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A CONCEPTUAL APPROACH TO THE CONSERVATION & MANAGEMENT OF NATURAL FORESTS IN SUB-SAHARAN AFRICA (Arid & Semi-Arid Forests & Woodlands)

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Foreword

Many people, all of them convinced of the importance of managing the dry forests of sub-Saharan Africa as a component of sector strategy, have contributed to this document.

As the title page indicates, it has been prepared under the auspices of the AID/AFR/TR-funded Natural Resources Management Support (NRMS) Project. The principal editor and the other authors are grateful to the colleagues in the Agriculture/Natural Resources Division, Office of Technical Resources, Bureau for Africa for their understanding and support regarding the topic and the logistics of putting together a document of this nature. **Dwight Walker, Greg Booth, Mike McGahuey** (all of AFR/TR/ANR) also contributed oversight, comments, and suggestions during the annotated outline phase of the process.

The authors were engaged by Associates in Rural Development, Inc. (ARD) to draft (and in some cases, redraft) various sections of this document. Each of them are highly experienced forestry or natural resources management specialists with many years of service in sub-Saharan Africa. Most of the section "Knowing the Resource" was prepared by **Ian Deshmukh**, ecologist and author of a unique book on the ecology and tropical biology of sub-Saharan Africa. The section "Resource Assessments" was prepared by **Roy Hagen**, a well-known forestry and forest inventory specialist, who has worked over the years throughout Africa. **James Thomson**, ARD's home-office institutional development specialist, and frequent contributor to the theory and practice of community-based management of natural resources, authored the section, "Organizing for Participation." The entire section on "Economics and Natural Forest Management" was contributed by **Steve Dennison**, ARD's resident forest economist and Africa forestry and agroforestry specialist. The final section, "Managing the Forest," is a joint effort by John Heermans, who recently received the Innovations for Development Association Award presented by the Swedish Royal Academy of Engineers for his many pioneering years of work on natural forest management, and **Thomas Catterson**, ARD's senior associate for forestry and natural resources, and an early proponent of natural forest management.

Several people have contributed substantively and substantially to the editorial process. **Bill Hegman**, ARD's GIS office head, using the firm's in-house ARC/INFO GIS facility, prepared the custom maps found in the document. **Star Albright**'s professional editorial and desktop publishing skills are evident on every page. **Tim Resch**, now with the AFR/TR/ANR staff, reviewed the final draft with great care and diligence, providing collegial and informed assistance in completing the document. The overall task of editing the document, and the ultimate responsibility for its contents, lies with Tom Catterson, who also drafted the introduction and parts of almost every section.

Introduction

Historical Perspective

Man has had a long-term relationship with the forests, woodlands, and rangelands of the arid and semi-arid zones of sub-Saharan Africa. Indications of human occupation date back as far as 600,000 B.C. (NRC 1983). Itinerant hunter-gatherers, nomadic herders, and caravan traders have utilized and lived in the zone for millennia. People settled in these zones for a number of reasons: health—they were perceived to be freer of the diseases such as malaria, typical of the more humid regions to the south; livestock production potential–herding animals in the grass savannah areas where forage was abundant according to the rains; and crop production—nomads occasionally practicing seasonal farming has gradually yielded to more sedentary herders and farmers planting cereal crops. While the dry landscape of the arid and semi-arid forest areas of the zone are often thought to be desolate and abandoned, the imprint of man, largely recorded through his impact on the relatively fragile vegetation, is visible to the careful observer almost everywhere.

During historical times, the forest resources of the arid and semi-arid zones were actively exploited, often in a more organized fashion than exists today. Gum arabic (*Acacia senegal*) collection and trading is known to have flourished along the West African coast in the 1400s and extensive areas of gum forests are thought to have been destroyed along its northern range in Mauritania and Senegal (NRC 1981). Charcoal was one of the preferred commodities of the trans-Saharan caravan traders. It was harvested widely along the margins of the desert and carried by vast camel caravans north to the Magreb. Hunting was a traditional pursuit of the desert people, and their early adaptation to the use of firearms has served to decimate the wildlife populations of the zone, to the point where species and biological diversity have been severely limited (NRC 1983).

In the latter part of the colonial period, the authorities, looking to the future needs of the country for the products of the natural forests, began to set aside forest and woodland areas (forest reserves or *forêt classee*). In certain areas (e.g., northeastern Senegal), these were seen as pastoral reserves. Most of these forest reserves were set up in a time of very limited population pressure and, as such, reservation was often nominal. Little effort was necessary to protect these forests and woodlands, and few efforts were made. In many cases, maps and gazettement decrees were prepared after only a cursory field visit; in other cases, the process was carried out in a serious manner according to the latest in professional practice. Neither approach appears to have been any more of a guarantee to ensuring the integrity of the resource.

Reservation meant different things in different countries. In some cases, the ban on utilization was total, essentially prohibiting local people from entering and/or removing anything from the forest. In other cases, there were arrangements for the continuation of traditional usage rights, the freedom of local people to collect firewood (usually dead wood), traditional medicines and foods, and to graze animals there. In yet other instances, reservation was merely seen as a politico-administrative impediment to the area being converted to other uses and no actual usage constraints were applied.

There were only a few instances of the actual establishment, and more importantly, the implementation of a management plan and silvicultural prescriptions. At the Bandia Forest in the Thies region of Senegal, classified in 1933, hunting was forbidden but woodcutting and grazing were permitted on a fee basis. A simplified management prescription consisting of clearcutting blocks of 500 hectares for commercial charcoal production on a 20-year rotation was also put in place and carried out (Gibson-Muller 1985). Although there was some "illegal" cutting taking place on this forest, management and silvicultural operations were considerably more successful there than on the majority of similar situations across arid and semi-arid Africa. This *forêt classe* is still relatively intact despite its proximity to the urban center of Dakar.

All too often, as the recurrent costs of protecting these forests rose in response to increasing population pressures, many of these reserved forests languished. In Niger in 1984, after an overall assessment of the situation of the 60 plus designated *forêts classees* in the country, 13 of them were officially declassified because they had, for all intents and purposes, disappeared under the pressure of the expansion of the agricultural frontier. This functional abandonment has certainly occurred in other countries as well, albeit without the benefit of the formal declassification process. Remnants of reserve forest are widespread throughout the region and, in some cases, the national forest service struggles to maintain and protect them. In some situations, owing to a perception of low potential productivity, governments were hard-pressed to fund the level of administration that would be required to protect them, especially in light of the difficult financial status many faced in budgeting for forestry operations.

