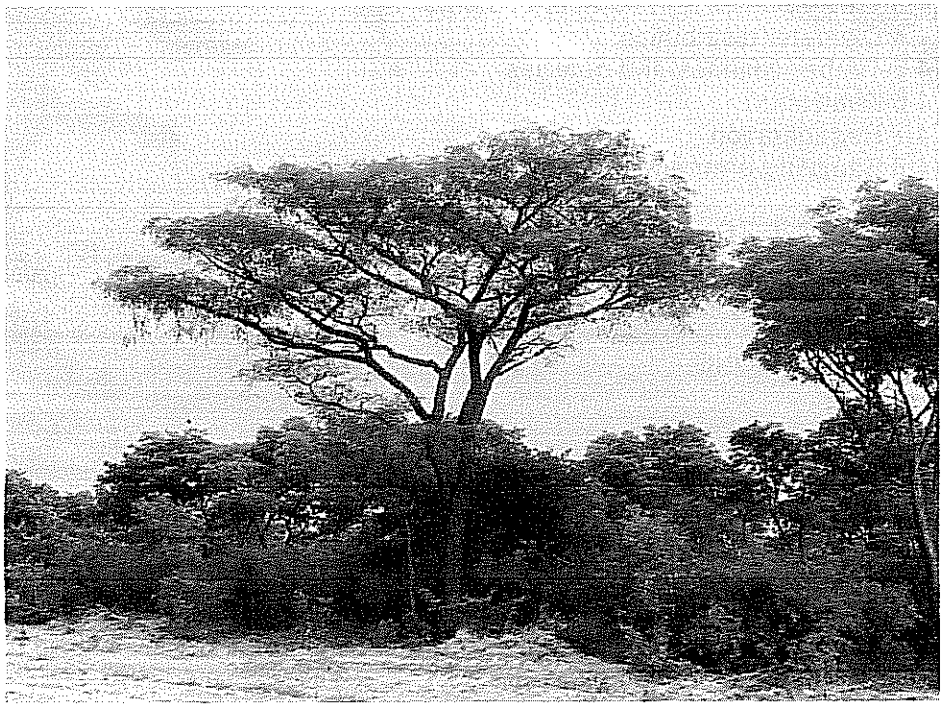
MINISTRY OF ENVIRONMENT AND TOURISM
Directorate of Forestry

INVENTORY REPORT FOR OTJITUUO CONCESSION FOREST



Namibia-Finland Forestry Programme

Ndapanda Kanime, Risto Laamanen and Simon Angombe

Windhoek, May 2002

INVENTORY REPORT FOR OTJITUUO CONCESSION FOREST

TABLE OF CONTENTS

List of maps:

List of figures:

List of tables:

EXECUTIVE SUMMARY

Otjituuo concession forest is situated in the eastern part of Grootfontein district in Otjozondjupa region.

The inventory was focusing on the potential for sawn timber production. There were many different tree species in the area, but only *Pterocarpus angolensis* was measured, because the forest manager of this communal land was interested only on this species. The inventory was carried out in two phases (two areas). The first area was stratified before the inventory in two strata. Only the results for the stratum "medium-dense" (11 306 hectares) are of satisfactory accuracy in the first area. Therefore, no results for the stratum "open" are given. The second area (234 216 hectares) was inventoried as one stratum.

There is a total number of 65949 of live trees (5.8 trees / ha) in the first inventory area stratum "medium". In the second area the total number of stems is 128609 (0.5 trees / ha). The total volume in the first area stratum "medium" is 62847 m3 (5.6 m3/ha). In the second area the total volume is 199693 m3 (0.85 m3/ha).

There is a total volume of 2841 m^3 of dead trees in the first area stratum "medium". In the second area the total volume of dead trees was 22081 m^3. Most of both live and dead trees are in small and medium size diameter classes.

In the first area stratum "medium", there is a total number of 7900 mature timber sized trees (> 45 cm). In the second area the number of timber sized trees is 35 130.

Regeneration of Pteorcarpus in both areas is low. In the first area stratum "medium" there are 12 saplings per hectare. In the second area, there are only 5.6 saplings per hectare. It is very important to have vital mature trees for seeding in the future too.

An annual allowable cut of 128 mature (> 45 cm) trees has been calculated for the first area stratum "medium". Respectively for the second area, an annual allowable cut of 1660 mature trees has been given. The log volume of the proposed cut is 1600 m3 annually.

