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Management of the NATURAL FOREST IN THE SAHEL REGION

by

J.K. Jackson
G.F. Taylor II
C. Condé-Wane

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Foreword

Management of the existing natural forest in the Sahel has gained renewed interest as mixed results have become known from the large number of forest plantation projects which were launched in the Sahel after the most recent drought.

At the biennial meeting of the CILSS Forestry Ecology Team held in Banjul, The Gambia, November 18-21, the idea of preparing a synthesis paper on natural forest management in the Sahel was endorsed. Following the meeting, the Forestry Support Program (FSP, a program funded by the U.S. Agency for International Development and jointly managed by the Forest Service and the Office of International Cooperation and Development of the U.S. Department of Agriculture) was asked by the Club du Sahel and CILSS to assist with the preparation of the paper.

The Forestry Support Program contracted J.K. Jackson to provide leadership for this effort. Mr. Jackson, with a long career in tropical forestry, including many years in the Sudan and Nigeria, was aided by G.F. Taylor II, USAID/Sahel Development Planning Team Forestry Advisor in Bamako, Mali and Mme Clémentine Condé-wane of Senegal's Forestry Department in the preparation of this report.

Although the organizations which sponsored or collaborated with this report concur with most of the observations and recommendations made by the authors, the views expressed are those of the authors and do not reflect the policy or position of those organizations.

PREFACE

This report on management of natural forests has been prepared by a team consisting of:

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The authors wish to thank the following for information and advice:

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The Librarian and Staff of the Commonwealth Forestry, Institute, Oxford, England.

Much of the information contained in this report has been derived from the "Analyses du secteur forestier" for the various countries, prepared by CILSS/Club du Sahel, and from the "Plan Directeur" of Senegal. Other references consulted are given at the end of the report.

Those who can provide additional information are requested to consult the Department de la Recherche (Cellule Ecologie/Environment), Institut du Sahel, B.P.1130, Bamako, Mali, or G.F. Taylor or Madame Condé-Wane at the addresses given above.

CURRENCY

(approximate rates, March 1980)

1 U.S. Dollar	=	360 CFA Frances (FCFA)
	=	720 Mali Francs (FM)
	=	72 Mauritanian Ougiya (UM)
	=	2.6 Gambian Dalasi (D)

ABBREVIATIONS

CCCE	Caisse Centrale de Coopération Economique
CILSS	Comite Permanent Inter-états de Lutte Contre la Sécheresse au Sahel
CNRF	Centre National de Recherches Forestières (Sénégal)
CTFT	Centre Technique Forestier Tropical
DDA	Direction Suisse de la Coopération au Développement et de l'Aide Humanitaire
FAC	Fonds d'Aide et Coopération
FAO	Food and Agriculture Organization of the United Nations
IDA	International Development Agency (of the World Bank)
IDRC	International Development Research Centre (Canada)
ILO	International Labour Office
INSAH	Institut du Sahel
UNDP	United Nations Development Programme
UNSO	United Nations Sahelian Office
USAID	United States Agency for International Development

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1. INTRODUCTION

The importance of forestry is being increasingly appreciated in the countries of the Sahel region, especially since the severe drought which began in 1968. Forests are needed to preserve the soil and local climate, and to help halt the spread of desert conditions. Forests are also important in providing fuel; wood and charcoal are relied on to provide at least 90 per cent of the energy needed to cook food within the region, and the uncontrolled felling of trees for fuel is a significant cause of deforestation in the more arid parts of the region. Many parts of the region are already experiencing a shortage of fuelwood, and by the end of the century this shortage will extend through the larger part of the region. Forest area is diminishing, as more and more land is brought under agricultural crops. The productivity and the protective value of the forests are being reduced by fire and overgrazing. To ensure wood supplies for the future is an urgent task.

There are a number of appropriate ways of dealing with these problems, including forest plantations in suitable, usually higher rainfall, areas; encouragement of rural forestry in the form of communally and individually owned woodlots; and management of natural forests. Up to the present the first two methods have received a great deal of attention, including large sums of money from international aid programmes, but the management of natural forest has been neglected until the last few years. This is despite the fact that the natural forests, especially the reserved forests (forêts classées), are a most valuable natural resource which up to the present has scarcely been utilized.

The present report considers potential productivity of natural forests, how this can be increased, and the administrative measures which will need to be undertaken to manage natural forests. It is concerned mainly with the forests as a source of wood, though the forests also produce a great number of other valuable products which are important in the life of the local communities living near the forest (see Section 4.3.3.2.). It is regretted that the very important question of forest grazing and browse cannot be dealt with adequately within the limits of this report, nor the function of the forest as a habitat for wild life.

To bring the natural forests of the region under management will be a long-term process, probably of the order of 20 to 30 years, and there is a need for a considerable amount of research to improve management techniques. This should not, however, prevent work beginning at once. Relatively simple techniques already exist which will increase productivity, and these can be used until better ones are found.

Thus it is recommended that a beginning be made in introduction of natural forest management, starting in a few carefully selected areas, such as forets classees near major urban centers, and gradually extending the work as experience is gained and markets are developed.

Section 2 of this report gives a general overview of the problems and main features of natural forest management in the countries of the Sahel Zone, and Section 3 gives details of the region. Section 4 discusses in detail the technical, economic, administrative and social aspects of natural forest management, and the research necessary to get it under way. Section 5 outlines the possibilities of natural forest management, constraints it is subject to, and proposes a list of priorities. Recommendations are given in Section 6. Section 7 gives a very brief summary of the conclusions.

2. STATEMENT OF THE PROBLEM

2.1. Definition and nature of natural forest.

Natural forest may be defined as any natural plant formation in which trees form an appreciable part of the vegetation. In the Sahel countries it ranges from open desert scrub with acacias to deciduous forest with an almost closed canopy.

In the driest areas Acacia tortilis subsp. raddiana dominates. As the rainfall increases this is succeeded by other acacias, notably A.senegal, and A.laeta, with A.seyal on the heavier soils, and areas of Commiphora africana, and Ziziphus mauritiana. Under still higher rainfall the Combretaceae begin to dominate, with Anogeissus leiocarpus, Combretum glutinosum, C.micranthum, and Guiera senegalensis. This is succeeded by forests which include Isoberlinia doka, Pterocarpus erinaceus, Daniellia oliveri, and Khaya senegalensis, and which in the wetter parts may form closed stands in places, while finally, in Casamance in Senegal, species more characteristic of the tropical rain forest, such as Daniellia ogea, and Erythrophleum ivorense, begin to appear.

A characteristic of many areas is a forest strongly influenced by man's activities, in which certain species mostly valued for their fruits are left after the remaining forest has been cleared for cultivation, leaving an open parkland. In drier areas the main species of this 'anthropogenic' forest are Adansonia digitata, the baobab, and Acacia albida, while Vitellaria paradoxa (karite) (Butyrospermum paradoxum), Parkia biglobosa (néré), and Tamarindus indica occur over large areas in the wetter parts of the zone.

Some formations are restricted to particular edaphic situations, such as Acacia nilotica subspp. nilotica and tomentosa, in seasonally flooded areas, and mangroves (Rhizophora, Avicennia) in areas periodically inundated by salt or brackish water. Mention should also be made of forests of doum palm (Hyphaene thebaica) and ronier (Borassus aethipium). The former is characteristic of temporary watercourses and river banks in very arid areas, while the latter is more generally distributed in moister areas.

The special technical problems of these formations are discussed in Section 4.2.6.

Legally the forests range from forest reserves (forêts classées) through the 'domaine protégé' to forest regrowth after

cultivation and trees left in farmers' fields (see Section 4.3.2.). The present report will deal mainly with the forêts classées, as these are already state property under the control of the forest services, and problems of land ownership do not arise. However the principles of natural forest management will apply mutatis mutandis to other forests, when these eventually are brought under management.

2.2. Definition of Natural Forest Management

Forest management, like the management of any enterprise, "embraces three main, interlinked functions, namely settlement of the purposes and main policy to be pursued, the consequent planning and organization of activities, and the conduct of operation." (80)

A clear statement of the basic purposes of management - the objects of management - is the essential foundation of any forest management plan. These objects of management will vary according to needs and resources; they may include, among other, protection of the forests, without exploitation, to preserve the soil, water supplies, and microclimate; management of the forests in the interests of wild life, such as in game reserves and some types of national parks; management with the main aim of providing forage for domestic animals; and management for the production of wood. Management for a forage is very important over large parts of the Sahel zone, but unfortunately it is impossible to consider it in detail here (see ref. 67 for further details). The main objects of forest management to be discussed will be the provision of firewood and charcoal, building poles, and to a lesser extent sawn timber, from the natural forests, and will consist of a conscious series of interventions designed to maximize output of a specific mix of products on a sustained basis. This type of management will allow local people to continue to collect dead firewood for their own consumption, and other non-wood products important to their daily life. When plantations are established these products are no longer available to them.

The emphasis is on maintaining the approximate composition of the natural forests, and excludes their conversion to plantations. It does not, however, exclude manipulation of the forest to favor certain species, or the use of artificial regeneration of indigenous species to supplement natural regeneration where this fails or is inadequate.

The types of intervention considered in this report apply primarily to the management of the reserved forests (forêts classées), existing or to be created, though many are also suitable for the protected forests (la zone/domaine protégé). They do not apply to areas currently under cultivation, or which form part of a bush fallow after cultivation.

It should be noted, however, that trees are an integral component of many cropping systems in the Sahel, and that areas of farmed parkland (in which certain trees are deliberately preserved by the cultivators) and farm fallow provide a wide range of wood and other forest products. Increased emphasis in

recent years on agro-forestry is beginning to provide a clearer picture of the role of the tree component in these systems. Once work on natural forest management is somewhat more advanced it will be important to bring together the two strands of natural forest management and agro-forestry, to provide a more complete picture of the full continuum from forêt classée on the one hand, to the karite, nere, baobab, Acacia albida, tamarind, and Borassus consciously left in farmers' fields on the other.

2.3. Reasons for increased attention to Natural Forest Management

2.3.1. Introduction

In recent years the possibility of obtaining needs of wood by natural forest management has been receiving increased attention in the Sahel countries. There are a variety of reasons for this, among them the relatively poor performance of large-scale plantations of 'fast-growing' exotics, a better understanding of the productivity of natural forest, and an appreciation that natural forests should not be merely regarded as a source of energy, but that they also provide a wide range of other products important in rural economy. Thus the concept of forestry should be considerably widened from the mere production of wood to the provision of a wide range of other products.

Thus although as recently as two or three years ago little attention was paid to the possibilities of managing natural forests, this attitude is now changing to a rapidly growing consensus that these formations will play a central role in the future development of forestry in the Sahel. To cite two examples only: the Plan Directeur of Senegal[98] notes that 'D'une facon generale, la recherche montre que l'aménagement des formations forestières naturelles, quand elle est possible, est de loin préférable aux coûteux reboisements' (emphasis in original). At the same time the Analyse du Secteur Forestier et Propositions for Mali[20] notes that 'le maintien et, si possible, l'augmentation de la ressource en bois passent d'abord par l'aménagement des forêts naturelles qui représentent encore, de toute évidence, des superficies considérables.'

Other countries have expressed similar opinions and there thus are good grounds for hope that the management and development of this important natural resource will receive much more attention in the future.

2.3.2. Large-scale plantations of "fast-growing" exotics

Following the most recent drought, Sahelian countries and foreign donors alike placed great hopes and considerable emphasis on the establishment of large-scale plantations of 'fast-growing' exotic species designed to help meet a rapidly growing demand for fuelwood and other wood products, and substantial sums of money have been invested in such schemes. One by one the assumptions upon which these efforts have been

based have been called into question: the exotics have in many cases not performed nearly as well as expected (in some cases only marginally better than the natural 'bush'); the costs have soared - due partly to rising oil prices and partly to the fact that lower than expected yields will have to cover the full cost of plantation establishment and maintenance; governments have been unable to meet recurrent costs (leaving plantations without maintenance once the funding for the projects that originally established them has run out); and constraints in finance, staff and logistics limit the number of hectares that Sahelian forest services are able to plant each year to only a small proportion of the area required even to approach meeting future demands for fuelwood and other forest products. To meet the whole demand from plantations, even if these were successful, appears to be completely impracticable in the foresseable future. In the Gambia, where plantations have been on the whole successful, it is estimated that, by the year 2000, an area of 12,000 ha of plantations will provide 15 percent of the country's needs in wood;[17] in Upper Volta, in the year 2000, an area of 100,000 ha of plantations yielding 5 m^3/ha/yr (considerably higher than the present increment), would provide only 5 percent of the country's needs.[19]

This is not to suggest that all work on plantations should cease. In regions of high demand where there is little natural forest left, such as near certain large towns, and irrigated agricultural schemes, plantations may still be the only solution. Also where it is clear that the increased yields, both in volume and in unit value - bearing in mind that the value per unit volume of straight poles is considerably higher than that of firewood - from plantations justifies the expense of establishment, obviously plantations are desirable, but really reliable estimates of costs and yields are needed before they are undertaken. Small scale village and individual plantations should also continue to be encouraged. What is to be discouraged is the replacement, at great cost, of natural forests by plantations which only produce slightly higher yields.

However it is clear that large-scale plantations are not the only, nor always the best solution, to the problem of meeting the growing needs of wood. Other methods must be sought, and one of the most promising of these is the management of natural forests.

2.3.3. The productivity of the Natural Forest

Dismissed by some as 'useless brush with a productivity that hardly deserved serious consideration', natural forests were generally ignored in the spate of forest planning that followed the most recent drought, with attention being directed primarily towards afforestation or reforestation. It has generally been assumed that productivity is about 0.5 m^3/ha/yr in the Sahel zone rising to about 1 m^3 in the Sudan zone. A useful summary of available information has recently been prepared by Clément[24], and this is reproduced in Tables 1 and 2.

TABLE 1
Yields recorded from different sites
(from Clement, 1982)

Country		Rainfall (mm)	Age (years)	(m^3/ha/yr)	Site	Protection	Reliability
CAMEROUN	NE Benoue	900	25?	0.84	mediocre	no	3
		"	25?	0.78	mediocre	no	3
CONGO	Brazzaville	1400	20	1.80	average	yes	3
UPPER VOLTA	Pinderesso	1200	23	1.40	average	no	2
	Toumousseni	1200	25	1.25	mediocre	no	2
	Gonse	900	25	1.05	mediocre	no	2
	Gonse	900	25	1.09	average	no	1
	Gonse	900	4	2.00[1]	average	yes	1
	Wayen	850	35	0.76	mediocre	no	1
	Wayen	850	4	1.25[1]	mediocre	yes	1
MALI	Monts Mandingues	1050	26	1.46	fairly good	no	2
	Monts Mandingues	1050	30	1.38	fairly good	no	2
	Monts Mandingues	1050	25	1.44	fairly good	no	2
	Monts Mandingues	1050	37	0.70	poor	no	2
	Foret de la Faya	900	60	0.73	mediocre	no	2
	Foret de la Faya	900	42	1.06	fairly good	no	2
	Foret de la Faya	900	50	0.75	average	no	2
	Foret de la Faya	900	42	0.93	fairly good	no	2
	Dioforongo	750	32	0.58	average	no	2
	Bougouni	1200	32	1.58	average	no	2
NIGER	N'donga	600	?	0.35	average	no	2
	N'donga	600	?	0.50	average	no	2
CENTRAL AFRICAN REPUBLIC	Bambari	1550	9	2.20	fairly good	yes	1
		1550	9	3.00	fairly good	yes	1
		1550	18	3.20	fairly good	yes	1
SENEGAL	Forets du rail	900/1000	20	0.80 to 1.20	?	no	3
		600/700	25	0.16 to 0.24	?	no	3
TCHAD	N'djamena		?	4.00	?	no	3
			?	4.80	?	no	3
			?	4.70	?	no	3
		1000 to 1200	?	1.00 to 3.50	?	no	3
TOGO	Mango	1100	13	1.50	?	no	3

1. Figure revised, according to ref.

TABLE 2

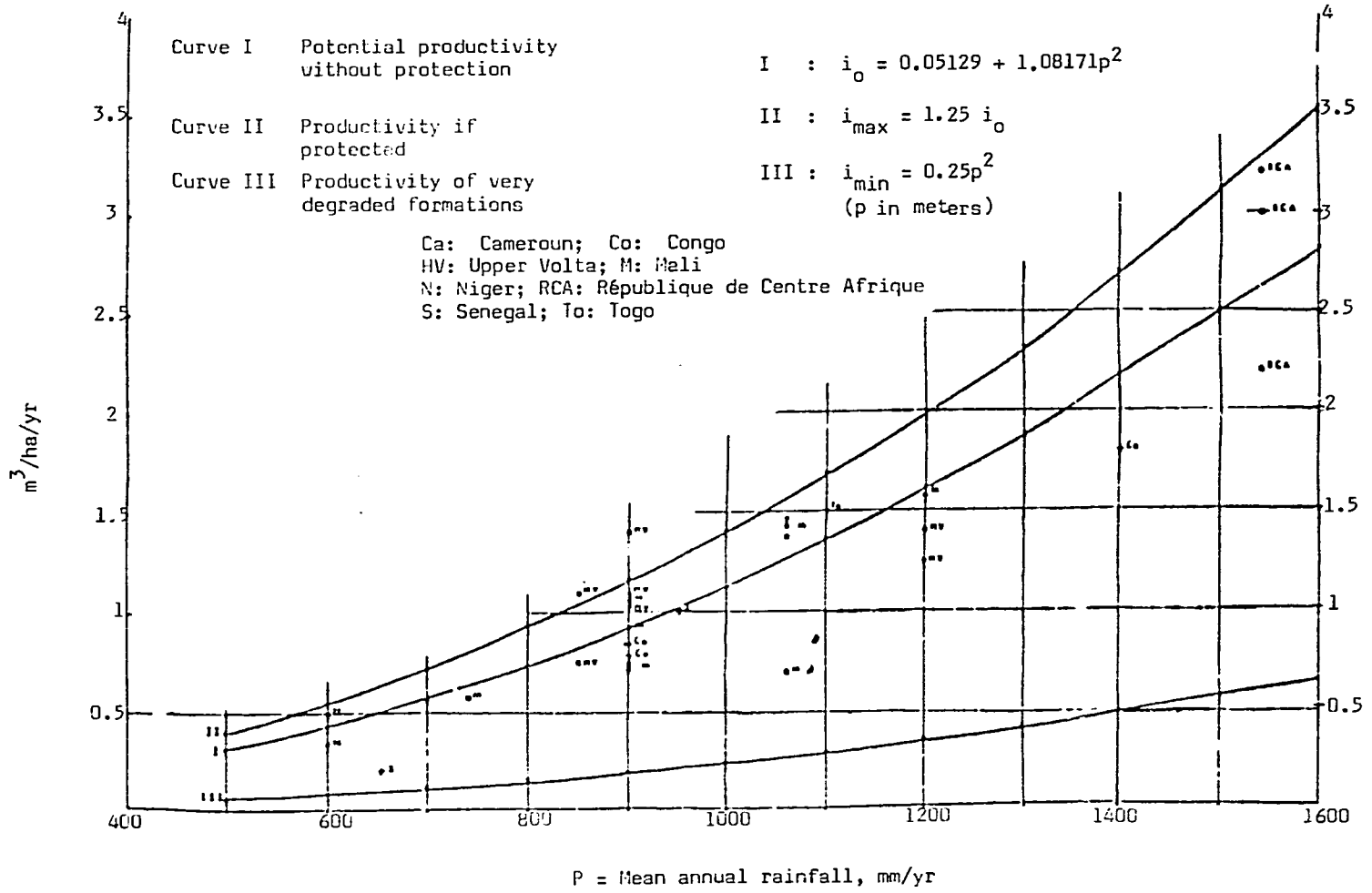
Yields as a function of rainfall

(from Clement, 1982)

RAINFALL	PRODUCTIVITY (m^3/ha/yr)		
(mm)	i_{max}	i_o	i_{min}
500	0.40	0.32	0.06
600	0.55	0.44	0.09
700	0.73	0.58	0.12
800	0.93	0.74	0.16
900	1.16	0.93	0.20
1000	1.41	1.13	0.25
1100	1.70	1.36	0.30
1200	2.01	1.61	0.36
1300	2.33	1.88	0.42
1400	2.71	2.17	0.49
1500	3.11	2.49	0.56
1600	3.53	2.82	0.64

GRAPH OF PRODUCTIVITY AGAINST RAINFALL

(from Clement, 1982)



These yields are admittedly low, but they are derived from unmanaged natural forest, usually without fire or grazing protection, some local use and with virtually no inputs. Also though low per unit area they are available from very large total areas; in Upper Volta, for instance, it has been estimated that increasing the yield of the natural forest by 25 percent would be equivalent to the yield from 500,000 ha of plantation.(6)

There are also indications that in some places yields may be considerably higher than has previously been thought. In the Forêt Classée of Guesselbodi in Niger initial estimates also indicate substantially higher annual yields than the 0.5 m^3/ha or less generally accepted for this zone. (116) In the Forêt Classée of Bandia in Senegal (rainfall 600-700 mm) yields from Acacia seyal forests have ranged from 0.67 to 2.35 m^3/ha/yr. This compares with yields from a Eucalyptus camaldulensis plantation, established after destruction of the natural forest in this area (which here had an estimated yield of 1 m^3/ha/yr) of only 1.5 m^3/ha, despite investment costs of the order of $1000 per ha. (p.9 of ref. 36). In the Forêts Classées of Wayen and Gonse in Upper Volta (800-900 mm rainfall) productivity based on four years of regrowth after cutting has been measured at 1.35 and 2 m^3/ha/yr respectively. (13, 14). All these figures are higher than those estimated by Clément for the corresponding rainfall zones.