Other factors were at work in determining the levels of investment in managing the natural forest resources in the arid and semi-arid zone of sub-Saharan Africa. In some countries, the modest production potential muted the interests of the government authorities in the economic development of these areas, shifting attention and resources to higher rainfall areas. The early post-colonial period also saw a degree of local backlash against the impositions of the former authorities and, as a result, some reserve areas were deliberately taken back by local people. Increasing population pressures, both of people and livestock, slowly began to take a significant toll in terms of land degradation and desertification.

As this situation became more manifest, national authorities in a number of countries started to nationalize all of the public domain lands with the notion of widening the scope of their control over the future use of the resource base and promoting its conservation. In effect, this control has proved extremely difficult to implement, again as a result of the thin spread of government employees, traditionally the forest service, and their limited capacity to enforce these new regulations. Unfortunately, these regulations also had the implicit effect of weakening the existing traditional land tenure (*Chef de Terre*) and land management systems that were in place. The older traditional systems had their origins in a basic common-sense understanding of the local ecology and the need to rotate land-use to avoid over-exploitation. Without either the traditional system or forest service control, the land and forest resource base became de facto common lands. In many areas, in the absence of the politico-institutional arrangements for use and management, everyone's land was no one's responsibility and the degradation became more widespread--the so-called "tragedy of the commons".

Natural Forest Management as a Potential Sector Strategy

Fuelwood production has been a recurrent theme for forestry sector strategists in the arid and semi-arid areas of sub-Saharan Africa for the last quarter century. Much experience with fuelwood production projects has accrued all over the continent. Capital-intensive block plantations designed to meet the urban fuelwood demand in these areas (e.g., around Dakar, Senegal, and Ouagadougou, Burkina Faso) have been crippled by the stifling combination of high establishment cost, slow growth, and low producer prices. Another option, the village woodlot formula, relying on shared work for shared benefits on "common lands" has proven to be an elusive goal for many reasons. In those areas where trees are needed, by definition, there is usually not enough real common land available to achieve adequate impact on the fuelwood supply situation. Farm forestry or agroforestry approaches appear to hold great promise, but whether they can produce surplus fuelwood beyond the needs of the rural people in the areas in which they are occurring, remains to be seen.

The emergence of the potential for fuelwood production through natural forest management is more recent. The advantages would appear to be many. The sheer predominance of natural forests and woodlands for present fuelwood supply immediately suggests the opportunity these formations represent. Even modest gains in sustainable productivity could have a significant impact on fuelwood supply. Forest management schemes can also provide a very viable and sustainable land-use option for vast areas of the continent. Properly managed, these areas could offer employment, income and an additional contribution to the livelihoods of countless rural people. Harnessing management to a rational fuelwood supply and marketing system to meet the demands for this basic source of household energy, even for many urban areas, will allow the forestry sector to play its rightful role in development and economic growth.

One of the greatest advantages of natural forest management is the potential it offers for a greater return on sector investments, especially compared to the costly plantation endeavors that will be required to rehabilitate degraded land and meet the challenge of increasing fuelwood demand. Preliminary data emerging from albeit very limited trials suggest that the costs may be as little as U.S. $200 per hectare to restore and rehabilitate the productive potential of even fairly degraded natural forest areas in arid and semi-arid Africa. These costs could be even less if utilization was carried out in such a way as to foster natural regeneration of these stands. This must be compared to the relatively high cost of large-scale reforestation, now estimated to cost on the order of U.S. $1,000 per hectare.

The overall working hypothesis of this document is as follows. Urban need for domestic energy and limited options to satisfy it has created a large and burgeoning demand for fuelwood. Harvesting and supplying this wood to the cities and urban areas of sub-Saharan Africa is still presently being achieved by cutting in natural forest areas—predominantly of a semi-arid savannah woodlands type of modest productivity. While there are some opportunities for both fuelwood substitution and conservation (improved stoves), it is apparent that the magnitude of the demand will, for the foreseeable future, have to be met from these same forest areas. This situation presents both challenges and opportunities: the potential for environmental degradation from unmanaged exploitation of the resource base; the need for sustainable production techniques and the systems to achieve them; the recurrent costs associated with setting up, administering, and funding such systems; and the impact of added cost of production through sustainable management approaches on producer and consumer prices. The real potential lies in the fact that the classical notions of forestry science--multiple use and sustained yield--long evoked as dogma, may now be implemented in light of the evident economic opportunity of a cash marketplace for fuelwood.

Drought, Desertification, and Deforestation

In many parts of the arid and semi-arid areas of sub-Saharan Africa, drought, desertification, and deforestation are closely linked and have an important impact on man's ability to manage the land and the forests. A clear understanding of these linkages is fundamental to a sound conceptual approach to natural forest management. Deforestation does not cause drought, nor does it necessarily mean that desertification will take place.

Drought is principally a climatic event. The weather systems which underlie the extreme variability of the rainfall in this part of Africa are thought to be the result of wind displacement and precipitation patterns induced by other climatic circumstances which take place well away from the affected areas. There is as yet little empirical evidence to link the occurrence of drought to human activity in sub-Saharan Africa. Some authors have suggested that to a certain extent, drought, through its effect on the vegetation and surface conditions in the affected areas, feeds upon itself. This relationship is important because land-use in these same areas may have the same effect. Policy analysis related to the destiny of large areas of natural vegetation in these parts of the world must recognize the enormous potential for damage inherent in the systematic though well-intentioned conversion of natural vegetation to areas of marginally sustainable agriculture. Although forest and woodland production may be quite modest, and little lost from such conversions, it is an extremely costly and long-term endeavor to rehabilitate these lands once they have been so cleared.

From another viewpoint, taking drought into consideration represents an exercise that demands special care in choosing alternative courses of action in stricken areas. Average rainfall, for example, is a deceptive indicator in assessing production potential in such areas. In approaching natural forest management plans for arid and semi-arid areas, there is a strong need for a sense of perspective. This perspective must take account of the long-term nature of the problem and the need to focus on the most achievable rather than the most challenging issues. Throughout the region, emphasis, at least for the near to medium term, should be given to the less degraded forest areas rather than the most denuded and barren areas. Furthermore, drought is unpredictable and recurring; it should be factored into the management planning scheme for any natural forest area. Natural forest management will be affected by the impact of drought on the vegetation and soils of the area; consequently, treatment prescriptions have to be a degree more conservative than might ordinarily be the case.