1. INTRODUCTION

The Directorate of Forestry (DoF) under the Ministry of Environment and Tourism in Namibia has a mission to carry out forest resource assessments in Namibia. In this task it has been supported since 1995 by the government of Finland. Initially the aim of the support was to build the capacity of the directorate to carry out regional forest inventories - that is inventories of very large areas (National Forest Inventory Component, NFI).

During the years, an increasing number of local level inventories have also been carried out to fulfil specific requests by projects and forest managers. The support from the government of Finland today- Namibia-Finland Forestry Programme Phase II- aims now more at strengthening the capacity of DoF to serve the needs for local level forest management planning.

A request to help assessing a communal area in Otjituuo was received by DoF in 2001. The objective of the assessment was to find out if there is a potential for commercial harvesting of *Pterocarpus angolensis* in two areas of interest. A systematic sampling was applied. The fieldwork was carried out using the methodology of the earlier NFI with the exception that only one species was included in the tree enumeration. The reason why the area is divided into two areas is that the border given to NFI for the first area was not correct. This was realized only after the field work of the first area had been accomplished. After that, the area was extended and it was called area two. This report presents the results from the inventory of two areas in "Otjituuo Concession Forest".

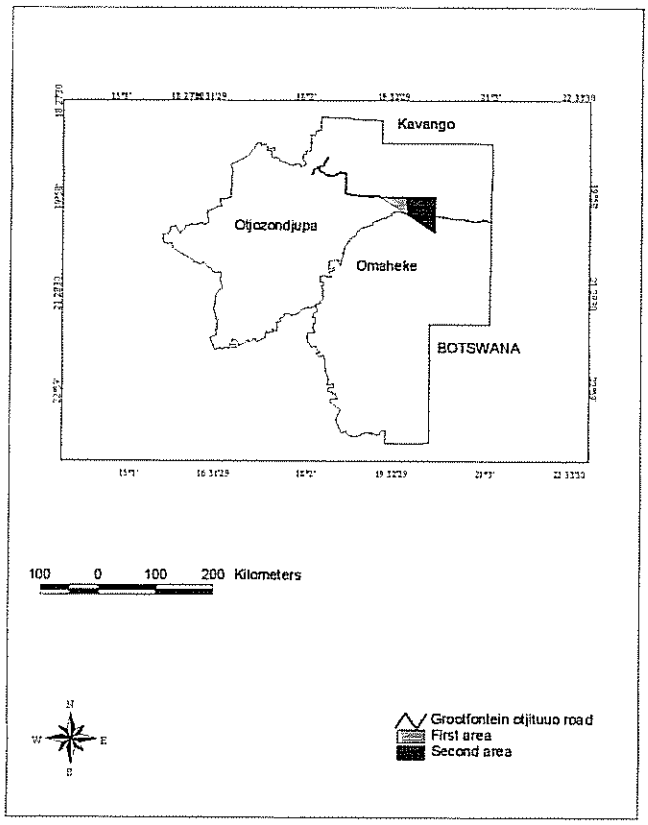
The results for all two areas are presented in this report. The two areas as a whole are referred later as the "Otjituuo Concession Forest". For those readers who may be interested to know what other forest areas the DoF has inventoried, a list of inventory reports has been attached at an appendix at the end of this report. These reports are available at the Directorate of Forestry in Windhoek.

2. DESCRIPTION OF THE AREA

Otjituuo concession forest is located in the Eastern part of Grootfontein district in Otjozondjupa and Omaheke regions. (See Map 1).

According to the Directorate of Forestry vegetation maps, the area is classified as both forest and savanna type vegetation. *Pterocarpus angolensis* is the dominant species in the area. The soil is sandy, but the soil colour may differ due to the mineral content.