It must be emphasized again that most of the yield figures previously reported are from unmanaged and unprotected forest, with unknown quantities of wood removed before final felling. It is also probable that many of the figures come from forests which from the point of view of optimum volume production are overmature. By introducing protection and sound management practices, such as establishing an optimum rotation, it should be possible to increase yields considerably at a fraction of the cost of establishing plantations. Clément, in his graph, estimates a yield increase of only 25 per cent from protection of the forests, but this figure seems low (see the data on fire protection in Section 4.2.5.1.4).

It is clear that much remains to be learned about the productivity of existing natural forests, in both wood and nonwood products. Inventory methods need to be refined and standardized. How to estimate for quantities of wood removed before the inventory is made is a difficult problem; if stumps of felled trees remain, some estimate could be made of the volume they represent. Otherwise measurements could be made in forests which it is reasonable to expect have suffered little disturbance, such as those in remote or sparsely settled areas.

Knowledge of the increase in yield to be obtained by managing the forests is still more scanty. Though some methods of increasing yields (protection, choice of optimum rotation) can be prescribed with confidence, there is little data available by which the increase of yields following such practices can be quantified. To obtain better information on

yields, how to increase them, and the amount of increase to be expected will be among the priority tasks of the various natural forest management projects that are currently getting under way in the region.

2.3.4. A broadened definition of forestry to include non-wood products

The forestry programs developed in the years following the drought were primarily concerned with halting 'desertification' and 'the other energy crisis' - the growing shortage of fuelwood, and these were given priority by the planners. For peasant farmers, however, forests are not merely a source of wood and the farmers often give more priority to the availability of a wide range of non-wood products traditionally collected from the forest such as edible fruits, fodder and browse for animals, fibres and bark, and medicinal plants (see Section 4.3.3.2). When natural forests are converted into plantations these products, essential to meeting the subsistence needs of local populations, are no longer available, and this can cause considerable resentment and hostility, leading in some cases to the burning of the plantations. (51)

Thus the idea of forestry needs to be broadened to include not only the provision of timber and wood for energy, but also the great range of other produce provided by the natural forests. The recognition of the importance of these products has been growing in recent years, and has provided an additional impetus to including natural forest management as an important component of forestry development within the region. However relatively little is yet known about the importance of non-wood products from the forest, and more studies are urgently needed.

3. OVERVIEW AND ASSESSMENT OF WORK TO DATE

3.1. Countries of the Sahel Region

3.1.1. Cape Verde Islands (18)

Out of a total land area of 403,360 ha only 590 ha remain under natural vegetation, so that it is clear that management of natural forests in this country is of virtually no importance.

3.1.2. Mauritania (21)

3.1.2.1. General situation

The total area of the country is 1,030,700 km^2, of which forests and savannas cover 151,340 km^2 and permanent pasture 392,500 km^2. The population was 1,339,000 in 1977 and is estimated to increase to 2,371,000 in 2000. Consumption of wood fuel was estimated at about a million m^3 per annum in 1980, rising to 1.7 million in 2000. The total area of forêts classées is about 320 km^2, but some of these "ne portent bien

souvent que le nom". It is clear that there is a strong imbalance between demand for wood and potential supplies.

Mauritania is the most arid of the countries of the Sahel region, and suffered severely in the drought of the late 1960's and 1970's. The only considerable forest resources are the Acacia nilotica forests along the Senegal River, and the gum forests (Acacia senegal) in the Sahel zone. Other forests are important mainly for the production of fodder for domestic animals, and should be managed with that object in view.

There used to be about 20,000 ha of forêts classées of Acacia nilotica, but only 12,000 now remain, and of these about three quarters will be affected by changes in the regime of the Senegal River, as a consequence of the construction of the Diama and Manantali Dams. The existing forests are heavily exploited for the provision of charcoal to the capital, Nouakchott.

Large areas of the gum forests were severely affected by the drought, with many trees dying. As a consequence gum arabic production, which before the drought used to average 6000-8000 tonnes per annum, dropped to an average of about 800 tonnes per annum between 1973 and 1976, and 260 tonnes per annum between 1977 and 1980.

3.1.2.2. Results to date

Management of natural forests has been largely confined to protection of certain areas against fire and grazing. In Guidimaka simple protection has resulted in good regeneration of Acacia senegal and the appearance of Bauhina reticulata and Acacia nilotica subsp. adstringens. A series of small plots to study the effects of protection against grazing was also established by UNESCO/IFAN in the 1960's. (1)

In the south east of the country about 5,000 km of firebreaks have been cleaned and maintained, though doubts have been raised about their effectiveness. The firebreaks were mainly for the protection of pastures, but will also help to protect the natural forest.

During the 1940's some research was carried out on gum arabic production, which showed the necessity of protection against fires, protecting natural regeneration against grazing for several years, and sylvo-pastoral management. Various projects have been proposed for improvement of gum forests, but so far little work has been undertaken in the field. The same applies to Acacia nilotica forests, where also a number of projects have been proposed.

A new Forest Law has been prepared, which awaits approval by the Comité Militaire de Salut National. This among other things provides for the setting up of Protective Perimeters (Périmètres de protection), outside the Forêts Classées, to protect such areas as hill slopes, stream and river banks, and zones containing pure stands of trees of economic importance (Acacia albida, A.nilotica, A.senegal, A.tortilis subsp. raddiana, Balanites, Borassus, Capparis decidua, Hyphaene, Khaya senegalensis, Maerua crassifolia, Raphia, and Ziziphus mauritiana).

3.1.2.3. Conclusions

Mauritania is largely a desert or semi desert country. It is difficult to see it ever being self-sufficient in fuelwood, and at present needs are largely met by inroads on the already exiguous forest capital. The long term solution may well be the import of a large proportion of the energy requirements.

This general scarcity of fuelwood means that the management of what natural forests exist, to provide the maximum sustainable yield of wood, is of great urgency. Thus the most urgent tasks in Mauritania are to bring what productive natural forests exist, primarily Acacia nilotica, under regular management, to protect and restore the gum forests (Acacia senegal), and especially to protect the remaining natural forests against fire and overgrazing, to halt the progress of desertification which already menaces large parts of the country.

3.1.3. Senegal (99-102)

3.1.2.1. General situation

The area of Senegal is 201,513 km^2; of this 33,000 km^2 are forests and wooded land, 88,000 km^2 uncultivated grazing, 15,000 km^2 sylvo-pastoral reserves, and 22,000 km^2 national parks, game reserves and hunting preserves. The forests range from tree steppe in the north, to savanna woodland, open forest, and small areas of closed forest and gallery forest in the south. The area includes forêts classées covering 13,550 km^2, of which 1550 km^2 are to be managed for fuel production while 12,000 km^2 consists of national parks and unmanaged forets classees in which exploitation is legally prohibited.

The total standing volume, underbark, of wood is estimated at 139.2 million m^3 from all types of productive forest and for all types of use. The existing potential volume of saw timber is estimated at 11.8 million m^3, but not all of this can be exploited because of legal prohibition of cutting in national parks and unmanaged forets classees, lack of technical knowledge of some of the timbers, and the risk of impoverishing the forests if all the standing crop were to be completely utilized. Thus the actual volume of commercially exploitable saw timber is estimated at 3.4 million m^3, while in the long term this may be expected to rise to 7.4 million m^3, from a total area of 22,000 km^2.

The theoretical annual yield of fuelwood from exploitable forests is estimated at 7.1 million m^3, and that of saw timber about 1.2 million m^3.

The present demand for fuelwood is estimated at 4,098,000 m^3 per annum, which is less than the potential annual increment. However resources are badly distributed, and in fact there is a fuelwood deficiency everywhere except in the southern (Casamance) and Eastern Regions of the country. These regions can therefore be regarded as the forestry "storehouse" of the country, and a capital which must be conserved; however the soils of the Eastern Region are very erodible and the forests

there are likely to play a protective rather than a productive role.

Fuelwood consumption is rising with the increasing population, though there are hopes of reducing it by increased use of bottled gas, by improving stoves, and by improved methods of charcoal production. It is estimated that by 2000 AD the demand will be for about 6,540,000 m^3 roundwood equivalent.

The drought caused heavy mortality of several species, for example in the Acacia nilotica forests along the Senegal River, and the natural forests continue to suffer from fire, overgrazing of domestic animals, and clearance of land for cultivation; thus there is little hope of natural regeneration under present conditions. It is estimated that 40,000 ha of forest are being lost each year, mainly through cultivation clearance, and this area is likely to increase through colonization projects aimed at relieving congestion in the "groundnut basin" of central and east Senegal. In addition over-exploitation of wood for fuel and building poles is estimated to be reducing the forest resources by 1 to 2 percent yearly, especially in the mixed formations of trees and grasses which constitute 90 percent of the forest resources of the country. Thus by the year 2000 AD it is estimated that the area of natural forest will be reduced to 112,000 km^2 if present trends continue. The area of plantations is expected to reach 30,000 ha by the end of 1982, and there is a further program of 10,000 ha annually. This will mean a total area by the year 2000 of about 200,000 ha of plantation. If yields of 5 m^3/ha/yr are obtained, and all the produce is used for fuelwood, this will produce about a million m^3 of wood per annum, or about 15 percent of the country's needs.

As regards industrial wood (timber for sawing, peeling and also including wood for canoes and handicrafts) present production is about 10,000 to 11,000 stems, or 20-25,000 m^3; almost entirely from Casamance. The main species used are Bombax costatum, Khaya senegalensis, Borassus aethiopum, and Daniellia ogea; supplies of Pterocarpus erinaceus, Erythrophleum ivorense, and Cordyla pinnata are also available, but at present the demand for these is low. Prodcution at present comes from about 8,000 km^2, and is excluded from national parks and fauna reserves (6,250 km^2) and non-managed forêts classées (4,000 km^2). With the growing demand for sawn timber it appears possible that some of the latter may eventually be exploited under careful management.

Imports of round timber are at present about 60,000 m^3 per year, mostly from the Ivory Coast, to which must be added about 33,000 m^3 of sawn timber, equivalent to about 66,000 m^3 of round wood. All paper and board is also imported.

Construction of canoes and boats uses about 1500 m^3 per year, 95 percent from Ceiba pentandra and Khaya senegalensis; and handicrafts 600-900 stems per annum, from Pterocarpus erinaceus, Prosopis africana and espeiallly Dalbergia melanoxylon.

Gum arabic production is a present about 1180 tonnes per year, as against 10,872 tones in 1970. Production of wild fruit is estimated at 4000 tonnes per year, and 876 tonnes of wild leaves are collected. There are more than 50,000 ha of oil palm forest in Casamance, Cap Vert, Saloum, and Eastern Senegal, with a controlled production of 660,000 litres of palm oil and an estimated production of 8500 litres of palm wine. Until such times as industrial oil palm plantations are established, management and protection of these palms, especially against excessive tapping for wine, is needed.

3.1.3.2. Results to date

Senegal was the first country of the region to begin natural forest management, and indeed is the only country where it has been undertaken on any appreciable scale.

The first forest brought under a simple form of management was the forêt classée of Bandia (10,400 ha) in the Thies region, in the Soudano-Sahelian zone. Regular felling for charcoal production began in 1940, and the first management plan was drawn up in 1953.(7) During 1940-1953 average yields were 45 quintals of charcoal per ha, equivalent to about 28 m^3 of wood, plus about 0.27 m^3 per ha of Khaya senegalensis timber. The management plan had the objectives of producing firewood, building poles, and sawlogs; enrichment; and trials of natural regeneration. The system applied was to be simple coppice on a 20 year rotation for firewood production, while for sawlog and pole production management was to be based on an annual inventory by sampling. Yields were forecast at 45 quintals of charcoal per ha per year (4.5 tonnes) and an annual revenue of 7900 FCFA was expected.

Production did not come up to expectations and the average yield per ha never exceeded 25 quintals. Valuable species reserved for sawlog production were not respected by the charcoal burners; this also resulted in the removal of the seed-bearers needed for natural regeneration.

Another item of early work that deserves mention is the establishment, through protection, of 10,000 ha of Acacia albida on agricultural land (see Section 4.2.6.5.).

The second phase of natural forest management began after independence with the second quadrennial plan for social and economic development (1965-69), when it was proposed to take up to 90,000 ha of natural forest under management, but the actual area brought under management during the second plan was only 30,000 ha. This 'management' appears to consist mainly of protection, and as far as is known, no actual management plans were prepared. Subsequent development plans have entrusted the forest service with the preparation of plans and management of natural forests in different regions (Acacia nilotica) along the Senegal river, Sine, Saloum, Eastern Senegal but lack of funds and other constraints have only enabled 40 to 50 per cent of the original objectives to be achieved. As in Bandia the system adopted has been simple coppice on a 20 year rotation. The method of dividing the cut among charcoal burners is described in Section 4.2.5.3.

Experience in managing these forests has shown that the following factors are indispensable for natural forest management:

(a) thorough knowledge, obtained by inventory, of the volume, structure and all other relevant information of the forest to be managed.

(b) strict control of fire and grazing.

(c) in the case of certain forests (e.g. the forets du Rail - forests originally intended to provide fuel for railway locomotives - in Eastern Senegal) orientation of forest management almost entirely towards protection. In some of these areas the soils are fragile, and a large part of the area is on shallow soils over laterite ("bowe").

The rotation of 20 years hitherto used should not be taken as an invariable rule. Closer analysis of the results from these forests would be interesting not only in Senegal but in other areas with similar ecological conditions.

The knowledge so obtained would include yields, their level, variability, and composition; profitability, labour needed, costs and benefits; rotation; techniques of felling, charcoal burning, loading and transport; inadequacy of specifications; and information on institutional aspects.

The third phase of management of natural forests began about 1975, under the 4th Development Plan (1973-77). During this plan a number of objectives in forest management were formulated and action proposed to achieve them. They included management, production, protection, reforestation, development of natural resources, education, and research. Projects which contained a natural forest management component included:

1. Le reboisement et l'aménagement de la zone sylvopastorale. In addition to plantations, 600 ha of natural vegetation were brought under protection, and extension of this area is envisaged.
2. Mise en valeur des forêts de Basse et Moyenne Casamance, covering the inventory of 260,000 ha of selected forest, and 62,000 ha of mangroves.
3. Aménagement et reboisement des forêts du Centre Est (Sine, Saloum, Senegal oriental). Includes the management of the natural forest of Koumputoum of 10,000 ha, involving firebreaks, tracks, and silvicultural work.
4. Mise en valeur des forêts de Tabor. Includes seeding fellings, enrichment plantations and construction of 80 km of internal and external firebreaks.

3.1.3.3. Conclusions

In this report it has been possible to deal more fully with Senegal than with some other countries, as much information was made available not only from the very full Plan directeur (99-102), but also from forestry departmental archives. It is the only country of the region where appreciable areas of

natural forest have been brought under systematic management for wood production; elsewhere work has been limited to small scale trials and experiments. The area managed is still, however, small compared with the needs; the main constraints which need to be removed are shortage of funds; shortage of staff with the right training; paucity of research results; and insufficient use of those available; wastage of wood through poor techniques of harvesting, and conversion into charcoal; over-rigidity of the forest laws and regulations; and, until recently, insufficient coordination between the forest service and those responsible for rural development in the field.

3.1.4. The Gambia (17)

The area of the country is 10,403 km^2, of which about 4,500 km^2, or 45 per cent, was wooded in 1968; the wooded area is presumably less today. The vegetation is of the Sudan and Sudano-Guinea types, and includes about 660 km^2 of mangrove forest.

Forest Parks (equivalent to the Forêts Classées of Francophone countries) cover 340 km^2.

The population was estimated at 601,000 in 1980. Total fuelwood needs for that year were estimated at 927,000 m^3, following a ban on charcoal production, which saved 147,000 m^3 a year. Demand in the year 2000 is estimated to be about 1,600,000 m^3 if consumption is unchanged, or 900,000 if consumption falls as firewood becomes scarcer. In 2000 natural woodland of 3,500 km^2 would need to produce 711,000 m^3 of firewood (the rest coming from plantations); this, at about 2 m^3/ha/yr is a high yield, and considerably higher than present production.

Officially recorded imports of lumber in 1978/79 were 861 m^3 (17), but this does not include unrecorded imports from Senegal. In addition a small government owned sawmill produced about 110 m^3 of sawn timber, of which about 30 percent was plantation-grown gmelina.

Up to 1980 1204 ha of plantation had been established, and by 2000 it is hoped to bring the total area to 12,000 ha.

Little attention appears to have been given up to the present to the management of natural forests, though efforts are made to protect them against fire and grazing. Some ecological research has been carried out in the mangrove forests, and an inventory prepared of the 8,700 ha of mangrove forest which will be affected by construction of a salinity barrier across the Gambia River. (56) This inventory showed that there were more than a million m^3 of mangrove timber (115 m^3/ha), of which about 600,000 m^3 was of millable size. The USAID-assisted Gambia Forestry Project includes a feasibility study of the exploitation of this timber.

The project "Assistance for the Gambian Forestry Service", aided by the Federal Republic of Germany, includes the carrying out of a forest inventory for the whole country, giving details of timber volume by species and rates of growth. This will be done between 1981 and 1983.

3.1.5. Mali (20)

3.1.5.1. General situation

Mail has an area of 1,240,000 km^2. There is no estimate of the total forest area, but of the 470,000 km^2 of land with a rainfall of over 400 mm, 21,000 km^2 are under cultivation and 94,000 km^2 are under fallow; thus 335,000 km^2 are under the egis of the forests service, either in the 'domaine forestier classe' or the 'domaine protégé', though this area includes some treeless land such as bare rock and shallow soils over laterite. The forests under a rainfall of less than 400 mm can be considered as virtually unproductive, as they should be preserved on environmental grounds with only dead wood being collected.

The vegetation ranges from a vast expanse of desert in the north, with open wooded steepe of Acacia tortilis subsp. raddiana on its southern fringe, to open forest with Isoberlinia and Pterocarpus in the south east.

The population was 6,309,000 at the latest census in 1976, and is expected to rise to 11,520,000 by 2000. One estimate of domestic fuelwood consumption is 3,030,000 tonnes in 1981 rising to 4,954,000 tonnes in 2000, but these figures are considered too low by some authorities. The volume equivalents of these weights are about 3,600,000 and 5,900,000 m^3 respectively. Potential production is estimated at 6,900,000 m^3 in 1976, falling to 5,035,000 m^3 in 2000, as the result of additional areas being cleared for cultivation. However these overall figures conceal considerable local deficiencies; the regions of Segou, Mopti, Gao and Tombouctou are already deficient in fuelwood, and all other regions, with the exception of Kayes, are expected to be in deficit by the year 2000. There are also the problems of supplying the capital, Bamako, with a population of 404,000 in 1976, expected to reach 887,000 in 2000.

The present consumption of industrial wood (for carpentry, furniture, box-making and matches) is at present 37,000 m^3 per year and is expected to rise to 93,000 m^3 in 2000, with at present 85 per cent imported. There are three sawmills at Bamako, and 1,500 m^3 of Bombax timber is used in a match-factory, also at Bamako; this is expected to rise to 2,600 m^3 by 2000, but part at least is expected to be replaced by Gmelina from plantations.

A number of other products are obtained from the forests. They include wild fruits, of which the most important is Vitellaria (karite), a factory near Bamako makes drinks from Tamarind fruits; leaves and flowers; palm wine; Raphia midribs and bamboo for building and furniture; leaves of Borassus and Hyphaene for mats and baskets - particularly mats sewn into sacks for the transport of dried fish; and medicinal products. Gum arabic export averaged about 1800 tonnes/annum from 1937-1948, 1260 from 1949-1960, and 1330 from 1970-1980.

The area of forêts classées is 11,307 km^2, to which must be added 29,454 km^2 of ex-partial game reserves, and 3,500 km^2 of National Park. However much of this area is quasi-abandoned.

3.1.5.2. Results to date

Between 1940 and 1955 a number of forests were exploited to provide fuel for the railway and river steamers. These covered 18,000 ha in the Sudan and Sudano-Sahel zones, and yielded an average of 35 sters per hectare (about 12 m^3). The method of exploitation was to clear parallel strips 250 m wide along the rail and 2-4 km long. A rotation of 20 years was envisaged.(104a) Ten years after exploitation, it was found that in forests unprotected against fire 20 years would be insufficient for regeneration. In the forest of La Faya, systematic sampling showed that after exploitation growth averaged 0.33 m^3/yr, despite several years of complete fire-protection followed by early burning; in the Monts Mandingues forest growth was about 1 m^3/ha/yr, but here soils and rainfall were better, and fire-protection was continued for 15 years after exploitation.