Whereas mean annual increment is normally the upper limit of annual allowable cut, under arid and semi-arid conditions, the potential for drought should be considered.

Similarly, not all tree cutting necessarily leads to desertification. In many cases, higher-level decision makers are reluctant to authorize actual tree cutting as part of forest management implementation plans because of the perceived potential for desertification (i.e., there has been a backlash against tree cutting in general). This approach tends to reinforce the factual depreciation of the forest value and undermines the ability to promote forest management schemes and invest in the protection and treatment of the resources base critical to avoiding the spread of desertification. Properly carried out, tree cutting can stimulate natural regeneration and coppice growth thereby enhancing the forest and woodland cover.

Extent of These Forests/Woodlands

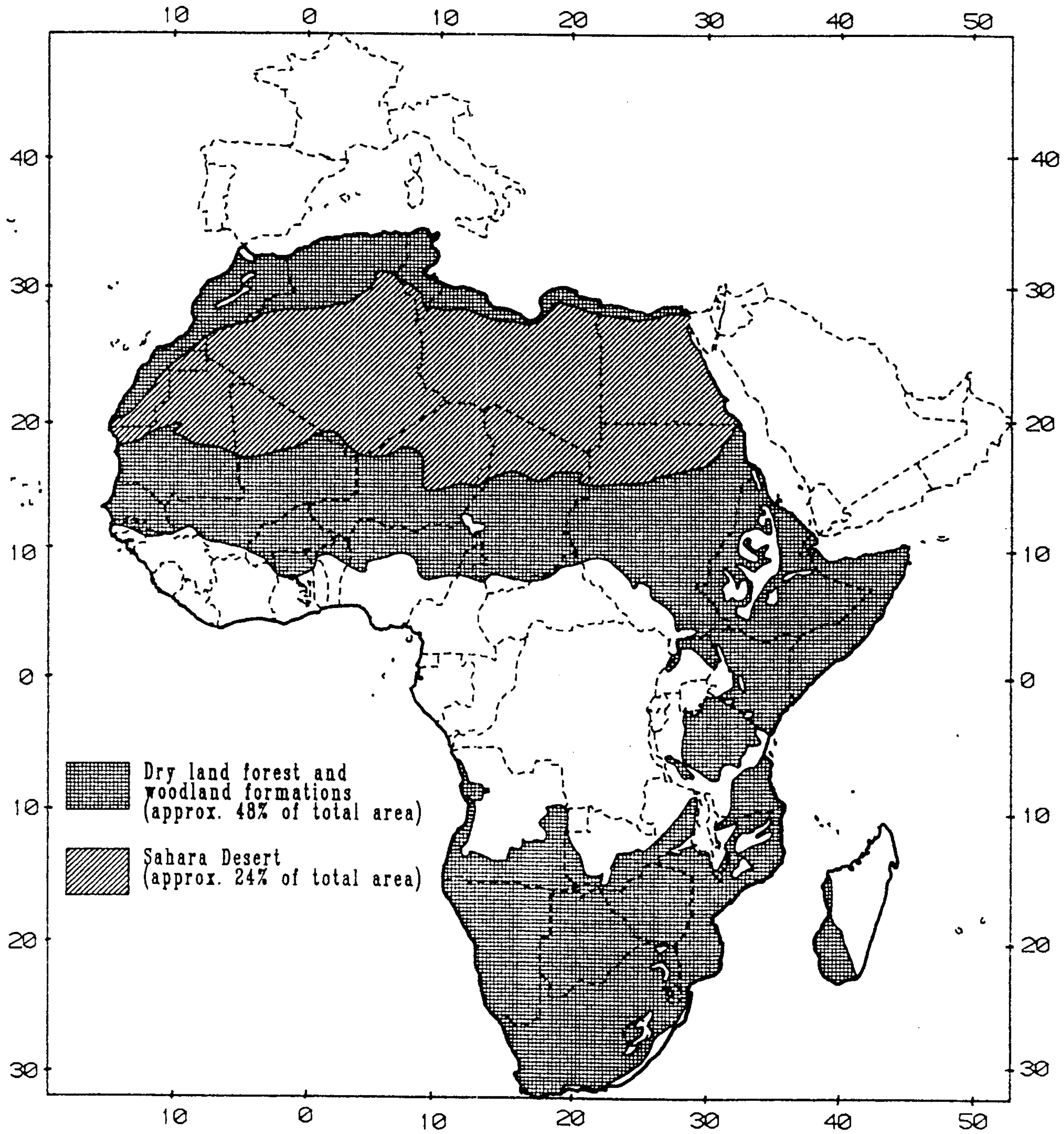
The arid and semi-arid forest, woodland, and savannah formations occupy a much larger area than is generally perceived. Sub-Saharan Africa is largely a region of dry open woodland formations. It has been estimated that there are approximately 500 million hectares of such tree formations and slightly less (420 million hectares) of shrub formations in tropical sub-Saharan Africa (FAO 1981). Such formations are found widely in West, East, southern and the Horn of Africa, covering more than 50 percent of the continent (see Figure 1). A basic tenet of this document is that these extensive areas of dry forests, found throughout the African continent, provide a basis for synergistic approaches and professional networking for the development of forest management among the concerned countries.

Accurate area and inventory data for these formations throughout sub-Saharan Africa is not readily available. In some countries, it is better than in others, but issues of comparability of data arise from the use of different descriptions and classifications. Some efforts were made to sort out these differences among the countries of Sahelian West Africa, and this document will, as necessary, adhere to the formulation given below. Clearly, the Sahelian classification system needs to be reconciled with the situation elsewhere in Africa, particularly that for southern Africa, in order to facilitate the exchange of technical information. The Sahelian classification (after CTFT 1982) is as follows:

- *Sahelo-Saharan sub-region*—150-300 mm annual rainfall—savanna and bush-covered steppes;
- *Sahelo-Sudanese sub-region*300-600 mm annual rainfall—savanna and tree-covered steppes;
- *Sudanese-Sahelian sub-region*—600-900 mm annual rainfall—forested savanna and sparse forests; and
- *Sudanese-Guinean sub-region*—900-1,200 mm annual rainfall—sparse forests and dry dense forests.

