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Past, Present and Future Forest Management in the Southern African Region with special emphasis on the Northern Regions of Namibia

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FOREWORD

Forests and woodlands in Namibia are important grazing areas for livestock both in commercial and communal areas. Most of Namibian population use a great variety of forest products for their household energy and construction, nutrition, medicines, and shelter needs.

To better understand the present forestry constrains and the need for the future challenges it is important to take into account past forestry practises. The author of this paper has extensive knowledge on the management of indigenous forests in southern African region, including northern Namibia.

The author has included his earlier unpublished research reports and notes from the mid-1970s and has attempted to translate them into the present Namibian sociological and ecological context. In the process he has given many valuable thoughts for future forestry development in Namibia. The paper was presented at the Strategic Planning Workshop organised by the Forest Management and Extension Division of the Directorate of Forestry. The workshop was funded by the Finnish International Development Assistance.

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PAST, PRESENT AND FUTURE FOREST MANAGEMENT IN THE SOUTHERN AFRICAN REGION WITH SPECIAL EMPHASIS ON THE NORTHERN REGIONS OF NAMIBIA

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1.   BACKGROUND

Forests and trees have provided Namibian populations with fuelwood, building material, food, and fodder for cattle, and had an important social, cultural and psychological impact. However, the forests and woodlands in northern Namibia have been rapidly degraded through logging and fires, which caused a shortage of fuelwood and building material, and soil erosion. Overgrazing in central Namibia has generated a serious bush encroachment and consequent decreased grazing capacity of the pasture lands and serious losses for livestock farmers. Erkkilä & Siiskonen (1992) reviewed the development of forestry in Namibia and summarised the forestry situation in Namibia as a basis for a future forest policy, but also suggested that the country can still be considered as 'fairly well wooded'.

The Forest Management and Extension Division of the Namibian Directorate of Forestry organised a Strategic Planning Workshop during October 1995. The main objectives of the Workshop were stated as the following:

- to evaluate the present situation, development needs, activities and impacts in various Regions and Forestry Districts;

- to identify, analyse and recommend prioritised action programmes, projects and activities for the preparation of a document "A Ten-year Strategic Plan for the Forest Management and Extension Division".

2.   OBJECTIVES

The main objectives of this paper are:

- To give a brief overview of the management of natural forests in the southern African region with particular emphasis on Namibia;

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- To present forest resources information and management issues (including for example forest fire management) on important forestry regions such as Katima Mulilo, Kavango, Ovambo and Bushmanland;

- To envisage future forest management and utilisation options on commercial farms and on communal land in Namibia;

- To include initiatives, proposals and emerging issues relevant to forest resources assessment and planning methodologies in Namibia.

3.   MANAGEMENT OF NATURAL FORESTS IN SOUTHERN AFRICA

The management of the natural forests in the southern African region must be considered in relation to the resource potential of the region. Geldenhuys et al (1994) initiated a study to develop an understanding of the resource potential, resource utilisation, and resource economics of African savannas and woodlands on a regional scale and to contribute to policy development for resource utilisation at a national and subcontinental level. The study was confined to the Southern African Region, as defined by the World Bank, which includes South Africa, Lesotho, Swaziland, Namibia, Botswana, Zimbabwe, Mocambique, Angola, Zambia and Malawi. Tanzania, as member of the Southern African Development Community (SADC), was also included. The following are important aspects of the study:

- Most of the land (57%) in the region (larger parts of Angola, Tanzania, Mocambique, Zambia and Malawi) is within humid climate zones, where 180 days or more are suitable for growth each year, on the basis of adequate available soil moisture (World Resources Institute, 1992; Table 1). Semi-arid climates, with growing season between 76 and 120 days, prevails in 15% of the area (larger parts of Lesotho, Swaziland and Zimbabwe). Arid climates, with average growing season <76 days per year, prevail in 28% of the area. Botswana and Namibia are mainly arid to semi-arid, whereas South Africa has large arid as well as humid areas. Only 8% of the land area in this region has no inherent soil constraints.

- Many types of natural vegetation occur in the region (White, 1983; Table 2). Moist woodland (49% of total land area) and arid woodland (27%) are the most extensive formations. These woodlands occur extensively in Angola, Namibia, Moçambique, Tanzania, South Africa, Botswana, Zambia and Zimbabwe.

- The population of the region amounts to about 120 million, and is growing at about 3% per annum (Table 3). The population density is relatively low, about 17 people per square kilometre. The three smallest countries, Swaziland, Lesotho and Malawi, have relatively high population densities,

Table 1. Climatic classes and soil constraints in southern African countries (World Resources Institute, 1992). Land area refers to total area, excluding the area under permanent water bodies, such as rivers and lakes.

| Country | Land area, km² | Percent of Land area | | | Land with no inherent soil constraints | | | |
| | | Arid | Semi-arid | Humid | Total, km² | Category a percentage of total | | |
						Arid	Semi-arid	Humid
Namibia	823290	78	21	1	93032	81	18	1
South Africa	1221040	55	13	32	74483	47	18	34
Angola	1246700	4	8	87	157084	17	15	68
Botswana	566730	62	38	0	48172	72	27	1
Zimbabwe	386670	8	41	51	9667	12	65	23
Swaziland	17200	0	26	74	1772	0	7	93
Tanzania	886040	7	15	78	50504	6	21	74
Moçambique	784090	8	9	82	49398	7	7	86
Zambia	743390	0	2	98	24532	0	0	100
Malawi	94080	0	0	100	11007	0	0	100
Lesotho	30350	15	13	66	9	100	0	0
TOTAL	6799580	28	15	57	519660	34	17	49

Table 2. Major structural vegetation formations in southern Africa. Forest includes thickets, and woodland includes savanna and wooded grassland. South Africa has 46393 km² sclerophyll shrubland

| Country | Area, km² | | | | | | | |
	Evergreen & deciduous forest	Moist woodland	Arid woodland	Arid shrubland	Moist grassland	Arid grassland	Wetlands & swamps	Deserts
Namibia	-	161111	506950	41846	19	-	-	113129
South Africa	6053	55394	366437	428472	187442	129475	-	1128
Angola	175782	849980	148535	-	63287	-	1110	3732
Botswana	-	186575	341551	-	-	24683	8709	-
Zimbabwe	6246	254989	114107	-	7955	-	2059	-
Swaziland	-	5457	8566	-	3267	-	-	-
Tanzania	15649	645103	72758	-	-	104880	63430	-
Moçambique	47375	494806	225144	-	5327	-	8907	-
Zambia	37135	583693	43897	-	66485	-	17507	-
Malawi	336	81922	15797	-	2956	-	4981	-
Lesotho	-	-	-	-	23175	7278	-	-
Total	288576	3319030	1843742	470318	359913	266316	106703	117989

whereas Angola, Botswana, Namibia and Zambia have low population densities.

- South Africa and Botswana have the stronger economies measured as GDP per capita. The share of GDP between different sectors of the economy shows major differences between the middle-income and low-

income economies (Table 3), with industry and service sectors dominating in the middle-income economies, and agriculture in the low-income economies. Zambia has a high contribution from its mining industry. The relatively high contribution of services to GDP in Malawi and Lesotho reduced the relative importance of agriculture in their economies.

Table 3. Population density, economic indicators and broad land use categories for southern African countries (International Bank, 1992). Population numbers are World Bank estimates for mid 1990, based on projections from most recent population censuses. In the case of Namibia, the population figures are according to 1991 census (Central Statistics Office 1993).

Country	Population 1990			Percentage share of GDP			a) Area (1000 km²) of land use in 1989 (World Resources Institute 1992; FAO Interim Report 1988)			
	Total x10⁶	Density /km²	Annual growth %	Agriculture	Industry	Service s	Agricultural land	Permanent pasture	Forest & Woodland	Other land
Namibia	1.4	1.7	3.1	11	38	50	6.6	101.2	560.7	154.9
South Africa	35.9	29.4	2.4	5	44	51	131.7	813.8	45.2	230.4
Angola	10.0	8.0	2.6	13	44	43	35.8	200.0	821.6	189.3
Botswana	1.3	2.3	3.3	3	57	40	13.7	20.0	525.6	26.0
Zimbabwe	9.8	25.3	3.4	13	40	47	27.0	6.5	235.0	117.3
Swaziland	0.8	47.1	3.4	-	-	-	1.6	11.1	1.8	2.7
Tanzania	24.5	27.7	3.1	59	12	29	52.4	161.4	600.4	71.8
Moçambique	15.7	20.0	2.6	65	15	21	31.0	3.4	581.6	168.1
Zambia	8.1	10.9	3.7	17	55	29	52.4	186.4	403.5	98.4
Malawi	8.5	90.4	3.4	33	20	46	23.9	9.6	47.3	13.3
Lesotho	1.8	60.0	2.7	24	30	46	3.2	19.8	0.2	7.2
TOTAL	117.8	17.3	2.9				380.4	1533.1	3822.7	1079.4

● A large area of the region is classified as unconverted forest and woodland (56.1%) and permanent pasture (22.5%). Some of this vegetation has been degraded through shifting cultivation, over-stocking with livestock or over-harvesting of wood products. Only 5.6% has been converted to crop agriculture.

● In recent times, the area of permanent pasture has remained relatively unchanged, whereas forest and woodland has undergone the largest reduction, i.e. more than the world average of -0.2% per annum (International Bank, 1992). Agricultural land and land generally used for urban and infrastructure development has increased in area.