Between 1951 and 1960 a program was begun of opening and maintaining firebreaks round the forêts classées (57), but this was discontinued after independence in 1960 due to shortage of funds.

Trials of freeing seedlings of valuable species (Isoberlinia and Afzelia) were undertaken in the La Faya and Monts Mandingues forests between 1956 and 1958, but these were not followed up.

In 1972 a project 'Aménagement des forêts classées de la Région de Bamako' began, and has been continued under the names of 'Aménagement et Reboisement dans la Région de Bamako' (1976-1980) and the 'Operation Aménagement et Productions Forestieres' 883/MLI (1980-1984).

During the first phase of this project there was some exploitation of natural forest for fuelwood on orthodox lines, with retention of valuable species, and the firebreak network was restored. During the second phase soil-vegetation maps covering 100,000 ha were prepared from aerial photographs taken at a scale of 1:15,000; this has proved of great value in management. Management of a further 1000 hectares of natural forest has been planned for the third phase, but work in the field has not yet begun. Part of this management will consist of selection of areas with a high concentration of valuable species and taking measures to favor these by removing competing vegetation and selective thinning.

A Swiss-financed project 'Projet Forestier de la Region de Sikasso' began in 1980. This has included the inventory of 16,000 ha, including soil studies. The main emphasis so far of the project, as far as management of forests goes, has been on plantations, but the management of some areas of natural forest is planned. This area has a fair number of timber-sized trees, and the possibility of bringing in a portable sawmill to utilize these is being investigated.

In 1980 a 'Projet de reboisement - Kayes' began, with financial aid from the Federal Government of Germany. Among its objectives are the management and eventual exploitation of the

forêts classées around Kayes and a study of management of the forests in the south of the region; work to date has consisted mainly in the establishment of nurseries and plantations, but a beginning has been made in the construction of firebreaks in the natural forest.

Over half the country has been covered by the 'Projet Inventaire des Ressources Terrestres', aided by USAID. This includes maps, at a scale of 1:500,000, prepared largely from Landsat imagery, and should form a useful basis for general forestry planning. The scale, however, is too small to be of much value in management of individual forests.

A pilot project for the High Intensity Use of Manpower in Public Works, aided by the International Labour Organization, had as one of its objectives clearing firebreaks around forests in the Kayes and Segou Regions. By June 1981 about 110 km of firebreaks 10 m wide had been cleared but not weeded.

3.1.5.3. Conclusions

In general management of natural forests in Mali, apart from early work, not continued, for providing wood for the railways, etc., has only reached the level of fire-protection of certain areas, plus a few very small research efforts. Obviously much still remains to be done.

3.1.6. Upper Volta (19)

3.1.6.1. General situation

The area of the country is 274,000 km^2, of which 93,200 km^2 is 'available' forest (excluding national parks, etc. where exploitation is forbidden, and also excluding fallows and parkland of *Vitellaria* and *Parkia*). This forest is estimated to have a standing volume of 228 million m^3 of timber.

The forests range from Acacia-dominated formations in the Sahel zone, to open forests with *Isoberlinia* and patches of gallery forest, in the Sudano-Guinea zone.

The annual requirements for fuelwood are estimated at 6.25 million m^3 for a population of 6.5 million. The population is expected to be about 9.6 million in 2000, with a fuelwood consumption of 9.285,000 m^3.

By 2000 it is estimated that the forest area will be reduced by 10,000 km^2, and forest fallow by 45,000 km^2, leaving about 50,000 km^2 of forest for firewood production, against the 65,000 km^2 needed, at the high yield of 1.5 m^3/ha/yr, to meet anticipated fuelwood demands. These countrywide figures, however, conceal considerable variations from place to place, and it is considered that transport of considerable quantities of fuelwood from the south to the north of the country will eventually be needed.

Consumption of sawn timber is about 20,000 m^3 sawn volume, of which 18,000 m^3 are imported from the Ivory Coast, the rest being produced at small sawmills at Banfora.

Forêts classées cover 7,270 km^2 (excluding National Parks, and fauna reserves). There are about 125 km^2 of plantations.

3.1.6.2. Results to date

Trials of encouraging natural regeneration of Khaya senegalensis and Pterocarpus erinaceus were undertaken in the forêts classées of the Mare aux Hippos, Niangoloko, and Kou, by demarcation areas around the seedbearers and weeding round the young seedlings. This resulted in very good seedling establishment (2000 seedlings of Pterocarpus per ha). Unfortunately growth was slow, Khaya senegalensis attaining heights of 12 cm after 2 years. (74) CNRST is continuing a study of the behavior of the principal woody species in the Mare des Hippos forest.

In 1963-64 a series of plots was measured in Gonse forest, in an area felled 25 years ago. These produced an average of 52.5 steres/ha, or an annual growth of 2.1 steres/ha/yr (equivalent to 0.7-1 m^3). Similar plots felled at Dinderesso gave a mean annual increment of 2.7 steres/ha/yr. (9)

A number of recent projects have included a natural forest management component. The Project de Reboisement de la Mission Forestière, aided by the Federal Republic of Germany, includes studies of natural forests in Gonse. The IDA project at Mare and the USAID project at Dinderesso contain components on natural forest management, but up to date no field work has been undertaken apart from the opening of firebreaks. The FAO/UNDP project of 1973-1977 included in its objectives the management under coppice of 6500 ha of natural forest, but none of this was done.

CTFT has established two plots at Gonse and Wayen, each of 1 ha, in which the regrowth after coppicing in 1978 is being carefully studied. Yields after 4 years have been recorded as 2 m^3/ha/yr at Gonse, and 1.1 m^3 at Wayen. (13, 14)

The FAO/UNDP project 'Développement des ressources forestières et renforcement du service forestier' (1978-82) has among its objectives the evaluation of forest resources and the identification of potentially productive areas. This has been done through a combination of Landsat images and sampling on the ground using a large number of sample plots.

In 1983 the Directeur de l'Aménagement Forestier et de la Reboisement gave instructions for the laying-out of plots to study production of natural forest after coppicing, the effects of fire, and the influence of felling the trees at different seasons of the year.

3.1.6.3. Conclusions

Although little practical work has as yet been undertaken on the management of natural forests in Upper Volta, its importance is well recognized by the Forests Service (see, for example references 47 and 48). It is hoped that this interest will soon be translated into work in the field, as it is clear that in the future the bulk of the country's needs in wood will have to come from natural forest management.

3.1.7. Niger (16)

3.1.7.1. General background

The area of the country is 1,267,000 km^2 with a forest area of 140,000 km^2. Of this area it is estimated that 21,000 km^2 could be relatively easily brought under management.

The forest type ranges from thorn steppe at the margin of the Sahara, to open wooded savanna of the Sahelo-Sudan type, with patches of gallery forest, in the south west.

The population was 5,697,000 in 1981, and is expected to rise to 10 million by 2000. In 1981 consumption of wood fuel (mostly firewood, as charcoal is little used in Niger), was estimated at 1.5 steres per head of population or a total of 8.5 million steres, which at 240 kg per stere is equivalent to approximately 2 m tonnes. Annual increment from 90,000 ha of natural forest, at 0.5 steres/ha/yr, is estimated at about 1 million tonnes. The Forest Service of Niger estimates that by the year 2000, 2.1 million hectares of natural forest could be brought under management, with yields ranging from 1 to 3 steres/ha/yr according to the ecological type of the forest, giving a total of 4.8 million sterest or 1.15 million tonnes. To this would be added 650,000 steres from 135,000 ha of non-irrigated plantation, and 320,000 steres from 8000 ha of irrigated plantation, giving total of 5.8 million steres, or 1.4 million tonnes. By this time annual requirements will have increased to 2.5 million tonnes. Thus at present demand for firewood exceeds the increment from the forests, and even if the ambitious Forest Service program is realized, there will still be a serious deficiency in 2000.

The needs for building poles are estimated at 5 to 10 percent of the needs for firewood. Split Borassus stems provide an important proportion of timer used in roofing. Sawn timber demand is low and all is imported from Nigeria. Gum arabic production is about 500 tonnes per year, with considerable variation from year to year.

The area of forêts classées is 2,118 km^2.

3.1.7.2. Results to date

During the 1960's CTFT did some studies on growth of species in the 450-500 mm rainfall zone, based on measurement of annual rings. These are reproduced in table 6 (Section 4.3.5.2.1).

CTFT also, at Dounga in 1974, set up plots to study a number of treatments of natural forest. These included the effects of fire, different methods of cutting, and lightly scarifying the ground after cutting. (12) The plots are due to be cut again in 1984, when the results of the different operations will be assessed.

In 1974 a project for plantation of Acacia albida was established with the assistance of USAID, and 2,900 ha were planted; a similar project, aided by FAC, began in 1981.

The World Bank in 1975-76 began a project for 'Protection et Exploitation des Gommeraies Denses Naturelles dans le Manga'. This consisted of selection of patches of over 50 ha of dense regeneration, from 5-10 years old, demarcating these, and protecting them by living fences (zaribas) and firebreaks. The aim was to continue this protection for 15 years. An area of 5,186 ha was treated in this way, but unfortunately the project only lasted 18 months, and the continuity of the work (maintenance of firebreaks and fences) is thus not assured.

In 1978 to 1980 a 'Projet d'Aménagement et de Reconstitution de la Rôneraie de Dallol Maouri' was aided by FAC. An area of 1934 ha was sown direct with Borassus fruit, and protected by a fence and a firebreak; this was continued with Swiss Aid (DDA) from 1981-83. The objectives during this latter phase included establishment of a felling regime, and adoption of a management plan. Four thousand ha were to be regenerated, 300 artificially, the rest naturally.

In 1980 the 'Projet pour la planification et l'utilisation des sols et des forêts', assisted by USAID, began. This large project includes forest inventory, natural forest management trials, fish and wildlife inventories, forest product pricing and marketing studies, and other activities related to the production of a long-term management plan. The project is due to last until 1984, by which time some very useful results should have been obtained. Already trials have shown that growth of some of the species of the Sudano-Sahel zone is considerably higher than expected; for instance Combretum grew into maturity 4 years after felling.

The $16.8 million Projet Forestier of the World Bank (IDA), phase 2, though to a large extent concerned with afforestation, (including gum arabic plantations) includes management of 6000 ha of natural forest, and 6000 ha of natural gum arabic management, fire control, research and training.

The project for 'Plantations des Bois Villageoises', aided by the IDRC of Canada has as one of its aims the application of effective and relatively cheap methods for the protection of natural regeneration, but so far no results are available.

3.1.7.3. Conclusions

Niger is already a fuelwood deficit country. Management of natural forests cannot close this gap completely, but can at least help to alleviate the situation. The USAID project should provide very useful data on this; it is to be hoped that it will be the beginning of a sustained effort.

3.1.8. Chad

Unfortunately little recent information is available from this country, which is a pity as there has been some interesting work there.

The area of the country is 1,284,000 km^2, and the population about 4.2 million. The vegetation ranges from desert in the north, to Sudan zone vegetation in the south. There are about 4,500 km^2 of forêts classées.

Some trials of the effects of enclosure by fencing near Abeche in the Sahel zone were begun about 1960. The effect of fencing was to increase the number of trees over 2 m high from 70 per ha to 260 per ha in 10 years. (31)

In the 1960's there were also a number of investigations on gum production. (30, 71)

A project aided by UNDP/FAO on 'Aménagement et Exploitation de la Vegétation Forestière dans la Région de Ndjamena' included employing the local people (using World Food Programme food) to make thorn fences (zarebas) and clear firebreaks 20 m wide round a number of forest areas, ranging from 50 to 300 ha, and totalling 1550 ha altogether. This protection resulted in a very rapid recolonization of the area by tree species, especially in formations dominated by Acacia seyal. The project is said to have been well received by the local people, and no fires or illegal fellings were recorded in the protected areas. Unfortunately the project was never completed. (see refs. 34, 65, 82, 83)

3.2. Experience in other African countries

Little management of natural forests (other than rain forests) has been done in the Anglophone countries bordering the Sahel Zone (Sudan, Nigeria). The main exception is the Sudan, where riverain forests of Acacia nilotica have been under management plans since 1949 (see Section 4.2.7.1). Otherwise management has been confined to fire protection and control, through the construction of firebreaks, mounting fire patrols in the dry season, and systematic early burning.

In Nigeria a number of experiments have been set up to study the effects of various treatment on regeneration of natural forest after cutting. In one experiment fire protection as against early burning increased basal area of the regrowth 5 years after cutting to 1.24 m^2/ha compared with 0.42 m^2/ha, while hoeing the ground after cutting increased the basal area to 1.97 m^3/ha. For more details see Section 4.2.5.1.4.

In the Sudan considerable study has been made on managing Acacia senegal forest for gum production. See Section 4.2.7.2.

3.3. Conclusions

In Senegal a simple form of management of natural forests is being practised in some parts of the country, consisting of felling the forest in a series of annual cuts. No management of this type has taken place elsewhere, other than on an experimental scale. There have been encouraging results in some places in obtaining natural regeneration of degraded forest through protection against fire and grazing. But in general natural forest management is just beginning in the region, though its importance has been emphasized by some foresters for a number of years (68, 105), and is being increasingly recognized by governments. Funds for natural forest management, however, still form only a small proportion of the quite considerable amounts of money being spent in the region by aid organizations and others.

There is a need to broaden the concept of forest management to include non-wood products, and grazing, and to involve local communities more deeply in the work.

A good deal more information is probably available on past trials of natural forest management and their results, from such sources as forest service archives, and the personal knowledge of older and retired foresters. Collection of all this information, plus a study of the literature, would be very valuable in providing a basis for future management. This should be combined, where possible, with a study on the ground of former trials and reassessment of their results.

It is also important that careful records should be kept of all work done on natural forest management in the future, and the information obtained be disseminated as widely as possible. This should not only apply to 'research' results; in the present early stage of development of a natural forest management in the region all work done can be regarded as to some extent experimental, or applied research. Good knowledge of the factors leading to success - or failure - in the next few years will be a great help in planning future work.

4. Getting natural forest management under way in the Sahel

4.1. Introduction

It has been shown that it is essential to bring the natural forests under management of the problems of supplying fuelwood and other forest products in the Sahel region are to be solved. To do this a number of operations are necessary for each forest, as detailed below.

4.2. Technical Matters

4.2.1. Reconnaissance and delimitation

It is assumed that management will begin in the forêts classées. Unfortunately not all of these have been demarcated on the ground, and where demarcation has been made, the boundary may no longer be clear. Also many of the forêts classées have suffered considerable encroachment, and in some cases there may be little forest left to manage. In this last case the alternative will be either to declassify the forest, or to resume protection of the forest with the hope that natural regeneration will in the course of time restore the growing stock. Which course to adopt will depend on local circumstances, particularly the socio-economic needs of the surrounding populaton.

Provided it is decided that the forest is to be retained the next step will be to resurvey the boundaries and demacate them with permanent marks such as cement pillars, or cairns of stones - blazes or numbers on trees are unsuitable as they soon become obscured. Then a firebreak needs to be cleared round the forest, and a guard appointed, with housing provided where necessary.

These steps will be needed even if the forest is not to be exploited in the immediate future, to protect the forest for future use.

The re-demarcation and protection of the forets classees is a priority task in the countries of the Sahel zone, if any forest estate is to be left for future generations.

4.2.2. Inventory and Surveys

4.2.2.1. Physical surveys

It will be necessary to obtain an estimate of the volume of growing stock within the forest, and to divide it into soil-vegetation units for management purposes. This is best done from aerial photographs at a scale preferably of 1:25,000, or larger. Ordinary panchromatic photographs are adequate for this. The 1:500,000 maps prepared from satellite imagery are not detailed enough for management of natural forests.

It is usually possible to distinguish the more important vegetation types - and hence soil types, for the vegetation is closely correlated with the soil - from steroscopic study of the photographs combined with careful checking on the ground. A map is then prepared on a scale of 1:25,000 or 1:50,000 showing the different soil-vegetation units on which the management of the forest is to be based.

Often, in describing vegetation types, physiognomic terms are used such as 'savane arbustive', 'savane arborée', 'savane boisée ouverte', 'forêt claire'. These terms are useful, but are not by themselves adequate for vegetation description for management purposes, which should include at least the names of the dominant or commonest tree, and where possible, grass species.

Further studies of the soil can be made by digging pits or taking borings within each soil-vegetation type shown by the photographs. For management of natural forests, as opposed to plantation establishment, this is not absolutely essential, though it would help to get a better understanding of the forest; it would be needed for research purposes. The most important soil features are depth (to rock or indurated ironstone (plinthite)), texture, drainage, presence or absence of stones or other inclusions, and pH. It should be possible for agents techniques or Préposés to undertake this work in the field, after a short period of training. Collection and chemical analysis of soil samples is rarely needed.

To make an inventory of the growing stock a suitable method is to stratify the forest according to the soil-vegetation types, and to select plots at random within each type, using the photographs to locate the plots. For logistic reasons (ease of access) it may be necessary to modify this procedure, for instance using cluster sampling methods.

Another method of making an inventory is by systematic sampling, which may take various forms, the commonest being to measure the trees along strips of fixed widths at fixed

distances apart. Thus for a five percent sample strips 25 m wide spaced 500 m apart would be used. This is likely to be more time consuming than the method of stratified random sampling mentioned above, but would be the most practicable method where aerial photographs were not available, as it would enable an outline soils-vegetation map to be prepared at the same time.

Within the sample plots or sample strips the trees will need to be measured. The procedure proposed for Senegal (Project pour la Délimitation, Inventaire, et Aménagement de forêts domaniales et forêts de collectivités rurales dans le Sénégal oriental et le Sine Saloum) is as follows:

All trees over 1 m in height are recorded by their vernacular names, and classified by species. For trees greater than or equal to 5 m tall heights are measured to the nearest 50 cm, and the circumference at 1.3 m above soil level; trees less than 5 m high are classified into 1 m height classes. Dead trees have their girths measured, and are classified into height classes, no distinction being made between species. Samples are then taken so that simple volume tables can be computed. It is also necessary to obtain stacking coefficients (solid volume in m^3 per stere) for large wood (over 5 cm in diameter) and small wood (under 5 cm) seperately.

A system of this sort, with modifications to suit local conditions, would be generally applicable for forests to be exploited mainly for fuel. It might be possible to reduce the amount of work in measuring heights by preparing girth height curves for the larger trees, so that only girths would need to be measured for these.

The final result should be expressed in volumes of individual species per hectare, for each soil-vegetation type.

In selected forests during the inventory it may be desirable to identify certain of the plots for retention as permanent plots for repeated remeasurement in the future; in such cases the original records of the plots may need to be more detailed.

There are some areas where detailed forest inventories have already been made, for instance the forests near Bamako in Mali, and Dinderesso in Upper Volta (see Section 3.1. under the different countries). In such cases the existing inventory should be studied; it should generally be possible to use it, perhaps with slight refinements.

How essential are soil-vegetation mapping and inventory? They are certainly very desirable if soundly based forest management is to be undertaken, but in cases of urgency it would be preferable to begin management without them, rather than wait for several years before accurate inventory could be made. In Senegal, where some natural forests have been successfully "managed" since 1938, there is no record of detailed inventory having been made before exploitation began.

4.2.2.2. Socio-economic surveys

For selected forests socio-economic surveys would also be desirable. These would cover the use of the forest by the local population, not only as a source of wood, but for edible fruits, fibres, medicinal herbs, and other non-wood products, and also for grazing. This could be combined with a survey of the likely markets for the produce, studying the demand for different sizes and assortments of wood of different species, and their uses for different purposes.

4.2.3. Assessment of markets and products

Before a forest is taken under management for production of wood or other products it is necessary that assured markets for the produce will be available, otherwise the forest should be protected only, until markets develop. In some cases it may be obvious that a market exists, but in others further investigations into local supply and demand may be needed (see Section 4.3.6.)

4.2.3.1. Types of production

With the exception of some special cases (Borassus, gum arabic), the main products yielded by the natural forest will be wood for fuel (including charcoal) and round building poles. Except in the forests of Basse and Moyenne Casamance, the production of timber for sawing and other forms of conversion will be ancillary to these, where it is possible at all.

The natural forests will continue to provide the local inhabitants and local and regional markets with fruit, leaves, fibres, medicinal plants and so on. In certain cases, particularly near large urban areas, trade in these products may be substantial, e.g., combretum leaves used for making tea in Dakar, dried leaves of the baobab tree, and its fruits and the flour prepared from them, chewing sticks, and honey. In general no special management provisions will be needed for this purpose, except the retention of certain fruit trees (Vitellaria, Parkia, Tamarindus) when the firewood crop is cut. There may be cases, however, where local communities consider that non-wood products should take priority over firewood production, such as near established markets; in such cases a special form of management plan will need to be prepared. Research into means of increasing the yields of certain non-wood products should also be considered.

