Forestry Department

Food and Agriculture Organization of the United Nations

Forest Management Working Paper

Management Practices for the Protection of Forest Reserves

The Case of Kalahari Sand Teak Forest Reserves in Western Zimbabwe

Based on the work by

John Mudekwe
Consultant, Zimbabwe

February 2007

Forest Resources Development Service
Forest Management Division
Forestry Department

Working Paper FM/31
FAO, Rome (Italy)

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For further information please contact:

Mr Froylán Castañeda
Forestry Officer (Tropical Forest Management)
Forest Resources Development Service
Forest Management Division
Forestry Department
FAO
Viale delle Terme di Caracalla
I-00100 Rome (Italy)
E-mail: Froylan.Castaneda@fao.org

Or FAO Publications and Information Forestry Coordinator: Forestry-Information@fao.org

For quotation:

FAO (2007). Management practices for the protection of forest reserves: the Case of Kalahari Sand teak forest reserves in western Zimbabwe. Based on the work by John Mudekwe. Forest Management Working Paper FM/31. Forest Resources Development Service, Forest Management Division. FAO, Rome (unpublished).

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ACRONYMS, SYMBOLS, ABBREVIATIONS AND CONVERSION FACTORS USED IN THE DOCUMENT

CAMPFIRE	Communal Areas Management Programme for Indigenous Resources
dbh	Diameter and breast height
FC	Forestry Commission
ha	Hectare
KS	Kalahari Sand
PSP	Permanent sample plot
PIP	Permanent increment plot
RDC	Rural District Council
SNR	Strict Nature Reserve
US$	United States dollars
ZW$	Zimbabwe dollars
1US$	= 259ZW$1

[1] November 2006 exchange rate.

PREFACE

Interest in sustainable forest management in conjunction with socio-economic, ecological and biodiversity conservation has recently increased. A large number of different organisations as well as science and research have emphasised the increasing rate of forest loss through unsustainable use and management practices and have called for more judicious approaches to the management and use of the remaining protected ecosystems in different parts of the world. In particular, protected indigenous forests and their relationship with people have received great attention. The high degree of biodiversity in these forests, the potential of genetic variability, their function as control areas for forest management and the uniqueness of these areas has made the political forum aware of the value of forests. Many examples prove this fact, e.g. the Earth Summit in Rio de Janeiro in 1992, the Ministerial Conference on the Protection of Forests in Europe (Helsinki, Finland, 1992) and the decline of tropical rain and dry forests. On another level, the subsistence use and commercialisation of forest products has given rise to a thesis that sustainable forest management for timber and non-timber forest products should be socially, economically and environmentally sound, encouraging the idea that utilisation and conservation may be pursued jointly.

This case study may be regarded as a summary of background information on subjects concerning the history of Kalahari Sand (KS) teak forests that are confined to the fragile Kalahari sand in Zimbabwe, a description of the forests, management objectives, management and research efforts and the range of stakeholders with interests in these forests. The case study may also be seen as background information on a forthcoming proposal for a transfrontier project for the management of KS teak forests in Angola, Botswana, Namibia, Zambia and Zimbabwe.

In this context the author wishes to express special thanks to Dr Froylán Castañeda (FAO, Rome) for initiating and providing financial assistance for the study, D. Duwa (General Manager Forestry Commission), E. Mufandaedza (Chief Conservator of Forests, Forestry Commission) and to foresters managing the protected forests for granting permission to collect data and information in the forests. Their valuable comments during the review process were much appreciated. Many thanks also go to Peter Lowe for his comments on the draft document and most importantly his encouragement with respect to the proposal for the KS teak forests transfrontier project.

SUMMARY

Baikiaea plurijuga forests, also known as 'Kalahari Sand' forests or 'Zambezi Teak' forests are endemic to the Kalahari sand geologic formation in western Zimbabwe. The forests are restricted to deep, loose and well-drained Kalahari sands. The protected forests, comprising over 800 000 ha, are managed by the Forestry Commission for the production of commercial timber and wildlife, the protection of the fragile Kalahari sand system and for biodiversity conservation. Commercial logging of the KS teak forests primarily for *B. plurijuga* and *Pterocarpus angolensis* has been described as the greatest threat to their survival. In addition, the hot dry season brings with it widespread destructive forest fires. In the past few decades the subsistence needs of the rural and peri-urban populations are threatening the future survival, functions and development of the forests. Their existence and current status can be attributed to the long history of state protection. However, state protection of the forests has not succeeded in preventing them from destruction and degradation that has resulted in the shift of the forests from climax to secondary formations. The same kind of forests on other land categories, e.g. communal and resettlement areas, have been modified and degraded through over-exploitation, overgrazing and clearing for agriculture.

Since they were gazetted the management approach in these forests has consisted mainly in only allowing formal public use through licences and permits. The management activities include protection from fire, supervision of forest utilisation programmes, veldt management to improve wildlife habitat, research on various aspects of the forests, wildlife management, silviculture, control of forest occupants and anti-poaching activities.

Management practices for the protection of forest reserves
The Case of Kalahari Sand teak forest reserves in western Zimbabwe

1. INTRODUCTION AND BACKGROUND

Baikiaea plurijuga forests, also known as 'Kalahari Sand' forests or 'Zambezi Teak' forests, are endemic to the Kalahari sand geologic formation in western Zimbabwe. The protected forests, comprising of over 800 000 ha, are managed by the FC. They are managed for the production of commercial timber and wildlife, the protection of the fragile Kalahari sand system and for biodiversity conservation. Commercial logging of the KS teak forests primarily for *B. plurijuga*, *Pterocarpus angolensis*, *Guibourtia coleosperma* and *Afzelia quanzensis* has been described as the greatest threat to their survival. In addition, the hot dry season brings with it widespread destructive forest fires. In the past few decades the subsistence needs of the rural and peri-urban populations are threatening the future survival, functions and development of the forests. Their existence and current status can be attributed to the long history of state protection. However, state protection of the forests has not succeeded in preventing them from destruction and degradation as local people increasingly became dependent on them through time.

Since they were gazetted[2] the management approach in these forests has consisted mainly in only allowing formal public use through licences and permits. The management activities include protection from fire, supervision of forest utilisation programmes, veldt management to improve wildlife habitat, research on various aspects of the forests, wildlife management, silviculture, control of forest occupants and Anti-poaching activities.

The protected forests of western Zimbabwe, hereafter the 'KS teak forests', represent a unique natural forest ecosystem with complex ecological attributes and an interesting historical background with respect to the management and exploitation of the principal commercial timber species, *Baikiaea plurijuga*, *Pterocarpus angolensis*, *Guibourtia coleosperma* and *Afzelia quanzensis*. Broadly, the KS teak forests are restricted to deep, loose and well-drained Kalahari sand of western Zimbabwe, south-eastern Angola, northern Botswana, north-western Namibia and south-western Zambia (Figure 1). *Baikiaea* is an African genus with four other species confined to the tropical lowland rain forests of west central Africa – the Guineo-Congolian flora region, the fifth in miombo woodland in eastern Tanzania, and the sixth, *Baikiaea plurijuga*, confined to the Kalahari sand of southern central Africa (Brummitt, 1986).

The first forest policy statement with respect to these KS teak forests was proposed in 1921 and submitted to the government in 1924. The policy called for the establishment of forest reserves, the provision of funds for protection and for the closer supervision of timber exploitation. In this regard, under the Land Apportionment Act of 1930, the first forests, Gwaai and Ngamo, were gazetted in 1930. The rest of the forests were gazetted between 1940 and 1954 under various amendments to this Act. The Forest Act of 1949 and the Forest Amendment Act of 1953 gave birth to the Forestry Commission (FC) in 1954. The last revision of the extent of the various forest reserves was made in 1969 describing the area of the protected forests totalling 847 419 ha.

These KS teak forests are distinguished from other savannah, woodland and forest formations by the dominance of the genus *Baikiaea plurijuga* in the family Leguminosae, subfamily Caesalpinioideae**.** The genus *Baikiaea* is named after William Balfour Baikie, a missionary-doctor-naturalist of West Africa (Brummitt, 1986). Amongst other distinctive features are the species associated with *Baikiaea plurijuga* for example, *Pterocarpus angolensis*, *Guibourtia coleosperma* and *Schinziophyton rautanenii*. The last two species are endemic to Kalahari sands together with *Baikiaea plurijuga*.

[2] A forest that has been "set aside" for a particular management objective.

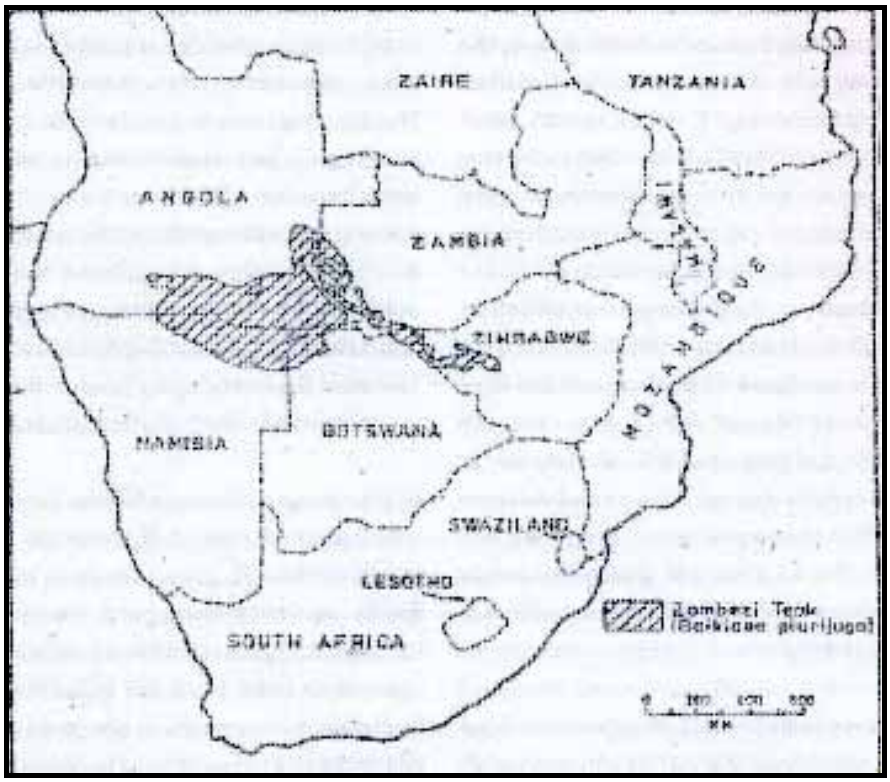

Figure 1. Distribution of Kalahari Sand teak forests in southern central Africa
(Source: Huckabay, 1986).

Protected KS teak forests perform a number of functions that include the protection of the fragile Kalahari sand, the protection of catchment areas for rivers that pass through the forests and flow into the Zambezi River, the provision of wildlife habitat, the conservation of biological diversity and the provision of timber and non-timber products. Over-exploitation of the forests for commercial use has been described as the greatest threat to their survival. The loss of the KS teak forests is especially worrying because unlike other savannah forest and woodland formations they are the more fragile forests in the sense that their soils (Kalahari sands) are easily degraded once the vegetation cover is removed. There are doubts whether the forests can ever be restored to their former climax, magnificence and productivity.

Protected forests have traditionally been used for the production and utilisation of commercial timber and wildlife. Through the national forest legal statutes these forests have been strictly protected from unauthorised uses. Their existence and current status can be attributed to the long history of state protection and prudent management practices.

The initial motivation for gazetting the forests was to control the wanton harvesting of the commercial indigenous timber species, mainly *Baikiaea plurijuga* (Zambezi teak) and *Pterocarpus angolensis* (mukwa). Timber of these species was mainly used to produce railway sleepers, furniture and mine props. Currently the species are commercially used for various forms of flooring, furniture, veneer and plywood.

The early objectives of gazetting the forest reserves included (a) a general preservationist ethic that prevailed in colonial times which saw huge forest areas being gazetted as protected areas (McGregor, 1991); (b) the forests were considered to be unique as conservation areas, as they are the only example in the country of extensive forest formations on Kalahari sands (Mujakachi, 1992); (c) gazetting provided for the protection of timber stocks, particularly for the mining industry; and (d) they were also gazetted for the protection of water catchments of the upper reaches of the Gwaai, Umgusa, Bembesi, Gwampa, Shangani, Lutope, Sengwa, Kana and Mbumbusi Rivers and tributaries. These rivers flow into the Zambezi River,

and this was an especially pertinent concern in the 1950s when the Kariba Dam was constructed on the Zambezi River (Mujakachi, 1992).

When the forests were gazetted and protected there were subsistence African farmers resident in most of them. Initially, these farmers were allowed to stay. The African farmer populations were considered a ready source of labour for fire protection. Later, in the early 1970s the population of the forests had increased and the FC made a decision to select households that were allowed to reside in the forests under a forest tenant basis. Households that were not selected were evicted from the forests. Forest tenant management became one of the major forest management activities. By 1985 the population of forest tenants had increased to unmanageable proportions. Illegal settlers encroaching into the forests exacerbated the situation. At that time a policy decision was made to evict all households from the forests. To this day households resident in protected forests are all considered illegal settlers despite the early ownership arrangements for some of them.

The management of wildlife in protected forests started in the late 1960s when wildlife was afforded protection similar to that resident in national parks. Wildlife management activities involved anti-poaching patrols, introductions, game censuses, the provision of water and salt licks and manipulation of some particular habitats. Wildlife management also saw the development of tourism activities such as safari hunting and photographic safaris. Apart from timber harvesting, wildlife utilisation is currently a major revenue-generating activity in protected forests.

Since the time they were gazetted, as well as before, protected forests have been major sources of a diverse range of services and goods including grazing, poles for construction, firewood, thatch grass, traditional medicines, honey, wild fruits, edible caterpillars and mushrooms. These products are particularly important to the livelihoods of rural communities living adjacent to the forests.

For a long time after forest management was instituted in western Zimbabwe, forest research featured very little in the management of the forests. One of the earliest research projects was Project E46 the aim of which was ‘The investigation into the effect of fire on regeneration and development of the KS teak forests’. Other research programmes included biodiversity conservation, growth studies of selected indigenous tree species, silviculture and ecology, and protection. Results from most of these research programmes have formed the backbone to the sustainable management of the protected KS teak forests (Judge 1975).

