1
ALBHA	Albizia harveyi	1
ALBHA	Albizia harveyi	9
AMBAN	Amblygonocarpus andongensis	8
ANCBA	Ancylanthos baniesii	9
ANCRU	Ancylanthos rubiginosus	7
BAIPL	Baikiaea plurijuga	2
BAIWU	Baissea wulfhorstii	9
BAPMA	Baphia massaiensis	9
BAUPE	Bauhia petersiana	9
BAUTH	Bauhinia thonningii	6
BERDI	Berchimia discolor	3
BOSAL	Boscia albitrunca	8
BURAF	Burkea africana	3
COLMO	Colophospermum mopane	4
COMAA	Combretum apiculatum (apiculatum)	9
COMAF	Commiphora africana	5
COMAL	Combretum apiculatum (leutweinii)	6
COMAN	Commiphora angolensis	5
COMCO	Combretum collinum	6
COMEL	Combretum elaeagnoides	6
COMEN	Combretum engleri	6
COMGL	Commiphora glandulosa	5

Appendix 6: Acknowledgements

The successful completion of the Forest Inventory Exercise in Omusati Region was a result of the cooperative efforts of the Steering Committee and many other 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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VEGETATION DESCRIPTIONS FOR THE "PROFILE OF NORTH CENTRAL NAMIBIA", DIRECTORATE OF ENVIRONMENTAL AFFAIRS (DEA).

1. Cuvelai palms and fruit trees on loamy sands

These are slightly raised areas that are characterised by dense settlements and intensive cultivation. Other than the Ondangwa area, these were the places which were first settled and it is here that the larger towns of Uutapi, Okahao, Oshikuku, Tsandi and Oshakati developed. The soils on these units are loamy sands, rather than the sodic sands found in other higher areas in the Cuvelai drainage. Of the few large trees present, palms (*Hyphaene petersiana*), Maroelas (*Sclerocarya birrea*), *Berchemia discolor* and *Diospyros mespiliformis* predominate. This is the only unit in which Baobabs (*Adansonia digitata*) are relatively common.

Disturbed areas are characterised by *Pechuel-loeshea leubnitziae* and *Acacia arenaria*. The most important grasses are *Schmidtia kalahariensis, Odycea paucinervis, Sporobolus tenellus, Wilkommia sarmentosa* and *Tricholaena monachne*

2. Dolomite hills

These make up the range of hills around Tsumeb and extending westwards into the south (for example at Halali) and western part of Etosha National Park. Two isolated hills occur in the north-western part of the region. The hills are largely dolomites. Shallow soils form in pockets between large boulders and cobbles. The vegetation is characterised by tall trees, with *Kirkia acuminata, Moringa ovalifolia*, Maroela and *Lannea discolor* being common. There is a well-defined layer of lower trees consisting of *Commiphora glaucescens, Steganotaenia araliacea, Elephantorhiza goetzii, Combretum apiculatum* and *Gyrocarpus americana*. A shrub layer of species such as *Grewia bicolor* and *Croton grattisimus* is always present. Grasses are sparse and dominated by annuals such as *Melinis repens, Brachiaria deflexa* and Aristida species. Grazing resources are poor. The unit has the most diverse community of plants in the area, with hills in the east having a greater diversity of plants than those in the west.

3. Large salt pans

This unit describes the large alkaline and saline pans of the Etosha basin. These pans are of varying size and are usually devoid of vegetation. Thirty seven of the largest pans have been mapped. These range from the giant Etosha Pan (about 4 850 square kilometres) to the smallest of about 40 hectares in size, but many other, smaller pans are present. The soils are calcareous, saline silts. Some of the pans have important salt reserves that have been exploited over the years, both for household and trade purposes.

The pans are generally devoid of all vegetation except for the annual grass *Sporobolus salsus* which grows after good rains or flooding on the pan. Along the pan margins the dominant perennial grasses are *Odyssea paucinervis, Sporobolus spicatus*, ioclados and tenellus. The sedge *Cyperus marginatus* is also common along the pan margins. Woody species are generally absent but the salt-loving woody dwarf shrubs *Suaeda articulata* and *Salsola tuberculata* are found on the pan margins.

