OSHANA REGION

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EXECUTIVE SUMMARY

The woody species
A total of 26 woody species were recorded in Oshana region, 11 species as trees and 20 species in the shrub layer. This is less than the number of species recorded in any other region inventoried so far, which indicates that among the regions so far inventoried Oshana region has the poorest species diversity. *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. Most of the woody species in the region are scarce.

The vegetation types
80 % of the region consists of areas with little or no woody vegetation. There are no areas in the region with a tree layer dense enough to be called forest. Even areas with some kind of a tree layer are scarce, and here the woody vegetation is very low, generally below 5 m. Most of the woody vegetation in the region is in the form of shrubs.

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. 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 Oshana region are extremely low. The region has the lowest mean tree volume (0.9 m^3/ha) of all the regions so far measured. The woody vegetation is quite homogenous when it comes to volumes and stems 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 extremely limited. The species at the moment utilised by the timber and furniture industry in the country are not found in the region. 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 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 demand for poles and fuel wood in the region is much bigger than what the woody resource in the region can sustain. Hence, either the utilisation of the wooded areas for this purpose is not sustainable, or the demand for these products are to some extent satisfied by wood collection from neighbouring regions. Most probably the situation is a combination of both. This means that there is no potential to increase the economic utilisation of the woody resources for fuel wood and poles. On the contrary, for the resource base not to vanish in the long run, the utilisation should be decreased.

The woody resources on the farms
Although the whole Oshana region is communal land, a considerble part of the region is fenced off into private farms. According to the inventory, 22 % of the region is fenced off into private farm land. 16 % of the total tree volume and 37% of the total number of stems in the Oshana region is inside fenced off areas, i.e. on private farms. In the Omusati region 28 % of the region was fenced off according to the inventory in that region. There are fewer species on the farms than in the region in general. *Colophospermum mopane* is the most common species in the region as a whole, but not on the farms. The trees growing on the farms are on

average smaller than for the whole region in general. The situation is the opposite compared to Omusati region, where the trees on the farms were bigger than the trees in the region in general. Another difference is that the indigenous fruit trees *Sclerocarya birrea, Hyphaene petersiana* and *Berchemia discolor* were profoundly more common on the farms in Omusati region than in the region as a whole. This is not the case in Oshana region.

The regeneration
There is on average 1195 shrubs/saplings per hectare in the region. This is quite a considerable amount taking into consideration that the major part of the region is basically without a shrub layer (grassland, herbs land, bare land). Therefore, where there is a shrub layer it is bound to be rather dense to reach the average figure mentioned above.

The woody vegetation in the shrub layer consists of both small specimen that will grow into trees and specimen that will remain as shrubs. The soil conditions in the areas where the woody species are growing will affect whether the sapling of a certain species will develop into a tree or if it will remain as a shrub. On the other hand, the reason why a certain species, known to grow into tree size, was found only as a shrub in the inventory might be over-utilisation. The species might have the potential to grow into trees with proper management.

Colophosperhemum mopane totally dominates the shrub layer. Although the number of species found in the shrub layer is rather high, 95 % of the woody vegetation is coming from the 5 most common species in the layer, namely *Colophosperhemum mopane, Commiphora angolensis, Dichrostachys cinerea, Elephentorrhiza elephantina* and *Rhigoszum brevispinosum*. No saplings were observed for *Sclerocarya birrea*, and very few for *Terminalia prunoides, Terminalia sericea* or *Hyphaene petersiana*.

With proper management there is potential to get a tree layer back in parts of the region. However, taking into consideration the species found regenerating, the domination of *Colophospermum mopane* in the region will even increase in the future.

Non timber forest products (NTFPs)
The economic value of the wooded areas of the region for fodder is significant. Mopane worms are another potentially important NTFP. Since *Colophospermum mopane* is the most common species both in the tree and in the shrub layer the environment for the mopane worm is favourable in the region.

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 northern regions of Namibia. This inventory indicates that there is at the moment a scarcity of indigenous fruit trees in the region, and that the situation is not likely to improve. On the contrary, due to poor regeneration, the supply of the fruits from these species will decrease and in the end eventually stop. To get more information on the indigenous fruit tree resources, an assessment would have to be carried out focusing on the farms. The DoF is in the process of starting a project to promote the use of indigenous fruit trees. This project could carry out this on-farm resource assessment, and also implement management activities to ensure the continuity of the indigenous fruit tree species.

The future of the woody resources in Oshana region
The population density in the region, 25.3 persons per km^2, is the highest in Namibia. The woody resources are very important for the well being of the rural population in the region. A considerable part 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 there are indications that 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 for the future well-being of the population in the region.

1. INTRODUCTION

The information of 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 the different level of inventories is different. The region level inventories provide information on the forest resource for the entire region for region level planning. The sampling intensity is low, 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 have 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 Oshana 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
- Inventory Report on the Woody Resources in the Omusati 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

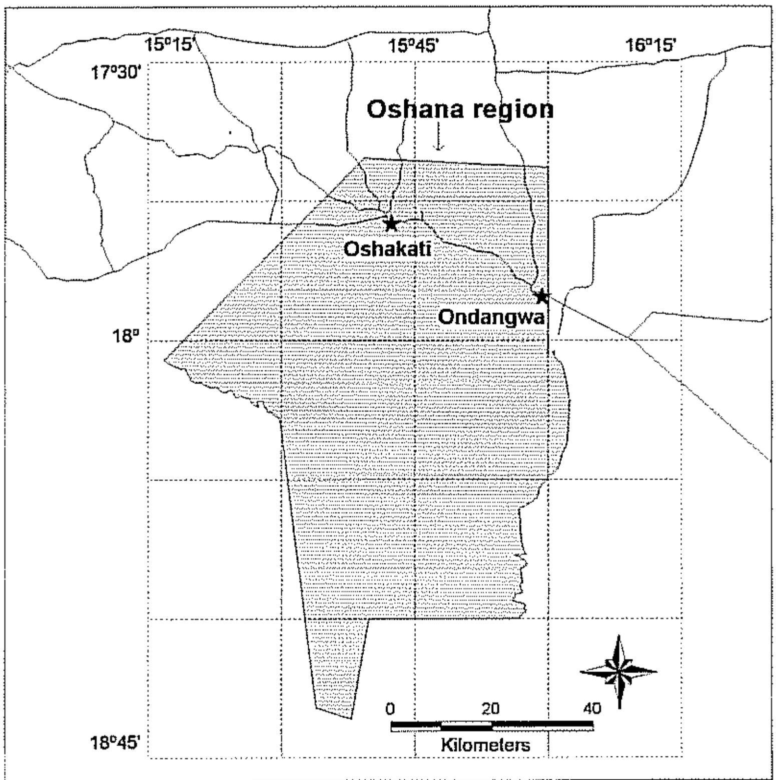
2. GENERAL DESCRIPTION OF THE AREA.

The Oshana Region forms the central southern part of the former Ovamboland. The region is the smallest in Namibia. According to the Vegetation Mapping Project (Directorate of Forestry) the size of the region is 0.51 mill 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 flat topography in combination with the predominant sandy soils results in an ill-defined drainage system for the region. Numerous interconnected shallow water courses, oshanas, form a wide delta in the region. The delta is a part of the Cuvelai drainage system, transporting water from the catchment area in Angola and Namibia into the Etosha pan. Hence, when the catchment area receives good rains a majority of the oshanas are filled with water and the whole delta is flooded. Annual rainfall in the region is 180 – 710 mm with the rains decreasing towards the south of the region.

According to The Namibia Regional Resources Manual, the vegetation in the region can broadly be classified into tree zones; (1) The Cuvelai Drainage Basin located over the entire northern part of the region mainly covered by palm savanna, (2) The Ekuma grassveld in the central and south of the region covered by seasonally flooded grasslands with patches of bush savanna of mainly Mopane, (3) The Kalkveld in the extreme south-western part of the region with open shrub savanna of mainly Mopane and Acacias.