● Use of woodlands for fuelwood and other direct benefits have not been quantified for the region. The crudest extrapolation suggests that, currently, use of woodlands constitutes a significant proportion of economic input for the region. People use woodlands for household needs as well as for raw materials for goods sold into the formal economy. They derive considerable value from the resources of these ecosystems. For example, Campbell et al (1991) compared farmgate prices with

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contingent prices from an evaluation exercise. Farmgate values for woodland products were as follows (Zim$ per household per year): utensils/tools/crafts ($29), livestock ($130), crops (trees/litter) ($135), wild foods ($63), fruit (woodland) ($280), fruit (yards/fields) ($29), woodfuel ($183) and building wood ($114). The total value to the household was $963 per year. Willingness-to-pay values for all tree products were as follows: health ($71), shade ($102), social services ($46), ecological services ($175), cash income ($82), animal feed ($181), crop production ($222), food ($136), woodfuel ($373), and building material ($290). Use may be perennial, as a more or less permanent element of the local economy (as in fuelwood), or intermittent, when people fall back on the fruits and other products of the woodlands during times of shortage, or for quality timbers. In Zimbabwe, woodland and tree benefits, from an economic perspective, were categorized as follows (Bradley & McNamara, 1993):

o   direct, local private benefits from fruit, woodfuel, construction wood, wooden utensils, honey, wild foods and medicinal herbs for immediate consumption;

o   indirect, local private benefits from nutrients (such as leaf litter and soil from termite mounds) transferred from woodlands to fields, and fodder and browse for livestock;

o   indirect, regional semi-public benefits from soil retention, stream flow regulation and recreation;

o   indirect, global public benefits from carbon sequestration and the preservation of biodiversity.

• Potential for timber production from the natural woodlands exists, but the utilisation of indigenous commercial timbers from the forests and woodlands have not been quantified for general comparison. These timbers are used for sawn timber, joinery, veneer, parquet flooring, railway sleepers and a diverse range of other products. For example, in Moçambique a total of 1.09 million m³ of logs were extracted over the period 1981-1990, which included valuable tree species such as *Pterocarpus angolensis, Afzelia quanzensis, Millettia stuhlmannii, Chlorophora excelsa* and *Androstachys johnsonii* (Bila, 1993). Currently utilisation of timber from these areas is often very inefficient, and with emphasis on only a few well-known species. Resource management is poor to non-existent, and prices paid for the raw product are much below their true value.

• Non-consumptive use of the region for tourism centres around the coastal areas, and the national parks and nature reserves, and some major scenic

spots. Consumptive use for ecotourism, such as hunting, occur mainly on private game farms and other wildlife sanctuaries, which increase in numbers in the woodland areas of the region. No comparative data on the tourism industry are available for the region. National Parks generate direct income and catalyse economic development outside their boundaries. However, financial returns often do not reach the rural communities in the areas, and they therefore do not experience the value of the ecotourism industries. New approaches to the management of wildlife resources on the basic common-property right trusts and other business models have begun to succeed in creating value to local communities in Zimbabwe and South Africa (for example through CAMPFIRE, Thomas, 1993).

- Estimates of land-use potential in the region were based on simulation modelling of four product types: fuelwood production as a proxy for subsistence utilisation of natural woodlands; *Eucalyptus grandis* timber production as a proxy for commercial production of roundwood timber; maize production as a proxy for production of agricultural field crops; and beef production as a proxy for red meat production from natural pastures. Table 4 indicates the current and potential production in the four categories. The opportunity index is the ratio between potential and current production. Aspects to take note of are:

  o The basic assumptions made in the modelling were as follows:

    - The model of sustainable fuelwood production from natural woodlands would include a proportion which relates to volumes of commercial timber dimensions. Current production of timber from natural forests and woodlands exists but is not reflected in any country statistics (see Bila, 1993).

    - The predictions of mean annual increment for *E. grandis* timber, within the limits of a mean annual precipitation of 900 mm, mean annual temperature exceeding 16°C and a mean July temperature above 4°C, responds positively to increasing rainfall and temperature.

    - Maize grain production potential considered rainfall and its seasonality, temperature, and soils. The potentials assume excellent crop management, including inputs of fertilisers, and that the entire landscape is planted to maize. The achievable national production will therefore be substantially lower, depending on factors such as competing land uses, and the fraction of the landscape which is suitable for cropping.

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Table 4.   Comparison of the actual (World Resources Institute, 1992) and potential (Geldenhuys et al, 1994) production of fuelwood, industrial timber, food and red meat from countries in southern Africa bordering onto Namibia

i) Potential fuelwood production vs current production of fuelwood & charcoal

Country	Current production million tons	Potential fuelwood production		
		% of land area	Production million tons	Opportunity index
Angola	5.5	83	148.0	26.7
Zambia	11.7	85	57.4	4.9
Namibia	1.4	80	17.7	12.7
Zimbabwe	6.3	100	9.6	1.5
Botswana	1.3	96	8.5	6.5
South Africa	7.1	0	8.4	1.2
TOTAL	89.5		429.4	4.8

ii) Potential *Eucalyptus grandis* timber production vs current industrial roundwood production

Country	Current production x1000 tons	Potential timber production		
		% of land area	Production x1000 tons	Opportunity index
Angola	1045	75	2262511	2165.1
Zambia	606	94	1197755	1976.5
Zimbabwe	1530	33	157174	102.7
South Africa	12168	5	86751	7.1
Namibia	0	0	0	0.0
Botswana	79	0	0	0.0
TOTAL	20368		6610996	324.6

iii) Potential maize production vs current crop (cereals & roots/tubers)

Country	Current crop production x1000 tons	Potential maize production		
		% of land area	Production x1000 tons	Opportunity index
Angola	2419	77	628800	259.9
Zambia	2245	92	384700	171.4
South Africa	16211	39	223000	13.8
Zimbabwe	2579	59	132800	51.5
Namibia	400	2	2800	7.0
Botswana	83	5	1000	12.0
Total	42456		1918100	45.2

iv) Potential meat production vs current meat production from cattle, sheep & goat

Country	Current production x1000 tons	Potential meat production		
		% of land area	Production x1000 tons	Opportunity index
South Africa	434.9	95	581.0	1.3
Angola	63.9	97	383.4	6.0
Zambia	53.5	94	333.7	6.2
Zimbabwe	131.4	100	199.3	1.5
Botswana	58.4	100	139.0	2.4
Namibia	91.6	86	106.8	1.2
TOTAL	1236.8		2757.3	2.2

- The model of meat production is related to the long-term equilibrium carrying capacity of African ungulates to rainfall and soil fertility. The actual cattle stocking rate in many regions is up to three times higher than the natural wildlife densities, but it is unclear whether such stocking rates are sustainable. It is however possible that diseases may influence stock production in some areas.

- The areas of permanent pastures, and natural forest and woodland (Table 3), or alternatively, the formally nationally protected areas could be used as a rough estimate of the potential for ecotourism.

○ Agriculture and commercial forestry can be significantly expanded in Angola, Moçambique and Zambia, as is the case for red meat production in Moçambique. On the other hand, there is relatively little further opportunity for such development in countries such as South Africa and Namibia. Ecotourism associated with natural areas has a major potential in most countries.

○ The southern African region has a large potential for increased production in different land uses, but also for conflicts between different land uses in the same areas. For example, Angola has a major production potential for fuelwood, timber, maize, and red meat, but also for ecotourism and indigenous commercial timbers. The potential could be realised through different means:

- to focus on sustained, multiple-use management of the large areas of moist and arid woodland for consumptive and non-consumptive ecotourism, and for timber and livestock production, over most of the area. In selected areas of high production potential, more intensive soil management practices such as irrigation and fertilizers, commercial agriculture and forestry could be pursued. This would require regional zoning of areas of high potential for optimal utilisation of the land for the best landuses. In this integrated approach the needs for food and timber can be satisfied from areas where it can best be done. It is however essential that the rural communities benefit from the most suitable economic activities in each area to obtain the financial means to buy food and other needs from where it can be produced at an affordable price. There is therefore a need to coordinate and integrate optimal utilisation of the biophysical potential, and the woodland resources, through a southern African economic community.

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- to develop the potential to shift the regional economy from an agriculture-based economy, often based on subsistence agriculture, to a regional industry- and service-based economy.

o Requirements for the optimal sustainable utilisation of the woodland resources are

- to develop an understanding of the characteristics of woody and non-woody biotic resources to control the harvesting levels, to monitor the impacts of the harvesting methods, and to facilitate their optimal use in order to ensure sustainable, multiple-use development of the resource potential;

- to implement participatory rural appraisal methodologies

  - to assess the socio-economic needs and perspectives of the people living in the area;

  - to develop an understanding of the existence and functioning of the traditional legal structures versus the national laws and administrative structures;

  - to ensure that rural communities contribute to and share in the regional development;

- to implement appropriate silvicultural management systems based on the key ecological processes, such as disturbance (fire, browsing, drought), recruitment (of desirable and undesirable species) and migration, to facilitate natural regeneration of the desired species and to reduce wasteful mortality;

- to implement appropriate regulations, legal procedures and control systems to ensure environmental and biodiversity conservation, and economic growth through long-term sustainable resource use. For example, resource depletion through the permit system for harvesting trees, as is happening in most countries of the region, should be abandoned in favour of long-term concessions over large areas, managed through an appropriate management plan, with good control, incentives for good management and penalties for poor management;

- to improve regional integration of the research programmes

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for agriculture, forestry, conservation of natural ecosystems, ecotourism and socio-economics to optimize human and financial resources and to develop regional expertise;

- to stabilise the population growth rate in rural communities.

4. FUTURE FOREST MANAGEMENT AND UTILISATION OPTIONS ON COMMERCIAL FARMS AND COMMUNAL LAND IN NAMIBIA

Key factors for development of forestry in Namibia relates to the constraints posed by the physical environment and the relatively low density of good infrastructure for long transport of commodities from production to use areas.