Figure 1.

The Extent of Dry Land Forest and Woodland Formations in Africa



Dry land forest areas were interpreted from the DESERTIFICATION MAP OF THE WORLD, FAO and UNESCO, 1977

1:55,625,000
APPROXIMATE SCALE

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Production Potentials

The forests and woodlands of the arid and semi-arid regions of sub-Saharan Africa can be characterized as multiple-use forests, even more so than some of the high forest areas found in the better watered regions of the continent. Man has traditionally sought and obtained a wide range of products from these areas: fuelwood and charcoal, service timber (posts and poles), grazing resources and tree fodder, foods and medicines, gums, resins, and other secondary forest products.

Little work has been completed to date to quantify the resource production potential as it is an extremely time-consuming and meticulous undertaking. Limited studies oriented to classical forestry approaches, measuring productivity in terms of wood increment (cubic meters per hectare per year), estimate the productivity of these forests and woodlands to be between 0.05 m^3/ha/yr and 1.5 m^3/ha/yr. These figures are rather abstract and only become more meaningful when compared with demand and use data. For example, average annual per capita fuelwood consumption in this region of sub-Saharan Africa is estimated at approximately 1.0 m^3/yr. This means that in order to satisfy the annual fuelwood needs of a family of five, without depleting the resource base (sustained yield principal-harvest equivalent to no more than annual increment) in the drier parts, would require 100 hectares (5 x 1.0 m^3 divided by 0.05 = 100) or in the least arid areas, roughly 3.3 hectares (5 x 1.0 m^3 divided by 1.5 = 3.3). This calculation, albeit a rather simple one, underscores the importance of the need to improve the knowledge of the resource base.

Fodder and grazing resources have also received similar attention, in terms of measurements of biomass productivity studies. For example, estimates of the productivity of the much sought after perennial grass species, *Andropogon gayanus*, range as high as 6,000 kilograms per hectare (PPS 1982). It should be noted, however, that biomass productivity is not a straightforward indicator of the usefulness of the species as there are wide fluctuations in nitrogen content (uptake) and digestibility in the annual cycle which alter the plants' suitability as animal fodder. For example, certain annual grasses produce considerably less total biomass but are higher in nitrogen (and thus protein content) during their growing cycle.

Often overlooked but frequently just as important as fuelwood or fodder are the numerous non-wood, "minor forest products" derived from the arid and semi-arid forests and woodlands of sub-Saharan Africa. One need only walk through the main markets of the cities and towns of the continent to fully appreciate the breadth of these products. The range of these products include: food from plant parts (seeds, fruits, leaves, and twigs), wild honey and game meat from large and small animals, medicines and other ingredients of traditional pharmacopeia, tanning extracts, a variety of gums, fiber, and oil products. There has been little comprehensive study of these products despite their continued use by rural people throughout the continent.

It is noteworthy that gum arabic (*Acacia senegal*), despite its importance in worldwide trade, is often still characterized as a minor forest product. Similar to the gum gardens of Sudan, some of these native species have become vital elements of local farming systems and lifeways, and people actively plant or manage them. For example, throughout the Fouta Djallon hills of Guinea, the primary crop species is Fonio (*Digitaria edulis*), a wild grass which grows well on the dry eroded hills of the area. The Shea-Nut Butter tree (*Butyrospermum parkii*) is an important cash crop of the Sudano-Guinean belt. The tree is often protected by local people as part of a natural multi-species overstory including a number of other species of special value to local people: *Prosopis africana*, an excellent local building timber, preferred wood for carving, and the source of tannin; and *Acacia albida*, a high-quality, dry-season source of fodder and nutritious pods. The Tamarind tree (*Tamarindus indica*), a source of fruits used for food, juices, and medicinal infusions, is thought to have originated in East Africa or Madagascar and is now found widely throughout Africa and in many other parts of the world. Rural people in Niger, Burkina Faso, and Mali actively plant and protect the trees of *Parkia biglobosa* the seeds of which are ground and mashed to produce a sort of vegetable cheese as the basis for numerous sauces used in local diets. The fabled gums of ancient times—frankincense and myrhh—are obtained from *Boswellia* spp. and *Commiphora* spp. found in the arid savannah woodlands of Ethiopia and Somalia.

These species mentioned above are among the most well-known and, while their existence and importance is often acknowledged, there has been little study of their economic significance, either as a subsistence crop for rural people or as a source of alternative cash income. There are undoubtedly numerous other species, especially among the plants whose local utility is unknown beyond the local area. These other products and attributes of the forest/range resource base are, on the other hand, very well-known to the indigenous people who inhabit the areas. Special terms denoting key utilization concepts abound in the local languages. In fact, in the most traditional societies, lifeways are ordered around these terms and meanings. People characterize plants (and animals, too) in many ways—according to fodder utility and nutritional value for animals, as part of the human diet, for medicinal values, as related to other practical applications for household use, and, as indicators of site conditions (e.g., good soils, shallow water tables, past use history). An improved knowledge of these species and their economic significance is vital. It could provide the basis for achieving a positive rate of return in the cost/benefit analysis of a natural forest management project and ensure a sound justification for genuine popular participation in such a scheme.

Purpose of This Document

Natural forest management in sub-Saharan Africa has been a relatively neglected component of the natural resources management sector. With a few notable exceptions, the natural forests and woodlands of most dry African countries have been taken for grantedthere to be used and considered nearly undepletable. It is now clear that this *laissez-faire* treatment is no longer appropriate if the natural forests and woodlands are to continue to provide the wealth of products, uses, and services they have in the past. There are also clear signs in many African countries that governments and people are willing to tackle the different problems associated with the sustained yield management of natural forests. However, commitment to do something about natural forest does not imply that policymakers and planners, foresters, wildlife managers and biologists, and others responsible for managing these natural areas have all the knowledge required. This management guide is intended to begin to fill this gap.