The population density in the region is the highest in Namibia, 25.3 persons per km^2, with the majority of the population in the northern parts of the region. The total population for the region in 1991 was 133,716, which represented 9.5 % of the national total.



Map 1: Oshana Region

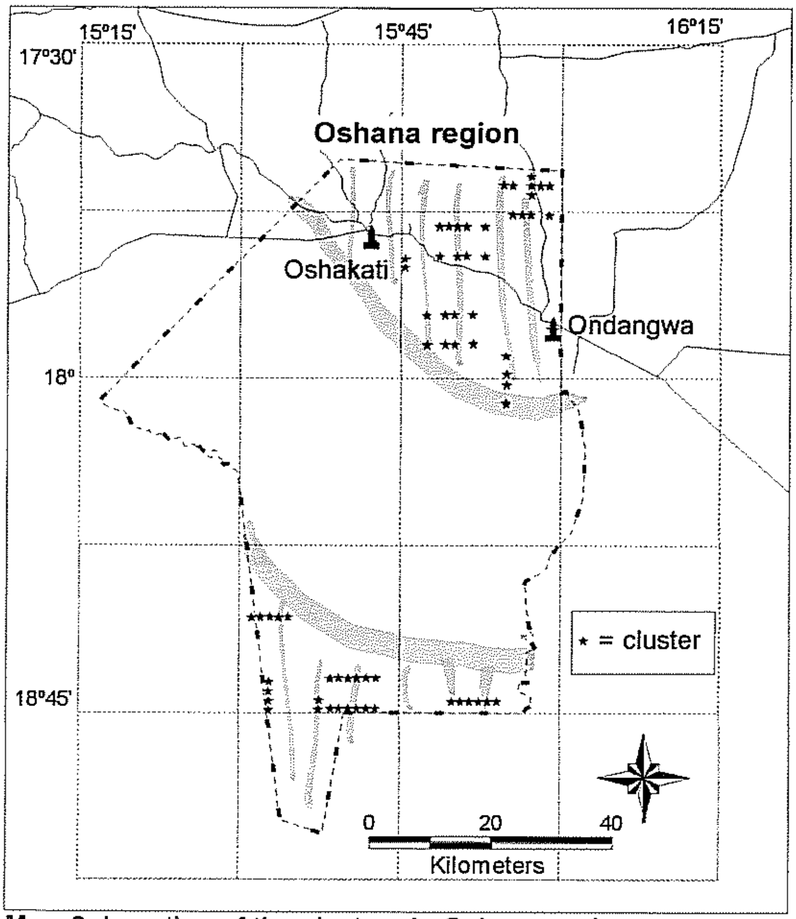
3. INVENTORY DESIGN

3.1 Sampling method

Stratified systematic plot sampling was used to estimate the quantity and quality of the woody resources in the Oshana region. Vegetation Maps at the Directorate of Forestry were used to stratify the region into 5 sampling strata excluding oshanas and grasslands. 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.

According to the vegetation maps almost half of the region (254,488 ha) is grassland or oshanas. Since there is no woody vegetation on these areas they were not included in the sampling and inventory field work. Therefore a total of 259,675 ha (50.5 % of the region) were covered by the inventory. Appendix 2 shows the location of the oshanas and the grasslands according to the DoF vegetation maps, i.e. the areas excluded from the inventory. However, this report covers the whole region and therefore the areas classified as grasslands and oshanas in the vegetation maps are included in the presentation of the results.

The total number of clusters located in the region was 66. Each cluster consisted of 2 sample plots at a distance of 100 m apart in the north-south direction. Hence, a total of 132 sample plots were located in the region. The clusters were located in groups, with 12 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 wooded areas in the region. Map 2 shows the final location of the clusters after corrections to fulfil demands from the stratification. Since the central part of the region are classified as oshanas and grass lands no clusters are located there.



Map 2: Location of the clusters in Oshana 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).

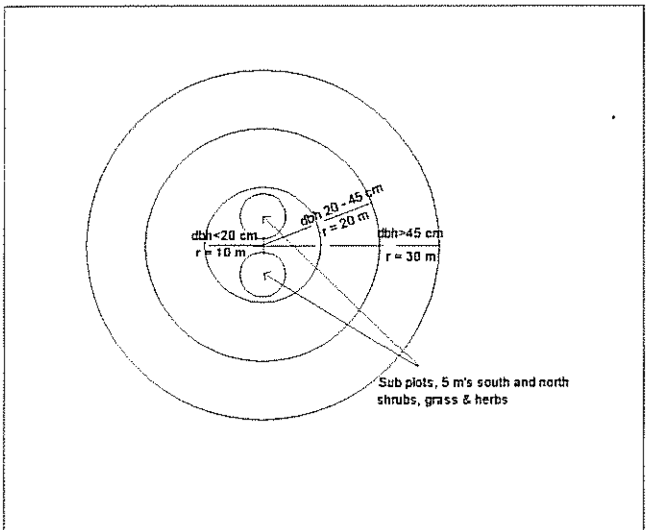


Figure 1: Plot Design

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 Volume functions.

So far stem analysis for the development of volume functions have been carried out in West Tsumkwe, Caprivi and Omusati regions. A total of 181 trees of the most common species have been felled and measured for this purpose. These volume functions were utilised also in the analysis of the data for the Oshana region.

Volume functions have been developed only for the most common species. For the other species the volume functions were applied to estimate the volumes of those species. For other users who may wish to use the models, Appendix 4 shows 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 Oshana region was carried out in June 1999. A total of 130 sample plots (65 clusters) were measured in the inventory. 76 trees with DBH ≥ 5 cm were measured in the sample plots (see Table 1 p. 11), which is on average 0.6 trees per sample plot. This is an extremely low number of trees and indicates the scarcity of trees in the region. Furthermore all areas classified as oshanas and grasslands on the vegetation maps (half of the region) were not included in the inventory. Hence the 0.6 trees per sample plot represents the half of the region where according to the DoF vegetation maps there is woody vegetation. Out of the 76 trees 33 were sample trees, i.e. trees where additional variables were measured (see chapter 3.2).

A total of 26 woody species were recorded in Oshana region. 11 of the species were recorded as trees, while 20 of the species were found as shrubs. The most frequent species in the data were as follows:

Species (trees)	**% of measured trees**
Colophospermum mopane	46.1
Sclerocarya birrea	10.5
Terminalia sericea	10.5
Acacia nilotica	9.2
Commiphora angolensis	7.9
Total:	**84.2 %**

Colophospermum mopane is the most common tree species recorded. Almost half of the measured trees are from that species. Together the 3 most common species, *Colophospermum mopane, Sclerocarya birrea* and *Terminalia sericea* account for 2/3 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	85.7
Commiphora angolensis	3.6
Dichrostacys cinerea (setulosa)	2.4
Elephentorrhiza elephantina	2.0
Rhigoszum brevispinosum	1.4
Total:	**95.1 %**

A total of 1538 shrubs were recorded (see Table 2, p. 11). *Colophospermum mopane* is by far the most commonly recorded species in the shrub layer. The 5 most common species together account for almost all the shrubs recorded. 2 of the most common species in the tree layer also occur among the 5 most common species in the shrub layer. 3 of the 5 most common species in the shrub layer (*Elephentorrhiza elephantina, Dichrostacys cinerea (setulosa)* and *Rhigoszum brevispinosum*) are typical shrub species, i.e. they were not found as trees in the inventory.