Namibia has a dry climate with extremely variable and unpredictable rainfall: from <20 mm on the coast to >700 mm towards the northeastern corner. The vegetation has been subdivided, primarily on the basis of rainfall, into three regions: desert, with woody vegetation only along the river beds; savanna, 64% of the country, on the Central Highland and the southern part of the Kalahari; and woodlands, 20% of the country and confined to the northeastern corner of higher rainfall, with important commercial timbers (Erkillä & Siiskonen, 1993). For forestry activities the country is therefore divided into three distinct regions: the Namib desert along the west coast; the Central Highland east of the desert, stretching from northwest to southeast; and the Kalahari in the northeastern corner of the country, an area underlain by unconsolidated Kalahari sand.

The savannas and woodlands are contributing to the local and regional economy, but this contribution has not been quantified. Products from these areas are used both in the formal and informal sectors of the economy, such as quality timbers, mining timber and energy sources, building and fencing material, fuelwood, household goods, wood carvings, and both consumptive and non-consumptive ecotourism. No statistics are available to assess the real contribution of this sector to employment, but I would think that much could be done to develop this sector of the economy to assist the creation and growth of small businesses and employment.

Unemployment and underemployment is a serious economic and social problem. Furthermore, there is a major fuelwood requirement in urban and settlement areas with a serious degradation of the vegetation. Bush encroachment has reduced agricultural productivity over large areas. The three needs in combination could be addressed together to make a positive contribution to the Namibian economy. The costs of transport of charcoal and fuelwood from the indigenous sources may prohibit the supply in the energy needs of the larger urban areas in the central part of the country. The utilisation of chipped wood

from clearing bush encroachment may provide both energy and job opportunities in some areas. Alternative sources of energy, such as electricity via hydro-power or solar power in remote areas, or means of more conservative use of energy in rural areas, such as different kinds of more energy-efficient stoves, need to be investigated.

Forestry activities in Namibia seem to be related to the three broad ecological zones: desert; savanna; and woodlands.

- *Desert:* The main (only?) forestry activity in the desert is dune stabilisation around Walvis Bay.

- *Savanna:* It seems that the focus in this broad zone is on providing an extension service to inform the farmers on the protection and utilisation through permits of selected tree species, selling of nursery plants to farmers for amenity purposes, and planting of useful introduced tree species for use as poles and fuelwood.

- *Woodlands:* The focus is on the development of suitable management on control of harvesting timber from the areas.

I suggest that in the desert and savanna areas the focus should be on appropriate productive dryland agriculture, whereas forestry provides an extension service through, and in close cooperation and coordination with, organised agriculture. The main emphasis of forestry management and extension in the savanna zone should be:

- Conservation of special tree habitats, and special and rare tree species. This could also be seen as a function of the nature conservation authorities, but sometimes local communities may depend on these resources. Part of the management function could be to develop sustainable and acceptable utilisation of such sites or species.

- Development of agroforestry and related systems, using both local and introduced tree species, to provide in needs for poles, fuelwood, building material and other needs, and to ameliorate site conditions to facilitate the growing of food.

- Tree planting for specific purposes:

  o   There are many trials of a range of introduced species, mainly *Eucalyptus* species. These should be evaluated in terms of establishment costs, growth rate in relation to the local species, and successful introduction into the local socio-economic development. The invasion of some species such as *Prosopis* into

the natural areas should be assessed and suitable management strategies should be developed to support local use and reduce the threat to the local biodiversity.

o   There are several local multi-purpose tree species which are important both in the informal and formal economies, such as *Colophospermum mopane* (Mopane), *Sclerocarya afra* (Marula) and *Spirostachys africana* (Tambotie). However, little or no knowledge exists for Namibia to develop and grow these species effectively. Appendix 1 gives an outline of a study for the domestication of Mopane, which is aimed at regional cooperation in and coordination of such a study, but which could be initiated in Namibia.

- Better utilisation and management of problem species such as *Prosopis*, *Acacia* and *Dichrostachys* which are key species in bush encroachment, but which reduce agricultural productivity.

- Community involvement and participation to develop small businesses around the management for utilisation of the resources of tree vegetation (woody and non-woody plants, and animals).

5.   FOREST RESOURCES AND MANAGEMENT ISSUES IN NORTHERN NAMIBIAN WOODLANDS

During the late 1960's and early 1970's the forest resources of the northeastern Namibian woodlands were assessed at two levels: regional resource inventories for strategic planning (Kavango & Ovambo), and a management plan inventory to guide operational harvesting of timber (Eastern Caprivi) (Von Breitenbach, 1968; Geldenhuys, 1975, 1976, 1977a). This was later expanded through additional studies in Kavango, Bushmanland and Hereroland (Hilbert, 1986, 1987, 1990).

The initial mapping of Kavango, Ovambo and Bushmanland was started due to a concern that the rates of logging *Pterocarpus angolensis* may lead to a depletion of resources because of the extremely sparse or totally absent natural regeneration of the species. The objective was therefore to obtain reliable information by which the harvesting rate can be planned scientifically, and to implement better control over the harvesting of the timber. Components of the study were seen to be as follows:

- to determine the extent of woodlands with exploitable *P. angolensis* from existing aerial photographs and to map them to facilitate a ground survey;

- to provide for intensive protection of only patches of valuable woodlands of *P. angolensis* through fire breaks and with roads which can both serve

as service routes for the control of fires and as logging roads;

- to reserve specific areas with dense and productive *P. angolensis* within areas zoned for agriculture, to supplement production of *P. angolensis* timber, and to secure protection and regeneration of trees in such areas through proper protection against fire, or controlled burning, and if possible, fencing to keep cattle out;

- to initiate steps to obtain natural or artificial regeneration to ensure a better cover and eventually an economic utilisation of *P. angolensis* timber;

- to relate the number of pit sawyers and the volume they saw to the demand for timber, and register only sawyers of demonstrated skill to increase the quality of the sawn products, and only those who saw regularly;

- to open only selected areas in each tribal area for logging, in order to improve control over volume and quality of logs cut, and the economics of timber transport, and to withdraw former concession areas, and therefore exploited areas, from logging;

- to determine the most suitable and economical utilisation of harvested *P. angolensis* trees.

5.1 Field reconnaissance and mapping of woodlands in Kavango, Ovambo and Bushmanland

The following procedures were followed in the mapping of woodlands in Kavango, Ovambo and Bushmanland:

- A field reconnaissance was done along a route of 3 500 km through the woodlands of Kavango, Ovambo and Bushmanland during August 1969 to annotate the aerial photographs (scale 1:75 000) by rough description and 5 to 6 colour photographs of the structure, composition and quality of the vegetation at 129 control points.

- The 1:75 000 contact prints of the aerial photographs were enlarged to a scale of 1:25 000 to aid photo interpretation. The field notes and photographs at the control points and careful study of the enlarged aerial photographs (shades of black and white, and the texture and density of tree crowns) were used to distinguish four cover types for a preliminary woodland type mapping. Identified roads, pans, dams, settlements, and other objects which are important for orientation during field surveys were also marked on the photos. Several factors affected the quality of the air-

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photo interpretation:

o   The quality and small scale of the aerial photographs were not very
        suitable for the job;

o   The field reconnaissance was done by one person and the photo-
        interpretation was done by a second person who never saw the
        woodlands before;

o   Different tree species could not be identified on the small scale
        photos, except perhaps closed *Baikiaea plurijuga* woodlands, and
        some large trees of *Guibourtia coleosperma*.

●   The preliminary woodland type maps were produced at a scale of 1:75
    000. The map for each area was subdivided into map sheets of 100
    (east-west) x 45 cm (north-south) each. Thereafter the areas covered by
    the different woodland types were determined for each map sheet.

5.2   Assessment of growing stock in Kavango and Ovambo

A regional scale forest inventory was done for Kavango (Geldenhuys 1975), and
partially for Ovambo (Geldenhuys 1976). The initial interest was in the available
volume of *P. angolensis* within easy reach of Rundu. The initial planning was
done accordingly, and the survey was confined to woodland type II (*P.
angolensis, Guibourtia coleosperma & Burkea africana*). The inventory was later
extended to woodland types I (*Baikiaea plurijuga, Ricinodendron & Burkea
africana*) and III (*Burkea africana, Terminalia sericea, Combretum* spp. & *Acacia*
spp).

The procedures of the survey were as follows:

●   The forest map of each area was subdivided into map units (or sheets).
    Each map unit was again subdivided into two rectangles of equal size
    (map sub-units) to facilitate representative allocation of sample points.

●   A grid of 2 cm x 2 cm was superimposed on the map units. Each grid
    intersection was a potential sample point, except when it fell on a
    physical feature not covered by vegetation (such as a road, pan, or rocky
    outcrop) or vegetation types considered to fall outside the scope of the
    study (such as agricultural fields). Points more than 4.5 km away from a
    road were excluded for practical reasons of accessibility.

●   Usable sample points were numbered consecutively, but separately for
    each usable vegetation type in each map sub-unit. The maximum number
    of possible sampling points over the total inventory area was determined

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by the time available for the study. The proportion of the total allocated sample points per woodland type was weighted according to the importance and total area of each type. The proportional distribution of the potential sample points over vegetation types and map sub-units was used to allocate the minimum number of sample points proportionately and representatively to the vegetation types and map sub-units. In each woodland type in each map sub-unit the same percentage of the total possible sample points were selected randomly with the aid of a table of random numbers. The procedure was followed to ensure that sampling was done over the entire area and to representatively sample the variations between and within the different areas. In Kavango 194 points and in Ovambo 75 points were sampled.

- At each sample point four plots were sampled to cover the variation at that point. Plots were confined to vegetation of that particular type. The plots at a sampling point were randomly allocated to four out of eight compass directions, and in each selected direction a plot was randomly allocated to one out of five distances from 100 m to 500 m from the centre of the sampling point.