4.2.3.2. Wood for fuel

There is a tendency to regard almost any sort of wood, irrespective of its species or dimensions, as being suitable for firewood. Where conditions of extreme scarcity exist this may be more or less correct, though even there wood of large diameter, which requires splitting, will not be favored. But in general the market is quite a discriminating one, both in regard to the size of wood and the species to be used. Different consumers have different requirements; domestic consumers

prefer wood or relatively small dimensions, but users such as bakeries, brick-burners and so on often use larger sizes. The assortment into different sizes, and preparation for retail sale, will normally be made by wood-merchants, but the management of the forests should take into account market requirements, in particular in establishing the length of the rotation.

To what extent the wood should be burnt into charcoal will depend on a number of factors. When firewood is converted into charcoal about 60 percent of its calorific value is lost; for this reason the use of charcoal has been banned in the Gambia. Against this, charcoal production allows wood to be used which is too large for firewood; also the relatively high value, both calorific and financial, per unit weight of charcoal allows it to be transported economically over much greater distances. Thus charcoal produced in areas where there is a surplus of wood can be used to meet the needs for fuel in deficit areas a considerable distance away.

4.2.3.3. Roundwood and poles

These will be produced from the firewood cut by selecting the longer and straighter stems of acceptable species.

4.2.3.4. Timber

Generally trees suitable for the production of sawn timber are very sparsely scattered in the natural forest, with the exception of Casamance and perhaps certain stands of *Isoberlinia* in the southern parts of Upper Volta and Mali. Such trees will rarely be found under rainfalls of less than 800 mm. Thus production of timber from natural forest is only potentially important in Senegal, Mali, Upper Volta and on a small scale in the Gambia and Niger.

(Though not strictly speaking sawn timber, rafters split from the stems of ronier (*Borassus*) and doum (*Hyphaene*) are widely used in building construction throughout the region. See Section 4.2.6.4.)

At present in Senegal there are 6 sawmills in Casamance dependent on indigenous timber, plus another 6 in Dakar converting logs imported from the Ivory Coast. These sawmills in 1980 used about 13,000 cubic meters of indigenous logs. In addition a match factory uses about 2000 m^3 of *Bombax* per year, for boxes.

In Mali there are three sawmills, all at Bamako, and a match factory; the recorded figure for trees cut for timber in 1980 was 11,700, m^3 though some of this was cut by hand sawyers.

In Upper Volta there has been one sawmill at Banfora producing 1,500 to 2,000 m^3 per year (equivalent to 3,000 to 4,000 m^3 of round timber), and a second one has now been opened. In the Gambia there is a small government sawmill, cutting *Khaya* and *Gmelina*, the latter from plantations.

Thus although the demand for timber for sawing is relatively small, it does exist, and as retaining standards of timber species in the natural forest is possible with only slight modifications of management systems this could be standard practice in appropriate areas.

The very scattered supplies of timber in the natural forest will often mean that collecion of logs and their transport to sawmills is uneconomic. The Swiss-aided project in the Sikasso Region of Mali is considering trials of a portable sawmill; results from this operation will be interesting. Otherwise the conversion of logs in situ by pit-sawyers would appear to be the most practicable way of using this type of timber.

Apart from sawn timber, timber is also needed for the wood-carving industries, for building boats and canoes, and for mortars for preparing food, and these needs should be considered when planning forest management. There is a growing demand for wood-carvings, masks, and other handicrafts, following the growth in tourism, and there are already some indications that supplies are becoming scarce, particularly in Senegal of Dalbergia melanoxylon, a small tree of the drier parts of the Sudan zone. This should be preserved when it occurs in areas which are being felled for firewood.

Wood for boats and canoes is essential for the fishing industry. Mortars are used for preparing food in almost every rural household. Some criticisms have been made of the amount of wood "wasted" in making mortars, but often this is wood of low value for other purposes (e.g., Sclerocarya birrea). In any case mortars are almost as necessary as firewood for the preparation of food, and the provision of wood for making them is essential.

4.2.3.5. Minor products

The importance of the so-called "minor forest products" (leaves, bark, fruit, fibres, resins, gums) to the local population has already been referred to, and is further discussed in Section 4.3.3.2. In addition to their importance locally, some of these products are exported (Parkia fruits and oil, Combretum leaves, gum arabic, tamarind fruit juice). Their use and potentialities deserve further study.

One advantage of managing natural forests is that the collection of these non-wood products will be able to continue.

4.2.4. Preparation of management plans

Once the inventory has been completed, and markets studied, simple management plans should be drawn up. These should define the objects of management of the forest; prescribe the system of management, how the forest should be divided up into working circles and annual cutting areas, and the operations for each year for each compartment; forecast annual yields, costs and returns, and staff needed; and make provision for the keeping of simple records.

Such plans should be submitted to the head of the Forest Service for formal approval, and important diversions from the plan should also require prior approval.

4.2.4.1. Systems of management and other silvicultural operations

In most cases the appropriate system of management will be simple coppice, or coppice with standards, with the yield regulated by area. Coppice with standards, or reserves, will be used when it is desired to retain certain species for the production of timber (Khaya, Pterocarpus, etc.) or for their fruits (Vitellaria, Parkia). Exploitation of the standards retained for timber would best be controlled by establishing minimum girth limits for each species, with trees which have reached the girth limit being marked for cutting at the same time as the surrounding coppice is cut.

It should be noted that in many cases retention of valuable species as standards will make little difference, in practice, to the management of the forest, as these species are very widely dispersed, of the order, for instance, of one Khaya per two or three hectares.

The forests of Basse and Moyenne Casamance are a special case. Here the forests are of the Guinea type, growing under annual rainfalls of between 1200 and 1750 mm., and their main function will be to produce timber. The appropriate management system for this type of forest is beyond the scope of this paper.

Certain other special cases are discussed in Section 4.2.6.

The trees should be cut within 15 cm from the level of the soil, as is prescribed and practiced in Senegal.

The system of simple coppice, or coppice with standards has the advantage that it can be controlled easily by relatively unskilled staff. Further refinements, such as improvement fellings and selective thinnings to favor particular species, require much more skill and experience, and in many cases staff is currently unavailable for this.

Among such measures suggested have been the removal of trees of poor quality for fuel, such as Bombax and Sterculia (though Bombax is one of the main timber species exploited in Mali), and removal of shrubby species of low yield (e.g., Combretum micranthum, Dichrostachys, Acacia ataxacantha). All such measures will increase costs, while their efficacy is doubtful. Such proposals as "canopy manipulation through intermediate and regeneration cuttings" are unrealistic in the conditions which prevail in most of the Sahel Zone countries.

In the past some operations have been undertaken to increase the stocking of timber species, such as at the Mare aux Hippos in Upper Volta (Khaya senegalensis and Pterocarpus erinaceus). (See Section 3.1.6.2). Although a large number of seedlings survived, growth was generally slow (12 cm in 2 years for Khaya senegalensis). In this case the effort put in seems scarcely justified by the results obtained.

Enrichment plantings have been proposed in some projects, notably the IDA project at Maro in Upper Volta, and the Forestry

and Land Use Planning Project in Niger. Enrichment planting can be regarded as a half-way stage between natural forest management and making plantations. If done properly it is not cheap - the planted trees need to be weeded, and freed from competition by trees of the natural forest, often in several stages during their life-time. The species chosen for enrichment need to be fast-growing, and of considerably higher value than the average ones already growing in the forest. Trials in Northern Uganda in the late 1940's, of planting Khaya grandifoliolia, Maesopsis eminii, and Chlorophora excelsa in woodland dominated by Terminalia glaucescens (26, 58) were eventually abandoned as unsatisfactory.

Enrichment plantings should be distinguished from sowing or planting to supplement natural regeneration in natural forests (see Section 4.3.5.2.4). At present enrichment plantings should be confined to small scale trials.

In Nigeria hoeing the ground after coppicing was found to increase regrowth of woody species by about 60 percent (see Table 5, Section 4.2.6.3). However this increases costs money (20 man-days per ha) and would require a considerable labor force. Other operations tried or recommended have been working the soil mechanically after felling, and sowing seed artificially to supplement coppice growth.

Research should continue into various methods of stand improvement, but until results are available from this research operations should be confined to simple coppicing or coppice with standards.

4.2.4.2. Division of the forest into compartments and series

There will be cases where different parts of the forest will require different treatments; for instance, in forests on ferrugineous tropical soils there will be productive forest on the one hand, and either unproductive areas (bowals) or areas which need protection, such as forest on laterite boulder ridges, on the other. In theory these should be regarded as two series, one for production and the other for protection.

The simplest way of dealing with such problems would be to attempt to arrange the compartments so that each contained approximately the same area of productive forest. Thus one compartment, consisting entirely of productive forest, might be of 100 ha, while another might be of 170 ha, consisting of 100 ha of productive forest, 50 ha of bowal, and 20 on bouldery ridges. Each year one compartment would be felled, but the bowals would naturally not produce anything, and the ridges would be excluded from cutting. Thus approximately equal annual yeilds would be expected.

The forest will normally be divided into compartments, each compartment corresponding to an annual cut, so that the number of compartments will be equal to the number of years in the rotation. However in areas where demand is initially low, but is expected to increase (as will normally be the case), the first compartments should be only large enough to meet the estimated demand, with other areas of the forest being held in reserve to meet the expected future growth in demand.

4.2.4.3. Exploitation

Senegal is the only country of the region to date in which regular exploitation of natural forest has taken place. This has been done by charcoal burners, each of whom is given a permit (carte professionnelle) to cut a demarcated area within the annual cut. This is issued free of charge, but royalty is charged on the basis of the number of sacks of charcoal produced. The permit also specifies the number of laborers to be employed and the date by which the work has to be completed, leaving the area completely cleared. The charcoal burners are responsible for clearing firebreaks round their felling areas, while the forest service maintains external firebreaks. Additional conditions are prevention of fires spreading from the site of the charcoal kilns, and making men available to fight forest fires where needed.

Such provisions could easily be adapted to firewood and pole cutting by contractors, each contractor being allotted a definite area and charged standard royalty rates on the produce.

An alternative method would be to sell the standing wood on the harvesting units to contractors, by tender or by auction. This would be quite a new concept in Sahelian forestry; as Hagen writes: (45) "The Upper Volta Forest Service has never conducted a timber sale", and nor have the forest services of any of the other Sahel countries.

One advantage of selling standing trees would be to establish the idea that standing trees have a market value, and also to provide an indication of what is that value. At present trees are regarded as a gift of nature, only acquiring value after they have been converted. The royalties paid to governments for forest products are not considered to represent the value of the standing timber but are simply taxes, which are not normally even credited to the budget of the Forest Department, though nowadays all or part of these taxes may be paid into a "Fonds forestier".

When standing timber is sold by contract or tender, the produce should be exempt from royalty, it being assumed that the equivalent of royalty has been included in the price paid for the standing timber.

Hagen (45) provides some useful general guidelines for selling standing timber: "Initial sales should be very small ... so the interested buyer will not be gambling too much on an unknown venture. Timber sales should be prepared and marked out on the ground, specifications drawn up and made public, the sales should be advertised widely, potential buyers should be invited to inspect the sale, and sealed bids should be received by a set date. Initial sales may go for a pittance until buyers gain experience and confidence - another reason for keeping initial sales small. The buyer with the highest bid should post a bond, and no wood should leave the cut until paid for by the buyer. If and when the sale is successfully completed, the bond is returned to the buyer."

It is important, as Hagen says, to begin this sort of work on a small scale, and then, if the method proves successful, to expand it gradually.

When saw timber occurs within firewood cuts it should be dealt with separately from the firewood and poles, either through giving permits for felling individual trees on payment of royalty, or by selling the standing trees.

4.2.5. Protection

4.2.5.1. Fire

4.2.5.1.1. Introduction

After clearance for cultivation, fire is probably the greatest hazard faced by the natural forest, especially in the wetter parts of the region.

Fire seems to have been used by man for at least 200,000 years (Peking man in China). When it was first introduced into Africa is unknown, but it is probable that soon after man discovered the use of fire he began to use it in hunting animals, long before the growing of agricultural crops began, as was the case with the Australian aborigines before that continent was colonized by white men. The result is that nearly all the more open vegetation formations in Africa are in a sense fire-climax, with the plants showing various adaptations to resist fire, such as the development of thick bark, and capability of producing shoots after burning.

With the increase in population and areas of cultivation fires have probably become more frequent and more intense. The reduction of tree cover through human activity increases the density of grasses and hence the danger and intensity of fires.

While it is true, as mentioned above, that most species of trees in the savanna zones of Africa have some resistance to fire, fires certainly reduce the rate of forest regeneration, by destroying seedlings and coppice shoots, and slow down the

rate of growth of surviving trees. Thus in managing natural forests it is important to reduce the adverse effects of fires as far as is possible. Virtually all fires in Tropical Africa are caused by man. What are the reasons for this?

Fires are caused in clearing land for cultivation, in hunting, to obtain new shoots of green grass for grazing, in collection of honey, through carelessness in extinguishing cooking fires (especially by people collecting forest produce), to revenge grudges against neighbors and the government, to make paths easier to walk along, and often for no very apparent reason at all - perhaps the pleasure of seeing fires burning. The fundamental reason is the acceptance of the idea of fire as a natural phenomenon; there have always been forest fires, so why worry about them?

In the long term the most effective way of reducing forest fires is to change this attitude. Fires are not inevitable; they do a great deal of damage; and can be prevented. This requires an intensive and sustained effort in education and publicity, in the schools, through the media, especially the radio, and through extension. Short term results are not to be expected though there is encouraging evidence of increased public awareness of the damage caused by fire in the more arid parts of the region; elsewhere it may take a generation to change attitudes. But the surest way of preventing forest fires is to persuade people not to light them, and in the long run this is the best hope.

Another way to reduce forest fires is to show people that it is in their immediate interest to prevent them and to put them out once they start. If the benefits from natural forests went largely to the local population, for instance, if they received a revenue from the sale of the products as would be the case in community-owned natural forests (see Section 4.3.3.2.), they would have much more incentive to protect them from fire. The production of gum arabic is greatly reduced by fire, and gum-collectors thus have an immediate incentive to stop fires. The same applies to pastoralists who depend on dry annual grasses for their dry season grazing. In such cases the harmful effects of fire are already known to the local people, and campaigns for fire prevention are likely to receive considerable popular support.

However in the present circumstances it is inevitable that some forest areas will be burnt each year. One way of reducing the damage is by division of the forest into smaller areas through the construction of firebreaks, so that if accidental fires occur they will be confined to relatively small areas.

4.2.5.1.2. Firebreaks

If fire protection is to be attempted, firebreaks are necessary to reduce the risk of fire entering the forest, and to divide the forest area into smaller units so that if fire should enter part of the forest it will not spread through the

whole area. It should be noted that even the widest practicable firebreak will not completely remove all risk of fires entering a forest; strong winds can carry burning materials, such as weaver-birds' nests, over long distances, and fires have even been known to cross broad rivers.

A number of different types of firebreaks have been used in West Africa. One of the commonest is the completely cleared strip, up to 30 m wide, in which all vegetation is removed leaving bare soil. These can be constructed manually, or by the use of machines (bulldozers to uproot the original vegetation and clear the ground; graders or disc-harrows for annual maintenance). This type of firebreaks are probably efficient, but are expensive to construct and maintain; they also have the disadvantage of removing considerable areas from production, and in some places could be an erosion hazard.

Another type of firebreak is made by clearing parallel strips and burning betwen them; one such type had cleared strips 3-4 m wide and 50-70 m apart. There seems to be no good reason for removal of trees on the area between the cleared strips; indeed retaining them will reduce grass growth as a result of the shading effect of the trees. The central strip will need to be burnt early in the dry season, and possibly reburnt once or twice thereafter, to remove "bridges" of unburnt grass across which fires could enter the forest from outside. These operations need to be done with great care and carefully supervised. Indeed one source (113) reports that carelessness in burning off fire-breaks was the most important cause of fire entering the forest.

For this reason further measures have been suggested such as cutting or breaking-down the grass adjoining the cleared strips, before the grass in the rest of the forest was dry, allowing it to dry in the sun for two or three days, and then burning it; or even cutting the whole of the grass in the central strip and treating it in the same way. A similar technique proposed is to use a mower or brush-cutter to cut the grass, let it dry, and burn it before the grass in the rest of the forest is ready to burn; this presupposes that the firelines have already been stumped.

Despite the difficulties this method of clearing parallel strips and burning between them should be perserved with in view of the very considerable savings in costs, especially where mechanical equipment is not available for firebreak clearance and maintenance.

Another approach to firebreak maintenance has been to encourage local farmers to grow crops on the firebreaks. This was tried in the FAO project at Dinderesso in Upper Volta. The difficulties are to persuade the farmers to cultivate the whole of the firebreaks, parts of which may be on unsuitable soils for crops; failure to remove crop residues, which are in themselves inflammable; and the abandonment of the cultivation when the soils become exhausted after a few years. Here the difficulties, especially in the long term, appear to outweigh the merits.

The possibility of establishing living firebreaks is worthy of further study. In the Sudano-Guinea zone a dense plantation of Gmelina arborea, at say 2 m by m spacing, will completely elminate grass. The dead leaves would need to be swept up and burnt in piles at the beginning of the dry season, after which such plantations would form very efficient firebreaks. In the same zone plantations of cashew or mango, which have the advantage of being evergreen, might also be tried. In drier areas dense hedges of Euphorbia tirucalli might be of a possibility. There are doubtless other species which could be tried.

Such living firebreaks would not need to be more than 20 m wide, as the trees themselves would prevent inflammable materials being blown across the firebreak. The main disadvantages would be the initial costs, which should, however, eventually be counterbalanced by revenue, necessity to produce sufficient planting stock, and variability of soils, some of which might not be suitable for the species proposed.

In making a system of firebreaks as much use as possible should be made of natural features such as rivers, rocky hills, and bowals. In the case of bowals the grass, which usually dries out before that on deeper soils, would have to be burnt off early in the dry season.

4.2.5.1.3. Early burning

Another way of reducing the damage caused is by early burning - burning the grass before it is completely dry, so that fires are less intense, and the damage done by them to trees is relatively mild.

4.2.5.1.4. Comparison of early-burning and complete fire protection

In a true early burn, when the grasses are just dry enough to burn but no more, little apparent damage is done to the trees. Even quite slender shoots appear to suffer little damage, though it is unlikely that many very small seedlings would escape being killed.

Another reason put forward for early burning is that if an area has been protected from fire for a number of years a great quantity of dry matter accumulates on the ground. Then, if an accidental fire does enter the area - and this, despite all precautions, does frequently happen - the resulting fire will be very fierce and will cause more damage than a whole series of years of early burning, or even of uncontrolled fires.

However, what experimental evidence exists indicates that early burning causes considerable loss of growth when compared to complete fire protection.

In Nigeria a number of experiments, beginning in 1939, have been laid down to compare the effects of fire control, late fires and early burning on regrowth after coppicing. The earlier experiments were unreplicated, and results were affected by heterogeneity in the original stands. However a later properly replicated experiment was laid down in 1955 and has given more reliable results.

Of the earlier unreplicated experiments, one in Isoberlinia doka gave a mean annual increment, at 22 years, of 1.33 m^3/ha for fire-protected plots, and 0.53 m^3/ha for both early burnt and late burnt plots. (59) Results from a stand of Anogeissus and Combretum micranthum are given in Table 3. (79) The volumes from the latter investigation are unreliable.

Results from replicated plots in Isoberlinia doka are given in Table 4. (62) The difference in basal area was maintained, and 11 years after coppicing the basal area of the fire-protected plots was 2.5 times that of the early burnt plots. (55)

Finally some experiments were laid down in the Kainji National Park, mainly to study the effects of fire on the grazing available for wild life. (2) Results are given in table 5.

All these experiments show a clear trend. Late fires destroy large numbers of shoots and young seedlings, and cause considerable deterioration in the tree vegetation. Early burning reduces this damage somewhat, but still reduces productivity considerably (by 50-60 per cent) as compared with complete fire-protection. Thus the aim should be to ensure complete fire-protection whenever this is practicable, and only turn to early burning as a last resort.

4.2.5.1.5. Techniques of early burning

Early burning should be confined to moister zones in which perennial grasses predominate, and should not be used in zones with less than 600 mm annual rainfall, where the policy should always be complete fire exclusion.

The object of early burning is not to remove the grass cover completely, but to reduce its intensity and to break it up into small patches which will prevent the passage of fire over large areas. Should such small patches eventually be burnt little harm will be done.

It must be emphasized that early burning is a skilled operation requiring careful supervision. It is not sufficient to prescribe a date on which early burning should take place. In a wet year, on the prescribed date, the grass might be too green for an effective burn, while in a dry year the fires might be so intense as to have the effect of a late burn. The same applies to different soil types within a forest; grasses on shallow soils dry out long before those on deeper soils, and will need to be burnt on different dates.