Map 4: Location of the Otjituuo Concession Forest

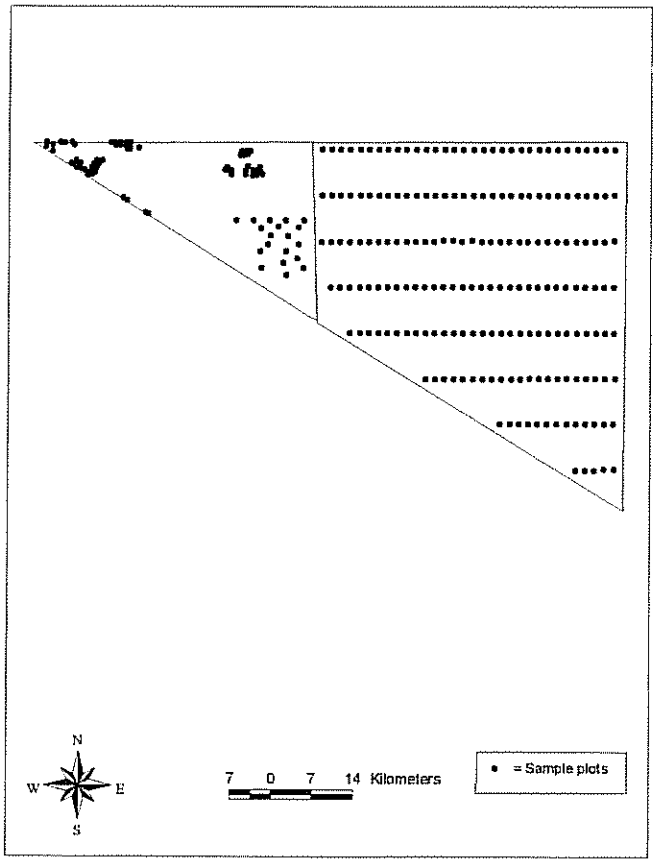


3. INVENTORY DESIGN

3.1 Sampling method

The total area for the first area is 69440 ha and for the second area it is 234216 ha. Prestratification was applied on the first area with the help of aerial photos and a preliminary field survey. The second area was not stratified prior to the inventory. Instead, a post stratification was done to point out sites with a higher number of *Pterocarpus* trees. A systematic sampling design was then applied. The total number of clusters located in the first area was 89 and for the second area it was 195. Each cluster consists of 1 sample plot. Each plot has its own coordinates. Therefore, a total of 89 sample plot on the first and 195 on the second area were located. Map 2 below shows the location of sample plots in the area.

Map 5: Location of plots in Otjituuo concession forest



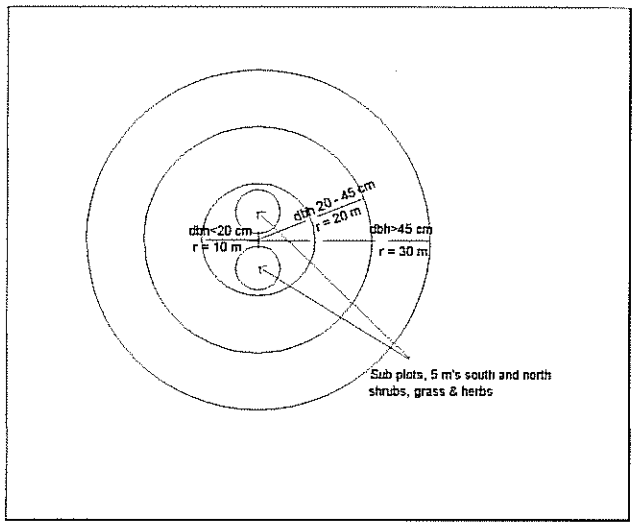
The plots plotted on the vegetation maps were digitised using Arcview to obtain coordinates for each plot. Co-ordinates and GPS were used for locating the plots in the field. The plots were not marked as permanent plots. Co-ordinates for both areas are shown in Appendix 1 and 2 for those who may wish to re-locate the plots in the field.

3.2 Field measurements

The data was collected in circular sample plots. All the measurements are described in more details in the field instructions (Manual for Woody Resource Inventory, 2001). The woody vegetation is classified into trees and shrubs. In this inventory, trees are defined as woody plants with dbh > 5 cm and shrubs are woody plants with dbh < 5 cm.

A different radius of sample plot was applied for small trees, medium size trees and big trees. For small trees (5 cm≤ dbh≤ 20cm) the radius is 10 m, for medium size trees (20cm<dbh≤45cm) 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 the sample plots. In addition, tree height, diameter of canopy, crown height and damages were also recorded for each tree. Regeneration of *Pterocarpus angolensis* was measured in two sub-plots (radius 3.99 m) located in each plot (See figure 1).

Figure 2: Plot design



3.3 Volume functions

The volume function used in the inventory has been developed by DoF. The data used for the developing has been collected from three areas: Tsumkwe, Caprivi and Omusati region.