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	35	46.1	18	54.5
Sclerocarya birrea	8	10.5	2	6.1
Terminalia sericea	8	10.5	6	18.2
Acacia nilotica	7	9.2		
Commiphora angolensis	6	7.9	1	3.0
Combretum zeyheri	4	5.3		
Diospyros mespiliformis	3	3.9	3	9.1
Terminalia prunioides	2	2.6	2	6.1
Acacia erioloba	1	1.3		
Combretum apiculatum (apiculatum)	1	1.3		
Unknown1	1	1.3	1	3.0
Total	**76**	**100**	**33**	**100**

Table 2: Total number of measured shrubs per species

Species	No. of measured shrubs	% of measured shrubs
Colophospermum mopane	1318	85.7
Commiphora angolensis	56	3.6
Dichrostachys cinerea (Setulosa)	37	2.4
Elephentorrhiza elephantina	30	2.0
Rhigoszum brevispinosum	22	1.4
Catophractes alexandri	16	1.0
Dichrostachys cinerea (Africana)	13	0.8
Croton gratissimus	10	0.7
Acacia mellifera	8	0.5

Terminalia sericea	6	0.4
Ozoroa schinzii	5	0.3
Tarchonanthus camphoratus	4	0.3
Grewia bicolor	3	0.2
Lonchocarpus nelsii	3	0.2
Terminalia prunioides	2	0.1
Acacia fleckii	1	0.1
Boscia albitrunca	1	0.1
Combretum zeyheri	1	0.1
Hyphaene petersiana	1	0.1
Ochna pulchra	1	0.1
Total	**1538**	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 herbland	The vegetation is in form of grasses and herbs. There is virtually no woody vegetation in the area.

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

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

The structure of the woody vegetation in Oshana Region is shown in Tables 3 and 4 (p. 13). Since the aim is to describe the vegetation types for the entire region, the areas of the region excluded from the inventory (classified as oshanas and grasslands on the vegetation maps) are also included in the tables. Therefore, the tables include both grasslands and bare land that was already in the vegetation maps classified as those vegetation types ("Area excluded from inventory: grassland, oshanas" in Table 3) and areas that in the vegetation maps were classified as wooded areas but in the inventory were found to be grasslands or bare land. E.g. "short closed grasslands" in Table 3 are areas that in the vegetation maps were classified as wooded, but in the inventory was found to be grasslands.
On 2/3 of the region there is basically no woody vegetation, i.e. grasslands, herb land and bare land. On another 12.1% of the area the woody vegetation is scarce. Hence 80% of the region consists of areas with no or very little woody vegetation. Closed woodlands, i.e. areas with some kind of a tree layer are very few. Here the height of the trees is low, generally below 5 m. There are no areas with enough trees to be classified as forest. On 1/5 of the region is there a distinct shrub layer, most of this area with a rather dense layer of shrubs.

To sum up:

- Most of the region consists of areas with no or very little woody vegetation.
- Most of the woody vegetation found in the region is in the form of shrubs
- There are no forests in Oshana region. Areas with some kind of tree layer are few.

Table 3: Vegetation types in Oshana region

Vegetation structure type	Area, in Ha	% of total area
Low Closed Woodland	7683	1.5
Tall Open Woodland	13751	2.7
Short Open Woodland	5970	1.2
Low Open Woodland	22722	4.4
Low Bushland	3624	0.7
Tall Closed Shrubland	75177	14.6
Low Closed Shrubland	15965	3.1
Tall Open Shrubland	9594	1.9
Low Open Shrubland	9594	1.9
Short Closed Grassland	54128	10.5
Herbland	5970	1.2
Bare Land	35498	6.9
Area excluded from inventory: grassland, oshanas	254488	49.5
Total area	**514163**	**100.0**

Table 4: Summary of the vegetation types

Vegetation structure type	Area, in Ha	% of total area
Woodland	50126	9.7

Bushland	3624	0.7
Shrubland	110329	21.5
Grassland	54128	10.5
Bare Land	35498	6.9
Herbland	5970	1.2
Area excluded from inventory: grassland, oshanas	254488	49.5
Total area	514163	100.0

Table 5 (p. 14) shows the average, minimum and maximum height of tree species in the area. The reason why height information is lacking for some species is that they were found only in the second plot of the cluster where height is not measured (see chapter 3.2 p. 8).

The tree layer in the region is very low. The most common species in the region, *Colophospermum mopane*, has an average height of 4.2 m. The highest tree found in the inventory was a *Diospyros mespiliformis* with the height of 16.4 m.

Table 5: Average and maximum height by species

Species	No. of sample trees measured	Average height	Minimum height	Maximum height
Sclerocarya birrea	2	11.1	9.4	12.7
Diospyros mespiliformis	3	10.7	4.5	16.4
Unknown1	1	5.6	5.6	5.6
Colophospermum mopane	18	4.2	1.0	6.2
Commiphora angolensis	1	3.8	3.8	3.8
Terminalia prunioides	2	3.2	3.2	3.2
Terminalia sericea	6	2.9	2.3	3.5

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 woody resource inventories (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 Oshana 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. Other 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 6 shows the number of clusters where each species was found for both trees (dbh $\geq$ 5 cm) and shrubs (dbh <5 cm).

Table 6: Species diversity by the number of clusters where each species was found

Species	No. of clusters Dbh < 5 cm	No. of clusters dbh ≥ 5
Acacia erioloba		1
Acacia fleckii	1	
Acacia mellifera	1	
Acacia nilotica		2
Boscia albitrunca	1	
Catophractes alexandri	2	
Colophospermum mopane	38	12
Combretum apiculatum (apiculatum)		1
Combretum zeyheri	1	1
Commiphora angolensis	9	2
Croton gratissimus	4	
Dichrostachys cinerea (Africana)	4	
Dichrostachys cinerea (Setulosa)	3	
Diospyros mespiliformis		3
Elephentorrhiza elephantina	9	
Grewia bicolor	1	
Hyphaene petersiana	1	
Lonchocarpus nelsii	2	
Ochna pulchra	1	
Ozoroa schinzii	1	
Rhigoszum brevispinosum	3	
Sclerocarya birrea		2
Tarchonanthus camphoratus	1	
Terminalia prunioides	1	1
Terminalia sericea	2	2
Unknown1		1

A total of 26 woody species were recorded in the region. 11 species are occurring as trees, while 20 species are found in the shrub layer. Hence, the species diversity in the shrub layer is bigger than in the tree layer. Only 5 species occurred both as trees and in the shrub layer.

Colophospermum mopane trees were found on 18% (12 clusters) of the measured clusters, while shrubs from the same species were found in more than half (38 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.

The other woody species are rather scarce. Out of the 26 species recorded 23 species were found in less than 5 clusters. 11 species (42 % of the species) were found in only one cluster. Therefore, the number of common species is rather low in the region. The species diversity in Oshana region is lower than in Omusati region, where the region inventory recorded 48 woody species.

4.4 Dominant species 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 7 shows the dominant species in Oshana 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

15% (78,064 ha) of the region is included in the table. The rest of the region is not included, since there are no trees on those areas and hence no dominant species.

On almost half of the area where there is a tree layer, the dominant species in that layer is *Colophospermum mopane*. On 86% of the area with a tree layer the dominant species is either *Colophospermum mopane, Diospyros mespiliformis, Acacia nilotica* or *Sclerocarya birrea* .

Table 7: Areas of dominant species

Species	Area, in Ha	% of total area
Colophospermum mopane	37031	47.4
Diospyros mespiliformis	13751	17.6
Acacia nilotica	8717	11.2
Sclerocarya birrea	7782	10.0
Combretum apiculatum (apiculatum)	5970	7.6
Commiphora angolensis	1812	2.3
Terminalia sericea	1812	2.3
Combretum zeyheri	1189	1.5
Total	**78064**	100.0

Table 8 shows the dominant species in the different vegetation types found in the region. Hence, the table shows which species that are likely to be found as dominant in tree vegetation of various densities. Since most of the areas have few trees, the table also generally shows in which kind of vegetation types different species are likely to be found. Note that the table shows only the 5 species most commonly occurring as dominant (see Table 7).