The management and use of the forests have been and are performed within the context of the national forest policy and legal frameworks. The forest policy has guided the development of the forestry sector while forest legislation has supported the implementation of the policy. Protected forest reserves in Zimbabwe are considered state property characterised by state ownership and control, under which other stakeholders, depending on use objectives, may or may not be permitted access (Mohamed Katerere, 2000). People living in or near the protected forests share ownership rights of the forest products with the state, usually in antagonistic circumstances. These circumstances are often mired in conflicts and challenges over the use of forest resources. The challenges are most often not formal legal challenges but acts that violate rules of exclusion and rules governing use as well as acts that test the will and ability of the state to enforce its rules.

2. OBJECTIVES OF THE CASE STUDY

The objective of this case study is to describe and document management practices and experiences for the protected KS forest reserves in western Zimbabwe. This is achieved through providing a broad diagnostic assessment of the status and dynamics of forest resources, describing the management approaches/systems, giving an overview of the purpose of managing the forests, describing the full range of stakeholders and their interests and participation in managing the forests, and providing a description of the tools used in planning and/or management of the forests. This case study is intended for managers, administrators, planners, researchers and college and university students, but may further serve as inspiration to others interested and engaged in the management of KS teak forests regionally.

3. MANAGEMENT OF PROTECTED KALAHARI SAND TEAK FORESTS

The management of protected KS teak forests in Zimbabwe dates back to the 1900s. Due to the extraordinary economic and ecological importance and uniqueness of the Baikiaea forests, interest in their conservation and management developed as early as the 1900s when the colonial regime settled in the country. Commercial timber exploitation was taking place in these forests by 1904; the first forest officer was employed in 1920; fire management activities were instituted in 1930; while schemes to deal with previous occupiers of the forests took place around the 1960s. Wildlife management and the development of related tourism activities began in selected forests in the late 1950s (Judge, 1975). More recently, participatory forest management has been taken on board.

3.1 Management objectives

The Forest Department was established in the then Southern Rhodesia in 1920 under the Ministry of Agriculture but it was not until later that a forest officer was posted to manage the *Baikiaea* forests in western Zimbabwe. The immediate terms of reference for the forest officer were to develop plans for the control of timber concession activities, fire protection and a working plan for the protected forests in western Zimbabwe (Judge, 1975; 1986).

Four main management objectives were set out in order to achieve sustainable management of the KS teak forests: (i) to produce exploitable timber of the main commercial species on a sustained yield basis; (ii) to increase productivity through multiple land use practices including utilisation of minor forest products; (iii) to increase the soil and water conservation value of the forests; and (iv) to develop the amenity value of the forests. Over the last few decades, the role of the protected forest reserves towards the conservation of biodiversity and their contribution to rural livelihoods has been increasingly highlighted (Matose and Clarke, 1993; Forestry Commission, 1994b; Mutsiwegota and Mudekwe, 1998; Cunliffe, 2000). These management objectives have not changed much since then. In practice the objectives focused on timber and wildlife production and enhancing the ecological services of the forests. The multiple land use practices implied in these objectives have not been developed to the fullest. The problem then, as now, has been how to put these ideals into practice given the then focus on a protectionist management approach to the forests and the lack of specialist staff to implement the ideals. Judge (1986) makes an interesting observation with respect to the potential multiple uses of the forests. He notes the early recognition that wildlife and timber production, livestock grazing, tenant agriculture, livestock production and the use of minor forest products all had roles to play in the development of the *Baikiaea* forests. He further comments that “when one examines the economics and ecological services, particularly the return per unit generated by each of the multiples, it is clear that to adopt any policy other than multiple land use would be foolish”. However, forest management in protected forests has remained focused on production of timber and wildlife, fire protection and protection from unauthorised local use.

In the very early days of forest management it was elaborated that sound management depended on the proper understanding of the basic factors of the environment, e.g. soil, rainfall, temperature, frost, topography and drainage. It was important to gain knowledge and understand the floristic composition of the vegetation strata. The silvicultural characteristics of the individual species, including flowering, seeding, methods of and requirements for natural regeneration, pests and diseases, responses to varying degrees of disturbances such as grazing, fires, subsistence harvesting and logging had to be understood to achieve sustainable forest management. Methods of artificial regeneration, including sound forest nursery techniques were to be investigated. It was also important to understand the ecological significance of wildlife, domestic livestock and anthropogenic activities. These protected forests were viewed in the broad perspective of the overall pattern of land use in the region in which they occurred. It was recognised that the forests were not isolated islands and the broad lines of development in them would impact on adjoining private lands, communal and resettlement areas, game reserves, tourist areas and local industry. Liaison had to be maintained with other stakeholders so that the FC’s activities and advice could be turned to good benefit for all. These pointers became the focal areas for the current management systems of the protected KS teak forests.

4. PRODUCTS OBTAINED THROUGH FOREST MANAGEMENT ACTIVITIES

4.1 Commercial timber

Timber is the main product harvested from the KS teak forests. Timber harvesting is selective, concentrating on species such as *Baikiaea plurijuga, Pterocarpus angolensis, Guibourtia coleosperma* and *Afzelia quanzensis.* Quantities of the latter two species are considered low due to the inherent low densities of the species per unit area. *Pterocarpus angolensis* has been heavily exploited in the past, due to its being highly favoured for furniture making. Sustainability of the species is questionable. The species is perceived not to be regenerating successfully under the current management prescription, although Mushove (1996) disputes this perception. The main products from these commercial species for internal and external markets are sawn timber for furniture, sleepers and flooring parquets and veneer. There are currently seven timber concessions operating in five different forest reserves and 13 formal indigenous hardwood firms in western Zimbabwe. The main tree species whose products go on to the export market are *Baikiaea plurijuga* and *Pterocarpus angolensis*.

4.2 Wildlife

After the establishment of the FC in 1954 wildlife production within the protected forests became one of the major activities. The production and utilisation of wildlife for ecotourism activities (consumptive and non-consumptive tourism) has gained increasing importance in protected forests during the last five decades. The forests are rich in populations of the big five, i.e. elephant, buffalo, lion, leopard and rhino and the larger and smaller antelopes. Game is also hunted by local people for meat although the practice is often illegal. Where forests, with large populations of wildlife species, border on communal areas there are formal arrangements with local communities to engage in the Communal Areas Management Programme for Indigenous Resources (CAMPFIRE) in which the locals benefit from utilisation of wildlife. In 2004 the FC took a policy decision that allows indigenous black entrepreneurs to participate in the eco-tourism activities in the protected forests. Currently there are 10 hunting safari camps in nine protected forests and six non-consumptive enterprises in three forests operated by black indigenous people.

4.3 Non-wood products

KS teak forests also provide a wide range of non-wood products and services to adjacent rural forest communities. These goods and services contribute substantially to the economic and social welfare of rural and peri-urban households. In studies in three protected forests firewood, thatch grass, construction poles and wild fruits were the most important products collected from the forests (Vermeulen, 1993; Forestry Commission, 1994; Mufandaedza, 2004; Mudekwe, 2006). Other products include plant medicines, edible caterpillars, broom grass, honey, mushrooms and wood for curios. The sale of firewood, wild fruits, thatch grass and curios is an important economic activity for harvesters living adjacent to the forests. In the past decade the FC has recognised the critical and potential value of the KS teak forest resources to the livelihood strategies of rural communities as well as the country's economy. The FC currently encourages the active involvement of local people in the management of the forests as a means of ensuring sustainable forest resource use. Observations are that the success of this involvement by the local people in the management of the resources is dependent on the existence of tangible benefits.

4.4 Grazing

Forests provide grazing resources for domestic stock, predominantly cattle. Three ways of managing domestic stock are available in protected forests. There are commercial rancher-leased cattle grazing schemes in selected forests and currently there are eight grazing leases in six protected forests. Most forests are surrounded by communal and resettlement areas and therefore domestic stockowners in these surrounding areas graze their cattle in the forests. In most cases the practice of grazing cattle in protected areas is considered illegal by forest managers unless prior arrangements are made. During drought years protected forests are used for drought relief grazing under some arrangements between cattle owners in the region and the FC. Livestock grazing is a valuable tool that is used to reduce fuel loads in protected forests. However, if long-term management objectives are to be attained, the practice requires knowledge of the structure and understanding of the ecology of the plant community.

5. CASE STUDY AREA

5.1 Location, climate, geology and soils

5.1.2 Location

*B. plurijuga (*Zambezi teak) forests occur in Angola, Botswana, Namibia, Zambia and Zimbabwe in southern central Africa (Figure 1). *Baikiaea plurijuga* is the southernmost species of the genus that is mainly confined to the topical lowland rain forest of the Guinea-Congolian floral region. *Baikiaea plurijuga*'s spread southward into the Zambezian region is largely due to the moisture retention of the deep Kalahari sand that favours the regeneration of the species. KS teak forests are restricted to the Kalahari sand under an annual rainfall regime ranging from more than 1000 mm in south-east Angola in the north to less than 600 mm in north-western Zimbabwe in the south (Huckabay, 1986).

In Zimbabwe the KS teak forests are restricted to the western part of the country. The forests are located between latitude 17^0 05'S and 20^0 02'S and longitude 15^0 00'E and 19^0 00'E. They straddle two provinces, i.e. Matabeleland north and midlands and seven rural districts (Table 1). Almost all forests share common boundaries with at least one or more of the following land categories: communal lands, resettlement areas, large and small-scale commercial farms and national parks.

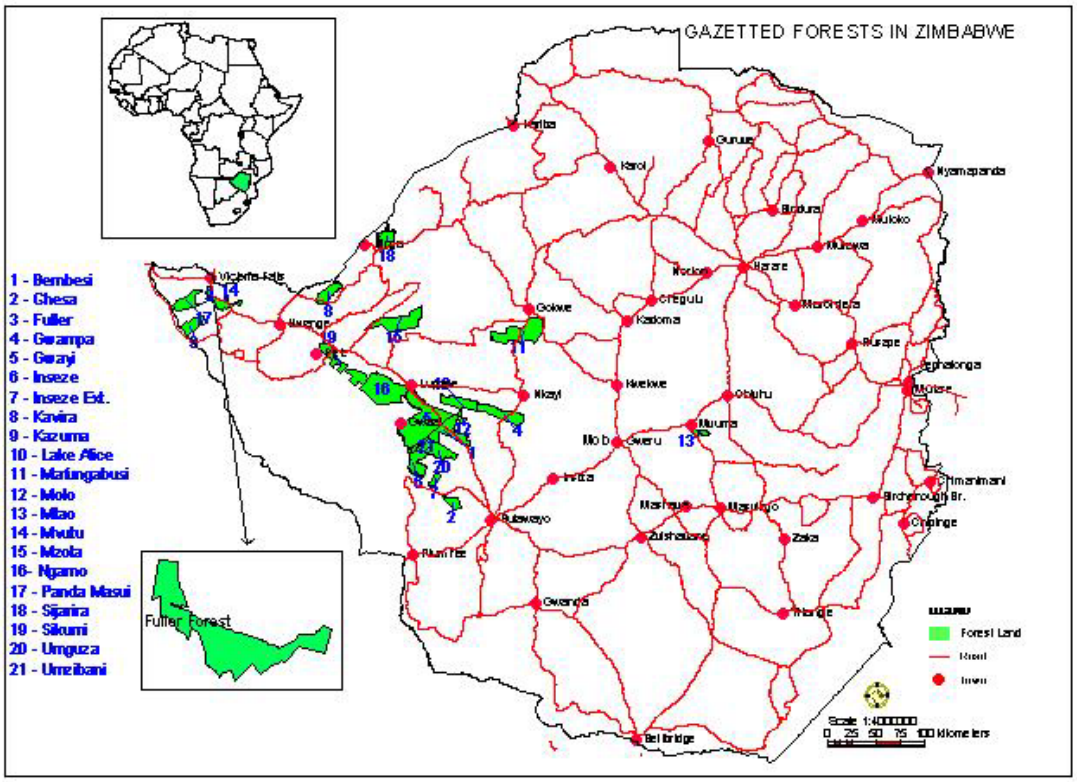

Figure 2. Protected KS teak forests in western Zimbabwe. (Source: Forestry Commission, 2006)

Table 1: Protected forest reserves in western Zimbabwe

District	Forest land	Area (ha)	Productive (ha)	Non-productive (ha)
Binga	Kavira	28 200	8 600	19 600
	Sijarira	25 600	-	25 600
	Mzolo	67 000	35 000	32 000
Bubi	Bembesi	55 100	39 240	15 860
	Molo	2 900	2 580	320
Lupane	Gwaai	144 300	105 020	39 280
	Lake Alice	39 000	24 360	14 640
	Ngamo	102 900	56 210	46 690
Nkayi	Gwampa	47 000	35 490	11 510
Umguza	Chesa	14 248	6 780	7 468
	Inseze	35 200	24 550	10 650
	Inseze Extension	8 400	6 010	2 390
	Umgusa	32 200	28 500	3 700
	Umzibani	2 471	2 260	211
Hwange	Fuller	24 700	16 470	8 230
	Kazuma	24 000	15 420	8 580
	Panda Masuie	33 500	29 300	4 200
	Sikumi	55 700	24 750	30 950
Gokwe	Mafungabusi	105 000	48 000	57 000
Totals		**847 419**	**508 640**	**338 779**

(Source: Judge, 1975; Forestry Commission, 1994).

5.1.3 Climate

The dominant climatic characteristic in the KS teak forests of western Zimbabwe is a short and erratic rainfall season from mid-November to mid-March. The dry season ranges from April/May to October/November. The average annual rainfall for the region is about 600 mm. The long-term (45 years) average annual rainfall for Victoria Falls in the north is about 450 mm, for Gwaai forest in the central area it is 650 mm, for Chesa forest in the south it is 600mm, and for Mafungabusi forest near Gokwe in the north eastern area of the region about 680 mm (Anderson *et al*., 1993). There is considerable year-to-year variation, such that in some low rainfall years the average annual rainfall is below 300 mm and in high rainfall years above 800 mm. Mean annual temperature in the region is approximately 21.5^0C. Mean monthly temperatures in the hot and cold months are about 30^0C and 17^0C, respectively (Nyamapfene, 1991). In terms of agro-climatic classification the forests generally fall within Natural Region IV. Natural Region IV is suitable for extensive livestock production and wildlife ranching. The exceptions are parts of forest areas in Mafungabusi and Mzolo that fall in Natural Region III. The low and erratic rainfall comprises a major constraint to dryland crop production and is also a major determinant of the annual availability of grass for livestock production.