The volume function applied for *Pterocarpus angolensis* is:

$v = e^{\wedge} (a_0 + a_1 * d + a_2 * d^2)$,
where v = tree volume in dm^3
d = tree diameter (dbh) in cm
a_o, a_1 & a_2 = parameters

Note: 1. ^ means "to the power of"
2. e = 2.71828

4. INVENTORY RESULTS

4.1 Stratification

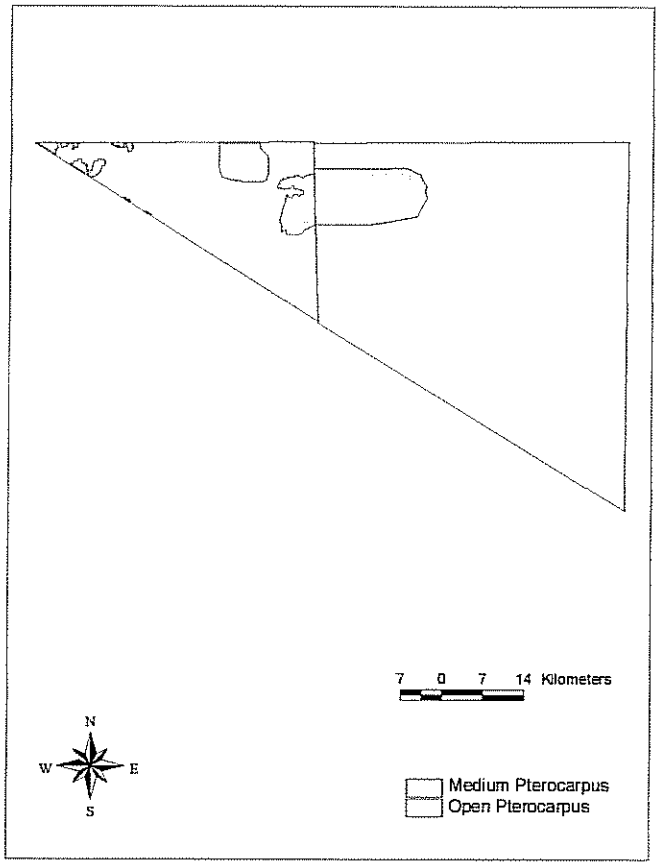
Prestratification was applied for the first area with the help of aerial photos and a preliminary field survey. The second area was not stratified prior to the inventory. Instead, a post stratification was done to point out sites with a higher number of *Pterocarpus* trees. Stratification resulted in following areas. "Medium" is a stratum with a somewhat higher number of *Pterocarpus angolensis* trees than what can be found on the "open" stratum.

Table 1. Area by stratum

	Stratum	Area in ha	% of total
First area	Medium	11305.7	16.3
	Open	58134.3	83.7
	Total	69440.0	100
Second area	Medium	16113.6	6.8
	Open	218102.6	93.2
	Total	234216.2	100

The location of the strata can be seen on the Map 3 below. Note that the stratification of the first area was done before the inventory. For the second area it was done after the inventory.

Map 6: Stratification map for Otjituuo Concession Forest



4.2 Measured data

The inventory fieldwork in Otjituuo Concession Forest was carried out from March to July 2001. A total of 89 clusters were measured in the first area and 195 clusters in the second area. In the following, results for both areas are presented. Results for the first area have been presented for both strata, but no totals for the first area have been given. This is because the results for the stratum "Pterocarpus open" are unreliable and should not be used for any serious calculations. The reason for the unreliability is that only 17 plots were measured in this stratum and the sampling error remained very high (see chapter 4.8). The sampling of the stratum "Pterocarpus open" clearly failed.

Results for the second area have been presented as totals for the whole area.

Results have been presented as tables and graphs whenever it has been possible. A total of 66 trees (on 89 plots) with dbh>5 cm were measured in the plots of the first area (See Table 1), which is on average 0.74 trees per sample plot. 18 trees (on 195 plots) were measured in the second area, which is on average of 0.09 trees per sample plot. The tree species measured in both areas was *Pterocarpus angolensis.*

Table 2. Total number of measured *Pterocarpus angolensis* trees

	Stratum	Total No. measured trees
First area	Medium	59
	Open	7
Second area		18
Total		84

4.3 Tree volumes and number of stems

All the woody stems with a dbh > 5 cm are regarded as trees. The number of *Pterocarpus angolensis* trees and volumes for the whole concession, both first area and second area are shown in table 3 below.