Table 8: Area (Ha) and % of dominant species in different vegetation types.

Species	Woodland				Bushland		Closed Shrubland		Grassland	
	Closed		Open							
	Area	%	Area	%	Area	%	Area	%	Area	%
Acacia nilotica									8717	16.1
Colophospermum mopane	7683	100	14941	35.2	1812.1	50.0	10783	9.8	1812	3.3
Combretum apiculatum (apiculatum)							5970	5.4		
Diospyros mespiliformis			13751	32.4						
Sclerocarya birrea			5970	14.1					1812	3.3
Total area of each vegetation type	7683		42443		3624		110330		54128	

The areas with the most dense tree layer in the region (closed woodlands) are all dominated by *Colophospermum mopane.* Regardless of vegetation type, the species dominating is likely to be *Colophospermum mopane*. Most of the areas with a tree layer in the region are open, therefore it is logical that most of the species occurs as dominant in areas with open tree layer. *Acacia nilotica* is found as dominant species in grasslands. This implies that the species is to be found in areas with extremely few trees. *Combretum apiculatum* is found as dominant species in closed shrublands, which implies that the trees species is found in areas with a dense shrub layer.

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. Stem analysis has so far been carried out in Otjozondjupa, Caprivi and Omusati regions. The volume functions used to calculate the volumes in Oshana 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; (1) the area included in the inventory and (2) the whole Oshana region are as follows:

	Area included in the inventory	The whole region
Total number of trees	3,234,190	3,234,190
Mean number of trees per hectare	12.5	6.3
Total tree volume, m^3	465,600	465,600
Mean volume per hectare, m^3	1.79	0.9

The tree volumes in the Oshana region are extremely low, both when it comes to total volume and mean volume per hectare. This is to be expected, since the region is rather small and a major part consists of grasslands and other areas without woody vegetation. In fact, Oshana region has the lowest mean tree volume of all the regions so far measured. The mean tree volume in Omusati region was 3.2 m^3/ha, in Otjozondjupa region 4.2 m^3/ha, in Caprivi region 17.8 m^3/ha.

The figures above include all different vegetation types inclusive bare land. Table 9 shows the volumes and number of trees for the main vegetation types. Note that Table 9 describes only the part of the region included in the inventory. Since the part of the region excluded from the inventory consists of grassland and oshanas, the information in the table on woodlands, bushlands and shrublands represent the whole region but the grassland figure is valid only for the area inventoried. The table shows that the mean volumes and number of trees even in areas with the densest tree layer in the region is low. Although the stems per ha are fewer, the mean volume in open woodlands is higher than in the closed woodlands. This is because the trees in the open woodlands are bigger than the trees in the closed woodlands. In fact, the mean volume in the open woodlands is rather high compared to the other vegetation types. The big trees found in the open woodlands are *Diospyros mespiliformis* and *Sclerocarya birrea.*

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

	Vegetation type				
	Woodland				
	Closed	Open	Bushland	Closed Shrubland	Grassland
Total No. of stems, 1000s	774.1	711.5	147.4	1312.3	184.7
Stems per Ha	100.8	16.8	40.7	14.4	3.4
Total tree volume, 1000s	21.0	376.7	6.9	17.7	32.3
Average tree volume, m3/ha	2.7	8.9	1.9	0.2	0.6

65 clusters (consisting of 2 sample plots) were measured in the region. The highest volume measured in a cluster was 31 m^3/ha. In only 2 clusters (3% of the measured clusters) was the volume above 10 m^3/ha. In only 4 clusters (6 % of the measured clusters) was the volume above 5 m^3/ha. In 56 clusters (86 % of measured clusters) the volume was below 3 m^3/ha. This means that the variation in the volumes between the 65 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 fuel wood and poles, and the non-wood forest products including fodder. There have been studies carried out on species utilisation (Salinas et al. 1998) and on wood consumption (Ojanen-Jarlind 1998) in Omusati region, which is bordering to the Oshana region. It is assumed that the information from these studies can be applied on Oshana region as well. The studies show that 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 study on wood consumption in Omusati region showed that 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 on wood consumption does not include firewood.

Table 10 shows the total number of stems and tree volumes per species for the region and the "stems per ha" and "average tree volume, m^3/ha" calculated both for the inventoried area and for the whole region.

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

Species	Total No. of stems, 1000s	Stems per Ha		Total tree volume, 1000s	Average tree volume,	
		Inventoried area	Whole region		Inventoried area	Whole region
Colophospermum mopane	1732.3	6.67	3.37	61.30	0.24	0.12
Acacia nilotica	544.4	2.10	1.06	32.04	0.12	0.06
Terminalia prunioides	190.0	0.73	0.37	1.75	0.01	0.00
Terminalia sericea	167.9	0.65	0.33	4.14	0.02	0.01
Sclerocarya birrea	147.4	0.57	0.29	192.53	0.74	0.37
Commiphora angolensis	144.2	0.56	0.28	16.42	0.06	0.03
Diospyros mespiliformis	108.8	0.42	0.21	118.91	0.46	0.23
Combretum apiculatum	95.0	0.37	0.18	4.13	0.02	0.01
Combretum zeyheri	75.7	0.29	0.15	5.63	0.02	0.01
Unknown1	23.8	0.09	0.05	25.86	0.10	0.05
Acacia erioloba	4.7	0.02	0.01	2.89	0.01	0.01
Total	3234.2	12.45	6.29	465.60	1.79	0.91

The table shows that the number of stems and tree volumes are very small even for the most common species in the region. The inventory did not find any *Dichrostachys cinerera* trees. The total volume of *Colophespermum mopane, Terminalia prunoides, Terminalia sericea,* and *Combretum* species is 76,950 m^3. This amount is very small considering the high population density in the region and the importance of wood both for fuel and construction. As earlier mentioned, the annual subsistence consumption of poles per farm is 3.5 m^3.

Furthermore, the 79,950 m^3 include trees of all sizes while trees only up to a certain diameter are used as poles. Therefore the volumes available for poles are even smaller than the above mentioned figure.
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.* The above mentioned species are not found in the Oshana region.

The data presented above indicate that:

- The potential for even small-scale forest industries in the region are extremely limited.
- The demand for poles and fuel wood in the region is much bigger than what the woody

resource in the region can sustain. Hence, either the utilisation of the wooded areas for this purpose is not sustainable, or the demand for these products are to some extent satisfied by wood collection from neighbouring regions. Most probably the situation is a combination of both.

4.6 Diameter distribution

A desired diameter distribution from management and utilisation point of view is one where the bulk of the stems are in the lower diameter classes, and the number of stems gradually decreasing as the diameter gets bigger. With this kind of distribution there is continuously going to be trees entering into mature stage and a continuous harvesting of timber 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 diameter distribution of trees of different species in Oshana region. Only 76 trees were found in the 130 sample plots measured in the inventory. Therefore the table is reliable for the 5 most common species only, and should be intepreted with caution for species where few trees were measured (see Table 1 p. 11).