There are two preconditions for launching into an improved understanding of natural forest management. The first is to establish a common understanding of the ecological and biological parameters that govern natural forest systems. Too often, efforts have begun to address natural resource problems without a clear understanding of the ecological systems in which they are operating. Natural resource managers have been guilty of not fully comprehending the causal linkages between the problems they are trying to address and the social and ecological context of these problems. Planners and managers alike must have a common level of understanding of these important issues or else project activities will continue to be misdirected. This will require in clear and straightforward terms an overview of what is known about both the natural and human ecology of natural forests and woodlands. At the same time, however, it is vital to avoid the phenomena of "paralysis through analysis". Forests and woodlands are complex ecosystems; compiling a fully catalogued compendium of their attributes can take much time—a luxury neither the forests nor the people who depend on them can afford. This guide will help to identify the baseline information requirements fundamental for competent, professional management interventions to get underway.

The second precondition is to convince the policymakers and planners that investment in natural forest management is worthwhile. Investment in natural forest management, as opposed to intensive plantations, has been shown to be economically more attractive. However, the data is scattered and in a form not readily available to decision makers. In addition, a case needs to be made for investment in natural forest management for more than primary forest products. Secondary and tertiary products, including those that do not have a readily established value, need to be considered in the analysis. This will require a thorough analysis of non-commodity product returns to investment. In language and level of detail, this analysis should be directed primarily at policymakers and planners. This type of analysis will also be a useful model for managers trying to demonstrate to their agencies the validity of investment in natural forest management.

The most pressing need for improved management of natural forests is increased knowledge of the state-of-the-art. Once decision makers are convinced of the importance of maintaining natural forest resources, they will need to know more about what can be done. Failure to clearly state the goals, objectives, and plans for natural forest management will frustrate further progress. Assistance must be given to managers in articulating their forest management plans based on the best possible information about approaches, means, and methods of natural forest management. This will help managers to secure the support of the policymakers and, more importantly, enable them to do the job. The type of information relates to the process of developing and implementing natural forest management plans. It implies not only an understanding of what a management plan involves, but also what information is needed as well as the best means to obtain the information.

Because the single most important element of the plan is the management alternative (s) selected, managers and decision makers need guidance as to what are the viable natural forest management alternatives currently in use. This includes management for commodity purposes (e.g., timber, fodder, game) as well as non-commodity purposes (e.g., tourism or watershed protection). In addition, the manager needs to have concrete examples of the process for making these fundamental management decisions. Process issues range from those of local community participation to evaluating the trade-offs between commodity and non-commodity uses of the forest.

Objectives of this Document

The overall goal and purpose of this document include the following:

- Promote the conservation and management of forests/woodlands in the dry zone as an economically viable and sustainable land-use option.
- Rationalize the utilization and increase the productivity of these forests/woodlands thereby improving their contribution to long-term socioeconomic development in the region.
- Contribute to maintaining local, regional, and global environmental stability—enhancing biological productivity as a key to rehabilitating and maintaining productive ecosystems.

More specifically, this document seeks to address the following immediate objectives:

- Increase the understanding among host-country and bilateral partner personnel of the real potential of natural forest management as part of a strategy for natural resources management and forest sector development in the arid and semi-arid areas of sub-Saharan Africa.
- Compile in a practical document state-of-the-art accounts of the ecological/biological, technical, socioeconomic, and administrative dimensions, including an assessment of present constraints and priority research issues, as a guide for action at the field level.
- Emphasize the importance of a genuine multiple-use approach to the management of natural forests/woodlands in the arid and semi-arid areas (i.e., range and forage, secondary products for rural use, and environmental stability).
- Underline the real potential of community-based, popular participatory approaches for cost-effective forest management planning and implementation.
- Foster the flow of information and facilitate intra-regional networking among those concerned with natural forest and woodland management in these areas of sub-Saharan Africa.
- Provide a foundation for the identification and design of programs and projects in natural forest management.

Audience for this Document

The audience for this document will be sector policymakers and senior managers/leaders whose role it is to make recommendations to their governments regarding development investments in the natural resources sector, and to help put in place the framework (policy, institutional, fiscal, economic, and regulatory) to facilitate the spread of natural forest management as a sustainable land-use option.

The document is also intended to serve as general guidance (a checklist) for professional/technical staff, including both local and expatriate, who may be given the responsibility to direct a field operation in natural forest management.

Implementing Natural Forest Management

Much of the work associated with getting ready for and planning natural forest management entails preliminary studies to collect data and information on the target area. Gathering knowledge about the ecology of the forests and conducting a forest inventory are traditional activities. More attention is needed on the policy framework, the socioeconomic and cultural dimensions, and the potential institutional and organizational arrangements for implementing the management plan. A major challenge to the further development of natural forest management in the arid and semi-arid areas of sub-Saharan Africa will be the economic considerations. There is as yet only limited data available on production, costs, and benefits. The present models, however, built on the few existing pilot operations, stand up well under a variety of assumptions.

The sections which follow here discuss the various aspects of the preliminary studies necessary for forest management. They are predominantly conceptual rather than methodological in emphasis, although the latter is treated where it is of particular relevancy.

The Policy Framework

Any serious consideration of implementing an accelerated management program of the natural forests and woodlands of arid and semi-arid Africa cannot overlook the policy framework. This framework provides the linkages between national development priorities and goals (e.g., meeting basic needs, socioeconomic growth, food self-sufficiency, commodity production, energy independence, environmental stability) and the issues such as deforestation and forest conservation and management. Numerous cases exist throughout the region where certain policy priorities are in conflict with or are poorly articulated with regard to natural resources management. Following are examples of such cases:

- providing cheap energy to urban areas has depressed the value of fuelwood and made management investments risky (Burkina Faso, Niger);
- promoting cereals crop production for meeting food self-sufficiency (the Sahelian countries) or for earning foreign currency through export (Sudan, Madagascar) has led to large-scale conversion of forests and woodlands to cereal crop production on marginal lands;
- archaic determinations about tree tenure on private lands affects the enthusiasm and motivations of rural people for forest management (Senegal);
- the promotion of livestock development among traditional people settled on ranches has impeded wildlife migration routes, causing friction between the people and the game authorities (Kenya); and
- government tax structure on forest products undermines returns to the rural producer (Burkina Faso, Sudan).

Many of these policy issues seem quite simple and straightforward when first reviewed. In several cases, there is definitely potential for quick actions which will have a meaningful impact on the capability for forest management. However, the opposite is more often the case; policy adaptations and adjustments are a complex undertaking (see Figure 2).