Table 3. Volume and number of stems by species totally and per hectare

	Area (ha)	Total No. of stems	Stems per ha	Total tree volume, m3	Average tree volume, m3/ha
First area, medium	11306	65949	5.8	62847	5.6
" , open	58134	117923	2.0	215548	3.7
Second area	234216	128609	0.5	199693	0.85
All	303656	312481	1.0	478088	1.57

The medium-dense stratum has a significantly higher volume per hectare than the area in general. Note that the result for the first area "open" stratum are unreliable as well as the results for the whole 1st area. Therefore in the following chapters, the results have been given to the areas 1st area "medium" and 2nd area only. These areas cover a total of 245 521 hectares.

4.4 Diameter distribution

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

In the first area stratum "medium", *Pterocarpus angolensis* has a majority (62.5 %) of the stems in the medium size diameter classes (25-45 cm) and much less trees in the bigger classes and smaller classes (see table 4 and figure 2). In the second area the majority of the stems are in the medium classes as well. However, in the second area there are trees in the bigger diameter classes (45-85 cm) too (see table 5 and figure 3). In the first area stratum "medium" 16 % of the stems are over 45 cm at dbh and in the second area respectively 30.8 %. Note, that in the second area no trees were found in the diameter class 5-15 cm. The diameter distribution presented in this chapter includes only live trees.

Table 4. First area, stratum "medium": Total tree volume and number of stems by diameter class for *Pterocarpus angolensis*.

Dbh class, cm	Total tree volume, m3	Total number of stems	% of total stems
5-15	417	9996	15.2
15-25	1022	3749	5.7
25-35	11195	21243	32.2
35-45	23329	19993	30.3
45-55	16648	8192	12.4
55-65	10236	2777	4.2
Total	62847	65949	100.0

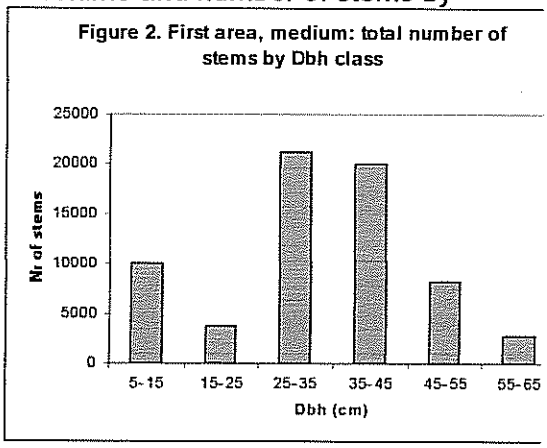
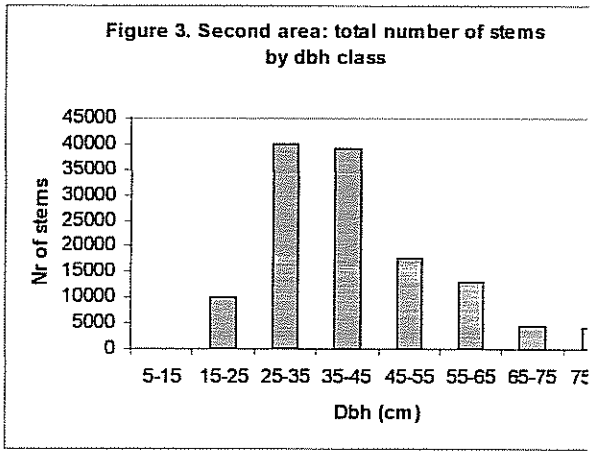


Table 5. Second area: Total tree volume and number of stems by diameter class for *Pterocarpus angolensis*.

Dbh class, cm	Total tree volume, m3	Total number of stems	% of total stems
15-25	2381	9995	7.8
25-35	26310	39981	31.1
35-45	47368	39060	30.4
45-55	35655	17770	13.8
55-65	43651	13122	10.2
65-75	20968	4442	3.5
75-85	23359	4238	3.3
Total	199693	128609	100.0



4.5 Timber volumes and qualities

Timber volume or saw log volumes means the volume of the part of the main trunk that has been regarded sawable. In the field, the dbh and length of the sawable trunk were recorded. The saw log volume was estimated assuming the log has a cylindrical form. The timber volumes and qualities for the stratum "medium" of the first as well as for the

whole second area have been presented in Table 6 and 7 for *Pterocarpus angolensis*. No results for the first area stratum "open" have been given as the accuracy of the results is not good enough.