- Circular plots of 30 m radius were used to give a plot area of 0.283 ha. The range finder of the Blumeleiss Hypsometer was used to determine the plot boundary, and saved much time. The results showed that a mean of 30 trees were recorded per plot.

- Trees of ≥10 cm DBH (diameter at breast height) were measured, and recorded by species and DBH. The utilisable stem length (to where the stem branches out) was measured in metre. Local volume tables for Zimbabwe for *P. angolensis, B. plurijuga & G. coleosperma* (Banks & Burrows, 1966) were not suitable for use in volume estimates. Volume calculations were based on the product of basal area at DBH and utilisable stem length.

- The number of stems per species per plot was used to develop a woodland type classification, following the Braun-Blanquet table method. This was complemented with a study of the geographical distribution of each identified type over the study area, and the diameter class distribution of the most important species. Importance values were calculated for each species in each of the identified woodland types.

5.3 Woodland types in Kavango and Ovambo

In each area five woodland types were identified, based on species composition and diameter class distribution. The five woodland types were basically all composed of the same species mix but which differed in the ratio of the stem

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numbers, probably depending on the site and disturbance history.

- Woodland type I in both areas consisted mainly of *Baikiaea*, with a fair contribution of *Lonchocarpus capassa* and *Combretum*. In Kavango the stands had an almost complete canopy, but where the canopy was less closed, species characteristic of the other types were present such as *Pterocarpus, Guibourtia* and *Burkea*. In Ovambo the stands were rather open woodland. This openness could possibly be ascribed to very frequent fires. The diameter class distribution in Kavango differed totally from the other woodland types with a clear deficiency in the smaller classes. The number of stems and basal area per ha was lower in Ovambo.

- Woodland type 2 represented the best developed woodland, with all species well represented and well mixed. The best represented species were *Baikiaea* (better represented in Kavango than in Ovambo), *Pterocarpus* (better represented in Ovambo than in Kavango), *Burkea* and *Guibourtia*. This woodland type had the best potential for timber production for all the species. Because the species represented both fire sensitivity (*Baikiaea* and *Guibourtia*) and fire tolerance (*Pterocarpus* and *Burkea*), it was recommended that fire management should be applied with caution. In Ovambo the stem density and basal area were relatively high when compared to the other Ovambo types, especially of *Pterocarpus angolensis* and *Burkea africana* in the smaller diameter classes.

- Woodland types 3 to 5 differed to a large degree between Kavango and Ovambo. *Baikiaea plurijuga* was almost absent and *Pterocarpus angolensis* was abundant in these types in Kavango, but the pattern was reversed in Ovambo. Stem density and basal area were average for Ovambo, but low in comparison to Kavango. In Kavango the diameter class distribution was characterised by a large number of stems of all the well represented species in the smaller classes, especially large numbers of *Pterocarpus* and *Burkea*, and a very high number of other species, excluding the important commercial species. These types were possibly largely the result of fire and a larger percentage utilisable tree species could be gained if fire could be better controlled.

5.4   Timber growing stock in Kavango and Ovambo

In most of the southern African countries timber harvesting is controlled through a minimum felling diameter. Inventories, if they are done, are used to give estimates of the utilisable growing stock of the commercially utilisable species. In Kavango and Ovambo the growing stock was expressed in terms of both diameter class distribution to show the future potential, and volume.

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5.4.1 Diameter class distribution

In Kavango the high stem density for the smaller classes of *Pterocarpus* and *Burkea* was attributed to the large number of fires which regularly sweep across Kavango. Both species are fire tolerant and their regeneration are favoured by moderate fires. It is therefore encouraging to find such a large stock of *Pterocarpus* in the smaller classes despite the rapid decline beyond 45 cm DBH and the associated low utilisable volumes. It shows the potential for *Pterocarpus* which occur over 78% of the area. The size class distribution of *Baikiaea* and *Guibourtia*, by contrast, was considered to be indicative of their fire sensitivity with a shortage in the smaller classes because their regeneration are damaged by fire and maintained in a dwarf form by regular fires, whereas a relatively high stem number occurred in the larger classes, especially above 45 cm DBH. It was recommended that sensible removal of the excess volume and desirable fire management and control may allow timber logging in certain areas. A large amount of the volume could be obtained from the excess large *Baikiaea* and *Guibourtia* trees, supplemented from the available volumes of *Pterocarpus* and *Burkea*.

The most important difference in the diameter distribution curves between Ovambo and Kavango could be seen in the curves of *Burkea* and *Guibourtia*. In Ovambo *Burkea* seemed to have a deficiency in the smallest diameter class similar to the pattern for *Baikiaea* in both Ovambo and Kavango. This tendency was present in all the Ovambo woodland types. In Kavango *Burkea* had a very high stem number in the smaller classes. *Guibourtia* in Ovambo did not show that deficiency in the smaller classes whereas the deficiency was present in Kavango. *Pterocarpus* followed the same curve pattern as in Kavango, but the level of the curve was much lower, except for type 2 with a very high number of stems below 30 cm DBH. The level of the *Baikiaea* curve in Ovambo was much higher which was ascribed to the higher frequency of the species in Ovambo as well as the inclusion of trees of type 1 in construction of the curve. The Ovambo curves were also characterised by the low level of all the curves in diameter classes above 45 cm DBH.

5.4.2 Timber volume

In the initial volume calculations in Kavango minimum utilisable DBH of 45 cm for *Pterocarpus, Baikiaea* and *Guibourtia*, and 35 cm for *Burkea* was used. At the time of the study, a minimum DBH of 50 cm for *Pterocarpus* and 40 cm for *Burkea* was in use in the Eastern Caprivi. It was argued that a large area of Kavango would be suitable for timber production, but the data showed that a large area of the woodland had little volume of *Pterocarpus* above 50 cm DBH. In relation to the DBH class distribution of the two species, it was argued that a more realistic volume calculation could be obtained if the minimum DBH of 50

cm for *Pterocarpus* was lowered to 45 cm, and for *Burkea* from 40 to 35 cm. At that time it was considered that the Forestry Department would harvest the timber. Therefore it was argued that if the minimum DBH for *Pterocarpus* for the relatively small area of a first reserve could be set at 45 cm, *Pterocarpus* trees in the other areas would continue to grow to larger sizes. It was considered possible to raise this minimum diameter to 50 cm DBH in the remaining reserves. This reasoning could only be applied to *Pterocarpus* because for *Baikiaea* and *Guibourtia* the largest volume occurred above 50 cm DBH (Table 5). A large volume of *Baikiaea* and *Guibourtia* could be harvested in trees above 45 cm DBH. However, it was suggested that the stocks of the two species should be harvested sensibly as the reserve stocks were not as large as those of *Pterocarpus*, and because *Guibourtia* had a low density over a large area (a fair number of seed trees would be required to improve the regeneration). From this background it was proposed that for calculation of the utilisable volume a minimum DBH of 45 cm for *Pterocarpus*, 50 cm for *Baikiaea* and 60 cm for *Guibourtia* be used. It was further argued that with protective fire management the reserve stock of all the species could be improved.

Table 5.   Number of utilisable stems for four species in the Kavango woodlands when different minimum felling diameters are used (Geldenhuys 1975).

Tree species	Minimum utilisable DBH (cm)	Number of utilisable stems		
		Total	Percentage of total	
			50+ cm DBH	60+ cm DBH
Pterocarpus	45	137	47,4	9,5
Baikiaea	45	225	72,0	29,8
Guibourtia	45	249	79,9	50,2
Burkea	35	386		48,7 (40+ cm DBH)

The same considerations were followed in Ovambo as in Kavango in determining the minimum utilisable DBH for the tree species. The volume per ha were calculated for the different woodland types and map sheets, but only the totals are shown for each area (Table 6). For Ovambo volume calculations for additional species or species groups were done because it was considered necessary that as many species as possible should be utilised. The volumes for the additional species are not shown in Table 6.

The Kavango and Ovambo forest inventories showed the distribution of timber volumes by species and woodland types, and also the potential of the different woodland types for timber production. The respective reports also indicated the

largest concentration of woodland area and timber volume and suggested where it would be logical to do further detailed planning. The following recommendations were made for further planning for sustained, multiple-use management of the woodlands:

- The northern woodlands should be subdivided into forestry reserves and the planning of each reserve should be integrated with agricultural and community development planning. Timber, pole and fuelwood production, cultivation of agricultural crops, grazing and game farming in the woodlands must be integrated in a multiple-use management system to gain the optimum economic return on investment in those extensive, low timber production areas. An important prerequisite was that utilisation should be performed in accordance with the ecological carrying capacity and characteristics of each woodland type.

- The basis of subdivision should be that a separate plan for sustained harvest over the management plan period must be possible. Other considerations could be that all the timber from the reserve should be harvestable to minimise the moving of a bush mill and the transport distances.

- Each reserve should be planned and managed in detail as was done for the Nakabunze Reserve in Eastern Caprivi (see par 5.5). After planning of the first reserve, planning should continue at two or more other parts of the area for the benefit of each major tribal area.

- Information on stocking and growth rate for each reserve, and on timber properties of the timber species should be gathered in order to utilise the full timber potential, i.e. the utilisation of all utilisable species (not only *Pterocarpus*) of all available timber from each tree, including branches. Furthermore, each species should be used for the best purpose, and each tree should be sawn for the most valued recovery.

- A system of fire protection priorities should be followed during times when fires do occur, based on the characteristics of the different tree species and the vegetation types with which they are associated (see par. 5.5.7). For example, areas which will be managed for *Baikiaea* and *Guibourtia* should receive almost total protection and fires occurring there should be extinguished immediately. In the other productive woodland types it would only be necessary to confine fires to a particular area when they occur during the dry periods. Furthermore, the intensity of fire breaks should not exceed the annual maintenance capacity. A network of fire lookouts equipped with a suitable communication system was considered a requirement for the control of fires.