5.1.4 Geology and soils

Kalahari sand covers the bulk of the protected KS teak forests. The sands comprise deep, unconsolidated and well-drained tertiary sands of Aeolian origin. The underlying geology is of sedimentary rocks overlying Karoo basalt and sedimentary deposits. These underlying formations are only exposed along rivers where the sands have been eroded. The dominant KS soils are uniform physically and chemically (Anderson *et al.*, 1993; Nyamapfene, 1991). The extremely low occurrence of silt and clay particles (< 10 percent) is due to the absence of any weather resistant minerals (Lockett, 1979). The soils are also highly infertile. Permeability is rapid and there is very little runoff. High permeability and low fertility severely constrain the potential of the soils for dry land crop production.

The valley soils along drainage lines are different and much more varied. This results from differences in the parent material of reworked Kalahari sand, basalts, sedimentary and alluvial deposits. The common

soil type in the valleys is locally known as “isibomvu”, literally meaning red sand soils. This type of soil is moderately well drained, deep, loamy sand highly favoured for agriculture.

There are three major soil colour divisions that can be recognised. These are the darker, finer and more fertile red sands; the pale, coarse, loose, infertile white or grey sands and the intermediate buff sands (Calvert, 1986). The red sands are the least extensive and are found adjacent to valleys and ridges where relief is relatively marked. The pale sands are associated with depressions and flatter areas where drainage is less free. The relatively extensive buff soils are intermediate between the two, in some places apparently overlying pale sands and in others red sands.

6. VEGETATION

6.1 Composition and structure

The dominance of the genus *Baikiaea* (Fabaceae, subfamily Caesalpinioideae) makes the KS teak forests distinct from other forest types and woodlands in Zimbabwe. The dominant *Baikiaea plurijuga* species is endemic to Kalahari sand. The *Baikiaea* forests are functionally different because of their great depth, high permeability, low water-holding capacity and the extreme nutrient poverty of Kalahari sand. Another feature of these forests is that all of the dominant tree species on Kalahari sand belonging to Caesalpinioideae family are endomycorrhizal (Hogberg and Piearce, 1986).

A number of vegetation types can be recognised in the protected KS teak forests and these have been described by Wilkinson (1941), Mitchell (1960), White (1962), Anon (1964), Fanshawe and Savory (1964), Calvert (1970), Fanshawe (1971), Von Breitenbach (1972) and Rushworth (1975). These vegetation types include:

i. Closed *Baikiaea* forest or woodland. This vegetation type displays a fairly closed overstorey with a distinct shrub understorey and moderate grass cover. The *Baikiaea* forest or woodland is the dominant type covering over 90 percent of the Zambezi teak forest ecosystem. The forest occurs primarily on the dominant Kalahari sand ridges. In this vegetation type *Baikiaea plurijuga* is the principal upperstorey species. Its other upperstorey associates are *Pterocarpus angolensis, Schinziophyton rautanenii, Guibourtia coleosperma, Afzelia quanzensis, Combretum collinum,* and *Erythrophleum africanum.* The sub-canopy species are *Peltophorum africanum, Erythrophleum africanum, Combretum apiculatum, Strychnos pungens, Croton gratissimus, Pseudolachnostylis maprouneifolia, Swartzia madagascariensis, Diplorhynchus condylocarpon, Peltophorum africanum* and *Terminalia sericea*. The understorey species are dominated by *Bauhinia petersiana, Baphia massaiensis, Grewia flavescens, Grewia monticola, Dichrostachys cinerea, Commiphora* species and *Acacia fleckii*.

ii. Open *Baikiaea* woodland. This woodland has a markedly discontinuous upperstorey. The dominant tree species in the upper canopy include *Guibourtia coleosperma*, relic *Baikiaea plurijuga, Pterocarpus angolensis, Burkea africana* and *Erythrophleum africanum.* This vegetation type includes open scrub or clumps of coppice regeneration of *Baikiaea plurijuga* and *Guibourtia coleosperma*.

iii. Dwarf teak woodland. This woodland type is characterised by a dense cover of multi stemmed *Baikiaea* coppice. Often the overwood is variable, from almost pure stands of *Pterocarpus angolensis* with occasional *Burkea* and *Erythrophleum* to scattered and isolated trees of other species.

iv. “Sinanga” woodland. This vegetation type is characterised by a broken upper canopy of *Baikiaea* with occasional *Entandrophragma caudatum* and/or *Afzelia quanzensis* over a dense thicket understorey of *Combretum* species. This vegetation type is typically found in Gwampa and Gwaai forests.

v. Miombo woodland. This woodland type is dominated by *Brachystegia spiciformis* with or without *Julbernardia globiflora*. The understorey is often open with scattered shrubs and small trees and

sparse to moderate grass cover. This woodland type is typical of parts of Mafungabusi, Sikumi, Ngamo, Gwaai and Bembesi forests where shallow sandy loam soils are predominant. Species composition in the upperstorey comprises *Brachystegia spiciformis, Julbernardia globiflora, Brachystegia boehmii, Combretum collinum, Combretum molle, Combretum zeyheri, Pterocarpus angolensis* and *Terminalia sericea*. The sub-canopy is composed mainly of *Combretum apiculatum, Burkea africana,* relic *Baikiaea plurijuga* and *Guibourtia coleosperma, Croton gratissimus, Pseudolachnostylis maprouneifolia, Swartzia madagascariensis, Diplorhynchus condylocarpon* and *Peltophorum africanum*. The understorey species are *Grewia monticola, Ochna pulchra, Dichrostachys cinerea, Grewia flavescens, Friesodielsia obovata* and *Vangueria infausta*.

vi. The *Kirkia acuminata* woodland occurs on shallow loamy soils underlain by rocks near the soil surface. The principal species in the upperstorey is *Kirkia* in association with *Brachystegia boehmii, Peltophorum africanum, Sclerocarya birrea* and *Pterocarpus angolensis*. The sub-canopy comprises species such as *Combretum apiculatum, Gardenia resiniflua, Albizia harveyi, Croton gratissimus* and *Ziziphus mucronata*. In the understorey are species such as *Grewia flavescens, Bauhinia petersiana* and *Commiphora mollis.*

vii. *Colophospermum mopane* woodland. *Colophospermum* is the principal upper canopy species on clayey soils. In the upperstorey, where it is not in a pure stand, it is in association with species such as *Combretum imberbe, Combretum hereroense, Acacia nigrescens, Sclerocarya birrea, Acacia nilotica, Loncocarpus capassa* and *Combretum apiculatum*. Sub-canopy species include *Terminalia prunoides, Albizia harveyi* and *Loncocarpus capassa*. The understorey is occupied by *Grewia monticola*

viii. Grasslands. There are two types. One associated with the vlei depression system and seasonally impeded drainage and the other found on apparently well-drained sands and primarily associated with repeated fire. The development of the grass, herb and shrub layer within the KS teak forests varies according to the overstorey layer. Where the tree canopy is densest there is minimal development of grasses, herbs and shrubs. The most common grasses on the Kalahari sand ridge include *Aristida* species, *Pogonarhria squarrosa* and *Digitaria* species. Most of the grass species found in this zone are coarse (sourveld grasses) that are palatable only in the growing season. The vlei depressions support a dense cover of a range of grasses including species harvested for thatch and brooms. Common species include *Aristida, Sporobolus, Cyperus, Eragrostis, Pogonarrhia* and *Perotis*. Vleis support significant quantities of thatch grass species, e.g. *Hyperrhenia dissolute* and *Hyperrhenia filipendula*.

The structure of the tree vegetation in the protected KS teak forests appears superficially to be relatively uniform over large areas, suggesting a broad similarity in key environmental conditions. Woody plants probably contribute more than 95 percent of the above ground biomass in the forests, with grasses and herbs making up the remainder. The forests typically comprise an upper canopy, a subcanopy layer that is often absent, an understorey of shrubs and saplings and a ground layer of grasses, herbs, forbs and suffrutices. The uniformity in appearance is due in part to the remarkably similar physiognomy of the canopy trees that are dominated by *Baikiaea plurijuga*.

Differences in forest structure are more apparent on the local scale. The origin of the differences appears to include edaphic factors, mainly soil moisture and soil nutrients (Campbell *et al,*. 1988); the effects of fire (Calvert, 1986); wildlife impact (Calvert, 1986; Wood, 1986) and past and present land use and anthropogenic disturbances (Huckabay, 1986; Wood, 1986).

The density of woody plants in the forests varies widely, 800-2 700 stems ha^{-1}, and the density varies by forest reserve (FC's inventories in Fuller, Mzola, Gwaai/Bembesi). Density seems to be related to rainfall, effects of fire, impact of wildlife, logging and anthropogenic disturbances. Tree height appears to be related to moisture availability and soil depth. Canopy dominants, such as *Baikiaea plurijuga, Pterocarpus angolensis, Burkea africana, Ricinodendron rautanenii* and *Brachystegia spiciformis,* growing on deep (more than 8 m) Kalahari sand soils, can reach up to 18 m but in general few trees grow taller than 15 m.

The recorded basal area of trees in Fuller, Gwaai, Lake Alice, Mzola and Bembesi ranges from 81.4 to 112 m^2 ha^{-1} (Forestry Commission, 1998; 1993; 1996; 1993). Basal area appears to increase with increasing annual rainfall.

6.2 Functioning

The KS teak forests have a marked seasonality of plant production, growth and reproduction, and highly variable rates of decomposition. These functions are driven directly or indirectly by the strongly seasonal rainfall, a large biomass of big herbivore in some of the forests, human disturbances and frequent fires. Seasonally limited moisture for plant growth and nutrient poor soils influences the patterns of plant production in these forests.

6.3 Phenology

Most woody species and shrubs found in the KS teak forests are deciduous, shedding their leaves during the dry season. The shedding of leaves peaks in July–August. The timing of leaf fall as well as the length of the period when trees are leafless varies from year to year. The driving factor appears to be the prevailing weather conditions and the genetic characteristics of the tree species. In draught years leaves are shed early in the dry season. Where trees are able to abstract subsoil moisture they tend to retain their leaves longer into the dry season.

6.4 Plant production

No complete studies of woody plant production have been done in the protected forests. However, shoot production is known to be dependent on carbohydrates and nutrient reserves stored from the previous growing season (Rutherford, 1984). For most tree species in these forests the current growth is completed early in the growing season. Stands composed of predominantly young or small trees produce more current growth per unit biomass than stands dominated by large trees. There is a lack of data on annual increments in biomass of the woody plants in the deciduous KS teak forests.

7. PAST AND PRESENT STATUS OF PROTECTED FORESTS

Before the turn of the century man and animals lived in harmony within the KS teak forests. The human population was low and did not cause serious destruction and degradation of the forests and forest resources (Judge, 1986). Fire played an important role in the shaping of the forests. Natural fires were less frequent compared to man-made fires of recent times. As long ago as 1909 the mine and railway sectors realised that the KS teak forests had some of the finest indigenous hardwood timbers of the *Baikiaea plurijuga*, *Pterocarpus angolensis* and *Guibourtia coleosperma* species. These species were over-exploited for railway sleepers and flooring material.

The ecology of the KS teak forests can be interpreted as one of a plant community whose climax status is forest but which has been reduced to woodland or secondary forest by burning, over-exploitation for commercial and subsistence purposes, browsing and grazing activities. Currently the plant community is in a dynamic state in which the structure and composition change under the interplay between rainfall, temperature, fire, domestic stock, wildlife and anthropogenic influences.

Human population pressures have probably caused more fundamental changes to vegetation composition, structure and functioning. Encroachment and clearing forest for agricultural purposes has had a marked impact on the forests. What is lamentable is that the agricultural potential of the Kalahari sand is low and crop production levels minimal. Wildlife production and extensive grazing by cattle are probably the optimum agricultural policy rather than crop production. Due to the disturbances mentioned above, characteristics of secondary forest types are becoming more apparent in most forest reserves.

There are many factors limiting the recovery of these forests. Fruiting of most of the woody species is erratic and hence natural regeneration from seed is poor. A high proportion of germinating seeds and seedlings are consumed by rodents and domestic and wild animals. A dense under storey of thicket shrubs

that greatly suppresses or completely prevents the growth of young trees is becoming increasingly predominant. Harvesting and grazing pressure is increasing as human and livestock populations continue to increase. The successional secondary forest is extremely sensitive to damage and destruction by late dry season fires.

Attempts at artificial regeneration of the forests has some potential but has so far met with mixed success. Specialised nursery and planting techniques need to be improved. So is the need to effectively control the competing vegetation of grasses and thicket shrubs to assist natural and artificial regeneration. Seedlings and saplings regularly suffer severe dieback, leading to stunting and bad form, caused by frost that occurs nearly every year in some areas.

The KS teak forests of western Zimbabwe have been progressively reduced over the years as a result of human disturbances. Human activities have long been recognised as a major influence on vegetation (Judge, 1975; Calvert, 1986; Wood, 1986). By harvesting plants for commercial and subsistence purposes, or clearing forests for agriculture and causing wild fires, man has directly altered the natural vegetation of the KS teak forests. The disturbances are such that once the vegetation is altered the climax vegetation is slow to return or may never return at all.

8. STAKEHOLDERS AND THEIR PARTICIPATION IN FOREST MANAGEMENT

Stakeholders in the protected KS teak forests are multiple inasmuch as planning, management of forests and forest resources, harvesting and use of forest products, communities within and outside the protected forests and agencies providing public services are being dealt with. While the focus is clearly on the protected forests there is a need to note the linkages with adjoining areas, which include communal lands, resettlement areas, small and large-scale commercial farming areas, and national parks. In addition, the forests are bisected by a variety of communication networks such as railways, state roads and telephone and electricity lines. In practice the key stakeholders that play a major role in the protected forests are limited to a few. But the overall stakeholder framework within which people live and work in and around the forest areas must be understood and appreciated as a whole.