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 (1000 stems)									
Species	**5-15**	**15-25**	**25-35**	**35-45**	**45-55**	**55-65**	**75-85**	**115-125**	**Total**	**% of total**
Acacia erioloba				5					5	0.1
Acacia nilotica	475		69						544	16.8
Colophospermum mopane	1347	328	24	31		3			1732	53.6
Combretum apiculatum (apiculatum)		95							95	2.9
Combretum zeyheri	19	57							76	2.3
Commiphora angolensis		115	29						144	4.5
Diospyros mespiliformis		95			3			11	109	3.4
Sclerocarya birrea	29	29	24	24		21	21		147	4.6
Terminalia prunioides	190								190	5.9
Terminalia sericea	144	19	5						168	5.2
Unknown1					24				24	0.7
Total	**2204**	**738**	**150**	**59**	**27**	**24**	**21**	**11**	**3234**	
% of total	**68.1**	**22.8**	**4.7**	**1.8**	**0.8**	**0.8**	**0.7**	**0.3**		**100**

The table 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 *Diospyros mespiliformis, Sclerocarya birrea* (Marula tree) and *Colophospermum mopane.*

The diameter distribution for *Colophospermum mopane, Terminalia serices* and *Acacia nilotica* 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. *Sclerocarya birrea* (Marula) trees were found in a wide range of diameter classes from small trees to big trees. This implies that there are going to be mature Marula trees producing fruits also in the future. The diameter distribution of *Sclerocarya birrea* is considerably better in Oshana region than in Omusati region where no small trees of this species were found in the inventory.

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 in Omusati region (Ojanen-Jarlind 1998) showed that pole diameters down to 5 cm and lengths down to 1.5 m were used.

Table 12 shows that 2/3 of the *Colophespermum mopane* volumes and all of the *Terminalia sericea* volumes are in the dbh classes below 35 cm, and therefore suitable for pole production. The rest of the volumes of *Colophespermum mopane* are in the bigger trees, too big to be utilised for pole production.

Hence, the sizes for both *Colophespermum mopane* and *Terminalia sericea* for use as poles are good. The problem is that the amounts of growing trees of these species and other species used for poles are much smaller than what would be needed to satisfy the present demand for poles.

Table 12: The stems and tree volumes per diameter class for *Colophespermum mopane*and *Terminalia prunoides.*

	C. mopane				Terminalia sericea		
Dbh class, cm	**Total tree volume, 1000 m3**	**Total No. of stems, 1000s**	**% of total stems**		**Total tree volume, 1000 m3**	**Total No. of stems, 1000s**	**% of total stems**
5-15	17.1	1346.7	77.7		1.6	144.2	85.9
15-25	17.7	327.7	18.9		1.2	18.9	11.3
25-35	5.1	23.8	1.4		1.3	4.7	2.8
35-45	16.2	31.0	1.8				
55-65	5.3	3.2	0.2				
Total	61.3	1732.3	100.0		4.1	167.9	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 extermely limited. The tree species at present utilised by the timber industry are above all *Pterocarpus angolensis*, and to a certain extent *Baikea plurijuga, Guibourtia coleosperma* and *Burkea africana*. These species are not found in the Oshana region.
- 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 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 not sustainable 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-timber forest products".

4.7 Damage to the woody vegetation

Damage to the woody vegetation was recorded both at stand level, for the sampled vegetation unit (Table 13), and at tree level 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 13: Damaging agent and the severity of damage at stand level, in ha

Damaging agent	Mild	Total area, Ha	% of total damaged area	% of total wooded area
Human	83877	83877	80	45
Mammals domestic	14941	14941	14	8
Mammals wild	5436	5436	5	3
Total wooded area with damage	104254	104254	100	56
Area without damages		81136		44
Total wooded area		185390		100

Note that Table 13 includes only areas with woody vegetation. Therefore, the areas excluded from the inventory and areas in the inventory that were found to be without woody vegetation (no trees or shrubs) are not included in the table. Hence, only 36 % (185,390 ha) of the region is included in the table.

The table shows that almost half of the woody vegetation in the region does not show any signs of damage. Where damage is visible it is mild, i.e. the damages can be observed but is not affecting the health of the trees.

The most common cause of damage is human, almost half of the damages are caused by human activities. Human activities means here cutting. This implies that there are signs of cutting on almost half of the wooded areas in the region. On the other hand, since the damage is classified into "mild" it indicates that where cutting was observed only small parts of the woody vegetation had been removed. Note that no damages caused by fire were observed in the inventory. Also in Omusati region damages caused by fire on the woody vegetation were few. Hence, the situation is completely different from that in Caprivi region, where the most common cause for damage on the woody vegetation was fire.

33 trees were measured as sample trees in the inventory. No damages were observed on these trees.

Therefore, the following can be concluded on the damages on the woody vegetation:

- Almost half of the wooded areas show no signs of damage.
- The damage, where it can be observed is not affecting the health of the woody vegetation.
- Signs of cutting can be observed on almost half of the wooded areas, but the cutting is selective and does not destroy a big portion of the woody vegetation.

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 will affect the desired diameter distribution mentioned in chapter 4.6 (p. 18) and hence also affect short or long-term management decisions.

Table 14 shows the estimated area covered by regeneration. Note that the table includes only areas with woody vegetation. Therefore, the areas excluded from the inventory and areas in the inventory that were found to be without woody vegetation (no trees or shrubs) are not included in the table.

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 14 shows that regeneration is visible on 121,103 ha. This means that regeneration is visible on 2/3 of the areas with woody vegetation. Or if the whole region is included, regeneration is visible on 23.6 % of the whole region.

Table 14: Extent of regeneration, in Ha

Regeneration	Area, in Ha	% of total area
No regeneration observed	64287	35
Seedlings or sprouts are present but only lower than 1.5 m	35054	19
Vital seedlings or sprouts higher than 1.5 m are present	86049	46
Total	**185390**	**100**

Table 15 shows the amount of saplings per species per hectare. The "per hectare" figure relates to the area of the region included in the inventory (259,675 ha), not the whole region. Note that saplings are defined as small specimen that are known to become trees in the region, i.e. species that were found as trees in the inventory. Therefore, the table includes only woody species that were found as trees in the inventory. Table 16 (p. 23) shows the whole shrub layer, i.e. all specimen found in that layer.

Table 15: Number of tree saplings per hectare by height classes and species

	Height class, cm									
Species	**0-25**	**26-50**	**51-100**	**101-150**	**151-200**	**201-250**	**251-300**	**300+**	**Total**	**% of total**
Colophospermum mopane	28	92	708	477	455	186	63	18	2028	95
Commiphora angolensis		3	57	22	3		2		86	4
Terminalia sericea				2	2		6		9	0
Terminalia prunioides						2	2		3	0
Hyphaene petersiana				2					2	0
Total	**28**	**95**	**765**	**502**	**460**	**188**	**72**	**18**	**2128**	
% of total	**1**	**4**	**36**	**24**	**22**	**9**	**3**	**1**		**100**

Table 15 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. This tree layer has now disappeared due to over-cutting. Remaining is a very sparse tree layer or a shrub layer that will develop into trees if properly managed. On the other hand, the *Colophospermum mopane* shrub land in the south of the region will probably never develop into woodland or forest even with proper management due to the soil conditions in the area. Hence, although Table 15 shows that the regeneration of *Colophospermum mopane* is rather good, the area where it is growing will have an impact on whether the sapling will develop into a tree or if it will remain as a shrub.

On the other hand, the reason why a certain species was found only as a shrub in the inventory might be over-utilisation (e.g. *Dichrostachys cinerera*), i.e. the species could have the potential to grow into trees in the region if left to grow. However, since the species was not found as a tree in the inventory it is not included in Table 17 as a sapling.

Most of the saplings found in the region are between ½ - 2 m in height. *Colophospermum mopane* is by far the most common sapling, with 95 % of all saplings coming from that species. For the other species the regeneration is poor. No saplings were observed for *Sclerocarya birrea*, and very few for *Terminalia prunoides, Terminalia sericea* or *Hyphaene petersiana*. Therefore, from this perspective the dominance of *Colophospermum mopane* in the tree layer 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, hence the economic importance of the woodland.