The tables include only trees with dbh>45 cm, i.e. trees that can be harvested. Note that the volume of standing dead tree of *Pterocarpus angolensis* tree has been included in the table. The volumes in Table 6 and 7 are log volumes, not tree volumes.

The quality classification used in the inventory is as follow:

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

Table 6. First area, stratum "medium": distribution of log volume by status and quality of *Pterocarpus angolensis* with dbh > 45cm.

Status	Quality	Stems per ha	Total number of stems	Total log volume, m3	Average log volume, m3/ha
Alive tree	Good quality	0.55	6248	3926	0.35
Alive tree	Medium quality	0.05	555	368	0.03
Alive tree	Poor quality	0.10	1111	663	0.06
Alive tree	Not sawable	0.05	555	512	0.05
Standing dead tree		0.05	555	248	0.02
Total		0.80	9025	5718	0.51

Table 7. Second area: distribution of log volume by quality of *Pterocarpus angolensis* trees with dbh > 45cm.

Status	Quality	Stems per ha	Total number of stems	Total log volume, m3	Average log volume m3/ha
Alive tree	No code	0.02	4442	5483	0.02
Alive tree	Good quality	0.04	8885	5806	0.02
Alive tree	Medium quality	0.08	17770	13247	0.06
Alive tree	Poor quality	0.04	8475	5626	0.02
Total		0.17	39572	30161	0.13

In the 1st area, in the stratum "medium" there is a total sawable log volume of 4957 m3 in 7914 trees (0.62 m3 / tree). Of this volume about 80 % (3926 m3) is of good quality. The remaining 20 % are of medium and poor quality. In addition to these log volumes, there are 512 m3 of non-sawable logs and 248 m3 of standing dead trees.

In the 2nd area, there is a total of 26 678 m3 of sawable logs in 35130 trees (0.76 m3 / tree). There is also a volume of 5843 m3 of logs which were not classified in quality classes. Assuming the non-coded trees are distributed in the quality classes as the other trees, the total sawable log volume is 25780 m3 in 29564 trees (0.87 m3/tree).

4.6 Deadwood

Table 8 shows the deadwood volume in the Otjituuo concession forest for the 1st area stratum "medium" and for the 2nd areas. A volume function for living trees were used to calculate the deadwood volumes. This function includes branch volume too, so for dead trees the function gives an overestimate. There is a total deadwood volume of 2841 m^3 in the first area stratum "medium". In the second area, the dead wood volume is 22 198 m3. Most of the dead *Pterocarpus angolensis* trees in both areas were found in a medium size diameter class (35-45cm). No results for the 1st area stratum "open" and the 1st area as a whole have been given here because of the low accuracy of the results.

Table 8. Volume and number of stems of dead trees (total and per hectare).

	Total no. of stems	Stems per ha	Total tree volume	Average tree volume m3/ha
First area, "medium"	3609	0.3	2841	0.25
Second area	19069	0.1	22198	0.09
Total	22678	0.1	25039	0.10

4.7 Regeneration

In the first area stratum "medium" 12 saplings of Pterocarpus angolensis per hectare were found, mainly in the height class 100-150 cm. In the second area only 5.6 saplings per hectare were found, mainly of 150 cm height. The regeneration of *Pterocarpus* is very low. This might be a natural level of regeneration as the number of bigger trees is low too. In any case this has to be considered carefully when the sustainable use of *Pterocarpus* is being planned.

4.8 Sampling error and confidence limits

Sources 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

The Otjituuo concession forest was inventoried by experienced NFI field staff and the field measurement errors can be expected to be very few. Field instructions were reviewed both in the office and in the field. In this work, specific attention was paid to guarantee good quality field data. Data processing programs have been 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, as well as reports were double checked.

Volume function

The applied volume functions are probably the main source of error. This error however does not affect the figures related to number of stems.

Sampling error and confidence limits for tree volume

The estimates for the standard errors of mean volumes were calculated using the formula applicable for random sampling. The sampling in Otjituuo was done with systematic sampling. Table 9 shows the sampling error and confidence limits for tree volume for *Pterocarpus angolensis*. Sampling error is presented for the first area as a whole and separately for both strata.

From the table it can be immediately seen that the accuracy of the results for stratum "open" as well as the accuracy for the first area as a whole is not satisfactory. Therefore the results of the stratum "open" and the results of the first area as a whole can not be used for any planning.