- Information on ecology of species, communities and sites, disturbance

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- The basic principle followed in fire management and control would be that the intensity of fire belts should not exceed the annual maintenance capacity. A system of protection preferences should be followed which relate to periods when fires do occur. Some communities require almost total protection whereas others need fire during specific seasons. Fire lookouts equipped with suitable communication systems were considered to be basic to proper fire management and control.

- Research should be considered as a necessary component of the plan and should be implemented to supply the important information which lacked for a more complete compilation of the plan.

5.5.1 Mapping and resource inventory

The initial sampling method was adapted several times to develop a method which was both practical and easy to implement, which would give representative cover of the terrain and which would render data with which woodland classification and mapping, yield regulation and management planning could be done.

- A systematic grid method was used in Blocks B to D, with east-west lines running parallel to the Caprivi-Zambia border to the north, and 500 m apart, and north-south lines running 150 m apart in Blocks B and C, and 300 m apart in Block D. Plots were sampled on each grid intersection. Thereby the location of each plot was easily identified with a line-plot number, and it eased type mapping and demarcation of compartments.

- Circular plots with radius of 30 m (plot size of 0.283 ha) were used. The area was relatively open and plot boundaries were easily determined with the rangefinder of the Blume Leiss hypsometer.

- The initial survey focused on *Pterocarpus angolensis* in stands where the species was concentrated. However, gradually plot data were recorded for plots with trees ≥10 cm DBH, and all species. Stem length, only for trees ≥30 cm DBH, was measured up to the first major branch, or to the next branch if a utilisable log with minimum length of 1,5 m could be envisaged. No form factor was used in the calculation of volume. Volume calculations excluded branch volume, which represented a considerable portion in large trees.

- The number of stems of each regeneration stage of *Pterocarpus angolensis* (according to Boaler, 1966), was determined for each plot. Later *Baikiaea plurijuga* regeneration was included for Block A, and from Block B seedlings and saplings were counted also for *Guibourtia coleosperma*. The difference between seedlings and saplings for all three

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species was based on whether the shoots that grow up were permanent or not.

- For *Pterocarpus angolensis* signs of elephant and fire damage were noted. Initial reconnaissance indicated that many *P. angolensis* trees and regeneration were damaged by elephants and that fire damage was often secondary to elephant damage.

5.5.2 Woodland type classification and compartment subdivision

The forest inventory data were used to identify stands of similar plant species composition for compartment subdivisions. An elementary plant community classification was attempted, based on the Braun-Blanquet table method. Ten woodland communities were identified:

1   *Burkea - Erythrophleum* woodland with a possibly different association of *Burkea-Dialium* in compartments D11 and D13

2   *Burkea* woodland

3   *Pterocarpus angolensis - Baikiaea - Ochna pulchra* mixed woodland (without *Guibourtia*)

4   *Pterocarpus angolensis - Baikiaea - Guibourtia - Ochna pulchra* mixed woodland

5   *Baikiaea - Pterocarpus angolensis - Guibourtia - Ricinodendron* woodland

6   *Baikiaea - Terminalia* mixed woodland

7   *Baikiaea - Combretum hereroense - Lonchocarpus* open mixed woodland

8   *Baikiaea - Combretum hereroense - Lonchocarpus* open woodland, with fewer associated species than type 7

9   *Baikiaea* woodland mixed with *Combretum hereroense* and *Lonchocarpus*

10 *Baikiaea* woodland mixed with *Lonchocarpus*, which differs from type 9 in the proportion of the associated species.

Compartment subdivision was based on relatively homogenous composition as noted on the aerial photographs. The lines of major change were noted on the

aerial photographs to serve as compartment boundaries, except where a donga or stream bed or major/secondary road could be used as boundary. In places where the composition was homogenous over large areas but where clearly identifiable natural boundaries were lacking, the subdivision resulted in some relatively large compartments, as can be seen on the map of Nakabunze reserve (Geldenhuys, 1977).

5.5.3 Yield regulation

When only one primary species with small, fluctuating percentages of secondary species are utilised, the silviculture and management of the woodlands become problematic and impede progress towards sustained utilisation. The plan therefore provided for the utilisation of all species when they are mature. Parry (1959) used the old Indian "Safeguarding Formula" which was developed by Smithies for *Shorea* to calculate the allowable yield as the rate by which mature (harvestable) trees grow from the lower diameter class into the mature diameter class. Most mature stands which are not harvested contain an oversupply of mature and overmature trees. The problem was to maintain the yield after the allowable harvest is removed. Most methods use the total growing stock to calculate the yield. *Pterocarpus angolensis* posed the opposite problem: there were very few mature trees which had to provide the yield. This meant that the increment and mortality of young trees had to be calculated over a very long period (≥100 years). The growth rate of the younger trees was relatively high which meant that the allowable yield became too high and immature trees were cut. Parry (1959) therefore used the mature diameter and the increment of the trees in the largest immature diameter class to calculate the yield. This meant that the utilisable diameter and the increment of trees in previous smaller diameter class had to be known to apply the calculation to the growing stock.

- *Increment of the more important tree species*: Very little information was available on the increment of the more important tree species. Calvert (1973) gave approximate increment figures for Barotseland for *Baikiaea* (0.25 cm DBH/yr), *Pterocarpus* (0.5 cm DBH/yr) and *Burkea/Erythrophleum* (0.36 cm DBH/yr). Geldenhuys (1977) gave figures for Kavango for *Baikiaea* (0.14 cm DBH/yr for 45-55 cm DBH class), *Pterocarpus* (0.17 - 0.29 cm DBH/yr for 35-45 cm DBH class), and *Burkea* (0.25 - 0.33 cm DBH/yr for 25-35 cm DBH class). For Kavango figures the length of periods required for the different species to grow through the specific diameter classes were

Baikiaea plurijuga	45-55 cm DBH	71 years
Pterocarpus angolensis	35-45 cm DBH	34-59 years
Burkea africana	25-35 cm DBH	30-40 years

The increment figures for *Guibourtia* are similar to those of *Baikiaea* (Calvert, 1973).

It was assumed that an increment gradient existed which increased from Kavango to Zimbabwe/Zambia, which meant that the increment of trees in Caprivi were higher and the increment periods shorter than those for the Kavango data. Woodland types 3, 4 & 5 were similar to the better Makambu burning trial plots in Kavango (Geldenhuys, 1977b), and the higher Kavango increment figures and shorter increment periods were therefore used for calculating the felling cycle and yield regulation in Caprivi. For *Pterocarpus* and *Burkea* an increment period of 35 years, and for *Baikiaea* and *Guibourtia* a period of 70 years was used, for trees to grow through the 10 cm DBH class which preceded the mature diameter class.

- *Felling cycle*: If one common felling cycle (the period between two consecutive harvests from the same area) of 35 years was used for the four more important tree species, it meant that the future harvest of *Pterocarpus* and *Burkea* was the present stem number in the preceding 10 cm DBH class, and for *Baikiaea* and *Guibourtia* it was the stems in the preceding 5 cm DBH class, with the assumption of other smaller losses from these classes.

The management plan period was therefore set on 35 years, and the harvesting period was set on 10 years. The total forestry area of Caprivi was divided as follows:

Reserve I	46 000 ha
Reserve II	28 000 ha
Reserve III	44 000 ha
Reserve IV	48 000 ha

It was argued that if each of the reserves I, III and IV was logged on a 10 year cycle and reserve II on a 5 year cycle, it meant that after 35 years the second management plan for reserve I had to be revised, and that a sustained timber yield could be achieved over the full 35 years over the total forestry area.

- *Yield regulation*: Two considerations were necessary to determine the yield (trees felled within the period of the felling cycle)

  o   Mature and overmature trees must be utilised before they are lost through natural mortality, and damage through drought, elephants, insects, and fire;

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o   The amounts for two consecutive felling cycles should not fluctuate
        too much for the sake of harvesting and marketing methods.

In the Eastern Caprivi forest reserves large volumes of mature and
overmature timber were present, especially of *Baikiaea*. The available
volumes by species given in the management plan were based on the
following minimum maturity diameters:

Baikiaea plurijuga	55 cm DBH
Pterocarpus angolensis	45 cm DBH
Guibourtia coleosperma	60 cm DBH
Burkea africana	35 cm DBH
Erythrophleum africanum	40 cm DBH
Terminalia sericea	30 cm DBH
Combretum hereroense	35 cm DBH
Combretum zeyheri	30 cm DBH
Lonchocarpus capassa	40 cm DBH
Other species	60 cm DBH

The timber volumes were calculated as the product of the basal area at
breast height and the utilisable branch-free stem length, and branch
volumes were excluded. Branch volume in larger trees could be
considerable. This had to be considered when the yield was regulated for
Baikiaea, Guibourtia and *Pterocarpus*. According to Banks & Burrows
(1966) the volume of branches from 22.5 cm diameter to 7.5 cm at the
thin end overbark contributes 30-37% of the total timber volume and 45-
58% of the stem volume up to 22.5 cm diameter, for the three mentioned
species. The trees measured in Caprivi often exceeded 22.5 cm at the
branch end. If the above-mentioned percentages of branch volume were
added to the stem volume, the estimates were considered to be still
conservative.

In view of the necessity to harvest the overmature timber together with a
steady timber yield of the relevant species, the following arrangements
were made for calculation of the harvest:

Baikiaea plurijuga: The total volume available above 55 cm DBH was 158
530 m³. In the first planning period only trees down to 65 cm DBH had
to be harvested. The remaining mature timber down to 55 cm DBH were
therefore transferred to the second period, for the following reasons:

•   the large volume of overmature timber in large trees must be
        reduced to reasonable levels before their value was lost through
        defect, mortality, elephants, fires and insects;

•   the stems above 65 cm DBH form 55% of the stems above the

minimum felling diameter of 55 cm DBH, whereas proportionally the volume must be much higher.