4.9 The shrub layer

Most of the woody vegetation found in the region is in the shrub layer. The woody vegetation in the shrublayer consists of both shrubs and saplings. To get a clear picture of the regeneration of the tree species, Table 15 (p. 22) 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 16 shows all the species in the shrub layer including also the saplings. Note that the "per hectare" figure relates to the area of the region included in the inventory (259,675 ha), not the whole region.

Table 16: Shrubs/saplings per hectare by height classes and species in the shrub layer

	Height class, cm									
Species	**0-25**	**26-50**	**51-100**	**101-150**	**151-200**	**201-250**	**251-300**	**300+**	**Total**	**% of total**
Colophospermum mopane	28	92	708	477	455	186	63	18	2028	86
Commiphora angolensis		3	57	22	3		2		86	4
Dichrostachys cinerea (Setulosa)		23	9	17	5	3			57	2
Elephentorrhiza elephantina		3	18	11	11	3			46	2
Rhigoszum brevispinosum			15	14	5				34	1
Catophractes alexandri			5	11	9				25	1
Dichrostachys cinerea (Africana)		2	3	3	11		2		20	1
Croton gratissimus			5	5			6		15	1
Acacia mellifera		12							12	1
Terminalia sericea				2	2		6		9	0
Ozoroa schinzii			8						8	0
Tarchonanthus camphoratus	2	5							6	0
Lonchocarpus nelsii			3	2					5	0
Grewia bicolor			3	2	0				5	0

Terminalia prunioides						2	2		3	0
Acacia fleckii				2					2	0
Boscia albitrunca				2					2	0
Combretum zeyheri			2						2	0
Hyphaene petersiana				2					2	0
Ochna pulchra			2						2	0
TOTAL	29	140	837	568	500	194	80	18	2366	100
% of total	1.2	5.9	35.4	24.0	21.1	8.2	3.4	0.8	100	

The table shows that the general height of the shrub layer in the region is ½ - 2 m. A total of 20 woody species were found in the shrub layer. 15 of these species only occur as shrubs. There is on average 2366 shrubs/saplings per hectare in the shrub layer, which is quite a considerable amount. Note, however, that this figure refers to the part of the region that was inventoried (51% of the region). If the whole region is taken as reference-area the average amount of shrubs/saplings per hectare is half of his figure (1195 shrubs/saplings per hectare).

A considerable part of the area inventoried was found to be basically without shrubs (grassland, herbs land, bare land). This means that the shrub layer where it occurs must be rather dense to reach the average figure mentioned above. As shown in the table *Colophosperhemum mopane* saplings totally dominate the shrub layer. Although the number of species found in the shrub layer is rather high, 95 % of the woody vegetation is coming from the 5 most common species in the layer. 10 % of the specimen occurring in the shrub layer are from typical shrub species, i.e. they are not found as trees in the region.

The classification of the specimen into shrubs and saplings should be treated with caution. The area where the woody species are growing will affect whether the sapling will develop into a tree or if it will remain as a shrub. Furthermore, the reason why a certain species was found only as a shrub in the inventory might be over-utilisation. The species might have the potential to grow into trees if left to grow.

4.10 The grass and herbs layer

Tables 17 and 18 show the grass cover and herb cover per different vegetation types in the Oshana region. Note that only the part of the region included in the inventory is represented in the table. Therefore the table does not give information on the grass or herb cover on the vast grasslands in the central parts of the region. The inventory field work was carried out in June 1999, hence the grass and herbs cover reflects the situation during that period.

Table 17: Cover of grasses per vegetation type

	Vegetation type					
	Closed Woodland	**Open Woodland**	**Bushland**	**Closed Shrubland**	**Open Shrubland**	**Grassland**
Average % cover of grasses	54.8	18.2	32.3	18.7	31.3	39.0
% of inventory area	3.0	16.3	1.4	35.1	7.4	20.8

The highest grass cover is found in the closed woodlands where grasses cover more than half of the land area. The grass cover in closed woodlands is in fact higher than in grasslands. The lowest grass cover is generally found in areas with dense shrub layer, which is logical since the shrubs and grasses are competing for 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 after the rainy season. Table 20 shows that the cover of herbs is generally very low

Table 18: Cover of herbs per vegetation type

	Vegetation type						
	Closed Woodland	Open Woodland	Bushland	Closed Shrubland	Open Shrubland	Grassland	Herbland
Average % cover of herbs	4.5	3.3	0	2.4	0	0.5	4.0
% of of inventory area	3.0	16.3	1.4	35.1	7.4	20.8	2.3

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 or collect information on roots, tubers etc. However, a considerable part of the NTFPs used in the region are related to trees. Therefore, the information on trees can be used to indicate the abundance or scarcity of some of the NTFPs. Below is presented a number of the NTFPs used in the Oshana region. Note that this chapter does not 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. Important fodder trees are e.g. *Baphia massaiensis, Combretum collinum, Acacia erioloba* and *Colophospermum mopane.* According to a study in Oshikoto region trees and shrubs contribute almost 60 % of the feed for cattle and goats (Chacks 1999). According toSalinas one of the most important uses of the wooded areas in the Omusati region is fodder for the cattle and goats. It can be assumed that the situation is the same in Oshana region as in the neighbouring regions, i.e. trees and shrubs are important as fodder. Therefore, although poor in timber and poles, the economic value of the wooded areas of Oshana region is significant to the rural communities in the form of fodder for their animals. The damage classification (p. 21) 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.

In Omusati region Mopane worms are both eaten as relish and sold for income generation (Salinas et al. 1998). The worm is utilised in the similar manner also in the Oshana region. Therefore, when found it is an important NTFP. The mopane worm is most commonly found in younger trees of *Colophospermum mopane*. The dominant species both in the shrublands and the woodlands of Oshana region is *Colophospermum mopane.* Therefore, althought the inventory did not assess the occurrence of the Mopane worm, the environment for the mopane worm is favourable in the region.

Important fruit trees in northern Namibia are *Sclerocarya birea* (Marula), *Berchemia discolor* (Eembe), *Hyphaene petersiana, Ficus sycomorica, Diospyros mespiliformis* and *Adanonsia digitata* (Baobab). No *Berchemia discolor, Ficus sycomorica* or *Adanonsia digitata* were recorded in the inventory. But at least *Berchemia discolor* and *Ficus sycomorus* can be found in the region. However, the fact that no tree or sapling of these two species were found inside the 130 sample plots in the region is a strong indication of the scarcity of these two species. The inventory recorded *Sclerocarya birea, Hyphaene petersiana* and *Diospyros mespiliformis.* According to the inventory *Sclerocarya birea* is the most common of the above mentioned species, but none of the species is very abundant. Hence the situation in Oshana region is most probably the same as in Omusati region; the demand for fruits from indigenous fruit trees is bigger than the supply.

Sclerocarya birrea (Marula) trees were found in a wide range of diameter classes from small trees to big trees. This implies that there will be mature Marula trees producing fruits also in the future. The diameter distribution of *Sclerocarya birrea* is better in Oshana region than in Omusati region where no small trees of this species were found in the inventory.
The regeneration of the indigenous fruit trees raises concern. The inventory found regeneration only for *Hyphaene petersiana.* No regeneration implies that the indigenous fruit trees are going to be even more scarse in the future. 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. The regeneration and younger trees of the indigenous fruit trees are mostly 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 were shortlisted, namely *Sclerocarya birea, Berchemia discolor, Strychnos cocculoides, Garcinia livingstonei, grewia spp.* and *Syzigium cordatum.* With the above information in mind, it seems that at least in the Oshana 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.

Birds of different species are an important source of food in nortern Namibia. Birds are more common in areas with woody vegatation than in open areas. Therefore, the potential economic value of birds for food is most probalbly not as high in Oshana region as in the other northern regions with more woody vegetation.