A useful approach is to send out men with matches or other ways of lighting fires early in the dry season, as soon as the grasses begin to wither. They should go along roads, compartment boundaries, and so on, and attempt to start fires. It is probable that the first attempt will be unsuccessful. The exercise should be repeated at intervals of three days to a week until a satisfactory early burn is achieved. As pointed out above, this is likely to vary in different parts of the forest according to the nature of the grass growth.

TABLE 3

Effects of different fire treatments on coppice growth in Anogeissus - Combretum forest at Bimassa, Nigeria, after 22 years (From Onochie, 1964)

Stems/ha	Fire protected	Early burnt every 4th year otherwise fire protected	Early burnt & fire protected in alternate years	Early burnt annually	Late Burnt
Stems/ha	6664	4762	3627	3639	1038
Stems/ha over 50cm girth	119	85	49	42	17

TABLE 4

Regrowth after coppicing in Isoberlinia doka at Afaka Forest Reserve, Nigeria, after 5 years (From Kemp, 1963)

	Early Burnt	Fire Protected		
		Unhoed	Hoed in October once after cutting	Hoed in October and thereafter in July and September annually
Stems/ha over 5cm girth	452	1391	2323	2414
Basal area m^2/ha	0.42	1.24	1.97	1.97
Height m.	0.73	1.25	1.43	1.43

TABLE 5

Effect of fire and grazing in the Kaimji National Park, Nigeria
(from Afolayan and Ajayi, 1979)

Plots felled 1973

Treatment	Annual early burning with grazing	Annual Early burning without grazing	Annual late burning with grazing	Annual late burning without grazing	Fire Excluded with grazing	Fire Excluded with grazing
Results						
(a) Termination macrootera vegetation						
No of seedlings and regenerating stumps, 1973	123	21	97	79	25	51
do. 1976	288	34	14	16	49	119
Mean percent canopy cover 1973	2	29	16	8	13	20
do. 1976	13	40	15	3	15	27
(b) Woodland vegetation						
No of seedlings and regenerating stumps, 1973	59	67	72	52	64	65
do. 1976	103	98	21	15	89	91
Mean percent canopy cover 1973	80	61	75	70	73	89
do. 1976	80	60	75	72	73	88
(c) Burkea-Detarium vegetation						
No of seedlings and regenerating stumps, 1973	146	109	132	127	139	114
do. 1976	293	182	51	39	243	267
Mean percent canopy cover 1973	18	13	9	11	14	3
do. 1976	21	20	8	11	18	8

With experience, it should be possible eventually to recognize the best stage at which to burn different types of vegetation. But this will require a constant, almost daily, inspection of the forest which must be done by somebody permanently on the spot.

In some cases, particularly when the grass is drier than optimum, it may be better to early burn against the wind, but the use of such techniques can only be learnt by experience.

4.2.5.1.6. Reduction of fire risk through controlled grazing

Grazing by cattle can considerably reduce the amount of tall grass in a forest, and hence the risk of fire. Against this overgrazing and particularly compaction of the soil through trampling, is in iteself a hazard to the forest. On some soil types, also, over-grazing can cause soil erosion.

The obvious theoretical answer is to limit the number of cattle grazing a forest to the carrying capacity of the area. But experience in many African countries has shown that this limitation of animal numbers is extremely difficult to enforce. If a grazier is given permission to pasture his animals in a forest, he will put in as many as he can get away with. There will also be the temptation to burn perennial grasses to obtain young regrowth, thus in fact increasing the fire risk. Any attempts to use cattle to reduce the fire risk should therefore be made with very great caution.

To keep perennial grass in check, grazing will need to begin fairly early in the dry season; once the grasses are tall and woody they are unpalatable and will not be eaten. Such grazing thus would essentially be wet season grazing, which is at a time when other supplies are relatively plentiful; for this reason it might not in any case be very attractive to graziers.

In any case grazing should not be allowed in the first two or three years after felling the forest.

4.2.5.1.7. Fire-fighting

Where large scale industrial plantations are established it is necessary, to protect the investment incurred, to set up a fire detection and fire fighting organization, consisting of fire look-out towers, radio communication, fire crews on standby, and transport to get the fire crews to the fire, together with equipment (beaters, knapsack sprayers) for putting out the fire. Such an organization is expensive (typical ten percent of total plantation costs) and would rarely be justified purely for the protection of natural forest. However when areas of natural forest are included in a forest containing industrial plantation schemes, these should also be included in the fire detection and fire suppression scheme; this can be done for relatively little extra cost.

Fire patrols and fireguards have had a certain amount of success in some countries in reducing the extent of forest fires. These patrol the forest during the fire danger season, and if a fire breaks out, take steps to put it out as soon as possible, calling on what assistance they can from laborers and

others (forest laborers should always be required to turn out to fight fores, when needed, stopping all other work to do this).

In some countries the law states that all people living in an area where a fire has broken out can be ordered by a forest guard or other forestry official to help in putting out a fire, but such laws are impossible to enforce, just as the laws prohibiting setting forest fires, and are of little practical value. Local farmers can certainly put out fires if they want to, for instance fires threatening their villages, but they are unlikely to attempt this arduous and uncomfortable task unless they feel their own interests, rather than those of the government, are threatened.

Fires in savanna, unless exceptionally fierce, are relatively easy to put out especially if detected at an early stage. They are grass fires which can be easily extinguished by beating; leafy branches are adequate for this. Firebreaks, even narrow ones, can form useful base-lines for containing fires.

Back-firing and counter firing should only be used by those with skill and experience in these techniques.

4.2.5.2. Grazing

Overgrazing and browsing, especially by goats, is a serious problem in the more arid parts of the zone, and is largely responsible for the barren and eroded perimeter round many towns and villages in this area.

To obtain adequate natural regeneration where grazing intensity is high protection against domestic animals is essential, and this will usually mean fencing. Admittedly villagers can often protect their own crops against grazing without fencing by seeing that their own and their neighbors' animals are kept well away from areas to be protected, though even then they frequently find it necessary to make thorn zarebas round their cultivation. To get them to use these measures to protect forest plots would require a great degree of close co-operation between the villagers and the forest service, a state of affairs which should be aimed at in the future but which sadly is often absent at the present day.

Two forms of fencing are possible. The first is by use of thorns piled round the area into a zareba; this is fairly cheap but only lasts a year or so. The second is by the use of barbed wire and posts, which is expensive, the cost rising as the area of forest diminishes. Live hedges are another possibility, but they are expensive and may be difficult to establish, and it is difficult to maintain them in a stock proof condition.

Whatever the form of fencing, it will need to be patrolled regularly to see that there are no gaps, which are often deliberately made, and no animals within the fence. This will necessitate the appointment of a full-time guardian, who will also need periodic supervision to see that he is carrying out his work conscientiously.

When the young trees are above grazing height the fence may be removed and re-erected elsewhere. Cattle grazing after the trees are two or three years old will do little damage to the trees and may even be beneficial, in reducing the amount of grass and hence the fire danger. Overgrazing by cattle, however, can result in compaction of certain types of soil by trampling with dangers of reducing the permeability of the soil and increasing erosion.

It is very difficult, once grazing is permitted, to control the number of livestock grazing any particular area. Stinted grazing, in which the number of head of livestock allowed to graze common land is strictly limited, was widely practiced in Europe in medieval times, but as yet is virtually known in Africa. To control numbers of cattle involves many socio-economic questions; perhaps range management specialists will eventually come up with a solution.

4.2.5.3. Protection against illegal cuttings and clearing of land for cultivation

This can only be done by having guards patrol the forest regularly. However if illegal cutting is widespread, it would be worthwhile to find out the reason; possibly local people may not have adequate supplies of firewood and building poles. If so, provision of alternative supplies might help to reduce illegal cutting.

One of the main causes of forest destruction in the zone is clearing of land for cultivation. Here again, it might be possible to find other areas of land, though this is likely to be complicated by traditional customs of land 'ownership' and land usage. In the long run the problem can only be solved by more intensive use of the land through improved agricultural practices (possibly including agro-forestry), thus obtaining increased yields from a smaller area. But this is a problem for the agriculturist.

4.2.6. Special technical problems of certain species and formations

4.2.6.1. *Acacia nilotica* (Gonakier)

This note refers to subspecies *nilotica* and subspecies *tomentosa*, which are typically trees of seasonally inundated areas. The third subspecies *adstringens* (= var. *adansonii*), is essentially a tree of upland soils, though it also occurs on the edges of flooded depressions; it will not be dealt with further here.

Forests of *Acacia nilotica* are important in Mauritania and Senegal, along the Senegal River, though their extent is likely to be reduced through the construction of the Diama and Manantali dams, and the changes in the flooding regime which will be caused by this. Some areas at present occupied by *A.nilotica* are also likely to be converted into irrigated agriculture.

Growth and yields vary greatly, according to the duration of flooding (two months seems to be about optimum) and the type of soil, growth being much better on silts than on clays. On good sites high yields may be obtained.

In the Republic of the Sudan Acacia nilotica forests growing along the White and Blue Niles have been managed for nearly 50 years, for the production of sawn wood (principally railway sleepers) on the good sites and firewood on the poorer sites. The system of management is clear felling. Acacia nilotica will only coppice when the trees are relatively small (less than 15 cm in diameter), and natural regeneration is mainly from seed. This has to be supplemented by artificial sowing, particularly on the higher contours where flooding has not been prolonged. The method used is to sow the seeds in shallow pits made by a hoe, spaced 2 m by 2 m, and with 6 seeds per pit. This is done as the soil gradually dries out following the receding flood. The seed coat is very resistant, and the seeds need to be treated with concentrated sulphuric acid for one hour before they are sown. Depending on the flooding, there may be strong grass competition which needs to be removed if good growth is to be obtained.

Yields in the poorer forests, managed for firewood and poles on a twenty-year rotation, average about 1.5 tonnes per ha per year. (Data derived from 64). This is from the total area of the forest, including poorly stocked and blank areas. In areas of better growth, trees to be used for sawlogs were about 35 cm in diameter at the age of 23 years, and are estimated to reach 40 cm at the age of 30 years. (55) (See also refs. 35, 43).

4.2.6.2. Gum Arabic (Acacia senegal)

The gum arabic tree, Acacia senegal, is an important species of the Sahelo-Saharian and Sahel zones in Mauritania, Senegal, Mali, Niger and Chad, and all these countries are exporters of gum arabic, though quantities exported have declined since the drought years.

Apart from producing gum, it is an important tree in other respects. It grows under arid conditions where few other species flourish, it restores soil fertility, and after it ceases to produce gum it can be used for firewood.

A number of projects concerned with Acacia senegal have been set up or proposed in the countries of the region. Most of these have been concerned with artificial regeneration of the tree by sowing or planting. There are also a number of earlier studies by French officials. (1, 30, 31, 39, 40, 71, 86, 91)

The world's largest producer of gum arabic is the Republic of the Sudan and it may be useful to describe the conditions in which gum is grown there. The best modern accessible description is by Obeid and Seif el Din. (77)

In the Sudan most of the gum comes from privately owned "gardens" around villages. Near the center of the village, particularly within 2 or 3 km of wells, grazing pressure is too intense to allow the trees to survive, while at a long distance out there are belts of "wild" gum, which are communally owned by the village, the local village headman being responsible for allocation of tapping rights each season. These "wild" trees tend to become senescent, and are eventually destroyed by fire.

The gardens occupy an intermediate zone, where gum trees form a part of the cultivation cycle. The owner of the gum garden is the descendant of the man who originally cleared the land for cultivation of crops (sorgum, millet, sesame). When the land is cleared for cultivation, the owner will often inspect the plot; if satisfied with the stock of natural gum seedlings he fells the trees in such a way that the stumps will die. If there are insufficient seedlings the mature gum trees will be cut close to the ground level to produce coppice shoots. Occasionally mature trees are left to produce seed.

The cultivation continues for a varying period, typically 4-5 years, when yields begin to drop through exhaustion of soil fertility and invasion by the root parasite Stiga hermonthica, and then the gum trees are allowed to grow up. The seedlings which were in the plot during the cultivation may have been cut back, but most of them will survive.

After about 6 to 8 years the gum trees will be big enough to tap. Tapping will continue for about 15 years and then the trees are felled again, for cultivation.

The system described above is perhaps somewhat idealized and unfortunately it tends to break down as cultivable land becomes scarcer; longer periods will reduce, or finally eliminate, the regeneration of the gum.

It should be noted that the cultivation period is an essential part of the cycle. During this period the young trees are protected from fire, and to some extent from grazing; also cultivation largely inhibits grass competition which is very harmful to the young seedlings. Without cutlivation the trees will eventually become senescent and grass will become denser, allowing fires to come in which finally kills the old trees.

Trials have also been made in the Sudan of supplementing natural regeneration of gum trees by sowing or planting. Sowing is best done using untreated seed sown into holes made by a digging stick in May; weeding is necessary if good survival is to be attained. More certain results can be obtained from young plants raised in polythene bags or balls of earth, but this is naturally considerably more expensive.

From the social point of view it should be noted that in the Sudan most of the gum comes from privately-owned gardens, in which the owner has an interest in obtaining good regeneration of gum trees, and indeed takes special measures to ensure this.

Marketing is done through government regulated auction markets, arranged so that both seller and buyer get a fair deal in a transaction openly arrived at. Government does not, however, buy or market the gum itself.

Gum trees are very sensitive to fire, which not only damages the trees, but if they survive, greatly reduces gum yields. In parts of the western Sudan it was the custom for local authorities to clear firebreaks to protect gum areas.

Overtapping is blamed for the destruction of gum trees in some of the Sahel zone countries, but it does not seem to be a great problem in the Sudan, presumably that as the trees are privately owned it is not in the owner's interest to destroy his assets. An unusually heavy tapping might be made before the trees were finally cut to make way for cultivation.

4.2.6.3. Bamboo

The indigenous bamboo, Oxtenanthera abyssinica occurs in patches, usually of relatively small extent, in the forests of the Sudan zone. It is of considerable local importance in building, the manufacture of cheap furniture, fishing poles, and woven bamboo mats (crinting).

Like many bamboos, Oxytenanthera flowers gregariously at long intervals, and then dies, to regenerate itself from seed. In the seedling stage it is very susceptible to being killed by fire, but once it has developed proper culms it is relatively fire resistant.

Bamboo clumps should not be clear-felled, as this weakens them considerably and the new shoots which come up are undersized. Indeed cutting all the culms of Dendrocalamus strictus, a similar Indian bamboo, nearly but not quite killed the clumps. (114) It took them four years to recover and to begin sending up undersized shoots.

The exact number of culms to be recoved at one cutting, and the intervals between cutting, need further investigation, but Indian results suggest that removing half the old culms, leaving the remainder well-distributed within the clump, and not cutting any culms less than one year old, would give satisfactory results. This method would enable each clump to be so cut every two years.

4.2.6.4. Borassus aethiopum and Hyphaene thebaica (Ronier and Doum Palms)

Borassus is an important tree in parts of the region, and in Niger most of the rafters used in house-building are made from split Borassus stems, much of which is imported from Nigeria. In addition the fruit and the young shoot from the newly germinated seed are edible; the stem may be tapped for palm wine; and the leaves provide a fibre for making mats, baskets, and sacks. Most of the dried fish produced in the Mopti region of the Niger bend in Mali is transported in sacks made from mats woven from Borassus leaves.

The Borassus palm is slow-growing. It takes about 6-8 years before beginning to produce a stem above ground level, and this period may be extended if the leaves are cut for fibre, or damaged by fires, or if the tree suffers competition from other vegetation. The stem then takes a columnar form, covered by the bases of the fallen leaves, and at the age of 20-30 years the stem produces its characteristic swelling, and the leaf bases fall off. At 30 years the height is estimated to be about 7 m, at 40 years 12 m, and at about 80 16-20 m. Only mature trees, that is about 80 years old, can be used for timber, and only the portion of the stem below the swelling can be so used. (44)

Borassus occurs scattered in a number of vegetation types, but its best development seems to be on alluival soil in river valleys. One of the largest areas is in Dallol Maouri, in Niger, where an inventory made in 1971-72 gave a total of 856,000 stems on 27,000 ha or about 72 stems/ha. (16) Improved protection since 1978 has confined felling to windfalls and dead trees. This forest was put under management in 1982, helped by two projects, the Projet d'Aménagement et de Reconstitution de la Rôneraie de Dallol Maouri, assisted by F.A.C., from 1978-1980; and the Project d'Aménagement des Rôneraies du Dallol Maouri, with Swiss technical assistance (D.D.A.). This work also included artificial sowing of Borassus fruit on 1934 ha between 1978-1980, (which it was intended to raise to 2,700 ha by 1983) and fencing against grazing animals.

Cultivation of Borassus can be combined with agriculture; indeed the removal of grass and other competition through growing agricultural crops assists the growth of the palm.

Some foresters have complained that the cutting of the leaves near ground level for fibre increases the time taken to produce a stem, and hence reduces timber output, which is quite true. However the production of fibre could also be regarded as a legitimate object of managment for Borassus stands, and whether to manage for timber or for fibre, or a combination of these, is question of local priorities. Research is needed on the optimum number of leaves to be recoved at each cutting, to maintain the production of fibre at a constant rate, if such is the object of management.

The Doum Palm, Hyphaene thebaica, is characteristic of more arid areas than Borassus, and is often found along seasonal water-courses in semi-desert areas. Like Borassus, it provides an edible fruit, fibre from its leaves, and timber from its stems, but this is inferior to that of Borassus, being less durable. In the Republic of the Sudan the hard kernel of the fruit used to be exported as a vegetable ivory for making buttons, but this has been hurt by the increasing use of plastics.

There is little reliable evidence on the rate of growth of the doum palm, but it is reputed to be even slower than Borassus in producing a stem above ground level (15 years or so). In the Republic of the Sudan trials were made of sowing the seed, and one or two small plantations were established. One of the difficulties encountered was the destruction of the seed by termites.

4.2.6.5. Natural forest types associated with agriculture (88, 89)

When farmers clear the forest for cultivating crops, it is their custom to leave certain trees standing, for the production of fruit or fodder from their pods. Thus after cultivation a modified type of natural forest remains.

The most important of these trees in Acacia albida. This produces pods which are of great value for animal fodder, and it is also very important in maintaining soil fertility through its fallen leaves (equal to 100 kg of nitrogen per ha per

year). It has the advantage of putting out its leaves during the dry season, so that is does not shade agricultural crops grown in the rains. (see 28, 40, 41, 70)

The importance of Acacia albida has been long recognized, and cutting or damaging the trees was punished by drastic penalties by some of the early indigenous rulers. Its value is well known to local farmers, but there are areas where the tree is relatively sparse and it is desirable to increase the stocking on agricultural land.

In Senegal during the 1960's, in the main groundnut growing region, the area was divided into blocks of 500 hectares, each block under a supervisor, who had the duty of marking the natural shoots of the Acacia, freeing them from competition, pruning them, and showing them to local farmers when the ground was cultivated. This cost about 800 FCFA per hectare, and is said to have produced spectacular results. 10,000 ha were so treated.

Other projects to increase the number of Acacia albida trees have been undertaken in Niger, the first (1974-1978) being financed by USAID; this was continued between 1981 and 1985 by the Project Acacia albida assisted by FAC. The first project consisted of planting nursery-raised seedlings at 10 m by 10 m or 10 m by 20 m spacing. Nearly 3000 ha were so planted, but results were not completely successful, perhaps partly due to the local custom that anyone who plants a tree obtains a claim to ownership of the land on which it was planted; thus the planting activities aroused considerable local suspicion. The results of the second project are not yet available.

Among other trees preserved by farmers the most important is probably Vitellaria paradoxa the source of shea butter, which is not only a very considerable importance locally, but is an article of international trade, both nuts and the 'butter' extracted from them being exported. Another important tree is Parkia biglobosa, of which the pulp surrounding the seeds is a much used local foodstuff. Other trees retained by cultivators are the baobab (Adansonia digitata)- they would find it difficult to remove them, even if they so wished - tamarinds (Tamarindus indica) and to a lesser extent Cordyla pinnata, Sclerocarya birraea, and Lannea spp.

Little needs to be done with regard to these species, apart from continuing the traditional protection afforded to them by farmers. They appear in no immediate danger of destruction, except in some places where demand for firewood is so intense that even these trees are cut. At present many thousands of square kilometers are covered by parkland of Butyrospermum or Parkia.

4.2.6.6. Mangroves

Mangroves are trees growing at the edge of the sea, in salt or brackish water. There are important areas in Senegal and in the Gambia, the species being Rhizophora racemosa on areas affected by daily tidal flooding, and Avicennia africana on areas which are only seasonally flooded.

Rhizophora, the more important species, produces good firewood and charcoal, and a durable timber used for construction work and railway sleepers. Avicennia can also be used for firewood and charcoal.