In the second planning period the felling diameter should be reduced to the minimum felling diameter of 55 cm DBH. By that time all the trees having a present diameter of 50-64 cm DBH should be mature.

Pterocarpus angolensis: The total volume available in woodland types 3, 4 and 5 above 45 cm DBH was 18 100 m³. In the first planning period all the trees above the minimum felling diameter of 45 cm DBH could be removed. In the second planning period the present stem number in the 35-44 cm DBH class would be mature, which was slightly less than the present mature stem number. There were however many *Pterocarpus* trees outside the reserve in areas required for other purposes. *Pterocarpus* in those areas should be utilised during the first planning period. For that reason the felling diameter in woodland types 3 and 4, with *Pterocarpus* contributing a larger portion of the stand, would be retained at 45 cm DBH, but in type 5 it would be increased to 50 cm DBH. Accordingly, in the first planning period 13.4 trees per 10 ha could be removed in woodland types 3, 4 and 5, and this stem number would increase to 16.5/10 ha in the second planning period. The larger number of parent trees in type 5 could possibly contribute to an increased regeneration in view of the removals of trees that will take place and the resulting larger growing space. In the other woodland types *Pterocarpus* could only be utilised if the trees were ≥60 cm DBH.

Guibourtia coleosperma: The total volume available in woodland types 4 and 5 was 8 100 m³. In the first planning period the species should only be utilised in the two mentioned types regardless of the high volume overmature timber in woodland types 7 and 8. In the latter two types the species had very few stems in the lower diameter classes with almost no regeneration. Although the regeneration was also poor in type 5, the general size class distribution was much better with enough trees in the smaller DBH classes. For woodland types 4 and 5 the same reasoning was followed as for *Baikiaea*, and only trees with minimum DBH of 65 cm could be utilised. The remaining trees above the minimum felling diameter of 60 cm DBH were carried over to the second planning period. Together with the present stems in the 55-59 cm DBH class, there should be as many trees, although of smaller volume, for harvesting as in the first period. If the fire management and control will have the expected impact on the recruitment of *Guibourtia* regeneration, then it may be possible to harvest some *Guibourtia* in the second planning period.

Burkea africana: The total volume available above 35 cm DBH was 13 300 m³ although volume calculations were not available for all Block A compartments. In the first planning period all trees above the minimum

felling diameter of 35 cm DBH should be removed, despite the possibility that the trees may be hollow (Banks & Kromhout 1966). In the second planning period more than double the stem number of the first period would be available. It seemed, however, that mortality of *Burkea* was high near the minimum felling diameter and it may be necessary to decrease the minimum felling diameter to 30 cm DBH.

Other species: The total available volume above the minimum felling diameters (ranging between 30 and 60 cm DBH for different species) was 35 100 m³. *Erythrophleum* above 40 cm DBH contributed about 9% in all types except 2, 9 and 10. *Terminalia sericea*, with reasonable numbers in woodland types 2, 3, 4 and 6, occurred mainly in blocks A and B. Trees above 30 cm DBH should be removed. *Combretum hereroense* and *Lonchocarpus capassa*, respectively above 35 cm and 40 cm DBH, could produce many trees in woodland types 6 to 10. All trees above the minimum felling diameter should be felled and utilised. Other species such as *Acacia erioloba, Afrormosia angolensis, Afzelia quanzensis, Entandophragma caudatum, Combretum imberbe* and *Ricinodendron rautanenii* could only be felled above 60 cm DBH if they form dense groups and are specifically marked by the Forester for removal.

It was considered important for all the species that their utilisation should not disrupt the natural balance of the composition of the stand and community. If too many trees of all species were removed in a particular site, then the canopy and soil disturbance could favour the more pioneer type species such as *Terminalia, Combretum, Burkea*, etc. When the more valuable species are removed, then not too many large trees of the other species should be left, and the canopy cover should not be reduced too much. Opening of a dense canopy may reduce the stand to an open woodland with lots of grass and shrubs and increase the impact of fire which may suppress the regeneration of desired species.

5.5.4 Ecological characteristics of the more important tree species

The following characteristics of the different important species were considered in the management prescriptions according to woodland types:

Baikiaea plurijuga & Guibourtia coleosperma: In general, but especially during the late dry season, fire is detrimental to the regeneration of these species. Exclusion of fire encourage their regeneration (Geldenhuys, 1977b). In the young stage the seedlings are killed by fire, or the plants assume a shrubby form because of many small stems which grow from the root system.

Pterocarpus angolensis: Its characteristics make this species one of the

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most fire resistant canopy species in the woodland. One special characteristic is that the above-ground stems of the seedling die back annually until the root system is strong enough to produce stems which can survive fire and drought. Boaler (1966) found more *Pterocarpus* in the community in areas of intensive human activity, in areas of larger canopy cover, and where an open understorey of shrubs and small trees and a vigorous herb layer occur. The tree is strong light-demanding and trees grow to a large crown and stem diameter where they can maintain a fast growth rate in relatively open stands. The seedlings and saplings develop and grow the fastest in open stands and when competition is removed (e.g. in deserted cultivated land, or where the shrub and herb layer is burnt). Trapnell (1959), Calvert (1973) and Geldenhuys (1977) indicated that fire promote the establishment and development of *Pterocarpus* regeneration.

Other species: Little information is available on the fire sensitivity of the other species. *Erythrophleum africanum* is fire resistant (Trapnell 1959), and it can be assumed that *Burkea africana* is relatively resistant. Mupupu (*Combretum psidioides, C. hereroense* or *C. mechowianum*) prefers fire protection during the early dry season (Geldenhuys, 1977b).

5.5.5 Management classes and prescriptions

The most important influence of the logging activities and the associated disturbance of the canopy and soil, is that the resistance to fire is weakened. The biomass of grass, shrubs and dead material and the fire hazard increase. Total protection may also increase the biomass of grass and shrubs which may impede the regeneration of some desirable species. It is therefore of the utmost importance that a woodland community be harvested and silviculturally managed in such a way that regeneration of the desirable species should be promoted, that the composition of the stand will be improved, and that a sustainable yield remain possible. The desired fire management to promote regeneration will therefore be determined by the adaptation to fire of the preferred species of a type, and the regeneration status of the community or compartment. Silvicultural management should therefore aim to

- create conditions for regeneration of the desired species;

- increase the survival and height and diameter growth of existing healthy regeneration.

The woodland types were therefore grouped into three management classes on the basis of the ecological requirements of their most important species.

○ *Pterocarpus* improvement and *Pterocarpus-Baikiaea-Guibourtia*

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improvement was primarily aimed at the improvement and survival of *Pterocarpus* regeneration. The areas should be burnt every second or third year early in the dry season which should result in a patchy burn. Burning biomass at that stage is haphazardly distributed and a fire would burn with varying intensity, and fire damage would be limited to spots of dense biomass. Logging must be aimed at the slower growing, suppressed or diseased trees, or trees with signs of crown die-back. The large, healthy *Pterocarpus* trees (with fast growth) must be retained as long as possible because such trees are a source of good regeneration. Denser stands of *Baikiaea* and/or *Guibourtia* trees or regeneration must not be opened too much.

o   *Baikiaea* improvement was aimed at the establishment, survival and improvement of *Baikiaea* regeneration. Areas with abundant young established *Baikiaea* trees should be burnt every third year in the early dry season. The larger area of the reserve, however, had old trees with abundant regeneration in the shrubby form which struggle to develop into the pole stage. Total protection against fire must be pursued until the regeneration has grown up to a stage where they become resistant to the moderate heat of fires in the early dry season. Marshy areas, grassy plains or areas which will not develop into *Baikiaea* woodland must be burnt annually in the early dry season to facilitate protection of the *Baikiaea* areas. Logging must be aimed at the old trees which show signs of decline, and special care must be taken not to open up denser spots by the removal of too many mature trees.

In all the areas the debris of leaves and branches left after logging should be scattered away from the regeneration and young trees to prevent damage during a fire. Special care must be taken not to damage the regeneration and young trees during the logging operation. When damage is unavoidable, such damaged plants must be cut back during the logging operation to promote the development of good coppice. It is however the responsibility of the Forester that such trees are not damaged on purpose. The DBH of such removed damaged trees should be recorded in the compartment register.

5.5.6 Logging of timber

The policy provided for the logging above the minimum felling diameter of both the important primary timber species plus the secondary species for which a market or use must be developed. An important principle of logging was to keep the logging costs as low as possible because of the low production per unit area. This could be achieved by

- reducing the transport distance through the use of a movable sawmill to reduce the transport of waste material;

- using equipment suitable for the transport of both logs and sawn timber;

- more complete utilisation of the available utilisable trees;

- aiming the end product at a high quality market.

It was proposed that a logging plan for each compartment and block should be approved by the responsible Forester and should be filed in the compartment file for future reference. A system of main roads, secondary roads and slipping paths should be used in a fish bone pattern to ease the transport with tractor and trailer in the thick sand.

It was further proposed that all trees which must or may be removed, must be marked by the Forester or a trained person appointed by him. The method of marking must be known to the person in charge of the logging. The species and DBH of each marked tree must be recorded in the compartment register for future reference.

According to Zimbabwean methods (C J Geldenhuys, unpublished report, 1974) and Hughes (1959) movable sawmill units are used to minimise the transport distances for logs. The move and re-erection of movable mills which were visited in Zimbabwe, took approximately 6 weeks. Transport distances from the logging area to the movable mill should not exceed 10 to 15 km. Although the cutting cycle was put at 35 years, the logging period would be 10 to 15 years depending on the capacity of the movable mill in use. Mills visited in Zimbabwe had a capacity for the handling of 14 000 m^3 to 17 000 m^3 timber a year. Another requirement stated was that the annual cut should include all the important timber species. This need will be determined by the contractor or by the market. A timber harvesting contractor should submit an annual logging programme to the Forester in which he should indicate in which compartments and in what sequence those compartments will be logged during the year.