Clearly, policy adjustment or change, especially that concerned with issues beyond the forestry sector, cannot be based on a single case forest management exercise. The forest manager(s) must, nevertheless, be cognizant of the policy realm and its implications, if only to be able to provide field-informed feedback to higher authorities. Once a body of understanding about forest management accrues, meaningful and informed changes can be made in the policy arena. In some cases, however, special authorizations from the authorities may be necessary to allow a pilot project to operate outside the bounds of national policy. Those interested in promoting natural forest management will find that the most critical policy relationships typically exist in the areas of land-use, tenure, and the marketplace.

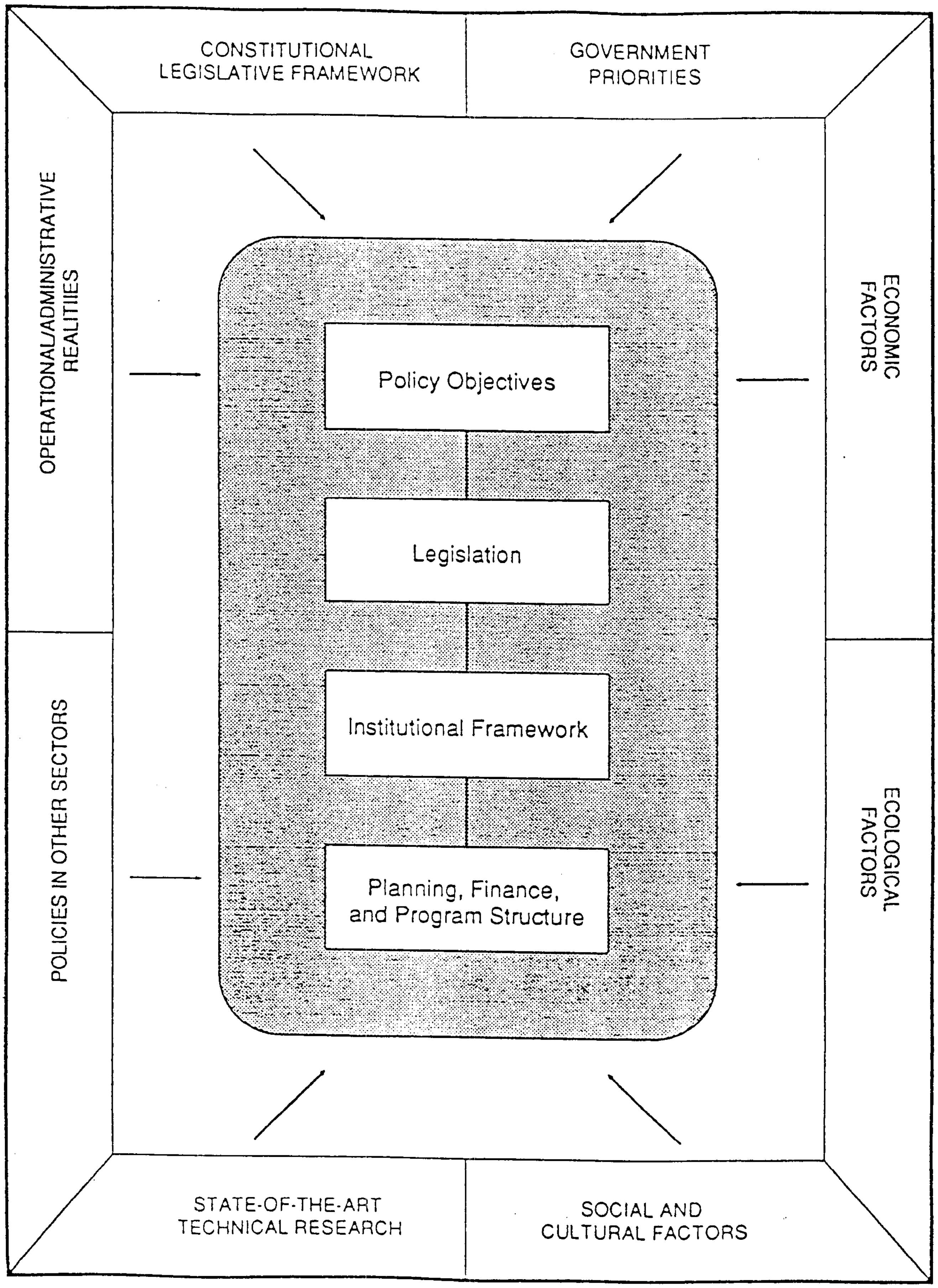
In the development of **land-use policies**, a variety of different needs have to be satisfied. Often as well, any systems employed under the policy must be responsive to different user groups. For historical reasons, forests and woodlands are frequently considered the bank on which one draws to make land-use decisions and changes. While this is logical, the net result is that forestry is not seen as part of the long-term mosaic of land-use essential to sustainable development. Forestry needs attention too, both for economic reasons (i.e., it may be the only feasible alternative given the market conditions) and for environmental reasons (i.e., eliminating forest cover is ecologically risky).

Foresters cannot assume that decisions to reserve some land for forest use and designate other lands, of suitable capability, for agriculture and livestock husbandry, will leave them free to operate in their own realm. Such decisions imply an understanding, on the part of government authorities, of demographic pressures and the future evolution of agricultural and livestock development. They imply a responsibility as well, on the part of those authorities, for promoting sustainable agricultural technologies and practices that allow farmers to survive and to get ahead.

Trying to manage an area for forestry purposes will be increasingly difficult, and perhaps ultimately a venture in frustration, if all around local people struggle for survival on poor land and with little or no help from government. Regrettably, in many areas of this African zone, this is precisely what is happening. Without recourse to improved agronomic practices, farm inputs, credit, and market opportunities, farmers exhaust their land simply trying to survive. Similarly, the livestock herders resort to increasing the numbers of their herds as their only strategy toward improving their situation, whether for survival or to get ahead. Their animals grow, survive, and reproduce, increasing the capital of the owner, and providing a hedge against the next drought. This creates the pressure to use more land.

Sound forest management can provide a counter to these trends. Forest and woodland areas in this zone can produce increased fodder for better managed, more productive herds. Employment opportunities or participation in the benefits stream of forestry can allay some of the pressures from farmers seeking new lands to cultivate. It is a basic premise of this document, therefore, that forestry management should be perceived, planned, and implemented as an integral part of the local land-use mosaic.