The key stakeholders are the FC, inscribed forest communities, forest-adjacent communities, lessees and concessionaires. These are in direct contact with the forests almost on a daily basis in terms of management and use practices. The FC has the management mandate over the forests and decides who should or should not use them. Protected KS teak forests are considered state property characterised by state ownership and control, under which other stakeholders, depending on use objectives, may or may not be permitted access (Mohamed Katerere, 2000). The FC is the legal owner of the forests according to the provisions of the Forest Act, Chapter 19:05. The forest-adjacent communities obtain forest goods and services from the forests formally or informally for daily subsistence and commercial purposes. The local communities harvest products such as firewood, construction poles, wild fruits, mushrooms, bark fibre, honey, bushmeat, thatch and broom grass, edible caterpillars, wood for curios and cottage furniture making and medicinal plants. Products that are mostly traded locally and in urban centres are firewood, wild fruits, curios, edible caterpillars, thatch and broom grass and bushmeat. Local livestock owners graze their stock in the forests as well. Distant livestock owners use the forests formally or illegally during drought periods. Leases are normally obtained for commercial cattle grazing, eco-tourism activities, commercial services such as general dealers' shops and grinding mills and carpentry shops (see section 9.2.11). Timber concessions are either private or community owned (section 9.2.2). In a few cases the FC and local communities have entered into agreements to co-manage the forests and share the resources and benefits obtained from forest-based enterprises with some of the stakeholders, e.g. forest-adjacent communities in Mafungabusi and Gwaai forests.

Secondary stakeholders are service providers such as the ministries responsible for the provision of transport networks, telecommunication, water, schools, veterinary services and electricity. There are also distant users of the forest to be considered as relevant stakeholders, i.e. those who temporarily migrate to the forests for the purposes of harvesting forest products for limited periods of time. This group of stakeholders includes curio carvers, firewood vendors and harvesters of thatch grass, mopane worms and

wild fruits. The group normally harvests forest products for commercial purposes. While these have no direct influence on the way the protected forests are managed, their activities, for example, result in opening up the forests when constructing infrastructure. In addition roads make it easier for people to encroach into forests for various purposes. Some stakeholders have the social responsibility of providing services such as water and schools irrespective of whether people are settled in the forests legally or not. The Department of National Parks has ultimate responsibility for wildlife in the country. Therefore the FC has to profit from wildlife resources in its forests in consultation with that Department. Respective Rural District Councils (RDCs) are responsible for inscribed communities in terms of political administration; hence the councils liaise with the FC with respect to issues related to these communities. Politicians are an important stakeholder group insofar as the inscribed communities are an important constituency for the politicians. The FC has not been able to evict these illegally settled communities due to political interference.

At most, several of the stakeholders do not actively participate in forest management activities and planning. Meanwhile they have *de facto* access to the forests and to forest resources and share forest resources with the FC by default. In Mafungabusi, Gwampa and Gwaai forests, where the forest-adjacent communities have entered into formal agreements with the FC, the communities participate in the planning of forest resource harvesting activities, protection of the forest from fire and outsiders and monitoring resource use. Under the arrangements the communities benefit through formal access to a range of mutually agreed forest products.

9. FOREST MANAGEMENT SYSTEMS

9.1 The protected forests estate

The protected Zambezi teak forest reserves of western Zimbabwe provide timber, grazing resources, agricultural land and wildlife. From the inception of forestry in this region it was realised that individually any of the multiple components of the forests would give a low economic return in relation to land area. Complementing each other the components would provide an entirely different picture and considerably increase the socio-economic potential of the forest reserves. On the other hand it was apparent that there was bound to be conflict in the management of timber, wildlife and a resident forest population that was engaged in livestock and crop production. None of these entities could be managed in isolation; therefore, this factor had to be taken into consideration in management plans. Compromises can be made without losing sight of the fact that timber was of paramount importance.

The protected KS teak forest estate is made up of 21 individual forest reserves. Each reserve was surveyed after proclamation and is clearly protected by a network of external fireguards that are regularly cleared of woody vegetation to keep them visible. Most of the individual forest reserves have common boundaries with communal areas, resettlement areas, large and small-scale commercial farms and national parks. For easy planning and control of forest management silvicultural prescriptions each forest is divided into blocks or compartments ranging in size from 5 to 10 000 ha.

The overall administrative responsibility for the management of the protected KS teak forests rests with the Chief Executive Officer of the FC, with the assistance of the Divisional Manager, Conservation and Extension. In the western region where the forests are located the administration, control and supervision of management activities lie with the Chief Conservator of Forests, under whom are 11 technical foresters, a forest ecologist, a wildlife ecologist, a forest protection officer and personnel involved in the maintenance of field vehicles and equipment. Arrangements for the administration and management of these forests are shown in Table 2 below.

Table 2: Forest management staff for the protected forest reserves

District	Administration and supervision	Forest land	Area(ha)	Technical managers
Binga	District Coordinator	Kavira	28 200	Forester
		Sijarira	25 600	
		Mzolo	67 000	Forester
Bubi	District Coordinator	Bembesi	55 100	Forester
		Molo	2 900	
Lupane		Gwaai	144 300	Forester
		Lake Alice	39 000	
		Ngamo	102 900	Forester[1]
Nkayi	District Coordinator	Gwampa	47 000	Forester
Umguza	District Coordinator	Chesa	14 248	Forester
		Inseze	35 200	
		Inseze Extension	8 400	
		Umgusa	32 200	
		Umzibani	2 471	
Hwange	District Coordinator	Fuller	24 700	Forester
		Kazuma	24 000	Forester
		Panda Masuie	33 500	
		Sikumi	55 700	Forester[1]
Gokwe	District Coordinator	Mafungabusi	105 000	Forester

(Source: Forestry Commission, 2006; [1]The two forests are managed by one forester)

9.2 Forest management approaches

The management approach of the KS teak forests may be categorised into five levels. The general characteristics of the approaches have been:

(i) conservation with limited use;
(ii) protectionist and exclusionary;
(iii) focus on timber and wildlife management;
(iv) application of the multiple use concept; and
(v) gradual move recently towards people-focused forest management.

The FC's obligations under the Forest Act include the management of four principal components of the KS teak forests. The components are timber, wildlife, people and grazing. Real organised management of the forests was not realised until 1920 when a Forest Officer was posted to work in the western region. The Forest Officer proposed the following management conditions that were subsequently adopted and implemented:

(i) minimum dbh limit of 40 cm;
(ii) normal safeguards for good exploitation such as drawing debris away from living trees;
(iii) restricting felling to poorly stocked stands;
(iv) fire protection of the whole and not part of the concession area;
(v) spot sowing of not less than 40 ha of the principal tree species; and
(vi) regular patrolling of the forests during the dry season.

In 1961 the Conservator of Forests elaborated far-reaching 'Objects of management and research' most of which have guided management of the protected KS teak forests to this day. The areas focused on included exploitation and enumeration, silviculture, fire protection, research, multiple land use and the exploitation of minor forest produce, finance and economics and administration and integration with other forms of land use.

9.3 Forest management plans

Currently the management of the protected KS teak forests is regulated through forest management prescriptions of properly authorised management plans, which are based on the principle of sustained yield. The absence of such management plans had previously imposed limitations on all aspects of management, protection, exploitation and administration of the forests. To this effect specific management plans for each protected forest were first produced in 1992 and are revised every five years. The management plans are used for strategic and annual operational work plans of the forests. Production of the management plans is the responsibility of forest officers with supervision from their co-ordinators and the Chief Conservator of Forests. All management plans are based on qualitative and quantitative data and information gathered by respective foresters for each forest reserve. In forest reserves where forest inventories have been conducted the management plans are based on inventory results data and information.

The forest management plans are prepared on two levels, i.e. the level of the whole forest and the community forestry level. The latter case involves situations where co-management arrangements exist and production of the plans is facilitated by foresters with the full participation of community members. In the former case, production is the responsibility of foresters at the forest reserve level. In both cases the management plans are approved first at the divisional level and secondly at institutional level, where the plans have to fit into strategic goals of the institution. According to plan production procedures the management plans shall contain the following generic chapters:

Chapter I	General background (history, size and location, physiography)
Chapter II	Forest resources
Chapter III	Forest utilisation
Chapter IV	Forest management
Chapter V	Management zones
Chapter VI	Fire plan
Chapter VII	Forest improvement
Chapter VIII	Administration

9.4 Management activities

Management activities in the forests include:

(i) forest fire protection;
(ii) supervision of forest utilisation programmes;
(iii) veldt management;
(iv) research support on indigenous forests;
(v) wildlife management;
(vi) silviculture;
(vii) anti-poaching activities; and
(viii) community participation.

These activities are elaborated below. They are carried out under the supervision of the respective foresters of each forest reserve. Each forester has a small team of permanent workers that is complemented by casual workers during the fire season.

9.4.1 Forest fire protection

Early foresters observed that fires damaged a large percentage of trees in these forests. Much of the harvested timber shows serious fire-related faults and blemishes. While complete fire protection has proved unsuccessful, early burning was abandoned in the 1970s and currently the major fire protection activities are manning of fire lookouts and fire fighting.

The first attempts at protecting protected forests from fire were instituted in 1925 and concentrated in areas exploited by timber concessionaires. The first annual fire plan was aimed at the protection of all

young growth using natural features such as vleis, rivers, streams and timber extraction lines. In his 1925 annual report *some observations on fire damage to Kalahari Sand forests*, Kelly Edwards attributed the causes of fire to superstition and the traditional practice of annual burns to improve grazing and honey hunting, particularly during times of hunger. Farmers caused forest fires during agricultural land preparation activities. Fires were also lit to flush game and fires were made to please the rain gods particularly when drought threatened. European hunters were also careless about fire. Two hunters, Lundin and Herbst, were the biggest culprits when they operated on the Ngamo flats capturing giraffe for zoos. They boasted about the fires they started deliberately or campfires they left un-extinguished (Judge, 1975). Locomotives on the Bulawayo-Victoria Falls railway line caused a number of fires. Lightning also started some fires.

Annually, local staff in each forest attends to numerous veldt fires. Protection of the forests from the effects of fire is the function of the territorial staff. The biodiversity of the forests changes drastically as a result of fires. Fires, therefore, remain the single largest threat to the growth and development of the forests. Fire protection procedures are the subject of the detailed forest management prescriptions of annual and periodic fire protection plans. In the plans it is recognised that to exclude all fire indefinitely is not practicable. The fire protection plans set out clearly the objectives to be achieved. The management of fire is based on the occurrence of different vegetation types, as well as an understanding of their different responses to fire. Fire plans are prepared based on the division of the forest into 4 000 ha blocks surrounded by burned fireguards. Fire plans cater for the specific protection of the most valuable and perhaps the most susceptible area. As the success of fire protection work partly depends on the sympathy of local communities living adjacent to the protected forests, propaganda and educational campaigns are of prime importance. The objective of the propaganda and campaigns is to make the local communities conscious of their dependence on the forests as a source of livelihood.

In an attempt to reduce the impact of fire in protected forests the following fire control measures are prescribed:

a) Controlled burning of fireguards and, around selected areas of productive forest, beating out the fire.
b) Maintenance of fire lines by disking or hand scuffling.
c) For permanent control, the construction of a network of fire lines to be kept clean of vegetation and patrolled.
d) Manning of fire lookout points for observation and communication.

From the early days it was recognised that the KS teak forests appeared to have developed under much less fire risk than that obtaining at present. There was a need to find cheaper means of protecting the forests from fire. Complete protection was considered too costly and far from practicable. Early burning alternating with complete protection in regeneration areas seemed to hold some promise. It was proposed that the most promising and effective way to keep out damaging fire was by controlled grazing. Cattle grazing is still practised today using livestock from forest residents, forest-adjacent communities and commercial grazing leases.

Between 1931 and 1970 extensive early burning in the dry season was practised with the objective of protecting clumps of good young teak growth. Although early burning was initially considered a success, damage to the forest was inevitable and the degree of damage depended on forest conditions at the time of burning. However, early burning was considered essential to supplement the fireguard system. Timing was important if desired results were to be realised. The objective was to reduce fuel levels and therefore minimise the occurrence of devastating late dry season fires. From the time early burning was introduced, concern was raised over its long-tern effect on the forests. It was noted and agreed that it was an extremely difficult operation to time and implement over large forest areas (Judge, 1975). In addition, severe damage to seedlings and pole stage stems was found in early burned forests. Early burning was considered an extremely difficult operation. The fires were either too intense or had no effect. More often than not the fires went out of control. As a result Project E46 was started in 1954/55 in Gwaai forest to understand better the effects of burning at various times of the year. In 1959 doubts were expressed as to the

effectiveness of early burning and the decision was made to confine early burning to known hot spot areas and to concentrate controlled burning on a network of fireguards, harrowed traces and fire lines. Because of these problems early burning was abandoned in 1970.

The early 1960s saw the beginning of the present-day system of fire protection that is centred on early detection, quick reaction and suppression. Success of the system is based on availability of fire towers, communication radios and telephones, efficient road networks and well equipped and highly trained fire-fighting gangs. During this time fire towers were constructed and equipped with compass roses and sighting devices and linked to offices by internal telephones. Tractors were made available for harrowing fire traces and fire lines. Radios are used for communication between fire towers, forest reserve offices and land vehicles. Currently there are fire towers in Bembesi, Gwaai, Umgusa, Gwampa, Fuller, Panda Masuie, Inseze, Ngamo, Sijarira and Sikumi forests.

Fire protection measures in timber concession areas, commercial grazing areas and areas leased for safari operations involve the inclusion of fire protection clauses in the agreements. Concessionaires are required to remove slash to a distance of two meters from any living stem of a commercial timber species. The concessionaires and lessees are responsible for the fire protection of the forests in which they operate. Three main clauses in the agreements with respect to fire protection are that all fires lit by concession in the field have to be put out after use and workers are responsible for fighting and putting out fires that occur in their areas. Workers in concession and leased areas are supposed to help forest managers put out fires anywhere in the forests. To be effective, the FC supervises these conditions.