The economic success of woodland utilisation is determined in part by the volume of timber harvested per unit area. It is therefore necessary to utilise as many species as possible, within the framework of what is permissible, and that the trees which are utilised are used as completely as possible and for the most suitable product.

5.5.7 Fire management and protection

Historical facts as well as research results require that fire be considered as a natural feature and therefore an integral part of the woodland vegetation. As

such fire could be used as a useful instrument in the management of the woodland to reduce and manipulate the woody vegetation. Apart from the fact that total protection against fire is undesirable for the natural development of the vegetation, with the exception of certain species and vegetation types, it remains unpractical and almost impossible. By considering the ecological requirements of the different species, can the conditions under which fire can be used as a management tool be prescribed and controlled. When fires do start under unfavourable conditions, such as during accidental fires (due to lightning or human activities) or deliberate unauthorised fires, then protection measures must be applied to reduce damage to the minimum. To use fire as a management tool requires that preventive measures must be used when favourable conditions become unfavourable to make protection necessary. It is known that uncontrolled fires cause severe damage to the woody vegetation because such fires usually occur during the late dry season when a large biomass of dead material exist. Measures to control such fires, both passive preventive measures and active suppression measures, were described in the management plan. Guidelines were provided (see Table 7).

Table 7. General prescriptions for fire management and fire protection in the Nakabunze Reserve

Management group	Fire management	Protection priority
Baikiaea improvement Regeneration in shrub form	Total protection Burn every 5 years in early dry season	Extinguish fire as soon as possible
Baikiaea improvement Regeneration mainly small trees	Burn every 3 years in early dry season	Limit burning area; allow fire to burn out
Pterocarpus-Baikiaea-Guibourtia improvement	Burn every 3 years in early dry season	Try to contain fire. Limit burning area; allow fire to burn out
Pterocarpus improvement	Burn every 2 years in early dry season	Limit burning area; allow fire to burn out
Grassland	Burn annually in early dry season	Limit burning area; allow fire to burn out
Open woodland	Burn annually in early dry season	Limit burning area; allow fire to burn out

5.5.8 Elephant damage to *Pterocarpus angolensis*

The survey data showed a pattern in the damage caused by elephants to *Pterocarpus angolensis* trees. Elephants have a preference for *P. angolensis* and selectively debark or damage them. The seedlings are damaged in that the swollen part of the roots are dug out. Younger trees are broken or pushed over, whereas the bigger trees are debarked. Sometimes the damage is minimal but often has a detrimental effect on the form and growth of the trees, and render the trees more susceptible to fire damage. Other species in the reserve which were also damaged were young *Burkea africana, Acacia erioloba* and *Baikiaea plurijuga*.

Many elephants occur in the Eastern Caprivi in herds of varying size. Control measures for the limitation of the elephant numbers to balance their feeding needs and destruction of the woodlands with those of sustained timber production have to be implemented in coordination and consultation with the Nature Conservation authorities. It cannot be afforded that stands of valuable *Pterocarpus* timber are damaged in such a way.

5.5.9 Research

As stated in the policy, research should be implemented as part of the management plan with the objective of providing the important information that were lacking during the compilation of the plan. The required information include increment data to determine the life cycle of the most important trees and thereby the time scale for management activities and yield regulation for specific communities, and data for the calculation of volume tables for the most important tree species. Prescriptions were provided on measurement and calculation of diameter and height growth of trees, height growth of regeneration, and compilation of volume tables..

6. DISCUSSION AND RECOMMENDATIONS

Namibia is not a forestry country because of its climate. It does not have the site potential for any type of commercial plantation forestry. Yet timber products are a basic commodity in the socio-economic development of the area. In the rural areas traditional practices of house and fence construction use large amounts of wood products. The population growth rate and the increasing need for wood products, including fuelwood, cause a serious degradation of the woody vegetation around towns and villages. Components of the population are poor and subsist on the resources of their immediate surroundings.

The Namibian forestry policy and the forestry development strategy should address the following questions:

- Is it of any value to continue with the planting of tree stands to provide in the needs for subsistence use of wood products? Are these tree plantings cost-effective and do they really contribute to the reduction in clearing of the natural woody vegetation? Should Namibia not perhaps focus on the production of goods and services for which it is best suited and exchange these with other countries in the region for those commodities which cannot be produced here?

- Is it possible to change the traditional customs and practices of the rural people in favour of alternative, more environment-friendly practices? It seems that the people dependent on the subsistence use of wood products are unable to break out of the traditional practices and to adopt new or alternative practices, and are in most cases too poor to buy surrogate products. Furthermore, in many areas with masses of poor people, the recipients of aid directed at their upliftment often become so absolutely dependent on the aid that they adopt an unproductive lifestyle.

- Is it possible to utilise the timber potential of the northeastern woodlands in a sustainable way? Is it possible to implement the forestry planning that has been done for Ovambo, Kavango, Eastern Caprivi, and other areas? If yes, then why is there no flourishing timber industry which is based on quality timbers and quality products: If not, could the planning be improved, or should there be more effort put into their implementation, or should forestry rather transfer the area to be managed as large ecotourism or agricultural areas?

- Would community participation in the management of the woodland resources, through development of small businesses, contribute to a better control and conservation of these resources?

Participants of a workshop on Dryland Forestry Research, held prior to the IUFRO XX World Congress at Hyytiälä Forest Station, Finland, August 1995, agreed a wide range of resolutions to which it wished to draw the attention of national governments, international donors and associated forestry research institutions (see Appendix 2). These were all designed to address the problems experienced by the people of the world's drylands and deserts, such as Namibia, in which research can have a significant role to play. I suggest that the following recommendations, based on the workshop resolutions, are particularly relevant to forest management and extension in Namibia:

- Management of natural vegetation should form part of integrated landuse planning, through a multi-disciplinary approach and regional cooperation. Specific attention should be directed at:

    o Appropriate resource inventories (see Geldenhuys, 1991) which should contribute to identification and description of the resource

base and its potentials and constraints, and a zoning of the resource area into priority landuse categories. The zoning could be based on the biosphere reserve concept of core, buffer and development zones. The core areas should be set aside for conservation of special sites, communities or species with minimal human interference, and which should provide a baseline for monitoring impacts caused in the other zones. The buffer zones should be identified for low-impact resource utilisation and which would contribute to the conservation of the core areas. The transitional zones should be developed to provide in the needs of the people.

o   The needs and knowledge of stakeholders in order to know what local communities need, how they utilise their resources, and what is required for local and regional socio-economic development;

o   Implementation of appropriate research programmes in order to generate information to

   •   promote understanding of the ecological processes (disturbance and recovery (see for example Geldenhuys, 1993, in press), plant-site relationships, recruitment, growth and mortality) as a basis for development of appropriate, site-specific, cost-effective and practical silvicultural management options, for resource-economic analyses, and for sustainable multiple-use management.

   •   monitor the impacts of resource-use practices;

   •   restore degraded areas.

•   Improved sustainable management of the resources of drylands should be planned, carried out and applied by all stakeholders, such as small farmer producers and direct sellers, resource owners, small and medium traders in products, processors, handlers and entrepreneurs, national and international markets, i.e. end users at all levels, and officials, donors and financial institutions. Attention should be directed at better utilisation and marketing of the widest array of forest and tree products (including animals) such as

o   non-wood products, such as local foods, gums, resins, fodder, medicines, meat products, leather;

o   woodfuel in the context of a broad national energy policy reform;

o   integration of revenues from ecotourism in its widest sense;

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o   substitution of potentially high value products used locally, through development of small enterprises;

o   high value-added wood products;

o   development of high-value speciality food markets, for example from fruit trees of riverine areas, or from Mopane woodlands.

- Development of appropriate tree planting strategies which would involve

o   selection of species (in particular multi-purpose woody species, including local indigenous species) and provenances for different uses and sites, utilising local knowledge on dry land vegetation and the expectation of local communities;

o   planting techniques to enhance survival and growth;

o   silvicultural techniques and productivity studies of plantations, in particular systems which involve tree-crop combinations.

- One of the core problems in most areas is inadequate participation of the local population in the planning and management of forestry and tree farming. Key aspects to be considered are

o   better utilisation of local knowledge on the utilization of the genetic resources and of ways of coping with environmental stress;

o   improvement of community structures and organisation, and people participation in the management and utilisation of forest and tree products;

o   influence of land tenure and ownership rights on the management of natural resources;

o   compatibility or impacts of local traditions and customs, including gender responsibilities and rights, with contemporary forestry and tree farming;

o   valuation and quantification of short, medium and long term gains from forestry and tree farming, including income and employment generation;

o   impacts of macro-economic factors and policies of other sectors of the economy on forestry and tree farming. It is particularly important to consider the price structure of timber sold from the woodlands through concessions. If one country sell the

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commercially valued timbers at very low prices which cannot support appropriate silvicultural management, then all the countries in the region will struggle to get good management in place.

o   the need for improved communication of knowledge on development needs and research results.

7.   ACKNOWLEDGEMENTS

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Project outline: for comment and discussion with interested parties

SUSTAINED UTILISATION AND DOMESTICATION OF THE SAVANNA TREE *Colophospermum mopane*

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1.   PURPOSE:

To improve the utilisation of Mopane woodland in southern Africa (South Africa, Namibia, Botswana, Zimbabwe, Mocambique, Malawi, Zambia & Angola) through better veld management systems and domestication i) to provide in the physical and social needs of rural people, ii) to develop opportunities for creating small businesses, and iii) to prevent desertification and erosion of the drier parts of the region.