4. Mopane Combretum savanna on sandy soils

The major part of this vegetation type is in the Omusati region, but a small area also exists in the far western part of Etosha. Much of the area is structurally open savanna. Mopane, *Combretum apiculatum*, *Terminalia prunioides* and *sericea* and *Lonchocarpus nelsii* are the most important tree species. Prominent shrubs and short trees include *Dichrostachys cinerea, Croton gratissimus, Rhigosum brevispinosum* and various *Commiphora* species. The most important grass species are *Schmidtia kalahariensis and pappophoroides, Pogonarthia fleckii, Aristida stipoides* and *meridionalis*, *Eragrostis porosa, Enneapogon cenchroides,* and *Stipagrostis hirtigluma* and *uniplumis.*

While some areas, especially depressions where the soils have higher loam contents, may be suited to cultivation, the low rainfall in the area makes the growing of crops difficult. Soils generally consist of red sands, but the sands are coarse and acid in the western Etosha section of the unit.

5. Mopane shrub and low trees on loamy sands
Much of this large area is covered in Mopane shrubs, usually at about 2.5 metres and lower in height. This is especially true of the area west of the Ekuma River where the shrub growth may be very dense and the soils tend to be more sandy than loamy. By contrast, soils around the Ekuma and Oshigambo drainages are more loamy and support Mopanes growing as low trees of 3-4 metres in height. These woodland areas also support tall *Terminalia prunioides* trees growing up to 6 metres.

In addition to Mopane, *Catophractes alexandri* is an important shrub species. Grass cover is provided mainly by *Schmidtia kalahariensis, Eragrostis porosa* and *annulata, Enneapogon cenchroides, Aristida adscensionis* and *Stipagrostis uniplumis.* While there are a number of cattle posts and fenced farms in the area, the pastures do not provide good grazing. Most cattle are watered from the complexes of deep wells that are a feature of that part of the region. Many of the large saline pans are also in this area.

6. Mopane shrub and low trees on oshanas
Broad open oshanas cut through this unit which differs from the Mopane, fruit tree, oshana mosaic to the north in its much shorter growth of Mopane. However, the boundaries between the much taller growth of Mopane trees and the extensive areas of shrub Mopane in this unit are not always clear. Much of this area is also intensively cultivated on the highest ground, where fruit trees (especially Maroelas, and *Berchemia discolor*) and palms (*Hyphaene petersiana*) also grow.

The soils are saline sands, but are not as sandy as those to the west or those in **Oshana-Kalahari mosaic**. In disturbed areas and fallow fields *Pechuel-loeshea leubnitziae* and *Acacia arenaria* and *hebeclada* predominate as shrubs, while the dominant grasses are *Odycea paucinervis, Sporobolus tenellus*, and *Wilkommia sarmentosa.*

7. Mopane, fruit tree, oshana mosaic
Oshanas cutting through this unit of higher ground are much broader than those in the **Oshana-Kalahari mosaic**. The soils are also less sandy, tall Mopanes dominate the landscape and fewer Kalahari sand species are present. However, the highest patches are heavily cultivated and many fruit trees grow here: Maroelas, Mangetti, and *Berchemia discolor.* Some palms (*Hyphaene petersiana*) also grow on the highest areas. Large stands of *Acacia kirkii* grow in some of the oshanas in the north-west of this unit.

The tall mopanes also set this unit apart from the **Mopane shrub and low trees on oshanas** to the south. The shrub layer consists of Mopane and, in disturbed areas, of *Pechuel-loeshea leubnitziae* and *Acacia arenaria*. Dominant grasses include *Schmidtia kalahariensis, Sporobolus tenellus,* and *Wilkommia sarmentosa*

8. Oponono and Ekuma saline grasslands
The extensive grasslands surrounding Lake Oponono are one of the most important grazing resources for livestock in the central areas of the region. Soils are calcareous sands underlain by a salty, impermeable layer of clay and sandstone hardpan layer. These shallow salty soils prevent the growth of most woody species. These soils are also unsuitable for cultivation.

Perennial grasses dominate this unit. The most prominent species are *Sporobolus iocladus* and *sporobulus, Odyssea paucinervis, Digitaria* species, *Stipagrostis uniplumis, Anthephora pubescens, Schmidtia pappophoroides* and *Eragrostis* species. Common annuals, which can

occur at high cover values, include *Enneapogon cenchroides, Schmidtia kalahariense* and *Aristida* species. Cover values are generally between 15-40 %. The species composition of any given area is variable and dependant on micro-topographic features and drainage characteristics. Where the calcareous sands are relatively deep species such as *Odyssea paucinervis* and *Schmidtia kalahariense* tend to dominate. *Eragrostis rotifer* dominates in wetter areas, and this species is the principal thatching grass of the region.

9. Oshana-Kalahari mosaic

Erosion processes have resulted in the development of a mosaic of low-lying and upland habitats in the area north of Ondangwa. The higher ground described by this unit is sandy, and has many species characteristic of the Kalahari further to the east. The area is heavily cultivated and little of the natural vegetation remains undisturbed. However, many large fruiting trees have been preserved: Maroelas, *Berchemia discolor, Diospyros mespiliformis* and *Ficus thonningii.* Oshanas flowing through this unit are narrower than those further west.