9.4.2 Timber exploitation

Timber exploitation for commercial purposes has been based on the principle of sustained yield, which is determined in two ways, i.e. through the minimum diameter allowed for harvesting and the cutting cycle. The objective of prescribing a minimum felling diameter is to ensure that the remaining trees grow to harvestable sizes over the cutting cycle period. Only trees of prescribed minimum diameter and above are harvested, and then only if these trees have not been marked for seed production. While this opens the canopy layer to allow regeneration and growth of suppressed trees, the system ensures that at no one time is the forest cover completely removed. In effect, therefore, the dynamics and functioning of the forests continue under minimum disturbance. The exploitation of major forest produce (timber and wildlife) is conducted by the private agencies operating under agreement or licences that are subject to periodic reviews in respect of changes in royalty rates, species and sizes that concessionaires are obliged to take.

Since 1904 timber harvesting has concentrated mainly on three commercial species, *Baikiaea plurijuga* (Zambezi teak), *Pterocarpus angolensis* (blood wood/mukwa/kiaat) and *Guibortia coleosperma* (mchibi) for railway sleepers, furniture and flooring (Judge, 1975). The selection logging system is the main method used in the management of timber production in the forests. The general aim of the selection system is to remove mature and over-mature trees so as to give the residual stock adequate growth resources. The system is supposed to result in stand improvement with a view to bringing the forest to a condition suitable for sustained yield. Under the system the ideal forest stand is described in terms of the number of stems of different species per hectare distributed over a range of diameter classes with the objective of maintaining a mixture of species and a balanced representation of the diameter classes.

The initial logging activities that started in 1904 involved wanton, indiscriminate and unsystematic harvesting practices (Judge, 1975; Calvert, 1986). In 1935, a licensing system was instituted that served to control logging through the felling of marked stems only. A working plan developed in 1966 treated the protected forests on a cutting cycle of approximately 60 years. In the initial cutting cycle, all over-mature trees of commercial species over 35 cm dbh, mature trees not required as seed trees or for the maintenance of canopy cover and diseased trees were liquidated (Judge, 1975). The minimum diameter limit was the only means of regulating yield and the situation has remained the same to this day. The demands of the timber industry have naturally led to the progressive reduction of the minimum utilisable diameters from the initial limits to the current average of 31 cm dbh for all commercial species.

The timber harvesting plans for the protected indigenous forests are based on a sixty-year cutting cycle. The first cutting cycle that covered most of the forests ran from as early as 1910 through to 1970. Effectively a harvested forest or forest block is not returned to earlier than sixty years. This gives the remaining trees time to grow to harvestable size. Currently the forests are going through the second cutting cycle that began in 1971. The second cycle started in the forest that was first logged in 1910. By following the sequence all the forests would have been logged by 2030 after which harvesting goes into the third cutting cycle. Only those forests or forest blocks that are due for cutting are those that should be logged. Divergence from this schedule is taken only after serious consideration of prevailing circumstances pertaining to the specific forest or forest block. For example, some forests have their schedules brought forward when it is considered that incidences of poaching would result in the decimation of the commercial species or where there is a high prevalence of tree diseases such as the mukwa dieback that kills stems of *P. angolensis*.

All timber harvesting operations in the protected forests are conducted in a transparent process. Firstly, forest inventory officers assess areas ready for harvesting to establish timber quantity and the feasibility of commercial timber harvesting operations. Once this condition has been met, tenders are invited through the public media facilities and also electronically

Once a tender has been awarded to the winning bidder, an environmental impact assessment (EIA) precedes all harvesting operations. The EIA aims at establishing all possible impacts of the timber harvesting operation and recommends ways of mitigating these impacts. The EIA is reviewed and approved by the Department of Natural Resources in the Ministry of Environment and Tourism. Timber harvesting proceeds only after approval of the EIA.

The FC reviews and, if satisfied, approves cutting plans submitted by the timber concessionaire. Among the key attributes of a successful cutting plan are proof of inventories conducted, minimum allowable diameters to harvest and volumes allowed to be harvested over the cutting period, and proof of adequate vehicles and equipment. A monitoring mechanism is put in place and is conducted by FC officers. The mechanism is aimed at controlling the species harvested, minimum harvestable diameter to harvest and allowable volumes to be harvested. In addition a checklist for pre- and post-harvesting inspection is mandatory. Further, annual audits are carried out to ascertain if timber harvesting operations are following the Timber Harvesting Policy (Gonah, 1994) and the Code of Timber Harvesting Practice (Forestry Commission, 2006).

A timber concession is a contractual agreement between the FC and an individual or group of people to harvest timber from a delimited forest area. The current maximum allowable period for a concession is five years. The timber harvesting agreement is renewed annually. The timber concession system in Zimbabwe originated in 1935. There is therefore considerable experience in concession procedures such as resource inventories, determination of sustainable yield, preparation of cutting plans, handling of concession process, policing and monitoring. A legal framework regulates timber concession procedures.

9.4.3 Wildlife management

One of the programmes that has added significant value to the protected KS teak forests of western Zimbabwe is wildlife management. The FC's ability to bring water and at times artificial feed (in times of drought) into the forests has resulted in greater numbers of almost all Zimbabwean wildlife species becoming residents in the protected forests. Through this programme, the FC's Ngamo Safaris prides itself on being one of the biggest safari operators in the country. This programme is of immense economic value to the FC, the local communities and the country.

When the Forestry Division was created in 1930 pioneers of the Division recommended that wildlife in the protected forests should enjoy game reserve status and complete protection. It was recognised that wildlife had to play an important role in the multiple land use concept of the protected forests, particularly in the tourism sector.

Wildlife management activities are grouped under the following management objectives: (i) to maintain a diversity of wildlife populations, paying close attention to the environmental requirements of the species concerned; (ii) to manage wildlife on a sustained yield basis for recreational purposes; (iii) to cull populations that show tendencies to build up beyond habitat limits; and (iv) to co-ordinate wildlife management with timber, agriculture and livestock grazing management.

9.4.4 Wildlife management in Zimbabwe

During the early 1950s there were moves to investigate the economic potential of wildlife in Zimbabwe. This led to three students from America being awarded Fulbright Research Grants in Zimbabwe. Thane Riney, one of the students, produced a working plan for wildlife management after spending much of his time in Hwange National Park. During this time Guy, the then Conservator of Forests in Matabeleland, invited Riney to visit Gwaai and Gwampa forest reserves to assess the wildlife situation. Other recipients of the Fulbright Research Grant were Mossman and Dasman who visited the lowveld in 1959 to study the wildlife situation there (Judge, 1975). The researchers recommended that the best approach to wildlife management in the areas they had visited was for landowners to economically manage the game on their property. Today the management of wildlife on different land categories is in line with these recommendations.

9.4.5 Wildlife management in protected forests

After the forest reserves were gazetted wildlife was protected from illegal hunting. Anti-poaching operations and the reduction of predators were the main management activities. In 1966 active game management was introduced in Gwaai, Bembesi, Ngamo, Sikumi, Gwampa, Fuller, Kazuma, Panda Masuie and Sijarira forest reserves. The management practices included provision of pumped water, anti-poaching, control of predators, and prevision of salt licks, population census, determination of quota and translocation and introductions. Although control of predators such as lions and wild dogs was undertaken in the early days, at present it is considered a desirable biological force. These activities are still being practised today.

The objective of water provision is to ensure favourable distribution and survival of wildlife populations. Anti-poaching activities are necessitated by the fact that forest inhabitants and communities living adjacent to the forests often hunt game for subsistence and they are generally considered a threat to sustainable management of wildlife in the absence of some arrangements that make them custodians of wildlife and beneficiaries of wildlife-related enterprises. A large portion of the annual budget was spent on anti-poaching activities.

For successful wildlife management in the protected forests a number of areas are targeted. These areas include:

- Annual game censuses that involve taking stock of existing populations. Combinations of methods are used to obtain reasonable estimates of species populations. The methods include 24-hour waterhole counts, spoor counts, walking strip counts, aerial counts, daily forest guard observations and hunting reports. An analysis of the census data provides essential information on the present status of the wildlife species populations and facilitates prediction of trends in composition and structure of these populations.
- Studies of the characteristics of various species including mating habits, sex/age ratios, breeding age, number of young at birth, feeding and roosting ranges, mobility, migration, saturation point, carrying capacity, habitat requirements, food preferences, water requirements and diseases.

9.4.6 Wildlife-related development in protected forests

Certain forests have been developed for eco-tourism purposes either by the FC or by private safari operators. The forests developed by the FC have largely involved wildlife introductions and the provision of game water points in Gwaai, Bembesi, Ngamo, Sikumi, Fuller, Pandamasuie and Kazuma forests. This development also included the construction of hunting camps in Gwaai, Ngamo, Kazuma, Fuller and Sijarira forests; the construction of photographic camps in Fuller and Sikumi forests; and the construction

of airstrips in Gwaai, Gwampa, Sijarira and Ngamo forests. The FC has also constructed a small-boat harbour on the banks of the Zambezi River in Sijarira forest. This infrastructure is in line with the organisation's emphasis on wildlife-based income-generating programmes in order to boost financial resources required for the management of the forests. These programmes complement timber harvesting activities for the same purpose.

Issues related to wildlife management in the protected forests are the responsibility of the wildlife ecologist with assistance from territorial staff.

9.4.7 Forest inventory

The exploitation of forests is plagued by destructive harvesting, over-exploitation and a basic disregard for the functional ecology of the plant populations and communities. One of the essential ingredients required for sustainable forestry is information. This information generally includes the density and distribution of resources in a forest, the population structure and productivity of the resources, and the ecological impact of harvesting levels and quantities of timber and non-timber products. This information can only be obtained through quantitative and qualitative forest inventories.

It is the responsibility of the FC's Mapping and Inventory Unit to conduct inventories in collaboration with the forest ecologist with assistance from territorial staff. In addition it was the duty of all territorial staff to add to the forestry records data and information pertaining to botany and vegetation types

Historically forest inventories were mainly focused on commercial timber species. In the last two decades the inventories have taken on board non-timber forest products. A combination of methods is used including field surveys and interpretation of aerial photographs and satellite imagery, ground proofing, the inventory proper and mapping. Information on the forest resources is gathered all at once, thus rendering the practice cost effective in terms of human, financial and material resources. Sometimes unscheduled inventories are conducted when circumstances demand that a concession be awarded in a forest before the scheduled harvesting period. As an ongoing regular practice, timber inventories have been conducted in Fuller, Mzolo, Gwaai, Bembesi, Inseze, Inseze Extension, Lake Alice, Umgusa, Sikumi and Ngamo forests. These inventories assist in refining management plans as new information and data on the current status of the forest resources is gathered. The information also assists in planning for forest resources utilisation programmes.

Staff involved in planning and conducting forest inventories have requisite skills in cartography, aerial photography and photogrammetry, statistical analyses, data capture and processing, mensuration techniques and the management of inventory resources, i.e. finances, manpower and equipment. Information acquired from inventories is used over a period of several years and hence errors during inventories may be costly in terms of accuracy and incompleteness.

The first known forest inventory in western Zimbabwe was done using the viree method. For a 5 percent enumeration, a base line was laid out and viree pegs put at 400 m intervals. On each viree, which was at right angles to the base line, every tree of *Baikiaea plurijuga*, *Pterocarpus angolensis* and *Guibourtia coleosperma* was measured for diameter. Each 200 m was marked off to represent a 0.5 ha plot. All trees that were 35 cm dbh over bark and over were recorded in 6 cm classes. Class I trees were 35 cm dbh and above, class II trees were 27cm to 33 cm dbh over bark, Class III were 19 to 25 cm, Class IV were 11 to 17 cm and Class V were 3 to 9 cm dbh over bark.

In each 0.5 ha plot the following were also recorded: the height of the commercial species to the nearest 1 metre; common shrubs in order of frequency and their approximate density; grasses and herbs and their approximate density, grazing intensity and soils and their colours and regeneration per species. The designs of the sampling units have changed from the viree transects to circular plots while the parameters and variables measured and recorded have remained almost the same.

Forest inventories are carried out as prescribed in the procedures manual (Kwesha and Mkosana, 1992). The manual states the steps to be followed in preparing and conducting an inventory.

9.4.8 Forest research activities

The early studies and research activities in the KS teak forests concentrated on the description of their vegetation types and structure (Judge, 1975; Calvert, 1986). The main objectives were to deepen knowledge on the original structures of the forests and on the commercial products that they contained. At the same time a considerable number of permanent sampling plots were established and have been measured continuously until today. The plots were intended to gain knowledge in order to improve silvicultural methods. In the recent past an ecosystem-oriented approach has received considerable attention in forest research in protected forests. A typical characteristic of this method is the interdisciplinary approach involving social, economic, ecological and institutional aspects. Some of the research areas since early days include vegetation studies including phenology and autoecology, pests and diseases, grazing by cattle, effects of logging, regeneration surveys, review of timber properties, germination requirements of indigenous tree species, soil types, growth studies, root morphology and wildlife ecology. Several of the studies were concluded while others are ongoing and the results obtained have been valuable in the management of protected forests.

The Forest Research Centre at the FC's headquarters in Harare is staffed with researchers of various disciplines including tree breeders, silviculturists, entomologists, pathologists, sociologists and economists. These specialists have the responsibility of assisting forest managers in the protected KS forests in conducting relevant research. They also collaborate with the forest ecologist and wildlife ecologist in the western region.

9.4.9 Silviculture

From the early days of forest management it was recognised and noted that the silviculture of the indigenous forests was closely linked to incidences of fires, commercial and subsistence harvesting, wildlife and land husbandry activities of the forest occupants. These are considered important factors controlling the establishment and growth of forest vegetation. Depending on their intensities and frequencies these controlling factors can either improve or hinder the development of forest vegetation. Knowledge of the silviculture of the indigenous forests and their component species is still being improved on.

Most of the silvicultural work in the protected KS teak forests involves attempts at understanding the effects of silvicultural treatments on stand and individual tree growth; methods of and requirements for natural regeneration; impacts of pests and diseases on tree growth; responses of woody species to varying intensities and frequencies of grazing, browsing, fire and exploitation; methods of artificial regeneration including nursery techniques; effects of the removal of competing vegetation on the growth and development of desirable species, and various methods of protecting artificially regenerated woody species (Judge, 1975; Malaya, 1986). Currently, there is a lot of information on these important issues, most of which is largely found in reports and publications of the Forest Research Centre of the FC. Despite the presence of this valuable information, implementation of the study results has been poor due to lack of appropriately trained personnel in the field of indigenous forest silviculture. The studies and implementation of silvicultural prescriptions are the responsibility of the silviculturist-indigenous forests.