2.   NEEDS:

Exponential human population growth in the rural and urban areas of southern Africa causes the degradation of the natural vegetation and food resources of the region. Various species were introduced to provide in the needs for food, building material and energy, often with limited success partly due to social unacceptance. Studies are needed to improve the use of indigenous species of the region. The uses of Mopane wood, fodder (leaves) and insects (caterpillars for food, silk) are socially entrenched in the cultures of the people living in the areas of Mopane veld.

3.   OBJECTIVES:

■   to synthesise current knowledge and understanding of the ecology and use of Mopane in the southern African region;

■   to identify potentials, priorities and constraints in the conservation and utilisation of Mopane veld;

■   to coordinate diverse studies in the southern African region to improve the understanding, management and domestication of Mopane and its associated organisms;

■   to coordinate the implementation of sustained-use management systems in Mopane woodland and of businesses which centre around the domesticated use of Mopane and its associated organisms.

4.   BENEFITS:

■   Synthesis of information of a useful, multi-purpose indigenous tree covering large areas in south tropical Africa.

■   Development of ecologically realistic and socially acceptable enterprises for sustained utilisation of the resources of Mopane veld which will contribute to their survival in the wild and environmental conservation in rural areas.

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- Development of a regional network of information transfer and a process of interaction and joint decision-making, between researchers, resource managers and rural communities.

- Examples will become available for demonstration of effective management systems for sustained, multiple use of natural resources combined with socio-economic development of rural communities.

- Funds and other benefits will be seen by the rural communities to be flowing to them from different forms of utilisation of their environment, and the evident benefits of conservation and planning will become visible.

5. IMPLEMENTATION:

Conduct study in three phases:

- **Phase 1:** Synthesis report to identify i) potentials of Mopane woodland, the Mopane tree itself and the associated useful insects, ii) the priority areas for focused development in the short, medium and long-term, and iii) constraints which need to be considered for successful further development of the project.

- **Phase 2:** Design studies in the priority areas identified in Phase 1, to overcome the constraints and to pursue the potential benefits and value of the resource. Perceived priority areas are
  - *Ecological studies* of essential aspects of sustainable levels of harvesting different components and domestication.
  - *Genetic improvement for domestication* through genetic material collected over entire geographic range, and genetic testing and selection of superior stock for distribution to community nurseries.
  - *Development of nursery techniques* to supply and encourage the use of cultivated (improved) crops.
  - *Development of Mopane worm and Brown Chopper cultivation* to suit requirements for small businesses run by rural people.
  - *Framework for support of Small, Medium and Micro Enterprises (SMME's)*, based on rural use, requirements for effective value-addition, marketing of products and trade logistics.

- **Phase 3:** Implementation of suitable sustained-use management systems in natural Mopane woodland and domestication systems through SMME's using an adaptive management approach.
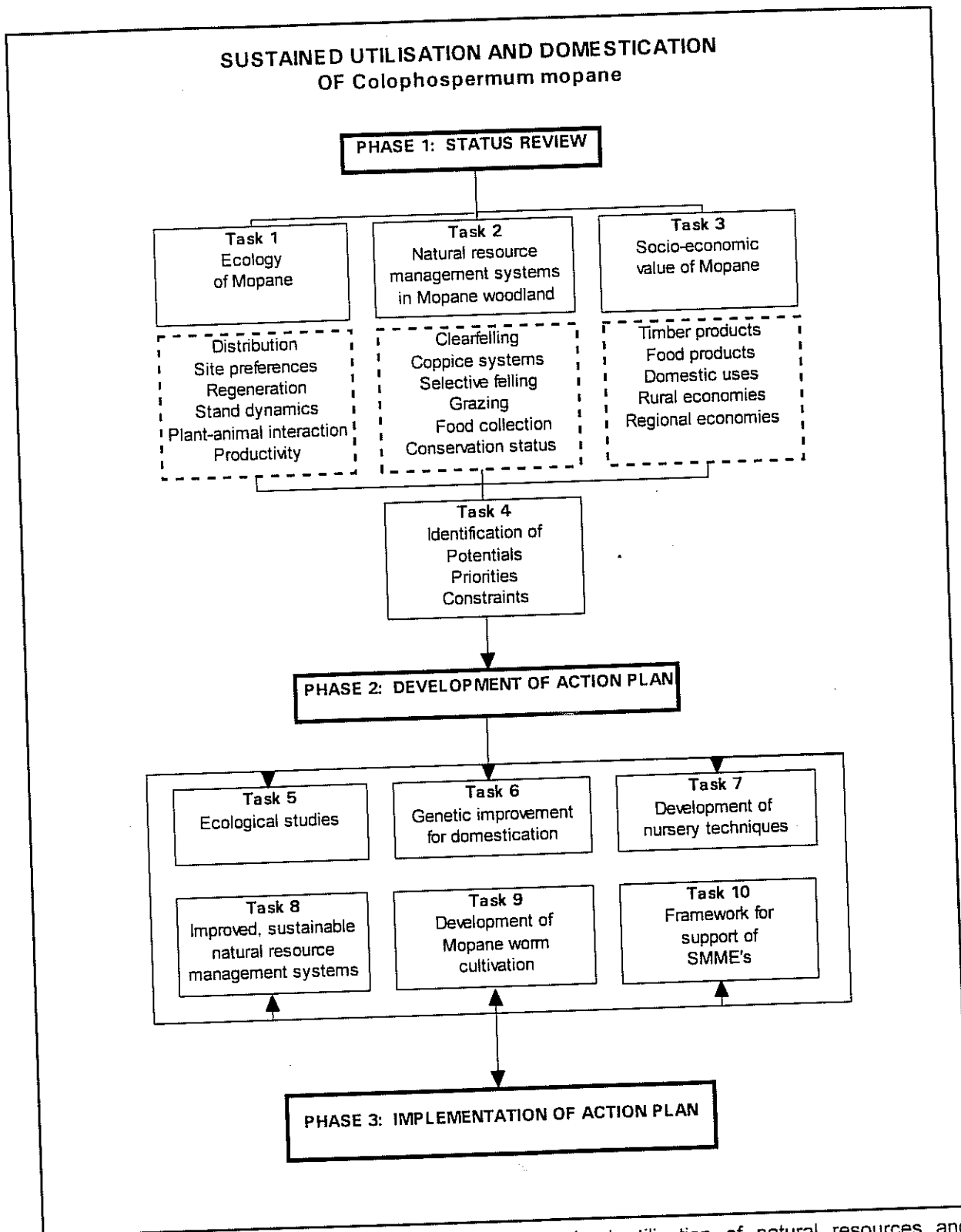
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Figure 1 Framework for the study of the sustained utilisation of natural resources and domestication of the savanna tree *Colophospermum mopane* in southern tropical Africa.

RESOLUTIONS ON DRYLAND FORESTRY RESEARCH (TREES AND DESERTIFICATION) adopted at pre-congress workshop, IUFRO XX World Congress, Hyytiälä Forest Station, Finland, August 1995

1. The workshop recognises the wide range of wood and non-wood products harvested from natural dryland areas and the lack of sustainable management of this resource, and recommends that priority be given to research on improved management of natural areas.

2. The workshop draws attention to the importance of developing new, cost-effective, socially and economically suitable management methods for plantations and natural vegetation and recommends that adaptive research should concentrate on technologies suitable for relevant communities.

3. The workshop recognises the need for maximising the returns to small producers of saleable products, and recommends intensified research on production and marketing of valuable products, using experts in marketing.

4. In order to achieve participation of relevant communities in research programmes for trees on community and other lands, the workshop recommends:

   a) that forest researchers actively seek closer collaboration between natural and social scientists in involving communities in all phases of identification, design, management and monitoring of research, especially for on-farm experiments.

   b) to all forestry researchers that participatory rural appraisal techniques be increasingly used to define research needs and to prepare participatory research plans.

5. The workshop recognises that land-use problems of the dry zone can best be solved by forestry research in collaboration with other scientific disciplines and therefore recommends that:

   a) increased support be given to multidisciplinary and regional research, and

   b) in dryland development projects a component of forestry research should be included and integrated into the project.

6. The workshop notes the valuable information to be gained from long-term monitoring, especially using permanent sample plots and recommends:

   a) that networks of such plots be regularly maintained and assessed;

   b) that the protected areas set aside should include the areas traditionally protected by communities for cultural reasons.

7. The workshop notes the vital importance of information storage, handling and dissemination in order to inform researchers and to avoid duplication of effort, draws the attention of national governments and funding agencies to the vital importance of maintaining national institutional capability in this area.

8. Since water is the critical natural resource in drylands the workshop recommends that research on tree growing and plantations should pay particular attention to the

optimisation of water use and the maintenance of site productivity. The following should be considered:

a) the hydrological effects of management practices in natural vegetation formations;

b) water use efficiency and hydrological effects of species adopted for planting;

c) the techniques and feasibility of using rain water harvesting techniques for planted trees;

d) where appropriate, management methods and technology for trees on irrigated lands;

e) water relations in farming systems which incorporate trees.

9. The workshop emphasises the importance and value of local and traditional knowledge for dry land management and recommends that support be given as a matter of urgency to collecting and consolidating local knowledge, and to exchanging and sharing such information with the people concerned, so that the best use can be made of all knowledge in achieving sustainable management.

10. The workshop recognises the expanding need for tree planting for a wider range of products and services and recommends that:

a) high priority be given to improving knowledge on the adaptability of species and provenances, especially with regard to difficult sites;

b) plantation performance (taking account of their socio-economic and environmental effects) should be compared with a range of alternative production systems, so as to provide tools for decision making on optimal land use.