The accuracy of the results for the first area stratum "medium" as well as of the results for the second area are better, however for the second area still not very good. The standard error of the mean volume of the first area stratum "medium" (5.6 m3/ha) is 20 %. It means that the true mean volume with 95 % probability is between 3.4 m3/ha and 7.8 m/ha. With a probability of 67 % the true mean is between 4.5 and 6.7 m3/ha.

The standard error of the mean volume (0.79 m3/ha) of the second area is 30 %. With a 95 % probability the true mean is between 0.32 m3/ha and 1.26 m3/ha. With a 67 % probability the true mean is between 0.55 m3/ha and 1.03 m3/ha.

Table 9. Sampling error and confidence limits for tree volume for *Pterocarpus angolensis* for both areas.

	Mean volume, m3/ha	Standard error (SE) of the mean, m3/ha	SE, %	Lower confidence limit, m3/ha	Upper confidence limit, m3/ha	Confidence level, %
First area total	4.0	2.3	58	0.0	8.5	95
Medium	5.6	1.1	20	3.4	7.8	95
Open	3.7	2.8	76	0.0	9.2	95
Second area	0.79	0.24	30	0.32	1.26	95

As already indicated above, the accuracy of the inventory is not very good. The results should be used with specific caution when decisions on possible harvesting are made.

5. INVENTORY COSTS

In this chapter the costs of the inventory of Otjituuo concession forest are presented. This information can in the future be used for planning new inventories. In all inventory designs, the cost-effectiveness of the work should be kept in mind. Here, only a rough estimate of the costs incurred in Otjituuo inventory will be given.

The inventory in Otjituuo concession forest was carried out from March to July 2001. From March to June there were 8 NFI-team members participating in the field work and in July there were five team members. In the calculation, a cost for a man-day includes the salary plus the daily subsistence costs. Altogether 5 field trips of 14 days in the field (700 km one way) were made using 3 cars. In the field, 4 ATVs were used for moving from one plot to another. The costs for fuel are real, but the cost for vehicle maintenance is an estimate which has been derived from annual maintenance costs. This calculation only includes immediate costs of the inventory. It does not include fixed costs and overhead costs like office facilities, computers, supervision etc.

Table 10. Cost calculation of Otjituuo concession forest inventory.

Cost item	Units	Cost/unit, N$	Total cost, N$
Inventory planning	1 week	1000	1000
Inventory equipment			10000
Inventory field work	518 man-days	530	274540
Fuel	1500 litres	3.50	5250
Vehicle maintenance			40000
Data entry	1 week	1000	1000
Data analysis	2 weeks	1000	2000
Report writing	6 weeks	1000	6000
Report printing			500
Total			340 290

The total cost of Otjituuo inventory was about N$ 340 000. The biggest cost items are the manpower in the field and the maintenance of the cars and ATVs.

6. ALLOWABLE CUT

In the following, a rough allowable cut for a 10 years period is presented for the first area stratum "medium" and for the second area. The low accuracy of the inventory in the stratum "open" in the first area does not allow cutting calculations.

First area, stratum "medium"

The limit for a mature tree that can be harvested is 45 cm. Based on the diameter distribution and timber quality classification of mature trees, the number of Pterocarpus trees is 2000 in diameter class 45-55 cm and 5900 in diameter class 55-65 cm. In addition to these, there are about 20 000 stems in the diameter class 35-45 cm – that is trees which are not yet mature. The principle used by DED in the cutting calculations for M'Kata forest seem to be appropriate also in the case of Otjituuo concession forest (Preliminary yield and revenue estimation for the M'kata pilot forest, 2001). According to this principle, overmature trees with dbh > 65 cm can be all harvested because the vitality of them is decreasing rapidly. However, no trees of this size were found in the first area. As the regeneration of *Pterocarpus* is low (12 saplings/ha) it is important to have vital mature trees to seed in the future too. Therefore, only 2/3 of the trees in class 55-65 cm can be utilized. Also, an assumed mortality of 10 % must be deducted. This calculation gives an estimate of 1200 trees which can be harvested during the 10 years time, or 120 trees annually in the class 55-65 cm.