Between 1990 and 1998 the project "*The ecology and management of indigenous forests in Zimbabwee* was co-sponsored by the Zimbabwean and Swedish Governments. The project covered a number of issues related to silviculture including secondary succession in Miombo/Baikiaea woodland, population structure of *P. angolensis*, artificial regeneration of selected indigenous tree species and thinning and copping trials in *C. mopane*. A summary of the findings is included under the results section.

9.4.10 Community participation

Forest management programmes must necessarily benefit the local people as well as include their participation. There must be a sense of ownership of nearby forests by local communities. The FC is currently encouraging the involvement of forest-adjacent communities in selected forests to achieve partnership in forest management.

In the early 1990s, the FC recognised that some forest values were being neglected especially the provision of non-timber forest products. In the history of management in protected forests, timber assumed major importance and appeared to be the only significant forest output. For the rural populations the prominence of timber and its products was ill founded. The reality was, and is, that non-timber forest products contribute enormously to the livelihoods of rural people. The FC initiated forest resource sharing programmes in Mafungabusi forest and shared forest management in Gwaai/Bembesi forests with forest-adjacent communities. The purpose of the new approaches to forest management is to improve local peoples' livelihoods while ensuring that the forests are well conserved. These programmes have formalised access to collectively agreed forest products. These products are consumed directly or are marketed for income generation.

In 2000 and 2004 the FC enunciated policy strategies that would allow local people to participate actively in forest-based income-generating businesses, such as timber logging and photographic safaris, and benefit from a Social Forestry Fund that is earmarked for developmental projects in areas adjacent to protected forests.

A common feature of these arrangements has been negotiations and conflict management between the FC and forest-adjacent communities on aspects of co-management, resource and benefit sharing, establishment and strengthening of local institutions, capacity building and drawing up rules and regulations for the use of mutually agreed forest resources. The processes started with the development of a project proposal by the FC with participation from communities and forest user groups. This was then followed by ecological surveys of the biophysical resources and, finally, implementation. Important responsibilities of communities in these co-management arrangements are the drawing up of consultative forest management plans, regular patrols to check for encroachment or for illegal activities, fire fighting, sanctioning those breaking the rules and regulations and education campaigns. All these activities are carried out in order to ensure the sustained supply of goods and services that the forests render. Most resources are harvested on an individual basis according to rules established in the community forest management plans.

Chapter 19.05 of the Forest Act of 1996 allows national citizens and local communities to harvest forest resources in limited quantities for their own consumption or income generation. In forests where there are no co-management programmes the FC issues simple licences for such purposes. Normally the contracts are short-term. The licences specify the period, type of resource and quantity to be exploited. Examples of such licences are those awarded for thatch grass and firewood harvesting. The licences do not normally require the installation of individual plants for processing the products. In practice, licence holders take no responsibility for the integral management of the forest except for fire protection.

9.4.11 Management of forest occupants

There is considerable land in the forest areas that, although it is integral with the forest, is more suitable for agricultural production than forestry. Such land is found mainly along the valleys where the soils are more varied and heavier in texture. Before the forests were gazetted indigenous African people occupied the valley areas of most of the currently protected forests. After the forests were gazetted the FC's policy was to incorporate some of the indigenous people as forest tenants on small agricultural units. The plan for the numbers and distribution of the tenants took into account such factors as forest protection and development. As far as the tenant system and agricultural development and management were concerned the forests fell into four groups as follows.

Gwaai Group (Gwaai, Bembesi and Ngamo forests)
Umgusa Group (Umgusa, Umzibani, Inseze, Inseze Extension and Chesa forests)
Gwampa Group (Gwampa, lake Alice and Molo forests)
African Area Group (Mafungabusi and Mzolo forests)

The objectives of the forest tenant system were to:

- create a plan for the optimum use of forest land and agricultural resources for the benefit of the Matabeleland region; utilise the agro-ecological potential of the forest areas taking into account the social and ecological factors and the need to integrate and balance agricultural development with forestry and wildlife management;
- manage the tenant community so that it plays its role in forest protection;
- devise a farming system based on cattle and veldt management that complements the forest enterprise, and allocate arable land to the required number of forest tenants so that the holdings, together with livestock production, would provide tenants with the opportunity to improve their livelihoods;
- establish an Agricultural Unit with trained staff and necessary resources to carry out required agricultural management and extension in forest areas;
- establish and maintain good working relationships between agricultural and forestry staff and other relevant departments and organisations so as to demonstrate the good results of agricultural management in protected forest areas.

It was generally appreciated in the early days of forest management that the KS forests were best suited to indigenous hardwood production together with wildlife management and cattle production. The valley and vlei areas, although located within the productive forest areas, are distinct from the timber production areas and more suited to intensive livestock production supported by small grain production.

It was anticipated that the development of a well organised tenant community in the forest areas would buffer the forests against future outside population pressure while providing a livelihood for a considerable number of tenant families. Thus, the multiple land use concept was considered to have many aspects and repercussions inside and outside the forest areas. The concept was taken as one of holistic forest management that reinforces the mutually supporting attributes of the various forest enterprises and reduces conflicting attributes.

The planned number of tenants for each forest group and their distribution was calculated on the basis of livestock carrying capacity and available arable land. The forest areas were to contain a number of economic agricultural units that would allow acceptable levels of income generation for the number of tenants that was consistent with forest management. Table 3 gives a summary of the Agricultural Plan Data.

Table 3: Summary of Agricultural Plan Data

Forest Group	Tenants' L.U.* numbers.	Arable (ha)	Tenant permit holders
Gwaai	9 060	9 000	180
Umgusa	6 010	5 900	118
Gwampa	9 140	9 100	182
Mzolo/Mafungabusi	4 600	21 000	420
Total	**28 810**	**45 000**	**900**

(Source: Judge, 1975; * L.U. denotes livestock unit equivalent).

During the intensification of the Zimbabwe war of liberation in the western region there was an increased influx of illegal settlers into the protected forests. This resulted in an increase in the population of forest occupants and an increase in illegal activities including opening up of forests for settlement and agriculture and illegal harvesting and collecting of forest products. By the time of Zimbabwe Independence in 1980 the number of forest occupants had risen to unmanageable proportions. At this stage the FC sought to evict all households from the forests including the ex-tenants. The strategy was not successful due to political interference. Evictions were not popular with politicians since the liberation war had been fought under the premise that people would get back land that had been appropriated by the

colonial regime, including forest lands. The table below shows the current human and livestock population in affected protected forests.

Table 4: Current numbers of human and livestock population in protected forests

Forest	Number of households	Total population	Area opened for settlement & croplands (ha)	Number of livestock (cattle)
Gwaai	552	5949	1104	-
Bembesi/Molo	997	7419	2860	-
Umgusa	107	949	250	1040
Chesa	59	739	220	615
Gwampa	51	306	50	300
Lake Alice	175	1400	350	-
Inseze	333	2874	750	2870
Inseze Extension	55	220	30	-
Ngamo	105	749	210	-
Mzolo	552	4868	4500	-
Kavira	34	376	-	-
Mafungabusi	166	680	-	-
Grants	53	486	120	244
Umzibane/Franklands	24	255	60	192
Sikumi	12	17	3	-
Total	**3275**	**27287**		

(Source: Forestry Commission, 2004).

Currently the FC controls the human and livestock population through annual censuses and by discouraging new entrants. The Forest Protection Unit regularly patrols the occupied areas in an effort to control and reduce illegal utilisation of forest products. In Gwaai, Bembesi and Gwampa forests households have been relocated in designated areas for proper control and to limit encroachment to core conservation zones. In some of the forests there have been initiatives towards participatory involvement of forest occupants in the management and conservation of local woodland resources. Extension work plays an important role in these initiatives

10. TOOLS USED FOR PLANNING AND MANAGEMENT

In the past effective conservation and management of the KS teak forest was difficult due the lack of comprehensive baseline vegetation and other biophysical data and information. As of 1993, the FC with assistance from the German Agency for Technical Co-operation (GTZ) launched a vegetation mapping and monitoring system (VegRIS) under the auspices of the Research and Development Division of the FC. VegRIS employs state-of-the-art technology such as satellite remote sensing, aerial photography, geographic information systems (GIS) and global positioning system (GPS) to provide up-to-date information on protected forests in terms of vegetation cover, cover change, forest types in both spatial and temporal dimensions, forest encroachment, distribution and numbers of forest settlements and fire occurrence. Remotely sensed data are normally obtained from landsat multispectral scanner (MSS), landsat thematic mapper (TM) satellite imagery and black-and-white vertical aerial photos. GIS contains a large amount of spatial and attribute data. The remote sensing and digital image processing software used by the Mapping and Inventory Unit of the FC includes ARC/GIS, ARC/INFOR, ARCVIEW, IDRISSI, TNT MIPS and ERDAS. The Unit has developed this GIS database with assistance from territorial staff in

the western region. Extensive ground verification exercises are conducted to validate the preliminary interpretation from satellite images and aerial photographs.

The outputs from VegRIS are woody cover database and forest maps at various scales showing different attributes of the forests, e.g. vegetation types, fireguards, fire lines, borehole sites, location of forest stations, different types of access roads, forest blocks/compartments, forest zones by use, topographic information, fire towers, forest settlements, cultivated areas and external forest boundaries.

Chesa Research Station, a sub-station of the Forest Research Centre, participates in the fire monitoring system for the SADC region in conjunction with the University of Maryland in USA. Information from this monitoring system complements annual forest fire reports compiled by territorial foresters. This has improved the system of accounting of forest fires in the protected KS forests. Fire maps are produced every five years using information from these two fire monitoring systems.

This information is used in the planning, management, updating of management plans and control and monitoring of the protected forests. Studies and research in the different aspects of the protected forests have resulted in a huge accumulation of data. These are stored in two forms, i.e. hard and soft copies. The ordinary Microsoft programmes excel and access are used for the storage and analysis of some of the research data.

11. COSTS INCURRED IN THE IMPLEMENTATION OF MANAGEMENT

Generally the costs of protecting the KS forests are much lower than the revenue collected. The accounts of the division responsible for managing the forests for the six months ending 30/09/06 (Table 5) show in more detail that over 44 percent and 33 percent of costs are attributable to casual labour employed during the fire season and the running of vehicles and equipment, respectively. Timber harvesting and sale of animals to Ngamo Safaris contribute 46 percent and 27 percent of the revenue generated.

Table 5:Forestry Commission revenue and expenditure[3] for nine months ending 30/09/06

Revenue item	12 months	Percent of total
Timber harvesting	79 980 420	46.50
Sale of animals-Ngamo	47 412 000	27.09
Sale of animals-other	16 430 000	9.55
Camp leases-Ngamo	90 000	0.05
Camp leases-other	4 991 587	2.90
Grazing	4 556 584	2.64
Firewood	2 305 043	1.34
Other	16 228 095	9.43
Total	**171 993 729**	
Expenditure		
Casual labour	12 847 079	44.35
V & E	9 798 979	33.82
S & T	784 056	2.70
Printing and stationary	307 637	1.06
Telephone	994 831	3.43
Maintenance of assets	1 171 479	4.04
Security	0	0
Electricity and water	206 829	0.71
Carriage charges	97 637	0.33
Rents and rates	6 260	0.02
Meetings	33 473	0.11
Other purchases	1 426 872	4.92
Field operations	1 290 269	4.45
Total	**28 965 401**	
Surplus/(deficit)	**143 028 328**	

(Source: Forestry Commission, 2006.)

12. RESULTS AND DISCUSSIONS

The KS teak forests of western Zimbabwe provide timber, non-timber products, grazing resources, agricultural land and wildlife. From the inception of forestry in Matabeleland it was realised that individually any of the multiple use components of the forests would give a low economic return in relation to land area. Complementing each other the components provide an entirely different picture and considerably increase the socio-economic potential of the forest reserves. On the other hand it was apparent that there was bound to be conflict in the management of timber, wildlife and a resident forest population that was engaged in livestock and crop production. None of these entities could be managed in isolation. Management plans take this factor into consideration. Compromises are always made without losing sight of the fact that timber and wildlife are of paramount importance.

12.1 Fire

Since 1970, fire suppression efforts have been concentrated on limiting the impact of fires. This is achieved through the establishment of a system allowing rapid detection of and response to fires. Key components of this system include fire towers, radio communications, good access roads, adequate manpower, tools and vehicles. In recent years the system has not worked as effectively as required. An average of 15 000 ha of protected indigenous forests are destroyed by late dry season fires annually (Table 6). This is partly due to inadequate resources needed for effective fire protection measures as annual government grants have been progressively reduced over the years. Radical changes in the

[3] 1 Nov. 2006: USD 1.00 = 259.00 Zimbabwe Dollar

approach to fire protection are necessary. There is a limit to the amount of protection that can be achieved with the manpower, finance and equipment resources available. The practice of harrowing and grading all fireguards and traces and fireguard burning are costly and in any case a considerable number of fires result from breakouts from own burning operations. The present road system in the forests is inadequate in terms of layout and ability to carry fast-moving traffic. The days of being able to call on reserves of labour from sawmill compounds, logging teams, forest neighbours and tenant villages in fire emergency are over. At the height of the fire season, standby crews are few and these fire fighters require regular training in order to be effective.

Nowadays, unlike in the past, it is impossible to avoid the starting of fires in protected forests due to increased human activities in them (Table 7). The best alternative would be the calculated reduction or elimination of the herbaceous fuel load before the damaging hot dry season of August–October. It appears that the solution to the reduction of fuel load without use of fire lies in the long advocated use of grazing cattle, complemented by wild animals. While it is difficult to use wildlife for this purpose, at least cattle can be manipulated to reduce fuel load.