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

- Trees and shrubs for fodder is one of the most important products from the wooded areas. A considerable part of the region consists of shrubland, where the main species are suitable as fodder at least for goats. It is not possible with the information in this inventory to determine the options to increase the utilisation of the woody vegetation for browsing.
- The environment for the mopane worm is favourable in the region. Therefore this worm is another potentially important NTFP in the region.
- The scarcity of the indigenous fruit trees implies that the demand for fruits from these trees

is most probably bigger than the supply in the region. The inventory did not find any younger trees or saplings for most of the fruit tree species, hence without management 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 Oshana 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 influence 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 19 shows the areas where such influence was visible. Note that the table shows agriculture in the form of cultivating the land. Table 20 shows the areas where land utilisation for grazing is visible. Note that the tables include only the part of the region that was inventoried. Hence, the human influence on the vast grasslands in the central parts of the region was not assessed.

The judgement on "human influence" is according to signs visible at the time of the assessment. Hence, the historical fact that over-cutting of the tree layer has resulted in the disappearance of the woodlands in the region is not noted if signs of cutting are no longer visible. Half of the areas with signs of cutting in Table 19 are areas where there is no longer any woody vegetation, i.e. the cutting has resulted in the disappeance of wooded areas and the area is now either grassland or cultivated fields. On the rest of the areas with visible signs of cutting the cutting has been selective, i.e. woody vegetatioin is still present.

However, the table shows that the human influence on the environment in the region is surprisingly limited. On more than half of the inventoried area there were no signs of cuttings or agriculture (cultivation). 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. The area under cultivation is quite small. However, the fact that the soil is not suitable for cultivation in a big part of the inventoried area is a major factor limiting the utilisation of the area for cultivation. The population is concentrated to the nortern parts of the region, while the southern parts are sparsely populated. The wooded areas are mainly in the far south of the region. Here the vegetation is dominated by low *Colophospermum mopane* shrubland. Fresh water is scarse.

Table 19: Areas of human influence

Accomplished measure	Total area, in Ha	% of total area
No accomplished measures observed	161178	62.1
Shifting cultivation	41466	16.0

Cuttings, fuelwood removed	51061	19.7
Cuttings, timber sized trees removed	5970	2.3
Total	259675	100.0

Table 20 "Grazing" (p. 29) and Table 21 "Fenced areas" (p. 30) give indications on the area used for cattle farming. Note however that the tables include only the part of the region that was inventoried. Hence, the utilisation of the vast grasslands in the central parts of the region for grazing was not assessed. 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.

Almost half of the inventoried areas showed signs of grazing. The areas seem not to be over-grazed, since most of the grazing is classifies as "moderate".

Table 20: Grazing

Grazing intensity	Area, in Ha	% of total area
No signs of grazing observed	149772	57.7
Moderate signs of grazing visible,vegetation still vital	103933	40.0
Signs of intensive grazing visible,vegetation vitality threatened	5970	2.3
Total area	**259675**	**100.0**

To conclude:

- The main human influence on the vegetation in the region comes from using the areas for grazing. Almost half of the inventoried area in the region showed such signs of grazing.
- The area utilised for cultivation is rather small taking into consideration the population pressure in the region. The poor soils are most probably a major factor limiting further utilisation.
- Half of the areas where cutting was observed represents deforestation, i.e. the woody vegetation has disappeared. The other half represents selective cutting, i.e. there is still woody vegetation remaining. According to the damage classification (p. 21) the selective cutting is not very severe.

4.13 The woody vegetation on the farms

Although the whole Oshana region is communal land, a considerble part of the region is fenced off into private farms. The fenced off areas are mainly small farms where the main part of the fenced off area consists of the homestead and the surrounding field for cultivation. Table 21 shows that more than 1/5 of the region is fenced off into private farm land.

Table 21: Fenced off areas in the Omusati region

Ownership	**Area, in Ha**	**% of total**
Communal area reserved for a specific use (fenced)	56776	21.9
Communal area open	202899	78.1

Total area	259675	100.0

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. On the next page this comparison is done for both species and volumes. Note that the figures refer to the area inventoried and not the whole region.

	The whole inventoried area	On the farms within the inventoried area
Total number of trees	3,234,190	1,203,000
Mean number of trees per hectare	12.5	21.9
Total tree volume, m^3	465,600	72,200
Mean volume per hectare, m^3	1.79	1.27

The table shows that 16 % of the total tree volume and 37 % of the total number of stems in the Oshana region is on private farms, i.e. inside fenced off areas. The average tree volumes on the farms and in the inventoried area of the region are more or less the same, but the trees growing on the farms are on average smaller that for the whole region in general. Hence, the situation is the opposite compared to the one in Omusati region, where the trees on farms were bigger than the trees in the region in general.

Comparing Table 10 (p. 18) and Table 23 reveale the 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 the most common species in the region as a whole, but not on the farms.

In Omusati the indigenous fruit trees like *Sclerocarya birrea, Hyphaene petersiana* and *Berchemia discolor* were profoundly more common on the farms than in the region as a whole. This is not the case in the Oshana region.

The information presented above is based on the 20 sample plots measured on farms. 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 22: Tree volumes and stems inside the fenced off areas

Species	Total No. of stems, 1000s	Stems per Ha	Total tree volume, 1000s	Average tree volume, m3/ha
Colophospermum mopane	635	11.18	14.3	0.25
Acacia nilotica	544	9.59	32.0	0.56
Unknown1	24	0.42	25.9	0.46
Total	**1203**	**21.19**	**72.2**	**1.27**

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 23 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 45 %. Therefore, the true average tree volume for all species is between 0.194 m^3/ha and 3.392 m^3/ha with the probability of 95%.

Table 23: Sampling error and confidence limits for tree volume for the inventoried 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	0.665489	0.8158	1.7930	45.50	0.194	3.392	95
Acacia nilotica	0.011767	0.1085	0.1234	87.93	0.000	0.336	95
Treminalia prunioides	0.000045	0.0067	0.0067	100.00	0.000	0.020	95
Terminalia sericea	0.000133	0.0115	0.0159	72.33	0.000	0.039	95

5. CONCLUSION

The woody species

A total of 26 woody species were recorded in Oshana region, 11 species as trees and 20 species in the shrub layer. The number of species found in Oshana region was less than the species found in the neighbouring Omusati region, where 46 woody species were found. The number of species recorded in Tsumkwe district in Otjozondjupa region was 56 species, and in Caprivi region 74 species. This indicates that the species diversity is less in Oshana region than in any other region so far inventoried.

Colophospermum mopane is dominant 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. 23 of the species (88 % of the species) were found in less than 5 of the 65 measured clusters. 11 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. On most of the region there is little or no woody vegetation. 80 % of the region consists of such areas. There are no areas in the region with a tree layer dense enough to be called forest. Even the areas with some kind of a tree layer are scarce, and here the woody vegetation is very low, generally below 5 m. Most of the woody vegetation in the region is in the form of shrubs.

The reason why there is no forests or woodlands varies. In some 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 Oshana region are extremely low, both when it comes to total volumes and mean volumes per hectare. In fact, Oshana region has the lowest mean tree volume (0.9 m^3/ha) of all the regions so far measured. The mean tree volume in Omusati region was 3.2 m^3/ha, in Otjozondjupa region 4.2 m^3/ha and in Caprivi region 17.8 m^3/ha.

In 86% of the measured clusters was the volume below 3 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 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.