The utilization rate for the class 45-55 cm is based on the estimate of average annual increment of the diameter. In the DED calculation an estimate of 0.11 cm / annum was used. A growth study carried out in Caprivi and Oshikoto showed much higher increments: minimum 0.25 cm in Caprivi and mimimum 0.27 cm in Oshikoto (Worbes, 2001), however in much more favourable climatic conditions. It is well justified to use a conservative increment value here too. Using the 0.11 cm annual diameter increment in calculations, it will take about 90 years for a tree to grow 10 cm in diameter. Assuming an even distribution of stems inside the diameter class, 50 % of the stems from class 35-45 will move to the class 45-55 during a period of 45 years. This indicates that 50 % of the trees in this class can be harvested in 45 years. Assuming a mortality rate of 10 % the annual allowable number of trees to cut in this class is (5900 – 5900*0.1) / 45 = 59 trees.

The annual allowable cut in by diameter classes in the first area stratum "medium" has been summarized in the following table:

Diameter class, cm	Total number of log quality trees	Nr of trees to be cut annually	Log volume to be cut annually, m3
45-55	5910	59	30
55-65	2004	121	98
Total	7914	180	128

Second area

In the second area, the regeneration of Pterocarpus angolensis was found to be much lower than what it was in the first area stratum "medium". In the second area, very big

trees with dbh over 65 cm were found. Differing from the principle of the DED calculations, it is proposed that 20 % of these very big trees would be left standing. In order to have vital mature trees for seeding, a harvest rate of 50 % (instead of the 2/3 used in the first area) has been suggested here for the diameter class 55-65 cm. Using the principles described above and here, an estimate of the annual cut of trees in the mature diameter classes is given here for a 10 years period for the second area:

Diameter class, cm	Total number of log quality trees	Nr of trees to be cut annually	Log volume to be cut annually, m3
45-55	17770	178	86
55-65	13122	791	764
65-75	4442	355	321
75-85	4238	339	288
Total	39572	1663	1459

In addition to the cutting of live trees it is possible to cut dead trees. However, no calculations on the rate of harvesting of dead trees are given here. In principle, not all dead trees should be harvested to sustain the biodiversity in the area.

The log volume to be cut in both areas annually is estimated to be about 1600 m3. Assuming a recovery rate of 50 % for sawn timber, a volume of 800 m3 of sawn timber can be produced annually. Assuming a price of N$ 2000 per cubic meter for sawn timber of *Pterocarpus angolensis*, the total value of the sawn timber produced annually is N$ 1 600 000.

7. RECOMMENDATIONS

When the harvesting is being carried out according to the allowable cut given in this report, it is very important to respect the following principles. Some other recommendations are given here too.

- The allowable cut of the first area concerns only stratum "medium", therefore the cuttings should take place only within the boundaries of this stratum

- Harvesting of *Pterocarpus angolensis* must be done evenly over the whole area in concern. So, if 1/10 of each area is harvested annually, it means that in the first area stratum "medium", only 1 tree per 6 hectares should be harvested. In the second area, 1 tree only in 14 hectares should be harvested. In reality, the trees do not grow evenly in the areas and the harvesting intensity may differ respectively. It is however extremely important to understand that the harvesting must not result in the complete loss of *Pterocarpus* in the harvested areas.

- As it is very difficult to regulate the number of trees to be harvested per hectare, it is recommended that the trees which are harvested will be marked by forestry staff before harvesting.

- Trees with less vitality should be selected for harvesting and trees with higher vitality should be left for seeding.

- The allowable cut has been calculated for a 10 years period. It is recommended that before extending the harvesting beyond this period, the inventory and calculations are renewed.

- Assuming that the government will charge a fee of N$ 110 per log (or per tree), and keeping in mind that the inventory costs were 340 000 N$, a total of 3090 trees must be harvested to cover the direct inventory costs only. This is about 17 % of the total number of trees to be harvested during the 10 years period (18 400 trees). In the future, the efficiency of the inventory should be improved by modifying the inventory methodology.

- In the future, any harvesting allocations in similar areas should be based on proper forest management plans in which other management aspects along timber harvesting are considered too.

REFERENCES

Selanniemi T., Chakanga M., Angombe S., 2001. Inventory Report on the Woody Resources in M'Kata Pilot Forest in Otjozondjupa Region.

Selanniemi T., Chakanga M., Angombe S., 2001. Manual for Woody Resources Inventory. Directorate of Forestry.

DED, 2001. Preliminary yield and revenue estimation for M'Kata pilot forest.

Worbes, M. 2001. Growth of Trees from Namibia – A dendrochronological study. Insitute of Forest Botany, Gottingen, Germany.