The greater the value of the forest the smaller the protected block and patrolling, which should be intensified. Fire protection activities in western Zimbabwe have progressed from the humble yet effective efforts of the 1920s to the comparative sophistication of the present day. However, incidences of fire and the relationship between area damaged each year and the area protected does not vary appreciably. High risk areas have been identified as those adjacent to the Bulawayo-Victoria Falls road and railway line and those adjacent to communal and resettlement areas. Cases of arson and fires started by squatters are an indication of the ever-increasing conflict between the FC and the squatters. Poachers use fires to divert attention during their operations. Under these circumstances large-scale early burning may be justified as inflammable material is eliminated early in the year. Although early burning may be a difficult operation to time and carry out effectively over large areas it can be the cheapest and most certain method of reducing the fire hazard given the limited resources for the current complete protection approach. There are pertinent questions about fire protection that require urgent attention. Protection measures in force date back many years - are they still applicable today? Is it really necessary to harrow or grade so many kilometres of fireguards and fire traces? Why do so many fires result from own burning operations? Most importantly, what is being protected? These questions become more pertinent considering the amount of forest lost through annual fires.

In the KS teak forests fire occurs basically at the forest floor level in fuels ranging from 2 cm to 5 cm of leaf litter to 2 to 3 m of dense grass and heavy regrowth (Calvert, 1986). Fire intensity rises from a low level at the beginning of the dry season to a peak in the hot dry season, falling gradually with the rise in humidity associated with the onset of the rains. The risk of fire is determined at least in part by the fuel load, and increases in proportion to herbaceous production, which is strongly influenced by the previous annual rainfall. Frost plays a critical role in increasing the risk of fire. As a result of its killing effects on vegetation frost results in an increased amount of fuel load and in the depth of fuel, such that the impact of fires occurring after severe frosts is likely to be much more marked than usual.

Logging operations directly increase fire hazard. Logging results in disturbance to the forest floor through dragging of logs. The disturbances result in an increase in grass growth, which significantly increases the risk of fire. In addition the slash that results from log preparation adds to the amount of fuel load on the forest floor. The relatively persistent fuel load response following logging operations could be reduced by adopting fewer site destructive extraction techniques such as felling and loading at stump. Equally important would be to spread out logging slash over the forest floor to avoid fuel load concentration.

Fire damage affects small plant materials low down in the fuel layer, while basal scarring of timber, cambial damage and crown scorch increase in severity and height above ground as the fire season progresses. Repeated burning has a cumulative impact on the woody vegetation. More frequent and severe fires occurring in the later part of the hot dry season will cause the woody community to move more rapidly towards grassland communities. Greater use should be made of the findings of the fire studies, most of which indicate that complete protection results in the highest regeneration and stocking density,

and early burning has been found to maintain good regeneration. Complete protection favours the regeneration and establishment of fire tolerant species such as *Pterocarpus angolensis, Burke africana and Erythrophleum africanum* (Farquhar, 1977; Calvert, 1986). This indicates the need for differential fire management for different vegetation communities and woody species. Understanding these factors and basic fire ecology should be the thrust in protecting protected forests.

Since the introduction of complete fire protection each fire, together with relevant data and information, is recorded including area burnt, reaction time, time spent putting out the fire, weather conditions, etc. (see Appendices 2a and 2b). The information helps to identify high-risk areas and causes of fire and to refine protection strategies. Despite these fire protection activities fire is an annual occurrence in the KS teak forests. Below is a summary of forest areas burnt between the 1989/90 and 1991/92 fire season.

Table 6: Summary of forest area burnt between 1989/90 and 1991/92 (ha)

Forest area	1989/90	1990/91	1991/92	Total area burnt (ha)	%
Gwaai	11 465	6 736	5 521	23 722	16.4
Panda-masuie	1 600	10 290	200	12 090	36.1
Gwampa	4 500	2 675	3 100	10 275	26.3
Bembesi	74	2 534	4 520	7 128	12.8
Lake Alice	0	100	4 900	5 000	15.5
Ngamo	13 094	1 615	24 500	39 209	38.1
Mafungabusi	1 052	11 527	0	12 579	12.0
Sikumi	17 400	6 200	0	23 600	42.4
Kazuma	3 500	9 465	0	12 965	54.0
Umgusa	9 600	0	0	9 600	29.8
Total	**92 285**	**51 141**	**42 741**	**186 168**	

With regard to the causes of fire, Table 4 provides a breakdown of causes for 167 fires recorded over a four-year period from 1985 to 1989 throughout the protected KS teak forests (Gondo, 1993). Some 60 percent of the fires are associated with forest and neighbouring residents, and these fires account for 75 percent of the total burnt area. During the period poachers caused 28 percent of the fires, neighbours 13 percent, travellers and smokers 13 percent and lightening 4 percent. These data suggest that there is potential for reducing the extent of fire through the establishment of harmonious relations with forest dwellers and forest neighbouring communities. Sometimes several reported fires have unknown causes indicating that investigations were not thorough enough.

Table 7: Causes of fire and corresponding areas burnt within protected indigenous forests over a four-year period (1985/86–1988/89)

Causes of fire	Number of fires	Area burnt
Fires relating to residents within or around the forests		
Forest dwellers	6	5 054
Herd boys	13	2 630
Grazing by adjacent farmers	25	32 292
Honey hunters	8	531
Poachers	47	124 157
Arson	1	22 000
Subtotal	**100**	**186 622**
Fires relating to other causes		
Lightening	7	12 569
Steam locomotives	9	4 790
Travellers along main roads	21	13 186
Breakouts from controlled burning	2	2 160
Unknown	28	33 321
Subtotal	67	66 026
Overall total	**167**	**252 690**

(Source: Forestry Commission, 1993)

12.2 Timber exploitation

The high demand for good quality timber has contributed to extensive logging of the protected forest reserves in Zimbabwe. This has resulted in over-exploitation of the commercially important tree species, thus driving the reserves towards secondary forests. In addition there are concerns about poor natural regeneration of the preferred commercial species. Over-exploitation coupled with increasing demand has resulted in forests being dominated by small diameter timber, as evidenced by the reduction in the minimum allowable diameter from 45 cm to 31 cm and sometimes 27 cm between the first and second cutting cycles. The situation is not sustainable in the medium- to long-term future. Alternatives could lie in imposing a moratorium for the heavily affected species in specific forests and charging premium fees for highly preferred ones such as *P. angolensis*. These alternatives should be built into the existing Timber Harvesting Policy and Timber Harvesting Code of Practice. This could reduce demand and allow recovery of the forests. The current timber royalty fees (stumpage price/m^3) are ZW$ 30 000/US$ 120 for all commercial species and all types of logs (Forestry Commission, 2006). It is the contention of the writer that these low prices cause wasteful logging and processing practices of valuable timber resources.

Table 8: Timber concessions operating in protected forests

Protected forest	Number of concessions	Total area of forest	Concession area	Annual off take
Gwaai	2	144 000		9 600
Gwampa/Lake Alice	1	86 000		4 800
Inseze Extension	2	8 400		9 600
Fuller	2	23 000		9 600
Total	**7**	**261 400**		**33 600**

(Source: Forestry Commission, 2006).

Table 9: Timber cutting cycles by forest in the protected forests

Forest reserve	Year exploited	Cycle
Part of Inseze	1910	1st
8 km belt of rail line in Umzibane, Franklands, Gwaai Block 'O', Sikumi and Ngamo	1910	1st
Ngamo 16 km belt north of rail line	1925	1st
Sikumi 16 km belt north of rail line	1925	1st
Umgusa Block 'B'	1927/27	1st
Panda Masuie	1926	1st
Rest of Umzibane	1930	1st
Bembesi	1932	1st
Gwaai Block 'A'	1944	1st
Gwaai Blocks 'B & C'	1947	1st
Rest of Inseze	1947	1st
Umgusa Block 'B'	1947	1st
Gwampa	1948	1st
Gwaai Blocks 'E-J'	1951	1st
Umzibane (unofficial re-entry)	1952	1st
Molo	1954	1st
Chesa	1955	1st
Gwaai Blocks 'K-L'	1961	1st
Umgusa Block 'B' (re-entry)	1963	1st
Lake Alice	1965	1st
Gwaai Blocks 'M&N'	1965	1st
Gwaai Blocks 'M&N' (re-entry)	1969	1st
Gwaai Block 'O'	1970	2nd
Umgusa Block 'A&B'	1975	2nd
Bembesi Block 'C'	1986	2nd
Inseze	1986/87	2nd
Inseze Ext.	1986/87	2nd
Gwaai Block 'A'	1988	2nd
Gwaai Blocks 'H&N'	1988	2nd
Gwaai Block 'J&H'	1992	2nd
Gwaai Block 'B'	1994	2nd
Gwampa (east of Byo-Nkayi Rd)	1994	2nd
Gwaai Blocks 'C&G' (north of Byo-Vic Falls RD)	1996	2nd
Bembesi Block 'A'	1996	2nd
Mzolo	1996	1st

The harvesting of timber and non-timber forest products in the KS teak forests is carried out by the selection system. The system has generally been found to be one of the most difficult forms of silviculture to apply properly in dry tropical forests, as the forest stand dynamics are not yet fully understood. However, if not well executed this type of harvesting practice may result in damages to the remaining growing stock and therefore forest recovery may take a long time.

Under the co-management programmes, forest resources sharing and shared forest management there is a need to up-scale the initiatives to other forests. The slow progress appears to be due to the lack of skilled and experienced personnel in the area of participatory forest management. The current approach of giving this responsibility to conventional foresters is not yielding expected results. In addition to promoting community programmes in the forests under their management, the foresters are expected to plan and implement other management programmes in the forests. Given the large size of most of the forests above

20 000 ha, and large communities around the forests, the tasks become untenable. The foresters are expected to plan and implement participatory management and utilisation of quite a wide range of non-timber forest products that include fuelwood, building materials, wood for household utensils, wood for curio carving, wild fruits and vegetables, medicinal plants, honey and beeswax, game and game products, thatch and broom grass, and grazing. This is no mean task for personnel who have been accustomed to conventional forest management and management approaches that focused on very few forest products. A major drawback with respect to the harvesting of non-timber forest products is a lack of resource inventories in several forests where subsistence harvesting of resources is taking place.

12.3 Wildlife management

Wildlife is one of the most important products of the KS teak forests. It is mainly managed for recreational purposes such as hunting and photographic safaris. An important aspect of its management is determining the characteristics of its population including distribution. A number of game population censuses are conducted annually for this purpose. At best any census method merely produces an index of the density and distribution of wildlife species in the forests. For the KS teak forests the collection and collation of key pieces of information pertaining to wildlife population characteristics has still a long way to go. This can be attributed to lack of qualified long-term serving wildlife ecologists within the FC. Setting conservative hunting quotas should be adopted in order to ensure sustainability.

Currently, the FC operates four hunting safari camps and leases out three. It also runs two photographic camps. In the late 1990s, 12 sites in selected forests were leased out to private photographic safari operators. In 2000, the FC took the initiative of inviting black indigenous Zimbabweans to participate in the eco-tourism industry. This initiative culminated in a policy reform where the FC gives out stakes to local communities and interested black indigenous Zimbabweans in the hunting and photographic safaris in the forests. This policy move was intended to make local people benefit from the conservation objectives of protected forests as well as ensure sustainability of the wildlife resource in forests.

Approximately 40 species of wildlife are resident in the protected forests of western Zimbabwe. Most of these species are of interest to consumptive and non-consumptive safari outfitters and are also used for re-stocking and introduction. Some 25 species of terrestrial and aquatic birds are also found in the forests. Their recreational and sporting value is high too.

12.4 Forest inventories

A number of forests have been inventoried and the status and characteristics of the various resources are known. The basic concept of forest inventories is to provide a constant or regular flow of diagnostic information about the ecological responses of timber and non-timber resources to varying degrees of management prescriptions and exploitation. Sustainable use and management are achieved through the continual process of adjusting management prescriptions and exploitation levels. The exact nature of this adjustment process depends on the experience of resource managers, the effectiveness of harvesting controls, the precision of the diagnostic data collected and the ecological behaviour of the resources. Currently the standard of data collected in the forest inventories is high in terms of information on vegetation types, the diverse forest resources and their patterns of distribution, volume estimates albeit of commercial timber species only, forest areas and forest stand structure and composition. What seems to be lacking is comprehensive information on non-timber forest products given that almost all protected forest reserves are under harvesting pressure from forest-adjacent communities. Availability of the relevant non-timber forest products data and information would assist in planning for utilisation programmes in order to achieve sustainability.

Results of timber volumes for inventories carried out between 1937 and 1975 are shown in Appendix 3. In the late 1980s, there were concerns about the depleting timber resources in the protected KS teak forests. Several forests were inventoried and these results are shown in Appendix 4. The results were taken as the baseline information for the production of the first ever management plans for the protected forests. Other inventories have since been done in Mzolo, Fuller, Mafungabusi, Gwampa and Lake Alice.

12.5 Research activities

The effects of timber over-exploitation, repeated fires, grazing, clearing of vegetation for fuelwood, agriculture and settlements have exacerbated the conversion of forest areas into secondary forests and wooded grasslands. In order to reverse the trend the FC embarked on corrective measures based on sound technical information obtained through research on the various aspects of the indigenous forests (Forestry Commission, 1996). The general objective was to develop methods for the management of protected forests under sustained yield and to protect biodiversity. Specific objectives included:

- Undertaking *in-situ* and *ex-situ* gene conservation measures to protect endangered tree species from extinction. This involved the establishment of 11 strict nature reserves (SNRs) in protected forests capturing the genetic variation of the target species and ongoing collection of seed from natural stands and its storage in the Seed Centre at the Forest Research Centre; and phenology studies on target species. SNRs are assessed for ecological and forest biodiversity changes every five years.

- Determining growth models of important indigenous tree species, since successful management and sustainable use of forest biodiversity requires a good understanding of the growth dynamics of individual tree species. This involved the establishment of permanent sample plots (PSPs) complemented by permanent increment plots (PIPs) established within the network of SNRs. By fitting growth data to regression models, diameter increments of four species have been established. The annual diameter increment ranges (mm) are 1.25-2.04; 1.30-2.72; 1.02-2.37 and 0.98-2.24 for *B. plurijuga*, *P. angolensis*, *G. coleosperma* and *T. sericea*, respectively.