In Gambia the mangrove forest is estimated at 28,400 ha of Rhizophora, and 27,200 of Avicennia. (17) Of this, an area of 8,700 ha will be affected by the construction of a salinity barrier across the Gambia River. This area is estimated to contain over 1 million m^3 of exploitable timber, 600,000 of which is sawlog size. A mangrove harvesting feasibility study, assisted by USAID, has been completed.

In Casamance, Senegal the yield of mangrove forests is estimated at 50 steres/ha (20 tonnes) of drywood over 4 cm in diameter.

Outside Africa a number of silvicultural systems have been used for mangrove forests in the past, including the selection system (114) but nowadays clear-felling is usually practiced, with natural regeneration supplemented by dibbling in germinated seed (the seed germinates on the tree). (76)

Mangrove forests are clearly a valuable resource especially when other supplies of wood are short; they have the additional advantagae of not being liable to be cleared by local farmers for agricultural crops, though some large-scale land development schemes have been proposed, e.g., in the Gambia, for growing rice. Their chief drawback is the difficulty of harvesting them, as they are under seawater for part of the day, while when the soil is exposed it is deep mud.

4.3. Economic, Social and Administrative Matters

4.3.1. Economics

4.3.1.1. Costs of management of natural forest

Morel and Pajor (72) estimate that, in Mali, for 600 ha of natural forest divided into 6 square blocks each of 100 ha (1 km^2) the capital costs of opening internal and external firebreaks 30 m wide, plus a house for a guard, and manual weeding of grass through the whole area would be 46,700,000 Mali Francs (U.S. $ 69,000) or $ 115/ha. Recurrent annual costs would be 2,300,000 FM, or 3,800 FM (U.S. $ 5.60) per ha per year. These costs include an estimate for supervisory staff.

However Morel and Pajor have included the costs of felling and stacking the wood from the forest and the firelines, which should rather be met against the sale value of the wood. This would reduce costs by 14,600 FM. Substitution of two parallel strips each 4 m wide, and burning between them, would reduce firebreak costs by a further 1.4 million FM, and omitting the manual weeding of the whole area would save a further 22 million FM, reducing the capital costs to 8.7 million FM, for 600 ha or 14,500 FM (U.S. $ 21) per ha.

Using the same method for annual clearing of the firebreaks the reduction of annual costs would be about 1.4 million FM giving a revised total of 0.9 million FM for 600 ha

or 1500 FM (U.S. $ 2.20) per ha. Assuming a mean annual increment of 4 m^3/ha/yr, without interest the cost would be about 1,150 FM/m^3 or about 1000 FM/stere. The present price in Bamako is about 8,650 FM/ stere, including a royalty of 200 FM/stere.

These costs should be considered as the absolute minimum.

In the project 'Formation forestière et développement' at Dinderesso, Upper Volta, estimate costs are: fire control and maintenance of firebreaks 36,000 CFA ($ 119) per hectare; inventory 112 CFA ($ 0.37 per hectare; and Boundary survey 8600 CFA ($ 29) per km. Even these considerably higher costs compare favorably with about U.S. $ 1000/ha for establishing plantations (not including annual maintenance).

Where fencing is necessary costs will be increased considerably. In Niger (16), in 1979, fencing cost an average of about 45,000 FCFA/ha for areas ranging from 45 to 175 ha, the cost per ha of course diminishing with the larger areas. This is equivalent to about U.S. $ 130/ha.

4.3.1.2. Returns

No values can at present be given for the value of the standing crop per ha. A farmer clearing his land will cut firewood, bring it to the roadside, stack it, and sell it to a trader, but how much of the value of the stacked firewood represents his labor in cutting, transporting, and stacking it, and how much the value of the standing timber is difficult to say; if this question were put to the average farmer he would probably consider it as meaningless, as he does not put an hourly or daily figure on the cost of his labor.

Nor are there any sales of standing wood within the region. In Senegal, the charcoal burners who work the forest pay the normal royalty per sack of charcoal.

This royalty is merely a tax on forest produce sold in various markets, and is usually collected when the produce enters the market, or at some point on the transport route. It is not even credited to the budget of the local Forest Service (though in some countries part goes into a Forestry Fund). It cannot be regarded as equivalent to the standing value of the wood, as this would obviously vary with proximity to markets. Some examples of royalty are as follows:

Gambia	Charcoal D 0.60 (U.S. $ 0.24) per bag (+ D. 25.00 per annum)
Mali	Firewood per stere 200 FM ($ 0.30)
Mauritania	Charcoal per quintal (100 kg) 60 UM ($ 1.20)
Niger	Firewood per stere 33 FCFA ($ 0.10)
Senegal	Firewood per stere 120 FCFA ($0.35)
Upper Volta	Charcoal 250 FCFA per quintal ($ 0.70) Firewood 150 FCFA/stere ($ 0.45)

To allow wood from managed natural forest to compete in price with wood from cultivation clearance, fallow, etc., which has cost nothing to grow, it is essential that the wood from managed forest should be exempt from payment of royalty, but instead a fee representing stumpage value should be paid to the forest managers, whether the state Forest Service, or local communities. This fee could be fixed at first, but it would be better if eventually it was based on sale of the timber standing, by auction or sealed tender, to contractors. A pass would still be needed to allow the wood to be transported, specifying the quantities, but once the stumpage fee had been paid such passes would be issued free. (Similar arrangements should apply to wood from plantations).

Royalties in most countries are very low in relation to the retail price of firewood. In Niamey, Niger, royalty is 1.3 per cent of the retail price; in Bamako, Mali, the figure is 2.3 per cent; in Ougadougou, Upper Volta, 2.4 percent; In Dakar, Senegal, 1.6 percent; and for charcoal in Nouakchott, Mauritania, the figure is about 9.5 percent. Most of the wood at present consumed has cost nothing to grow, but the days when wood could be considered as a 'free good' will soon be past, and in the future an increasing proportion of wood used will have to come either from managed natural forest or plantations. Although the costs of producing wood from natural forests may be lower than from plantations, these costs will still have to be incurred, and royalty rates or stumpage fees should be adjusted to cover the costs of replacement of the wood. Similar arguments apply to building poles and sawlogs, but it is not possible to go into details here.

4.3.2. The legal position

In the Francophone countries of the region French colonial laws stated that the state had the title to all land not otherwise legally registered, (the law of eminent domain) and that all vacant lands without an owner were the property of the state. Vacant lands included all lands which had not been used or occupied for ten years. Customary rights could be exercised on such lands (except where specifically prohibited, as in the forêts clasées), but no ownership of the land could be claimed as a result of the exercise of these rights.

Some of the countries of the region have modified these laws since they gained independence; for instance, in Upper Volta land is no longer presumed vacant unless there is proof to the contrary, but the vacancy must be proved by an official enquiry. However, the principle in general remains.

This contrasted with customary law, in which land was usually regarded as the property of the community, with the local chief having the responsibility of allocating land for cultivation or other purposes. Land abandoned after cultivation, or fallowed, reverted to the community. Sometimes the 'community' owning the land consists of the descendants of the original settlers, who nowadays only form a small part of the community as a whole. The bulk of the population in some places probably still continues to follow the customary laws.

The forests of the area are divided into two categories, the 'Domaine forestier classé' and the 'Domaine protégé'. The former consists of Forêts Classées equivalent to Reserved Forests in English-speaking countries, ('Forest Parks' in the Gambia), which have definite boundaries established after a settlement procedure, and then are decreed as Forêts Classées by government; in them the exercise of customary rights is forbidden, except the collection of dead wood, gums, fruits, and edible and medicinal plants, and such others as may be recognized when the forests are classified.

The Domaine protégé consists of all other forests on land which is not privately owned, and thus covers much of the land area of the various countries of the region. In it customary rights can be exercised (with some limitations, e.g., the prohibition of cutting protected species of trees, except under permit) for the satisfaction of personal or collective needs, but not for production of wood or charcoal for sale, which is subject to permit. Forest fires, except for controlled fires to clear land for cultivation, are prohibited in all forests.

The forest services are responsible for the control of both types of forest, but generally have a very small staff for this purpose. Needless to say enforcement of the forest law is only possible over a small proportion of the forests it is intended to cover.

Some countries have other types of forest or protected land. In Mauritania it is proposed to classify some areas as 'Périmètres de protection'. These would include hill slopes, stream banks and sources, and also areas containing pure populations of certain economic species.

In Upper Volta it is possible to classify forests for use for the benefit of 'collectivités', and hence presumably for local communities. In Niger the administration may give state land to individuals and communities for afforestation, but not apparently for management as natural forests.

In Senegal rural communities, each comprising several villages and numbering from 3,000 to 17,000 inhabitants, have been given considerably increased responsibilities for controlling land use within their areas, regulating rights of usage, grazing and fires. The aim is to give local communities a part in the management of their areas, and this will clearly have considerable effects in the domaine protege. Forêts classées remain the responsibility of the state forest service.

The Gambia, being an ex-British colony, has a somewhat different legal system. Customary land tenure rights are protected by law, with villages and compounds having the right to use land which is held in trust by the District Council under the district chief.

Unused and unclaimed village land is allocated by the village headman to those who request it, but once it has been allocated the head of the family obtains usufruct rights, which in practice are tending to be regarded as ownership rights.

Forest Parks in Gambia are analagous to the Forêts Classées of Francophone countries. Outside Forest Parks it is forbidden to fell protected trees, or cut wood for sale, without a permit.

Although the theoretical basis is different, in practice the forest laws in the Gambia would appear to have very similar results as those in the other countries of the region.

4.3.3. Social

4.3.3.1. Introduction

Forestry is not concerned solely with growing trees; it also involves people, especially those people living near the forest. They are going to be affected by any changes in forest management, and are entitled to see that their interests are taken into account when these changes are made.

Furthermore the cooperation of the local people may be crucial to the successful introduction of forest management. If they are prepared to cooperate they can make things much easier, by refraining from lighting fires, by keeping their grazing animals out of young regeneration areas, and in many other ways. If, on the other hand they are antagonistic to the forest service they can do a great deal of damage by deliberately burning the forest, uncontrolled cutting of trees, and reluctance to supply labor.

At present there is often a degree of hostility between the forest service and the rural population. The forest guard, the official with whom the local people most often come in contact with, often sets himself up as a sort of rural "boss", deriving his influence from the punishments he can have inflicted on those who break what to them seem arbitrary and unnecessary laws. There is a need to change this repressive attitude into one where the forester is regarded as an adviser and extension worker, rather than merely as a policeman, but to do this changes will be needed in the attitude of the forest services to the local people, and in the attitude of the local people towards the forest service. The latter can only be assured through extension and persuasion of the local people that what is being done is in their interests, at least in the long term. This may well be a long and difficult process.

4.3.3.2. The impact of natural forest management on local people

It has already been pointed out how valuable in terms of forest products, other than wood, the natural forests are to the people living near them. Marilyn Hoskins (50) writes, of Upper Volta, that "Local women .... collected shea nuts (*Vitellaria paradoxa*) from which they made cooking oil, they gathered leaves and seeds essential for the nutritional sauces they put over their starchy staple grains, they searched for grasses and bark for weaving and dyeing mats and elaborate baskets, concocted home remedies from leaves, pods and roots, and let their goats browse on the shrubs and bushes in this unused looking area. Women also piled their heads high with dead branches and sticks to carry home for cooking fuel. Their children ate the nutritious monkey bread or baobab (*Adansonia digitata*) fruit or hunted small animals in the undergrowth. Their husbands cut chew sticks (the local substitute for tooth

brushes) and stripped and twisted bark into ropes. The whole family picked and ate "desert raisins" (Cissus fruits) and other fruits and nuts, and various family members earned small sums selling firewood or other surplus items which the bushland provided."

The list is by no means exhaustive, and could be duplicated, with changes of details, from most natural forest areas. Management of natural forest would allow most of these uses to continue (with the exception of goat browsing in regeneration areas) and the local population to continue to benefit from them. It should be noted that collection of these forest products is largely a woman's activity and contributes a good deal to women's incomes.

Natural forests are also, in the more arid areas, an important reserve of food and fodder during periods of drought,

Management of natural forest would have other impacts on the local population. It would provide employment - an initial 4,700 men-days per year, according to the calculations in Section 4.3.1., for 600 ha, in addition to the labor needed for felling and stacking firewood. The need for this labor would fall mainly in the dry season, when the demand for labor is less than during the rains. However it is necessary to study the farming year, so that as far as possible forestry operations are done at periods of low agricultural activity.

The management of natural forest would also have some negative impacts on the local people, through restrictions on burning, on grazing in certain parts of the forest, and on clearing land for cultivation. A campaign of extension and publicity should be mounted, to show the people the benefits they were receiving from the forests.

This would be easier if the forests were the property of the local community, and they received the benefits from them, as discussed in the following section.

Also to involve local people more closely in the management of natural forests amendment of the forest law is needed in all countries, with more emphasis on social aspects, and partnership between the people and the government.

4.3.3.3. The possibility of management of natural forests by local communities

At present local communities in the Sahel have little interest in preserving the forest, especially the forets clasees. It is true that they obtain a number of their essential needs from the forests - fruit and other forms of food, fibres, medicinal plants, and wood for their own consumption (but in principle not for sale). But in general they regard the forêts classées in particular as land taken from them by the government, and forestry officials largely as policemen whose task it is to prevent them doing things in the forest which they have traditionally done. It is therefore not surprising that they have little interest in forest preservation and protection.

Population growth is increasing the pressure on the land, and thus the questioning of the purpose of Forêts Classées, which the people see as largely unused land. Hence it is not surprising that they burn the forests, cut down trees illegally, and surreptitiously clear areas for cultivation.

How can this attitude be changed? J.T. Thomson (112) correctly states that "Rural people will not however automatically move to manage renewable resources, nor will they be moved by propaganda urging conservation consciousness and participation in sustained-yield management unless

1. They see a real need for such investments of time, energy and money and,
2. Technical, economic, financial, legal and political constraints they currently face are overcome or reduced to the point where participation becomes feasible".

To this might be added:

3. They are convinced that they will gain real advantages, within a relatively short period, as a result of their efforts. These advantages should preferably be financial ones.

One of these advantages would be if the local community, rather than the Government, were recognized as the owner of the trees within the forests, and obtained the revenue from the sale of the forest products. In this way they would have positive incentives to protect the forests - their own property - and to prevent outsiders from damaging them.

Another advantage would be a reduction in the numbers of forest department staff needed to manage the forests. During the next decade or so very large areas of natural forest will need to be taken under management, and exploited systematically, if growing needs for wood are to be met. It is unlikely that most forest departments in the Sahel countries will have the staff, the logistical means of support, and the finances to undertake this. By giving the local communities some of the responsibility for managing the forests these administrative burdens could be considerably reduced.

Thus, the idea of ownership and management of natural forests by local communities has a number of attractions. It must not, however, be thought that introducing this type of management will be simple. Merely handing over natural forests to the local community, as their own property, without conditions, would lead to lack of all management, and very likely a rapid increase in forest destruction.

Thus the initial approach to management of forests by local communities must be a cautious one. It will be necessary to begin with a few very carefully selected pilot areas, and in the initial stages to mount a very intensive program of persuasion and extension.

A suggested outline of the steps to be taken is as follows:

1. Make sure there is a market for the produce. There is no point in trying to exploit any forest by annual cuts unless the produce can be sold. Do not involve the villagers at this stage.

2. Go to the villagers, and explain to them very clearly what it is intended to do, and what their obligations will be (following a prescribed plan, protection against fire and grazing, etc.). Make it quite clear what work will be undertaken by the government, and what by the villagers. Involve as many of the villagers as possible, not just the local elite. Listen to what they have to say about the proposals, to any objections they may raise, and difficulties they may foresee. Do not try to persuade them to accept a scheme if they are obviously reluctant to do so. Do not make promises which cannot be fulfilled.
3. If an agreement is reached, select an organization, such as a village committee, who will be responsible for managing the forest. If there is an organization already existing which is suitable, it is better to use this than to create a new one. Agree on how the proceeds from the sale of wood and other products should be used or divided up among the villagers.
4. At the appropriate time, demarcate the first cut. This could either be cut by the villagers themselves, or sold by them to a contractor, as the villagers thought fit. The cut should be of a manageable size, but not so small that returns would be negligible.
5. Produce from forests managed by local communities should be exempt from royalty, to give a financial incentive.
6. Continue close supervision and frequent visits and extension work until it is clear that the scheme is running satisfactorily.

There are other factors which may need to be considered, such as the impacts of local customs of land tenure. Precautions may also need to be taken that the benefits from the forest do not fall into the hands of a few individuals, rather than the community at large.

Another possible line of approach is suggested in the Niger 'Analyse'. (16) This is:

1. To select one or two pilot villages in the firewood supply zones of one or two urban centers, and to ask the Forest Service to reserve a forest area for the benefit of these villages, in such a way that they will have ownership under collective title.
2. To station there a permanent agent, a good extension worker, who, using labor provided by the state (or external aid), will make the following demonstrations:
   (a) Delimitation of the area, and construction and permanent maintenance of a firebreak.
   (b) Management in 10-12 annual cuts (delimitation and demarcation).
   (c) Demonstration of exploitation by simple coppice, allowing good regeneration by coppice shoots (felling at ground level).
   (d) Demonstration of commercial stacking.
   (e) Sale of the wood to the exclusive profit of the villagers.

(f) Protection of the cut against fire and animals.

If this operation, which should last 4 to 5 years, is well explained and laid out by the extension worker, it is to be hoepd that the villagers will realize the advantage of the protection, and the profit which they derive from this, with their only obligation being to protect the area; it should be well understood that they will continue to be free to light fires and use traditional grazing methods outside the protected area. Perhaps, after the four or five years that this demonstration lasts, they will have the idea of continuing such an operation at their own expense and to their own profit, and that little by little, through constant propaganda in the schools and through the media, existing attitudes may be progressively changed, so that the idea of protecting a well-defined and delimited forest estate becomes part of local custom." (Translated from the original)

All this will require a great deal of patience and sympathy with the villagers' point of view, with readiness to hear their side of the case. However this process is very necessary if lasting co-operation is to be obtained.

Failure to fully involve the local people is illustrated in the following schema which summarizes the experiences in a forest in Casamance in Senegal. (98) This was basically a plantation project, in which considerable efforts were made to involve the local population, but the same sequence of events is all too likely to happen in other projects.

The sequence of events was summarized as follows:

Onset of the program	--	Mistrust	--	Refusal to co-operate
Beginning of the program	--	Hope	--	Massive co-operation
Increased activity	--	Fear of deception	--	New demands
Status quo	--	Hostility	--	Sabotage (in this case burning the forest)

An example of what, initially at least, appears to be successful co-opeation of local people in forest management comes from Chad. (82)

This work consisted of the protection as village forests of 1,550 ha of natural forest in 13 villages, by surrounding them with thorn zarebas and firebreaks 20 m wide; within these forests 240 ha was enriched by direct sowing of Acacia senegal, A.nilotica, A.sieberiana, and Balanites aegyptiaca. First results were very promising with no forest fires or illicit fellings during the first two years. The construction of zarebas and firebreaks was paid for through a mixture of cash wages and food supplied by the World Food Programme. A paid "guardian", usually the chief of the village, was employed to patrol the zareba and prevent trespass. There was no formal involvement of the villagers in managing these village forests, apart from employing them as hired laborers. It is unfortunate that the eventual results from this interesting project are unknown.

Complete management of forests by local communities is one method of proceeding, in a continuum ranging from full Forest Service management and control, to full control by the local community. There are many difficulties in bringing in

management by local communities, as described above. However, it is recommended that trials of these methods should be begun on a limited and carefully selected basis within the countries of the region.

Forest guards will still, at least to begin with, be needed for local community forests, but their role will no longer be primarily that of policemen, but rather of extension agents. Some policing may still be needed, but this will be as agents for the local community, not for a remote central government. To convert forest guards into extension agents will require retraining and re-orientation and their pay will need to be increased so that they can achieve a reasonable standard of living without resorting to bribery and extortion.

Natural forest should not in general be allowed to become the property of individuals (unlike woodlots planted by individuals, who should receive the benefit from their work). An exception might be made in the case of land containing natural forest already in private ownership.

Forest services should for the time being at least retain control of Forêts Classées deemed strategic for the supply of wood, particularly firewood, to urban centers.

4.3.4. Administrational and Institutional Aspects

4.3.4.1. Staff

Model and Pajor (72) estimate that one guard would be needed for 600 ha. The areas of forêts classées or their equivalent are as follows:

	Forêts Classées, ha	Guards needed
Mauritania	32,000	54
Senegal	1,271,114	2119
Gambia	34,027	57
Mali	1,130,723	1885
Upper Volta	727,000	1212
Niger	211,753	353

Actually, in Senegal only 190,010 ha of forêts classées are considered exploitable, managed forests. These would need 317 guards.

The only country approaching the figure of one guard per 600 ha of foret classee is the Gambia, with 37 guards (17 of whom work on Forest Protection), and 60 Forest Scouts, whose duties include fire protection and reporting forest offences. For the rest the figures may seem absurdly high. Admittedly a forest which is not being currently exploited, and in which little work is being done, will need less guarding and supervision than one which is being intensively managed; but even forests which, for the time being, are protected only, need some staff for supervision and maintenance (one man for 2,000-10,000 ha).