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 and poles, and the non-wood forest products including fodder. The most preferred species for poles are *Colophespermum mopane* and *Dichrostachys cinerea*. Other species used for poles are *Terminalia prunoides*, *Terminalia sericea* and *ombretum* 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 extremely limited. The species at the moment utilised by the timber and furniture industry in the country are not found in the region. 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 demand for poles and fuel wood in the region is much bigger than what the woody resource in the region can sustain. Hence, either the utilisation of the wooded areas for this purpose is not sustainable, or the demand for these products are to some extent satisfied by wood collection from neighbouring regions. Most probably the situation is a combination of both. This means that there is no potential to increase the economic utilisation of the woody resources for fuel wood and poles. 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 Oshana region is communal land, a considerble part of the region is fenced off into private farms. The fenced off areas are mainly small farms where the main part of the fenced off area consists of the homestead and the surrounding field for cultivation. According to the inventory, 22 % of the region is fenced off into private farm land. This means that the fencing is less than in the Omusati region, where 28 % of the region was fenced off according to the inventory in that region.

16 % of the total tree volume and 37% of the total number of stems in the Oshana region is inside fenced off areas, i.e. on private farms. The trees growing on the farms are on average smaller than for the whole region in general. Hence, the situation is the opposite compared to Omusati region, where the trees on the farms were bigger than the trees in the region in general. Another difference is that the indigenous fruit trees *Sclerocarya birrea, Hyphaene petersiana* and *Berchemia discolor* were profoundly more common on the farms in Omusati region than in the region as a whole. This is not the case in Oshana region.

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

- There are fewer species on the farms than in the region in general.
- *Colophospermum mopane* is the most common species in the region as a whole, but not on the farms.

The regeneration

Most of the woody vegetation in the region is in the shrub layer. 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. However, the area where the woody species are growing will affect whether the sapling of a certain species will develop into a tree or if it will remain as a shrub. Furthermore, the reason why a certain species was found only as a shrub in the inventory might be over-utilisation. The species might have the potential to grow into trees if left to grow.

There is on average 2366 shrubs/saplings per hectare in the shrub layer, which is quite a considerable amount. This figure refers to the part of the region that was inventoried (51% of the region). If the whole region is taken as reference-area the average amount of shrubs/saplings per hectare is half of his figure (1195 shrubs/saplings per hectare). A considerable part of the area inventoried was found to be basically without shrubs (grassland, herbs land, bare land). This means that the shrub layer where it occurs must be rather dense to reach the average figure mentioned above.

Colophosperhemum mopane completely dominate the shrub layer. Although the number of species found in the shrub layer is rather high, 95 % of the woody vegetation is coming from the 5 most common species in the layer, namely *Colophosperhemum mopane, Commiphora angolensis.*
Dichrostachys cinerea, Elephentorrhiza elephantina and *Rhigoszum brevispinosum.*

No saplings were observed for *Sclerocarya birrea*, and very few for *Terminalia prunoides, Terminalia sericea* or *Hyphaene petersiana*. Therefore, from this perspective the domination of *Colophospermum mopane* in the tree layer 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, hence the economic importance of the woodland.

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 or collect information on root tubers etc. However, a considerable part of the NTFPs used in the region are related to trees. Therefore, the information on trees can be used to indicate the abundance or scarcity of the NTFPs.

The economic value of the wooded areas of the region for fodder is significant. It is however not possible with the information in this inventory to determine the options to increase the utilisation of the wooded areas for grazing or for browsing.

Mopane worms are another potentially important NTFP. The inventory did not assess the occurrence of the Mopane worm, but since *Colophospermum mopane* is the most common species both in the tree and in the shrub layer the environment for the mopane worm is favourable in the region.

Fruits from *Sclerocarya birea* (Marula), *Berchemia discolor (*Eembe), *Hyphaene petersiana, Ficus sycomorus, Diospyros mespiliformis* and *Adanonsia digitata* (Baobab) are used for various purposes in the northern regions of Namibia. The inventory did not find any younger trees or saplings for most of the fruit trees. This indicates that threre is at the moment 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. Therefore regeneration and younger trees are mostly found 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 Oshana 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 Oshana region

The population density in the region is the highest in Namibia, 25.3 persons per km^2, with the majority of the population in the northern parts of the region. The woody resources are very important for the well being of the rural population in the region. A considerable part 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 Oshana Region

Note: coordinates are in decimal degrees

MAP SHEET	CLUSTER	LATITUDE	LONGITUDE
1515B	1	-17.6969	15.9525
1515B	2	-17.7097	15.9097
1515B	3	-17.7103	15.9237
1715D	5	-17.711	15.9665
1715D	6	-17.7109	15.9808
1715D	7	-17.7239	15.9527
1515B	8	-17.7537	15.9235
1515B	9	-17.7544	15.9377
1515B	10	-17.754	15.9519
1515B	11	-17.7548	15.9804
1715D	12	-17.7716	15.8093
1715D	13	-17.7714	15.8234
1715D	14	-17.7718	15.8372
1715D	15	-17.7716	15.8515
1715D	16	-17.7719	15.8808
1515B	17	-17.8201	15.7558
1515B	18	-17.8328	15.7559
1515B	19	-17.8157	15.8093
1715D	20	-17.8157	15.8368
1715D	21	-17.8153	15.8513
1715D	22	-17.8157	15.8807
1715D	23	-17.9046	15.7905
1715D	24	-17.9041	15.8194
1715D	25	-17.9037	15.8336
1715D	26	-17.9035	15.8618
1715D	27	-17.9487	15.7911
1715D	28	-17.9479	15.8196
1715D	29	-17.9481	15.8346
1715D	30	-17.9469	15.8632
1715D	31	-17.9653	15.9142
1715D	32	-17.9924	15.9152
1715D	33	-18.0086	15.9154
1715D	34	-18.0363	15.9146
1815B	35	-18.3562	15.5188
1815B	36	-18.356	15.533
1815B	37	-18.3556	15.5481
1815B	38	-18.3563	15.5611
1815B	39	-18.3555	15.5757

MAP SHEET	CLUSTER	LATITUDE	LONGITUDE
1815B	48	-18.4469	15.699
1815B	49	-18.447	15.7139
1815B	50	-18.48	15.626
1815B	51	-18.4938	15.6254
1815B	52	-18.4932	15.6439
1815B	53	-18.4923	15.6568
1815B	54	-18.4927	15.6707
1815B	55	-18.4931	15.6847
1815B	56	-18.4928	15.6988
1815B	57	-18.4928	15.713
1515B	58	-18.4825	15.832
1515B	59	-18.4825	15.8454
1515B	60	-18.482	15.8595
1815B	61	-18.4824	15.8739
1815B	62	-18.4823	15.8877
1815B	63	-18.482	15.9022
1815B	64	-18.5092	15.5489
1815B	65	-18.5228	15.5496
1815B	66	-18.5356	15.5495

1815B	40	-18.4529	15.5469
1815B	41	-18.467	15.5463
1815B	42	-18.4811	15.5467
1815B	43	-18.495	15.5473
1815B	44	-18.448	15.6429
1815B	45	-18.4469	15.6565
1815B	46	-18.4477	15.671
1815B	47	-18.4475	15.6846

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 Oshana 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 Oshana 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 Oshana 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.

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. 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.

3. 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.

4. 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.*

5. 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*

6. 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.

7. 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 thus 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, Ricinodendron 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.

8. 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.

9. Palms and pans mosaic
Open, flat country characterised by the presence of palms (*Hyphaene petersiana*) and very many small pans. Some of the pans link to form short oshanas, but most remain unconnected when filled after good rains. Other than palms, there are relatively few other large trees. Shrub growth is prevalent, especially in disturbed areas, where shrub Mopane, *Pechuel-loeshea leubnitziae* and *Acacia arenaria* are the dominant species. The sodic sands have high salt concentrations. The area is densely populated, with many fields having been established on the highest ground.

Dominant grasses are *Schmidtia kalahariensis, Eragrostis porosa* and *annulata*, *Aristida adscensionis, rhiniochloa* and *stipoides, Odycea paucinervis, Sporobolus spicatus* and *tenellus, Wilkommia sarmentosa*, and *Monolytrum luederitzianum.*