- Understanding the natural dynamics/ecology of indigenous forest ecosystems through studying the natural and artificial regenerative capacities of target species. In a secondary succession, study the natural regeneration of dominant species following rapid disturbance averaging a mean height of 4.5 m and a dbh of 6.1 cm at 12 years. This regeneration was mainly from stump coppice, root suckers and stunted seedlings. In comparison mean height growth rates for the best performer in artificial regeneration plots at two sites were 3.4 m and 2.7 m for *B. plurijuga* after 16 years and eight years, respectively. The lowest performer for the same variable was *A. quanzensis*, 0.8 m and 1.6 m over the same number of years. In another experiment the average dbh of artificially regenerated *B. plurijuga* was 6.8 cm and the average height was 8 m with the range between 4.8 cm and 9.1 cm, 4.6 m and 13.5m for diameters and heights, respectively, after 20 years (Malaya, 1986; Saramaki *et al.,* 1986).

- Determining the effect of prescribed fire on regeneration of indigenous tree species and the degree of die-back and its causes in *P. angolensis*. The results indicated that annual late dry season fires cause changes to species composition and increase coppice stems of regeneration. In general fire was found to have a depressive effect on the structure of forests. Regular late fires favour species such as *Burkea africana* and *Terminalia sericea*, but not *Baikiaea plurijuga*. Complete protection from fire permits development towards dense *Baikiaea* woodland. Symptoms of the die-back disease include wilting, yellowing and premature leaf fall, asymmetric dying of the crown and appearance of epicormic shoots on affected sides of the host. *Fusarium oxysporum* fungus has been blamed for the disease. Fire, drought and frost have been regarded as predisposing factors that are more pronounced in smaller diameter trees. The disease is continuously being monitored in permanent sample plots while means of eliminating it and reducing its impacts are being sought.

12.6 Community participation

In the last decade it has been recognised that the state alone can no longer reduce the rate of forest destruction and degradation. In addition the previously alienated local communities were increasingly contesting restricted access to forest lands and forest products. The FC has negotiated with and engaged forest-adjacent communities in forest resource sharing programmes, community timber concessions, forest protection and monitoring of resource use. In the pilot areas in Mafungabusi, Gwampa and parts of Gwaai protected forests these participatory programmes have reduced cases of poaching, incidences of annual fire and cases of conflict over resource use.

Local communities obtain a wide range of forest products from the protected KS teak forests, which they use for direct household consumption or for sale to generate household incomes. Households tend to be involved in harvesting, collecting, processing, using and selling forest products, resulting in extremely dynamic livelihood systems (Vermeuelen, 1993; Mudekwe, 2006). The protected forests in western Zimbabwe contribute to the increased wellbeing of some households in that they are a valuable source of subsistence goods and materials (firewood, mushrooms, honey, bushmeat, construction poles, thatch and broom grass) that supplement inputs from farming activities. Some forest products act as subsidies to agriculture, for example in the form of leaf mulch, ploughing implements, e.g. yokes and hoe handles. Large numbers of rural and urban people generate a portion of their income from forest products. For some households, forest-based income-generating activities can be a major source of income. Forests provide a reserve of products upon which people can fall back for subsistence and income in times of hardship, for example crop failure or unemployment (Arnold, 1996).

13. CONCLUSIONS

This case study gives the context in which protected KS teak forests are managed in Zimbabwe. It also highlights overriding issues with respect to the management of the forests. These issues are linked to ecological, socio-economic, scientific and institutional aspects. The KS teak forests are endemic to the fragile, deep, loose and well-drained Kalahari sand geologic formation. The loss of the Zambezi teak forests is especially worrying because unlike other savannah forest and woodland formations they are the more fragile forests in the sense that their soils (Kalahari sands) are easily degraded once the vegetation cover is removed. Different stakeholders are already accessing forest goods and services from the forests; what remains to be seen are arrangements that would involve these stakeholders in active management of the forests.

Management of the forests is guided by the forest policy for indigenous forests and implemented and regulated through the provisions of the Forest Act. The forests are managed on the basis of well-formulated management plans. Management is for the production of timber, wildlife and non-wood products and for biodiversity conservation. The principle of multiple land use is well imbedded in the management plans of the forest reserves. Considerable progress has been made in terms of research agendas aimed at improving forest management and protection. The problem lies in putting many of the research findings into practice.

There is need for a more holistic management approach to the KS teak forests by looking at the wider KS ecosystem, i.e. protected and unprotected KS teak forests on other land categories and similar KS teak forests in neighbouring countries, Angola, Botswana, Namibia and Zambia. A more embracing transfrontier project for the management of these unique forests is proposed.

14. CONSTRAINTS AND SHORTCOMINGS

The proper management of the KS teak forests has been constrained by annual decline in government grants to the FC. This has been exacerbated by the FC's failure to capitalise on the increasing demand for high valued products such as timber and wildlife in terms of its failure to charge commercial fees for the forest resources. The FC has also received little government support in its endeavour to find a lasting solution to illegal settlements in the forests. According to the provisions of the current Forest Act, settlements in protected forests are illegal. This requires the FC to look again at these provisions in terms of its powers to make by-laws with respect to forest settlements and the concept of joint forest management.

There is an acute shortage of staff to manage the KS teak forests. Only 11 foresters and 30 forest guards are available to manage and protect 840 000 ha. While the FC is gradually moving towards a people-oriented management approach for protected forests, the institution does not have a social forestry specialist to drive the process, a situation that is hindering progress in this sphere.

Perhaps the greatest constraint in the management of the KS teak forests is conflict of interest between forest users and the FC. While some actors are working towards managing the forests for conservation and sustainable use, the interests of the local communities, whose aim is immediate benefit, cannot be met. Currently, forest regulations forbid any form of unauthorised use of the forests, but communities have been consistently breaking the regulations and destroying the forests. The FC responds to these infractions through high-handed policing that often results in increased conflicts and hostility.

15. LESSONS LEARNT AND REASONS FOR SUCCESS

Since the early 1920s management objectives for the protection of the KS teak forests were explicitly elaborated and these have formed the basis for the successful management and protection of these forests to this day. The KS teak forests have a clear legal status, a feature that has prevented their complete loss as a result of national land redistribution processes. The semi-autonomous authority of the FC has enabled it to focus on the development of the forestry sector within the provisions of the national constitution and with little political interference. Until the last decade there was a strong drive in staff development that enabled the FC to be highly competent in the sphere of indigenous forest management and protection in the SADC region. Despite the lack of specialist training for field technical staff, the past and present staff has managed to implement and maintain high standards of forest management approaches including incorporating the latest concepts and initiatives such as participatory management and various forms of biodiversity conservation. One of the most important lessons has been the recognition and acceptance within the FC that it can no longer afford to protect the forests successfully alone without inputs from stakeholders that are dependent on the forests for subsistence.

From the time the forests were gazetted the FC has had a high regard for the concept of holistic management and multiple uses involving timber, wildlife, people and domestic livestock. Compromises have always been made between the mutually conflicting objectives in order to achieve sustainability of the forests. This is a rare attribute of state forestry authorities.

The value of periodic forest resource assessments is evident in that after almost 100 years the indigenous timber industry and protected forest-based tourism in the region are still active players in the economy of the country. This has been achieved through the continuous assessment of the resources, determining appropriate harvesting rates and making adjustments where necessary. These periodic assessments have been achieved as a result of strict adherence to requirements of the forest inventory policy and articles of management plans for each of the protected forests.

A very important lesson learnt is the willingness of some of the traditional technical foresters to change their traditional ways of thinking with respect to forest resource sharing, shared forest management and community timber concession programmes. Letting go of forest resources, relinquishing certain powers and adopting a role as monitor and facilitator of the processes that reduce their direct authority and revenue-generation capacity requires radical reorientation. In these participatory programmes the foresters are required to change their role to one of enabling community participation in forest management. The fact that these technical foresters have managed to work with communities (most of whom are illiterate) through the process of producing community forestry management plans and business plans is commendable. The foresters have garnered considerable willingness to embrace new concepts and acquire new skills in participatory forest management. The FC has supported rather than hindered initiatives of these foresters.

In southern central Africa Zimbabwe is probably the first country to offer community groups the opportunity of logging valuable timber resources as a form of benefit sharing and for income generation. The community timber logging concessions in Gwaai and Gwampa forests are exemplary in this respect. This has been made possible by the FC’s strategic policy of indigenising forest-based enterprises such as timber logging and eco-tourism.

16. RECOMMENDATIONS

- For the proper management of protected forests there is a need for the maintenance and regular updating of databases related to the various resources found in protected forests, e.g. timber, wildlife, non-timber products, domestic livestock, forest residents and of research activities taking place in the forests.

- It is important to match resource use needs as a process of continuous resource assessment in order to achieve resource use and management.

- Traditionally, foresters in tropical dry forests have often used silvicultural systems that were not specifically developed for these types of forest. It would be beneficial to base silvicultural treatments of such forests as the KS forest on practices ordinarily carried out by users and appropriate for the individual species. For example, most indigenous tree species are capable of coppicing and this characteristic needs to be understood better for wider application as a silvicultural tool. The protected forests are degrading and wasting because the necessary conditions for natural regeneration of the desired species are not understood. In most cases there are assumptions that the necessary conditions are similar for all species – which are wrong assumptions.

- Monitoring disturbances and recovery processes and taking necessary practical remedial measures are vital for the stability and sustainability of individual species. These aspects are only remotely considered in protected indigenous forests.

- The forest tenant system could be revisited given the available knowledge of joint forest management processes, conflict management, resource tenure and access.

- Participatory forestry initiatives need to be up-scaled to other forest reserves based on lessons learnt from pilot projects.

- The KS teak forests are not only found in Zimbabwe but also in Angola, Botswana, Namibia and Zambia. There should be a transfrontier management approach to this unique resource that potentially has immense social, economic and ecological importance in these countries.

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18. APPENDICES

1. Summary information on protected forests of western Zimbabwe

1. **Country:** Zimbabwe
2. **Name of the forest:** Case study generally covers management of all gazetted forests in western Zimbabwe.
3. **Land tenure:** Gazetted or protected forest reserves.
4. **Ecozone:** Deciduous dry forests.
5. **Forest type:** Zambezi teak/*Baikiaea plurijuga* forests;
6. **Extent of the forest (ha):** Total area of gazetted forests covered in this case study is approximately 847 419.
7. **Forest area under management (ha):** 847 419.
8. **When did the management start:** In 1920 when the first Forest Officer was appointed.
9. **Designated functions of the forest under management:** Conservation, soil and water protection, and timber production.
10. **Tree taxa (botanical names):** Dominant species is *Baikiaea plurijuga* (Zambezi teak) in association with *Pterocarpus angolensis, Guibourtia coleosperma Schinziophyton rautanenni, Afzelia quanzensis, Combretum collinum,* and *Erythrophleum africanum* in the upper canopy. The sub-canopy species are *Peltophorum africanum, Erythrophleum africanum, Combretum apiculatum, Strychnos pungens, Croton gratissimus, Pseudolachnostylis maprouneifolia, Swartzia madagascariensis, Diplorhynchus condylocarpon, Peltophorum africanum* and *Terminalia sericea*. The understorey species are dominated by *Bauhinia petersiana, Baphia massaiensis, Grewia flavescens, Grewia monticola, Dichrostachys cinerea, Commiphora* species and *Acacia fleckii*.
11. **Other taxa.**
12. **Location of the forest (including longitude and latitude):** Protected forests are located in western Zimbabwe, in Matabeleland North Province. The forests are located between latitude 17^0 05'S and 20^0 02'S and longitude 25^0 03'E and 29^0 00'E.
13. **If the study/area has an URL, kindly provide it:** None.
14. **Contact organization:** Forestry Commission, PO Box HG 139, Highlands, Harare, Zimbabwe

2. Example of a fire report form – Gwampa forest.

1. Name of forest.
2. Date and time of outbreak.
3. Who discovered the fire?
4. What time?
5. Who reported the fire and at what time?
6. To whom was the fire reported and at what time?
7. Action taken by 7. above:
8. If fire alarm was sounded, what time was this?
9. What time did the fire fighting team leave the station?
10. What time did the team arrive at the scene of fire?
11. Approximate distance from station to scene of fire:
12. Position and area burnt (attach sketch map):
13. Cause of fire:
14. Officer in charge of fire fighting team:
15. Number of men:
16. Date and time when fire was put under control:
17. Type of damage:
18. Severity of damage:
19. How could the fire have been prevented?
20. Cost of putting out the fire:
21. Legal action taken, if any:
22. General comments:
23. Recommendations:

3. Volume summaries for *Baikiaea plurijuga, Guibourtia coleosperma* and *Pterocarpus angolensis* from forest inventories in 1991 and 1996

Forest	Total area (ha)	SPECIES 1991															
		Volume over bark to 15 cm tip diameter (m^3)															
		Baikiaea plurijuga				*Guibourtia coleosperma*				*Pterocarpus angolensis*				*Pterocarpus angolensis* (dead)			
		I	II	III	TOTAL	I	II	III	TOTAL	I	II	III	TOTAL	I	II	III	TOTAL
Grants & Umzibani	9960	4458	1874	687	7 019	1913	751	340	3 004	2517	863	88	3 469				
Ngamo	102900	120834	26639	5427	152 900	157010	16173	3874	177058	69025	9638	741	79405	5033	1742	103	6877
Sikumi	54400	84685	15900	3393	103978	61486	4961	12229	67677	52371	2336	145	54853	3729	131	-	3861
Inseze	35200	46581	21907	6812	75302	5147	3130	852	9129	17057	5834	376	23268				
Inseze Ext.	8400	17856	5277	1572	24705	3973	1516	557	6048	2346	1244	271	3861				
Gwaai	144300	198656	94986	24012	317655	77491	31680	8229	117400	63626	23567	1862	89055				
Bembesi	55100	81021	25513	5208	111742	41769	16569	13845	72184	13689	3563	457	17710				
Umgusa	32200	30896	15019	4262	50177	24893	14007	3876	42866	7646	2296	134	10075				
Total		**584987**	**205241**	**51373**	**843478**	**373772**	**88787**	**32804**	**495366**	**228277**	**49341**	**4074**	**278227**	**8762**	**1873**	**103**	**10738**
		1996															
Mzolo		-	79500	76800	156200	-	1300	1300	2600	-	37700	11500	49200	-	2000	-	2000
Fuller		233699	89705	76657	400061	3262	1864	9087	14213	4194	4194	36115	45503	-	-	-	-