Figure 2. The Policy Environment



Few countries in these areas of the continent have the data and information to facilitate a genuine land-use planning exercise. Even fewer would be able to enforce such a system. Effective land-use policies and strategies are built on a strong experiential base. Data and information of this nature needs to be both specific enough to characterize a given situation as well as the problems of resource mismanagement or under-management, including suggested site-specific interventions that maximize productivity without degradation.

It is thus vitally important that land-use policy formulation should be a dynamic process which encourages inputs from projects and field activities which can help confirm or contradict policy directions. Foresters, with their background in the ecological sciences, are well suited to participate in the discussions about land-use; however, they must keep in mind the fact that "food comes first". Fuelwood shortages occur where people have enough food to cook. Where land capabilities are such that traditional agriculture cannot be sustainably practiced, new technologies involving soil and water conservation and agroforestry will be needed. Under current population pressures, rigid land-use prescriptions adapted from other parts of the world may not be applicable.

Land tenure and tree tenure issues and conflicts in arid and semi-arid Africa are of particular relevance to natural forest management. There are a number of important, albeit gradually evolving changes in the way rural people in sub-Saharan Africa view land tenure. These changes will have major implications for natural forest management in two critical ways. First, land-tenure changes are accelerating the rate at which forest lands are disappearing, thus underlining the urgency of the action required to develop forest management schemes. Such schemes will have to take full account of perceived proprietary rights and interests in order to build local consensus and support for their operations.

Second, in the past when population pressures were less, land uses were traditionally allocated by a single individual in the village, the *Chef de Terre*, or something parallel to that arrangement. Land was considered community property and all lands left in fallow reverted to the community for some future reallocation. Increasingly, land adjudication is being decided on a more decentralized basis by the heads of family or lineage groups. The tendency, in reaction to scarcer resources, is to try and preserve rights over land; thus, there is a gradual emergence of the sense of private property. Family groups have actively attempted to establish their rights over portions of the community land, often extending their overall domain over even unexploited areas. They lack confidence in the equity of future land distribution and need to be able to provide a reserve of land for future generations.

In other areas, studies suggest that even this system is breaking down and land-use decisions are being made among individuals. Peoples' attitudes and actions are moving toward taking over land-use rights, large areas of unexploited land are and will gradually disappear. As this happens, marginal lands with soils barely sufficient for cultivating crops will be cleared as farmers and others attempt to establish and demonstrate, through clearing, their rights to the land.

In choosing forests and woodlands to earmark as potential managed areas, a reconnaissance social survey will be needed to compile an understanding of tenure rights. The assessment must distinguish between traditional nonconsumptive rights (grazing, fuelwood collection, non-wood forest products collection, sacred areas) and local perceptions and/or aspirations of ownership. A heightened level of conflict could arise by allocating forest management privileges to the wrong community.

Involving local people from the very start of the planning, accompanied by independent social surveys and analyses with an early focus on tenure, is essential. Here again, the importance of working in forest areas in better condition is suggested in order to satisfy the interested parties to the maximum. This will also enable forest service staff to gain valuable experience as well as establish precedents for dealing with delicate tenure issues. The understandings reached should be recorded in the official agreement document (see page 92) for each management unit.

Where there are conflicts, negotiation and compromise are essential, and if well guided, quite feasible. Rural people comprehend (better than most) the finite dimensions of the resource base. Where land-tenure-generated conflict cannot be overcome, the whole endeavor should be seriously reconsidered. Conflict increases the need for protection which in turn raises costs and decreases returns on the management investment. One match starting a fire can undo a good deal of hard work and is difficult, if not impossible, to guard against.

In many parts of dry Africa, tree tenure issues also add a degree of complexity to the notion of sustainable forest management. Cutting live trees was previously prohibited and sanctioned both within the traditional and official systems. Dead wood, however, was considered community propertyfree to whomever wanted to collect it. In certain areas, a number of naturally occurring "fruit" tree species (such as *Parkia biglobosa*) are often identified as individual property and are scrupulously protected.

At present, however, there is considerable flux as traditional systems break down under increasing demographic pressure. A heightened official scrutiny of tree cutting, the permit system, and the sanctions imposed in many countries but often difficult to enforce, further confuse the situation. Despite the high-minded and conservation-oriented intentions, forestry agents have come to be viewed by local people as a repressive policing force and a disincentive to tree planting and forest management. Similarly, rural people encouraged to plant trees under various planting schemes (village forestry programs and agroforestry programs) are often uncertain about their rights and the future flow of benefits from their efforts.

As forest management schemes are established, it will be important to clarify tree tenure and usage rights. Contradictions within the regulatory framework about what can take place on a managed forest (e.g., prescribed burns, cutting live trees) and on other areas will have to be thoroughly and carefully explained, lest precedents be set which cannot be controlled.

The marketplace can play an extraordinary influence on forest management. In many cases, both intentional policy decisions as well as inadvertent policy implications, affect the market, its price structure, and, in consequence, the value of forest products (see Box 1). Management of natural forest areas will necessitate investments and these costs must be capitalized over the length of the rotation. For example, one hundred dollars equivalent invested in forest management (protection, timber stand improvement, or soil and water conservation) on a hectare of semi-arid woodlands will represent a value of approximately $171, assuming a modest 8 percent interest rate, at the end of a seven-year fuelwood rotation. This means that the fuelwood harvested (say 15 steres) would have to yield a net price, after allocation of the costs of harvest and any other recurrent costs over the life of the rotation, of $11.40 per stere. In most circumstances, this product moving into the marketplace would likely incur additional costs in the form of taxes applicable to the fuelwood supply system. To this overly simplified equation, one must add other costs associated with the marketplace (i.e., the cost of transport, cost markups by intermediate entrepreneurs, and the cost of handling and retailing the commodity).