However accepting the figures above for the time being, the requirements of intermediate level staff (techniciens superieurs, etc.) at the rate of 1 for 6 guards, and the needs for Ingenieurs (professional staff) at 1 per 6 technicians would be as follows:

Country	Guards	Technicians	Professional
Mauritania	54	9	2
Senegal	317	53	9
Gambia	57	10	2
Mali	1,885	300	50
Upper Volta	1,212	202	35
Niger	353	60	10

Again these figures are approached by the Gambia, which has 12 technical staff employed on forest protection, but only 3 professional staff altogether, all of whom are at headquarters (The Gambia being a small country, outposing of staff is not as essential as elsewhere). In the other countries, apart from the professional staff in Mali (which has 123 Ingénieurs and 185 Ingénieurs des Travaux, 197 Contrôleurs and Préposées, and 34 Guards), numbers are considerably fewer than needed, especially at the technician level. It must be recalled that this staff is needed for management of natural forests in forêts classées only, and no account is taken for those needed in plantations, research, and any work done in the domaine protégé.

Also there will be a need for more specialized staff, in management, inventory, planning and other fields. At present the shortage of staff, at higher levels especially, has compelled most of them to be generalists while there is a growing need for specialized work in many fields. The increased staff needed for research must also not be overlooked.

Staff need transport, and in remote areas, housing. An official without transport to visit and inspect the forests is virtually useless; yet transport is often scarce, with what exists being often in a poor mechanical state. Also funds for fuel for motor vehicles are often very low.

It is clear that the desired levels of staff cannot be obtained immediately, and it is necessary to envisage a gradual build-up of staff, as more and more forests are taken under management, for perhaps two decades or more.

Lack of transport and other reasons have prevented forest service officials, from the rank of Ingenieur downwards, from spending enough time in the field, which is after all where forestry activities take place; field work should take precedence over office work. It may be necessary to review the system of rewards and incentive to encourage officials to spend more time in the field.

There will also need to be a change in the attitude of forestry officials, from guards upwards, from one of repression and policing, to one of advice and extension.

In some forest services the establishment of a separate division for natural forest management may need to be consider though this will depend on staff being available. It should not be done, however, at the expense of staff working in the field. A separate group specialized in forest inventory might also be called for, moving systematically from one forêt classée to another within a region, and carrying out the necessary inventories in each forest.

4.3.4.2. Training

There are four institutions for higher level forestry education (university level) within the region, the Institut Polytechnique Rurale at Katibougou, Mali, the Ecole Supérieure d'Agronomie at Niamey, Niger, the Institut National de Développement Rural in Senegal, and the Institut Superieur Polytechnique de Ouagadougou, Upper Volta. Other countries send staff abroad for training at this level.

Training of intermediate level staff is done within the individual countries, with the exception of Gambia and Mauritania. Most institutions for training staff have a common course for agriculturists, livestock officers, and foresters for two or three years, followed by one or two years training in forestry. There are criticisms that too much emphasis is placed on agricultural training at the expense of forestry, that instructors are too few in numbers, and in some cases certain fields of importance in forestry are inadequately covered, for instance surveying in Mali.

Many institutions for training forestry staff are not under control of the respective forest service (Among exceptions is the school for préposés and agents forestiers at Dinderesso, Upper Volta). Thus the close links which should exist between the forest administration, and training such staff as ingénieurs des travaux, agents techniques, préposés and gardes forestiers, are often absent. The forest services should, at least, be responsible for advising on the curricula in such institutions. These curricula should have increased emphasis on training on natural forest management, with substantial amounts of time being spent on practical work in the field.

There is also a need to harmonize training between the different countries of the region, and to have many more contacts between officials facing similar problems in different countries.

One way of improving these contacts, and to ensure that foresters are kept up to date in theory and practice, would be to organize short referesher courses on a variety of subjects, at both national and regional levels.

In addition to academic instruction, there is need for on-the-job training of forest workers and also those employed in forest utilization. Also local populations have the right to expect training of the 'know-how' type, when their participation in forestry work is required.

Forestry projects employ great numbers of local laborers in various tasks, and a trained workman can save time and money, which directly affects the profitability of operations. Unfortunately these workers are often illiterate, or almost so, especially the women who undertake many forestry tasks. This gives rise to difficulties, but they are not insuperable, and practical training can still give useful results. An example is the systematic training in the use of the improved 'Casamance' kiln for charcoal production, organized in Senegal.

If local people's participation in forestry development is to be effective, professional foresters will have more and more to play the role of technical advisers to these people. Such a technical adviser must be able to transmit 'know-how' - the efficient means of carrying out operations. The people have a right to such assistance, and ways and means of providing it should be immediate tasks.

This is also a way of changing the role of the forester from the policeman, whom he traditionally represents in the eyes of the people, to someone who can be trusted as a wise counsellor. In such ways new methods and techniques will be adopted more easily.

Social training is important, and training in development of human resources should have an equal place in forestry programs with conservation and the development of forestry resources.

4.3.4.3. Finance

It has been shown in Section 4.3.1. that the cost of bringing 600 ha of natural forest under management may be very conservatively estimated at $21 per ha; thus the cost of bringing 5000 ha under management would be $105,000, equivalent to 35 million FCFA, 70 million FM, 260,000 D., or 700,000 UM. This excludes supervisory staff but includes guards.

To this must be added an annual recurrent charge of about $10,000 for 5000 ha.

At 5000 ha a year it would take 7 years in Mauritania and the Gambia, 38 years in Senegal (exploitable forests only), 42 years in Niger, 146 years in Upper Volta, and 226 years in Mali to bring all forêts classées under regular management.

Even 5000 ha per annum would, however, put a strain on most forestry budgets. The total budget for operations in Mali, for instance, is FM 45,500,000, though this is supplemented by the Fonds Forestier which in the 5 years from 1976-1980 disbursed an average of 92 million FM for forestry, about a quarter of which went on forest operations. (The fund has recently been increased, see below).

Other countries face similar, though not always quite as extreme, problems over finance. Some help may be expected through international technical assistance, but unless technical assistance programs are to be of extremely long duration, there must be some assurance that when the project ends the host government has the financial and administrative capacity to continue it. This has been lacking in the case of some recent projects.

A number of countries in the region have a Fonds Forestier, which would seem to be eminently suited for introducing management of natural forests. In Mauritania (there called Fonds pour la Protection de la Nature) this is financed by 25 percent of the fines collected for forestry offences; in Senegal by 75 per cent of forest receipts (royalties, etc.), recently increased from 50 percent; and in Mali by 100 percent of forest receipts (increased from 50 percent). Similar funds should be established in those countries where they do not exist, and should be financed by 100 percent of forest receipts, which, after all, the forest services are responsible for collecting.

It is clear that funds for management of natural forests are inadequate in nearly all countries of the region and if this important function is to get under way these funds will need to be increased considerably, whether from a Fonds Forestier or from other sources.

4.3.5. Research

4.3.5.1. Present position

Research to date on management of natural forests is described in Section 3. It has been on a very small scale, and consists of a number of rather ad hoc projects, many of which have not been followed through to completion. This is not surprising, considering the small number of researchers and the large range of problems they have to investigate.

In most countries of the region forestry research does not come under the egis of the forest service. One exception is Mauritania, where in 1982 directions were issued for setting up a forestry and pasture research station under the Direction de la Protection de la Nature. In Mali forestry research falls under the Institut National de la Recherche Zootechnique, Forestier et Hydrobiologique (INRZFH). In Senegal it falls under the Institut Sénégalais de la Recherche Agronomique (ISRA); in Upper Volta it is part of the Centre National de la Recherche Scientifique et Technique (CNRST), of the Ministry of Higher Education and Research; and in Niger it is under the Institut National de la Recherche Agronomique du Niger.

This separation of research from the main body of forestry activities has tended to result in a lack of coordination and liaison between researchers and those who need to use the results of the research, and who should have a strong say in drawing up research priorities.

Most research organizations are understaffed and underfinanced, and of the staff available, few have had much research experience, or specific training in research methods, with the exception of a few expatriate researchers, mostly seconded from CTFT.

4.3.5.2. Research programs and priorities

The two most urgent problems in forestry research are

(a) What is the present productivity of the natural forests?

(b) How can this production be increased?

The first requires inventory, combined with studies of growth rates. The second has a number of facets:

(i) What is the best rotation for optimum yield?

(ii) What increased yields can be obtained from protection against fire and grazing?

(iii) What other methods can be used to increase yields (cultivation, supplementing natural regeneration by sowing or planting, tending, etc.) and how cost efficient are they?

These all can be considered as applied research. There is also a need for more basic research studying the evolution of natural forests through time, seed production an dispersal, seedling establishment and survival, effect of herbivorous mammals, relations with soil and climate, rooting habits, and many other factors.

4.3.5.2.1. Present productivity

This can be studied by sampling forest of known age, repeated measurements of stands, or, in some cases, from the study of annual rings. Some results from measurements of stands of known age have been given by Clement (see Table 1). In sampling stands care should be taken to select stands at random otherwise there will be a tendency to select the better-stocked ones. However stands known to have been subject to illicit cutting should be avoided.

Repeated measurements of stands over a period of years can provide growth data, but extrapoltation from a partial growth curve should be done with caution.

Not all trees of natural woodland in the region have annual growth rings, but some do. Some results from the study of growth rings are given in Table 6. Nowadays sophisticated methods for the study of indistinct growth rings are available; CTFT in France has been engaged on this work and their cooperation would be desirable in future studies (see ref. 70).

4.3.5.2.2. Choice of rotation

This will again depend on study of growth rates, referred to above. Two factors will need to be considered: the rotation with the highest mean annual increment, and that required to produce the optimum mix of sizes of wood required by the market.

4.3.5.2.3. Increasing yields by protection

Some results from protection against fire, from Nigeria, have been given in Section 4.2.5.1., but such trials need to be repeated over a wide range of vegetation types. It is desirable that plots to study the effects of fire should be statistically replicated, to remove the effects of possible inhomogeneity in the original stands. Use of covariance techniques in the analysis of the results would add to the precision of the experiments.

Table 6

Determination of age and growth during one year's observation
Ader - Doutchi, Niger (Rainfall 450-500 mm/yr)
(from Catinot, 1967)

Species	Diameter under bark (cm)	Age (years)	Annual growth width of ring observed, in cm)
Acacia laeta	5	18	0.3
	7	20	0.1
	9.5	22	0.35
Acacia seyal	3	10	0.3
	6.7	18	0.1
	9	18	0
	9.7	24	0.1
Commiphora africana	9	22	0.4
	6.5	19	0.2
Boscia angustifolia	10	22	0.1
	6.5	35	0
Acacia ataxacantha	3.5	12	0.2
	5	14	0.5
	2.2	10	0.05
	11	11	1.5
Dichrostachys cinerea	2	11	0.05
	3.56	15	0.1
Ximenia americana	3	9	0.1
	2	10	0.1
Combretum glutinosum	15	40	0.1
Cassia sieberiana	5	17	0.2
	11	23	0.3
	17	26	0.5
Combretum micranthum	1.4	7	0.2
	3	5	0.6
	3	7	0.3
	14	37	0.2
Bauhinia reticulata	12	12	0.8
Bauhinia reticulata	13	14	1.8
	12.2	10	1.9
	12.7	13	0.9
Balanites aegyptiaca	15	?	0.05
	20	?	0.5
Zizyphuys jujuba	3.2	13	0.8

Protection against grazing and browsing has given dramatic results in some areas, but it has rarely been possible to quantify this as an increased yield in m^3/ha. Further trials with proper control plots are needed. These could also study the effects of grazing by different types of animals (e.g. cattle and goats), at different seasons of the year, and with different intensities of stocking (head of cattle per ha). The most immediate need, however, is to study the effect of complete exclusion of grazing (by fencing) as compared with no grazing control.

4.3.5.2.4. Other methods of increasing productivity

These should be given a lower priority, as all require extra expense and man-power. In Nigeria hoeing of the ground by mattock, after felling, was found to increase the basal area of the subsequent regrowth by 67 per cent (see Table 4 Section 4.2.5.1.4). The question is whether the increased costs and labor required for this operation (20 men-days/ha) would be justified by the increased yield obtained.

Direct sowing and, in the case of Acacia senegal, planting to supplement natural regeneration is often carried out in Acacia nilotica, Acacia senegal, Borassus, and mangrove forests. How far it would be of value in mixed natural forests is uncertain. The species chosen would have to be one of good growth and form. Some success was achieved in Nigeria by dibbling in neem (Azadirachta indica) seed beneath bushes of Guiera senegalensis in savanna dominated by Combretum micranthum, though this is introducing an exotic and perhaps falls outside the scope of management of natural forest in the strict sense. Sowing or replanting would be mainly justified in filling up blanks where there was insufficient regeneration from natural seeding or coppice.

Some trials have been made in favoring the growth of valuable species (Khaya, Pterocarpus) by selective tending. (See Section 3.1.6.2). These species are slow-growing, however, and trials of this and similar methods such as selective thinning to favor good stems of useful species are not of high priority, in view of the costs, the general low value of the produce to be obtained, and the scarcity of skilled personnel to do the marketing and selection.

4.3.5.3. Basic research

This can be divided into two aspects, synecological research to study the development of whole communities, and autecological research to study factors influencing the growth and reproduction of individual species.

Synecological research would be based mainly on the study of permanent quadrats within the forest recording the changes of the vegetation and how this was affected by various factors. Autecological research on different species would include such

factors as their occurrence in relation to soil and climatic factors, root systems, periods of flowering and fruiting, seed viability, di persal and germination, survival of seedlings, and the effects o' animal feeders and parasites.

This type of research is important to provide the basic data from which applied research and silviculture are derived. However the solution of practical problems in the field must, for the time being, take priority over it. Basic research is the sort of field which universities and similar institutions could play an important part.

4.3.5.4. Socio-economic research

Research is needed on the impact of natural forests, and changes in their management, on the local population. In particular more studies are needed of the use made of non-wood forest products such as leaves, fruit, fibres, gums and medicinal plants by local people and their economic and nutritional importance to them; and the possibilities of external markets. Already Senegal exports annually about 100 tonnes of a herbal tea made from Combretum leaves, and shea nuts and shea butter from the karite tree (Vitellaria) have long been traded internationallly. In Upper Volta a company has been formed to examine possibilities of collection and commercialization of natural gums, resins, and latex from such trees as Acacia, Sterculia, Combretum, Terminalia, Lannea, Anogeissus, Commiphora, Boswellia and Daniellia.

Research is also needed into wood consumption, distribution and marketing in all its aspects. Wood consumption surveys have been made in a number of countries, but in some cases serious doubts have been cast on their reliability, and some of the work may need to be repeated. The effect of increased prices on consumption, and on the acceptance of more efficient stoves, needs study. The production and marketing of charcoal should be investigated, including its relation to the price of firewood, and how this is affected by distance from producing centers. Costs of charcoal production also need study. In Mauritania, on the average, yields of charcoal are about 15 percent by weight of the wood used; improved methods of production, for example the 'Casamance' kiln, can increase this to 25 percent or more, but these methods need more labor and, as long as wood in the forest is free or almost so, the savings in cost of using less wood may be offset by increased labor costs.

4.3.5.5. Utilization research

Research on wood technology should be given relatively low priority. The apparatus and equipment for this is expensive, and requires skilled researchers. If research into the properties of local timbers is needed, it could probably be done more cheaply and more efficiently in laboratories outside the region, in Europe or North America.

Research into improved wood-burning stoves should continue. Charcoal production research is not, however, of high priority, as an efficient form of earth kiln well-adapted to local conditions (the 'Casamance' kiln) is already available.

Improvement of the durability of wood, especially that used in housing, could help to reduce the drain on the forest, but there are difficulties in finding a method which is both cheap and efficient. The use of home-grown timber, treated if necessary, for transmission and telephone poles would also be worth investigating.

4.3.5.6. Organization of research

As mentioned above, in nearly all countries of the region forestry research is carried out in instititions outside the control of the Forests Service and sometimes in different ministries. This is in many ways regrettable; it may be administratively convenient to lump a large range of research activities together, but it tends to reduce the contact between the producers and the users of the results of forest research. Also the head of a large multi-purpose research institute may have his own interests and priorities, which may not include forestry.

At the very least forestry research should be allocated a separate amount within the research budget, and the program of research and priorities should be discussed with the head of the forests service, and given formal approval by him.

Liaison between the forest service and forest research organizations should be close and continuous. One way of improving this would be for the research organization to organize regular field days, which foresters would be invited to attend so that research activities and results could be demonstrated and explained to them.

Any efficient forest research will need field trial plots in forests in different parts of the country. While the management of experiments and investigations is usually best done by the research organization, the forest official who is in charge of the site where the experiments are taking place should be involved as closely as possible in the work, and his interest maintained.

Research into natural forest management will cover work in a number of climatic and vegetation zones. If this is done in every country of the region, there will be considerable duplication and unnecessarily increased expense. It is therefore recommended that the countries of the region meet together and decide on the outlines of a general research program, dividing the different activities among them. Thus for instance Niger might specialize in problems of the Sahel zone, and Upper Volta or Mali, of the South Sudan zone. A committee would need to be set up to coordinate this research, and to ensure that results were disseminated promptly throughout all the countries of the region. INSAH should play an active role in establishing such a committee and ensuring the regular collection and dissemination of research results.

It should be unnecessary to point out that research needs adequate numbers of highly trained staff, and proper funding. The continuity of this funding must be assured, as research projects, particularly long-term ones such as research into natural forests, cannot be started and stopped at a few months notice according to the vagaries of an annual budget. Indeed

the long-term nature of research into natural forest management cannot be over-emphasized. Studies of growth and production of natural forest may take twenty or thirty years to complete, and if there is a break in this period much of the value of the research may be lost.

There are many questions which need to be answered if natural forest management is to be carried out efficiently, and only a well-thought out program of research can answer these questions. Thus the formulation, financing, and execution of the well-designed research program is of high priority.

4.3.6 Policy

The following translated extracts from the forest policy of Mali (20, pp 122-124) are worth quoting:

"1. Criteria of the national forest policy

To be realistic and effective the forest policy for the management of renewable natural resources must meet the following criteria:

It must have popular acceptance, that is to say, it must obtain participation of all the population.

It must receive the continuous and whole hearted support of the political and administrative authorities.

It must be integrated into the framework of national development in particular, and regional development in general.

It must not sacrifice long term aims to short term management demands.

"2. General objectives

National sufficiency in basic materials, especially in food and in energy.

The battle against desertification.

The improvement of the conditions and the standard of living of the people.

"3. Foresty strategies

The protection and conservation of the patrimony of natural resources, to combat desertification.

The development and expansion of the resources, and the production obtained from them.

The rationalization of the exploitation and use of natural resources.

"4. Organization

The forest policy will be put into practice by:

The forest service

Rural development schemes (integrated projects)

Village association (community activities)

However the success of the policy will depend essentially on popular adherence and action." (End of translation).

All these points are applicable to the management of natural forests, the policy for which can be stated as follows:

1. To preserve the natural forests, as a protection against soil erosion and desertification.

2. As far as is compatible with the above, to manage the forests to provide for the needs of the people in wood and other forest produce on a sustained or increasing yield basis.

3. To take all economically feasible steps to protect the forests against degradation, and to increase the yields from them.

4. To improve the harvesting, transformation, utilization and marketing of wood and non-wood products from the forest.

5. To keep all operations as simple and as cheap as possible, and within the financial and organizational capabilities of the local forest services.

6. To make a sustained effort to obtain the cooperation and involvement of the local people in management activities.

Further elaboration of these points is given below.

Preservation of the protective nature of the forests, especially in the vulnerable arid zones, is the first priority, and no action should be taken which is incompatible with this. In some areas all that can be done is to protect the forests from fire and overgrazing, with any exploitation confined to the collection of dead wood and such minor forest products, for example gum, as can be collected without damaging the trees.

Where forests can be harvested without permanently damaging the environment they should be managed to produce the maximum possible sustained economic yields of marketable or utilizable produce. The marketability of the produce is emphasized as it is a mere waste to fell forests unless the wood for them can be sold. The sort of mistake made by a project in Upper Volta, where 17,000 steres of wood cleared for a plantation scheme are lying rotting by the roadside for lack of purchasers, should not be repeated.

Utilizable produce is not only wood, but incudes the fruits, fibres, leaves, etc. which play an important part in the daily life of the local people (see Section 4.3.3.2).

Protection of the forest against uncontrolled fires and overgrazing is essential, if the forests are not eventually to be destroyed. Production can be increased in a number of ways ranging from fire protection to cultivation and the artificial sowing of seed; before the more elaborate methods of increasing production are introduced, a comparison should be made of their costs and the eventual returns, in increased volume of wood, expected from them.