Woody species characteristic of the Kalahari sands are *Burkea africana, Schinziophyton rautenniana, Combretum collinum, Pterocarpus angolensis* (in the eastern areas of the unit) and *Terminalia sericea.* The shrub layer consists mainly of *Combretum collinum* and *Terminalia sericea.* Mopane is also present locally in dense stands of tall trees or shrubs.

The grass layer is usually dominated by *Schmidtia kalahariensis, Wilkommia sarmentosa, Sporobolus spicatus* and *tenellus, Aristida* species, *Melinis repens* and *Eragrostis* species. The grazing resources are of little value within this unit, although livestock densities are very high.

10. Oshanas

This unit comprises the mosaic of wetlands and grasslands in the main channel system of the Cuvelai drainage system. Soils are generally saline clayey sands, but the upper slopes of the system often have a layer of highly leached sands. The soils are unsuitable for cultivation.

Mopane grows along the edges of the oshanas. The drier margins are dominated by the perennial grasses *Wilkommia sarmentosa, Eragrostis trichophora* and *Sporobolus ioclados.* Where extensive areas of saline soils are flooded *Sporobolus coromendalianus* is the commonest species. Perennial grasses and sedges generally dominate the wetter areas. *Diplachne* species, *Eragrostis rotifer* and *viscosa*, *Brachiaria deflexa*, and *Elytrophorus globularis* are all common grasses. Several sedges are characteristic of these wetter seasonal habitats including *Cyperus halpan*, *Kyllinga albiceps* and *Pycreus* species. Open water habitats usually have a distinct floating mat of grasses such as *Oryzidium barnardii*, *Echinochloa* species *and Oryza longistaminata.* A number of *Cyperus* species sedges are abundant along the edges of water channels and pools. In the deepest open water habitats waterlilies *Nymphaea* species and other floating plants are common.

11. Ruacana sand plateau

Lying west of the Cuvelai drainage and south of Ruacana, this area of deep Kalahari sand forms is isolated from similar vegetation types far to the east. Woody species form a mosaic of distinctive, patchy, vegetation types. Well-developed dune structures and deeper sands are dominated by tall *Baikiaea plurijuga* with a distinct understory of fairly tall *Combretum apiculatum.* Other characteristic trees include *Terminalia sericea, Commiphora glandulosa, Combretum collinum* and *Combretum psidioides.* This form of woodland becomes shorter and more open towards the south and west. *Baphia massaiensis, Grewia retinervis* and *Bauhinia petersiana* dominate the shrub layer. The grass layer is characterised by annuals, with *Schmidtia kalahariense* being the dominant species.

Within the mosaic of woodland types found within this unit, *Combretum apiculatum* dominates areas on moderately deep sandy soils overlying calcretes and other rocky substrates.

Terminalia prunioides is more abundant where the calcretes are on the surface. Patches of scrub mopane (*Colosphermum mopane*) are characteristic of heavier sand clay loam found on old pans and drainage lines.

12. Western mopane pan mosaic

This is a spectacular mosaic of thousands of small pans and some larger ones, surrounded by higher ground supporting copses of woody species, the most important being Mopane, *Catophractes alexandri, Acacia newbrownii, reficiens* and *luederitzia,* and *Terminalia prunioides.* The loams and loamy sandy soils have high salt concentrations.

The most important grass species in the unit are *Eragrostis porosa* and *annulata, Odycea paucinervis, Sporobolus tenellus, Wilkommia sarmentosa, Stipagrostis hirtigluma* and *uniplumis,* and *Monolytrum luederitzianum.* Many of these species provide good quality pastures.

13. Western sand plains

This large flat area of red and brown sands is characterised by a mixture of woody species in a monotonous savanna with low cover. There are relatively few calcrete outcrops, and also few small pans or other drainage features. There are a number of isolated permanent settlements in the area, for example Uutsathima and Onambandje, and also many cattle posts.

The most prominent species are Camelthorns, *Acacia reficiens, Lonchocarpus nelsii* and *Terminalia sericea.* A variety of shrubs are found, especially *Catophractes alexandri, Acacia mellifera, Croton gratissimus* and *Grewia flava.* Pastures provide moderate grazing values and the most abundant grass species are *Schmidtia kalahariensis, Aristida stipoides* and *meriodinalis, Eragrostis porosa* and *annulata, Enneapogon cenchroides, Stipagrostis hirtigluma* and *uniplumis.*