Improved harvesting, transformation, and utilization of wood should include the aims of economy in wood, to reduce the drain on the forest resources. Improved marketing should attempt to reduce the price of wood to the consumer, and to enable more types and assortments of wood to be sold. Improved marketing of non-wood products could have an important impact on the livelihood of the people living near the forest.

Operations should be kept as simple as possible, as for a considerable time to come there is likely to be a shortage of trained staff to apply more sophisticated and difficult techniques. Low cost techniques should be used wherever possible, for instance by the use of hand labor instead of bulldozers for maintenance of firebreaks. Governments, when accepting intenational aid for natural forest management projects should look ahead beyond the period of external funding, and be satisfied that they can take over the projects, when external funding ceases, using their own resources, thus developing self-reliance.

The importance of cooperation by the local people has been emphasized in several places earlier in this report, and it is unnecessary to elaborate on it further.

To carry out these policies there will need to be:

1. Adequate and assured finances.
2. Adequate staff, with appropriate training, and the necessary logistic backing, who are prepared to spend considerable amounts of time in the field.
3. A substantially increased, properly orientated, research program.
4. A sustained effort, through extension and personal contact, to gain the support of the local population.

To begin with, it is expected that management of natural forests will be done by the forest service in forets classees. However serious attempts should be made to encourage local communities to undertake the management of natural forests within their areas (see Section 4.3.3.3.).

5. The road ahead

5.1. Possibilities

Natural forest management has great possiblities for helping to meet the growing demands for wood and other forest products within the region, in many cases at lower cost and with less reliance on external resources than the creation of industrial plantations.

The first application of forest management will be to the forêts classées, which cover large areas and are not at present (with a very few exceptions) legally utilized for the production of wood (though quite a lot of wood is cut illicitly, and they also provide other products of value to the local people). Introduction of forest management practices will need to be on a small scale at first, gradually expanding as experience is gained. The first beginning will probably be in forêts classées near the larger towns, where there is already a demand and market for the produce. As other supplies of wood become scarcer, such markets will become more widespread, and the opportunities of managing natural forests will increase.

Simple techniques for managing the natural forest already exist, and could be put into practice immediately. Refinement of these techniques can take place as more results are obtained from research. At present constraints on developing natural forests are more administrative and social than technical.

Outside the forêts classées there is the domaine protégé, covering almost the whole land area, except for the deserts. In Senegal the management of the domaine protégé is gradually being given to local communities, and this may well happen elsewhere. These communities could also play in the management of natural forests, by placing certain areas under protection, and by managing forests for the production of wood (see Section 4.3.3.3.).

To convince local communities that managing and protecting natural forests is in their own interests will entail a long and patient process of persuasion and extension; that is all the more reason for beginning this work as soon as possible.

5.2. Constraints

There are two general constraints, which must be overcome if a beginning is to be made in natural forest management. They are:

1. Lack of assured finances.
2. Lack of sufficient staff with the appropriate training, and necessary logistic facilities, especially in the field.

Constraints which reduce the efficiency of natural forest management, but would not prevent a beginning being made on it are:

1. Lack of knowledge of the existing growing stock; inventories have so far covered only relatively small areas.
2. Lack of knowledge of growth rates and rotations.
3. Inadequate knowledge of the best means of protection, and its effect on growth rates.

Constraints which may effect some areas, but are not universal are:

1. Necessity to preserve and not exploit some forests, to protect and environment.
2. Lack of markets; it is futile to exploit the forests, unless the produce can be disposed of.
3. Encroachments on the forest, which have so reduced its stocking that management is no longer possible.
4. Uncontrollable over-grazing.
5. Hostility of the local population.
6. Inadequate road networks, or other means of transporting the produce.
7. Shortage of labor.

5.3. Priorities

The first priority is for governments to acknowledge the importance of natural forest management, and to allocate sufficient finance and staff for this work.

Following this, the next step is the selection of pilot areas for natural forest management, preferably beginning near centers of population with an assured market for wood, and if possible where inventories have already been made. As experience is gained from these pilot areas, management can gradually be spread to others.

At the same time an inventory program should be drawn up, and aerial photography arranged, with the aim of eventually covering all forests in the country. Also simultaneously with this a program of resurvey and redemarcation of borders of forets classees should be begun.

When management of the pilot forests has been successfully brought into operation, studies of the possibilities of bringing forests under management by local communities should begin.

In the initial stages the management of productive forests should concentrate on the production of building poles, and in some cases sawlogs, the latter to be retained as standards.

More sophisticated systems of management should only be introduced after research has demonstrated their effectiveness, including cost effectiveness.

The management program should include the protection of forests in arid areas.

Particular problems which should receive priority treatment are the management of the Acacia nilotica forests along the Senegal River, and the restoration and management of gum arabic forests (Acacia senegal).

In research priority should be given to getting better data on growth and productivity of fuelwood species, and obtaining quantitative data on the effects of protecting the forests against fire and overgrazing.

Socio-economic research should be begun on markets for forest produce, and on the economic benefits provided by minor forest produce.

In training priority should be given to training in extension work and social relationships, and reorientated from regarding the forester as purely a policeman.

In the legislative sphere foresters need to be able to work within the framework of remodeled forest law adapted to modern conditions. Thus the revision of the Forest Acts in the countries of the region is a priority. It is also necessary to harmonize forestry legislation between the different countries, and to establish frameworks for bilateral cooperation between neighboring countries.

6. Recommendations

General

It is recommended:

1. That the countries of the region should recognize the contribution that management of natural forests can make to supplying needs of forest products, and should give this at least equal priority to the establishment of large-scale plantations, with adequate provisions of staff and finance.
2. That a study be made of all available results obtained so far from management of natural forests and related fields (e.g. inventories, direct seeding, protection) within the Sahel region, including material in national and forest service archives, and a synthesis paper be prepared. Wherever possible this study should include interviews of older forest service personnel, including those who have retired.

Bringing forests under management

3. That a reconnaissance should be made of all forets classees, to arrange an order of priority in which these should be brought under management.
4. That where not already done, inventories be gradually made of all forets classees, beginning in those which were likely to be brought under management soonest.
5. That each country should select a pilot area in which management of natural forest could be begun, such an area being one where there are assured markets, and preferably where an inventory has already been made.
6. That, where not already done, boundaries of all forets classees should be resurveyed and marked with permanent markers, and firebreaks opened round them.
7. That management plans be prepared for all forests to be taken under management.
8. That in selected forests socio-economic surveys should be made to study uses of the forest by the local population, including non-wood uses. An attempt should be made to quantify these uses.

9. That before any felling of a forest for wood-production is undertaken, investigations should have shown that there is an adequate market for the produce. Where markets are limited, the size of the cut should be controlled by market requirements.
10. That in selecting methods for managing natural forests, the cheapest and simplest ones should be preferred. Use of more costly methods should be justified by a study of their cost-effectiveness.
11. That the system of management to be used should, in general, be simple coppice, with reservation of traditionally protected trees, such as karite, nere, and Acacia albida and, where desired, trees for sawlogs, as standards. Felling of timber trees should be controlled by girth limits. Otherwise the yield should be controlled by area (annual cuts).
12. That trials should be made of selling standing wood to contractors, by auction or sealed tender. Wood so sold should be exempt from royalty.
13. That limited pilot trials be made in each country on the management of natural forests by local communities, with a view to establishing methods of working, approach to the people, and discovering difficulties and constraints which may arise.

Fire protection

14. That wherever possible, the policy should be protection against fire rather than early burning. If early burning has to be used, staff and labour should be given careful training in the techniques to be used.
15. That trials should be made of different forms of firebreaks, including completely cleared strips, clearing parallel strips and burning between them, and the use of living firebreaks.
16. That propaganda and extension against forest fires should be vigorously continued, through the schools, the media, and direct contact with the people.

Research

Physical research

17. That research on natural forest management should be expanded and given priority comparable with that of other fields of forest research, with adequate funds and properly trained staff.
18. That forest services should be consulted on the drawing up of research programs, with specific programs and funds allotted to natural forest management.
19. That better liaison should be established between research workers and forest service officials, to allow exchange of views and ideas between the producers and the users of research results.
20. That in applied research, priority be given to studies of growth and yield and natural forest, with a view to obtaining better data on productivity and optimum length of rotation, and to the effect of different methods of protection against fire and grazing on growth and yields.
21. That basic research should be expanded on the synecology of natural forests and the autecology of the more important species.
22. That research be begun on the optimum cutting regime for bamboos and of Borassus leaves for fibre.

Socio-economic research

23. That more studies should be made of the role of fire in Sahelian agricultural and pastoral systems, the reasons why fires are started, traditional strategies, and changes which may realistically be brought about.

24. That studies be made of marketing of forest products, including non-wood products, including market structure, evolution of prices, and projection of further supply and demand.

25. That special studies be made of the existing and potential use of non-wood forest products, and an attempt be made to quantify, on a selective basis, their contribution to local national and regional economies.

26. That studies be made of land and tree tenure and their implications for natural forest management.

General

27. That research should be co-ordinated between the countries of the region, to avoid unnecessary duplication of effort, and ensure prompt dissemination of results. This type of active co-ordination should be provided by INSAH.

Regional co-operation

28. That CILSS/Club du Sahel move with all deliberate speed to organize and convene a Regional Workshop on natural forest management designed to bring together technicians working in this field. Technicians from non-CILSS countries with similar climate and vegetation should also be invited (Nigeria, Sudan, Cameroun, etc.).

29. That the Sahel Institute (INSAH) together with CILSS/Club du Sahel devise methods for monitoring the progress of natural forest management projects and project components and that INSAH (Cellule Ecologie/
Environment) and Réseau Sahelien de Documentation (RESADOC) take the lead in establishing a network for information dissemination, exchange and co-ordination among these various projects. The first step will be the publication of the inventory of forest research which has been undertaken by the Cellule over the last few months.

30. That as part of the proposed CILSS/Club du Sahel Sector Bilan-Program for Chad, special attention be given to evaluating the results of the Project 'Aménagement et exploitation de la Vegetation Forestière dans la Region de N'Djamena' (FAO/UNDP).

31. That other regional organizations should be brought into this work, as appropriate.

Training

32. That curricula in instititutions for training staff at all levels should be approved by the relevant forest services and should include emphasis on natural forest management, and increased field work.

33. That training, especially of lower grade staff, should be re-orientated away from pure policing and revenue collecting duties, towards extension and liaison with local communities, and teaching them efficient methods of forestry work.

34. That in-service practical training courses be given to workmen and laborers, including those working on forest utilization.

35. That extension programs to teach rural people the value of natural forests and the importance of protecting them should be pursued with vigor, through the schools, the media, and by face to face discussions.
36. That refresher courses, at both national and regional levels, should be organized for forest officials of all grades.

Other social and administrative matters

37. That staff should be given adequate transport to allow them to make the necessary field visits, and that they should be given positive encouragement to spend considerable amounts of time in the field.
38. That the pay of staff, particularly in the lower grades, should be reviewed.
39. That, when staff is available, consideration be given to the setting up of a section for natural forest management within the forestry service, and also a mobile inventory team to carry out systematic inventory work within the forets classees.
40. That the Forest Acts should be revised to bring them into accordance with modern concepts, particularly in the social aspects of forestry and the need to obt in peoples' participation.
41. That in particular the forest laws should be revised to allow local communities to manage natural forests for their own profit.
42. That the royalty or stumpage charges on wood should be adjusted to reflect its full production or replacement costs, to give incentives for planting and protecting trees.
43. That such royalties and stumpage charges should be credited in full to the budget of the respective forestry department, except where the wood originates in forests managed by local communities under an approved plan, or from community or privately owned plantations. In the two last cases the revenue should go to those responsible for growing the wood.

7. Conclusions

The natural forests of the countries of the Sahara are a great potential asset which up to the present has been lmost completely undeveloped. Developing the natural forests is tae only feasible way of overcoming the growing energy problems of the region. Plantations, even if programs are greatly expanded and yields considerably higher than those achieved in practice, can only provide a small proportion of the region's fuel needs (15 percent by the year 2000, in Upper Volta (19)).

Natural forests also provide a great range of non-wood products which are very important in the life of the people of the region.

The technical problems in managing these forests are not great. Simple management techniques already exist which would enable natural forest management to be undertaken on a large scale. No doubt these techniques will be improved as a result of experience and research, but they are adequate for a start to be made.

Management of natural forests can also be undertaken without heavy inputs of imported machinery and fuel.

The main problems are administrative rather than technical. Governments and policy makers are now realizing the potential importance of natural forest management, in theory at least. The time has now come to put these theories into practice, by allocating

adequate funds and staff, and getting work started in the field. This re-orientation towards natural forests will also require changes in forestry education, research, the forest law, and in the attitude of forestry department staff to the local population, from being their adversaries to becoming their instructors and helpers.

None of these problems are insoluble. It is hoped that they will be overcome quickly so that the natural forests can begin to make their proper contribution to the well-being of the people in the region.

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APPENDIX 1

PRELIMINARY LIST OF RECENT AND PROPOSED PROJECTS CONTAINING A COMPONENT OF NATURAL FOREST MANAGEMENT, OR RELATED ACTIVITIES

(* Project at present active)

1. Mauritania (Service Protection de la Nature, BP 170, Nouakchott)

   Existing Projects

   Projet gestion des ressources renouvelables
   1980-85. To be financed by USAID, but at present suspended. Includes Landsat mapping on 15 million ha and regeneration of 500 ha of gum forest.

   Proposed Projects

   Programme d'inventaire et programmation des aménagements des terres Forestières.

   Activités préparatoires de l'inventaire en vue de l'aménagement du tapis végetal.

   Projet UNSO de lutte contre l'ensablement.

   *Projet FED/EEC de restauration des gommeraies (project getting under way).

   Esquisse d'aménagement d'une forêt de gonakier avec planation en sec.

   Régeneration du gonakier dans le bassin du fleuve Sénegal.

   Amélioration et extension du reseau de pare-feu.

   Projet USAID 'Restauration de l'Environment'.

   Project documents for all these have been prepared but (up to 1982) none has obtained financing.

2. Senegal (Service des Eaux et Forêts, BP 1831, Dakar)

   *Le Reboisement et l'aménagement de la zone sylvopastural
   1975-1985. Financed by GTZ (Federal Republic of Germany).

   Includes protection of pastoral areas.

   Mise en valeur des forêts de Basse et Moyenne Casamance
   1973-1977. Financed by FAO.

Inventory and mapping of 260,000 ha of mixed forest and 62,000 ha of mangroves.

*Aménagement et reboisement des forêts du Centre-Est 1979-1984. Financed by the World Bank, FAC (France) and CCCE.
Includes management of 10,000 ha of natural forest in the foret classee of Koumpentoum, plus research (with ISRA/CNRF) on natural forest management techniques. Contact B.P.I., Kaffrine.

Mise en valeur des forêts de Tobor
Financed by FAO; at present suspended.
Includes seeding fellings and the protection of the forest by firebreaks. Technical and social difficulties have caused suspension.
(For research, contact Centre National de Rechereches Forestières, BP 2312, Dakar).

3. The Gambia (Forestry Department, Banjul)

*Gambia Forestry Project
1980-85. Financed by USAID.
Includes a feasibility study of mangrove exploitation.

*Assistance for the Gambian Forestry Services.
1981-83. Financed by GTZ (Federal Republic of Germany).
Includes a national forest inventory.

4. Upper Volta (Directeur de l'Aménagement Forestier et du du Reboisement, BP 7044, Ougadougou)

*Projet de reboisement de la mission forestière
1974 - Financed by GTZ (Federal Republic of Germany).
Includes natural forest management research at Gonse.

*Projet IDA (Banque Mondiale)
1979-84. Financed by World Bank/CCCE/FAC.
Includes management of 1000 ha of natural forest at Maro, near Bobo Dioulasso. (Contact BP 2072, Ouagadougou).

Développement des ressources forestières, de la faune sauvage, et de la pêche.
1973-77. Financed by FAO/UNDP.
Included management of 6500 ha of natural forest, by simple coppice, in the Nobere region, but this does not seem to have been carried out.

Développement des ressources forestières et renforcement du service forestier
1978-82. Finance by FAO/UNDP.
Includes mapping by Landsat imagery, and taking volume samples.

*Formation et Développement Forestiers
1978-84. Financed by USAID.
Includes a management plan, including natural forest mangement, of the Foret Classee of Dinderesso. (Contact BP 1105, Bobo Dioulasso).

*Inventory and mangement plan for the foret classee of Sissili
Financed by CIDA. To cover 30,000 ha.
(Contact BP 2013, Ouagadougou).

In addition research on natural forest management is being undertaken by CTFT/Institut de Recherche en Biologie et Ecologie Tropicale (Contact CTFT, BP 303, Ouagadougou). Some natural forests have been inventoried by the Forest Service.

For research also contact Centre Nationale de la Recherche Scientifique et Technique, BP 7047, Ouagadougou.

5. Mali (Direction Nationale Eaux et Forêts, BP 275, Bamako)

Aménagement des forêts classees de la Région de Bamako
1972-75. Financed by FAC (France).
Included management of forest "on orthodox lines", plus firebreaks.

Amenagement et Reboisement dans la Region de Bamako
1975-80. Financed by FAO.
Included aerial photography and soil vegetation mapping of 100,000 ha.

*Projet forestier 883/MLi (Opération Amenagement et Productions Forestières)
Continuation of above, financed by the IDA of the World Bank, CCCE and FAC.
Includes managing of 1000 ha of forets classees at La Faya and 200 ha near Segou (not yet done). (Contact BP 2537, Bamako).

*Projet Forestier de la Region de Sikasso 1980 - Financed by DDA (Switzerland).
Includes an inventory of 16,000 ha (done) and management of natural forest at Farako (not yet begun). (Contact BP 178, Sikasso).

*Projet de reboisement - Kayes 1980-85. Financed by GTZ (Federal Republic of Germany).
Includes the management of natural forest around Kayes.

Projet Inventaire des Ressources Terrestres
1980-83. Financed by USAID.
Small scale mapping, based on Landsat, of most of southern Mali. (Contact BP 2357, Bamako).

Programme pilote spécial de travaux à haute intensite de main-d'oeuvre
1980 - Financed by ILO.
Includes construction of firebreaks round forets classees in the Kayes and Segou regions.

Proposed Projects
Inventaire des gommeraies.
Lutte contre les feux de brousse.
Amélioration des gommeraies au Gourma.
Amenagement et Reboisement dans la Region de Segou.

For research, also contact Institut National de Recherches Zootechniques, Forestières et Hydrologiques, Sotuba, Bamako.

6. Niger Direction Centrale des Forêts et Faune, BP 578, Niamey)
*Project pour la planification et l'utilisation des sols et des forêts
1980-84. Financed by USAID.
Includes inventory of natural resources, development of plans for syvo-pastoral management: and preparation of management plans. (Contact BP 578, Niamey).
*Project IDA, Phase I 1978-1981: Phase II 1982-
Financed by World Bank/CCCE/FAC.
Management trials in 3 or 4 contrasting situation, on 6000 ha (rainfall, population and livestock pressure, species, etc.). Sites to be selected. (Contact BP 10496, Niamey).
Protection et Exploitation des Gommeraies denses naturelles dans le Manga
1975-76. Financed by World Bank.
Projet d'Aménagement et de Reconstituition de la Rôneraie de Dallol Maouri
1978-80. Financed by FAC. continued by
*Projet d'Aménagement des Rôneraies du Dallot Maouri
1981-83. Financed by DDA (Switzerland).
Acacia albida project
1974-78. Financed by USAID.
*Project Acacia albida - Dosso I
1981-85. Financed by FAC.
*Project Acacia albida - Dosso II
Financed by UNSO.
*Plantation de bois villageoises
Second phase, 1981-83. Financed by I.D.R .C. (Canada).
Includes introduction of efficient and cheap methods for protection of natural regeneration.
(For research also contact Institut National de Recherches Agronomiques du Niger, Dépt. des recherches forestières, BP 275, Niamey).

7. Chad (Direction des Eaux et Forêts et Reboisement, BP 447, N'Djamena)
Aménagement et exploitation de la végétation forestière dans la région de N'Djamena
1975 - Financed by FAO/UNDP; not completed.

The list presented above is only preliminary. In order to help set in motion the exchange of experience and information between the various natural forest management efforts getting under way across the Sahel, readers are requested to provide both corrections and additional information to the Department de la Recherche (Cellule Ecologie/Environment), Institut du Sahel, BP 1530, Bamako, Mali.

APPENDIX 2

AREAS OF FORETS CLASSES AND FOREST PARKS
in square kilometers

Country	Total area	Area of forets classes	Percentage
Mauritania	1,031,000	320	0.02
Senegal	190,823	12,711 1/	6.7
The Gambia	10,366	340 2/	3.1
Mali	1,240,000	11,307	0.9
Upper Volta	274,000	7,750	2.8
Niger	1,267,000	2,118	0.2
Chad	1,284,000	4,500	0.4

1/ Forets amenagees total 1900 km^2; exploitation in the remainder of the area is forbidden.

2/ Forest Parks.