Although these figures are fictitious (see the section which follows on the economics of forest management for a further elaboration of this scenario), they may approximate the realities in many countries of the zone producing fuelwood through natural forest management. If the market price for fuelwood is artificially low, either as a result of government-imposed price limitations on this commodity, or because fuelwood is harvested from natural areas without the payment of a stumpage fee, forest management may not be economically feasible. If the net effect of this situation, dictated by policy determinations about the fuelwood supply and demand system, is to lower the producer price, it will be difficult to directly justify the investment in management whether by the forest service itself or by a local participatory management group. Forestry-related policy decisions need to be carefully analyzed and elaborated, even if the goal is a simple one—such as the long-term conservation of certain areas, or the maintenance of a certain percentage of vegetative cover, as a reserve against future needs. **It is also critical that policy determinations be enunciated**, not just as a national decree, but also **at the local level** where they are likely to have the greatest impact. All too often field staff at the lower levels, let alone local people, do not fully comprehend the rationale behind policy determinations, be they sound or otherwise.

Box 1. Gum Arabic in the Sudan—A Policy Turnaround

During the early 1980s, as severe drought endured in the Sudan, large numbers of gum arabic trees (***Acacia senegal***) were cut down and made into charcoal. Many attributed the disappearance of these trees to the ravages of drought. As the drought abated and people returned to the areas, however, the trees were not replanted. For years before, the Government of the Sudan which controls 85 percent of the gum arabic trade worldwide, had been applying a rather high export tax (40 percent) to the commodity to generate needed foreign exchange. Similarly, in order to do so, it had imposed a centralized parastatal marketing structure in which inefficiencies and high overheads consumed much of the earnings. Rural people, the basic gum producers, had seen the prices paid to them decline in real terms and therefore were little motivated to incur the expense of replanting the trees and/or nurturing the natural forest areas where it grew. The net result was a drastic decline in gum arabic production and export and tangible losses to the economy and government finance. Realizing the issues, the government instituted new higher producer prices, raised commodity prices on the international market, and set about to revitalize the Gum Arabic Trading Corporation. New gum gardens have since been planted, lopping natural gum trees in the bush for fodder has abated, and production has increased dramatically.

Local Participation: A Key Policy Consideration

Any revisions to the policy to promote the development of natural forest management must involve fully participatory arrangements with local people if the policy is to succeed. Promotion of this concept has permeated the rhetoric of the forestry sector throughout the continent. In many countries, there are now excellent opportunities to implement it. Government officials from the policy level to field-level personnel, as well as the rural people themselves, will have to make meaningful changes in the present approach if participation is to evolve from theory to practice. Understanding why participation is so important in large-scale efforts to develop natural forest management will be the key to identifying the adjustments and changes necessary so that policy directions are accompanied by field action.

Rural villagers and farmers are presently and inextricably involved in cutting the local forests to supply fuelwood for sale and for home consumption. They are the basic producers who cut the wood and sell it to transporters and commercial fuelwood merchants. They are unlikely to simply cease this practice as it produces vital income generation opportunities for which few alternatives exist. In a number of countries (Niger, Burkina Faso), the government has recognized this situation and has supported the organization of woodcutter groups and pre-cooperatives. The objective of these governments is to direct the harvest to designated areas and to facilitate control and revenue collection.

This approach has as yet to improve forest management at any scale. In order to do so in a given area, decisions about harvest rates and production trade-offs, investments in management, and common understandings and agreements about access to the forest will be required. The advent of a potentially lucrative cash marketplace for the basic commodities of the forest (woodfuels and poles) has created the economic core around which an interest group, ideally a participatory forest management cooperative or similar arrangement, can be organized. Funds generated in the marketplace can and should be set aside to employ significant numbers of local people in the activities inherent in carrying out the management plan. This facility will offset the production trade-offs associated with a more controlled approach to harvest.

There are certainly other issues that will require a collective consensus among villagers living adjacent to a forest area designated for a participatory management scheme. If a reasonable number of villagers from the area can be organized into a management cooperative, they can work with their other peers and the village authorities in brokering the understandings and consensus necessary to ensure that the management plan, particularly the protection activities, can be effectively implemented. The potential gains to the local economy from the income generated by harvesting and management, and its secondary distribution benefits within the community, should be a significant inducement for a collective decision to support the cooperative. Other direct contributions of the management scheme toward local livelihoods will enhance that reality. Grazing privileges, sale, or access to fodder on a cut-and-carry basis, fuelwood collections from the harvest residues, and collection of non-wood forest products can go on in an organized way in parts of the forest where they will not adversely affect sustained productivity.

Indigenous knowledge and feelings about trees and forests provide both the basis and rationale for popular participation in natural forest management. Local people often understand and lament the disappearance of natural forests from an economic as well as a cultural perspective. Securing genuine and reasonably equitable participation in such a scheme should not, however, be taken for granted.

Rural people are fully able to understand the give and take surrounding resource-use decisions. They make these same sort of decisions on their own farms everyday. Management and conservation will necessitate production trade-offs. A delicate and critical issue for many priority natural areas will be the need to control access to and the harvest of the products in certain areas under regeneration at critical stages in the management scheme. Traditional usage rights, so prevalent in rural Africa, particularly for grazing domestic animals, will need to be controlled and, over time, livestock-carrying capacity will need to be fixed for the area.

Brokering these trade-offs implicit in the management scheme can best be accomplished under most circumstances through a participatory approach. Local people must fully comprehend the objectives of management and the policy determinations behind them. They will also need to understand and accept their roles and responsibilities for achieving management objectives and how they in turn will participate in the benefits stream. These are all elements of the policy framework which must permeate to the field level.

As stated in the discussion of production potentials, these forest and woodland areas are by definition multiple-use areas--an often-sought objective in the forestry sector. Almost every inhabitant of the broad belt of arid and semi-arid lands in Africa depends in one way or another on the forest and woodlands. In many cases, traditional cultures depend heavily on the natural areas as an outlet to supply basic needs when farming systems collapse under the stress of drought. The pervasive destruction that is taking place—the continued loss of vegetative cover, soil erosion and degradation, and desertification—is eroding this buffer and increasing the vulnerability of millions of rural inhabitants. This interdependency calls for new analytical paradigms which account for this wider range of values, some quite tangible and others less so. There is a general awakening regarding the importance of these less tangible values, particularly those concerned with integrated approaches aimed at promoting natural resource management as part of the overall development of the rural systems and lifeways.

Although the management of natural forests and woodlands will require the full and concerted support of the concerned governments, it is not and should not be viewed as a panacea. However, it can help to buy time for the wider array and longer-term development efforts (sustainable agricultural technologies, industrialization, new income and employment opportunities, urbanization, and the full spectrum of government services) needed for individual and national growth and well-being.

Knowing the Resource

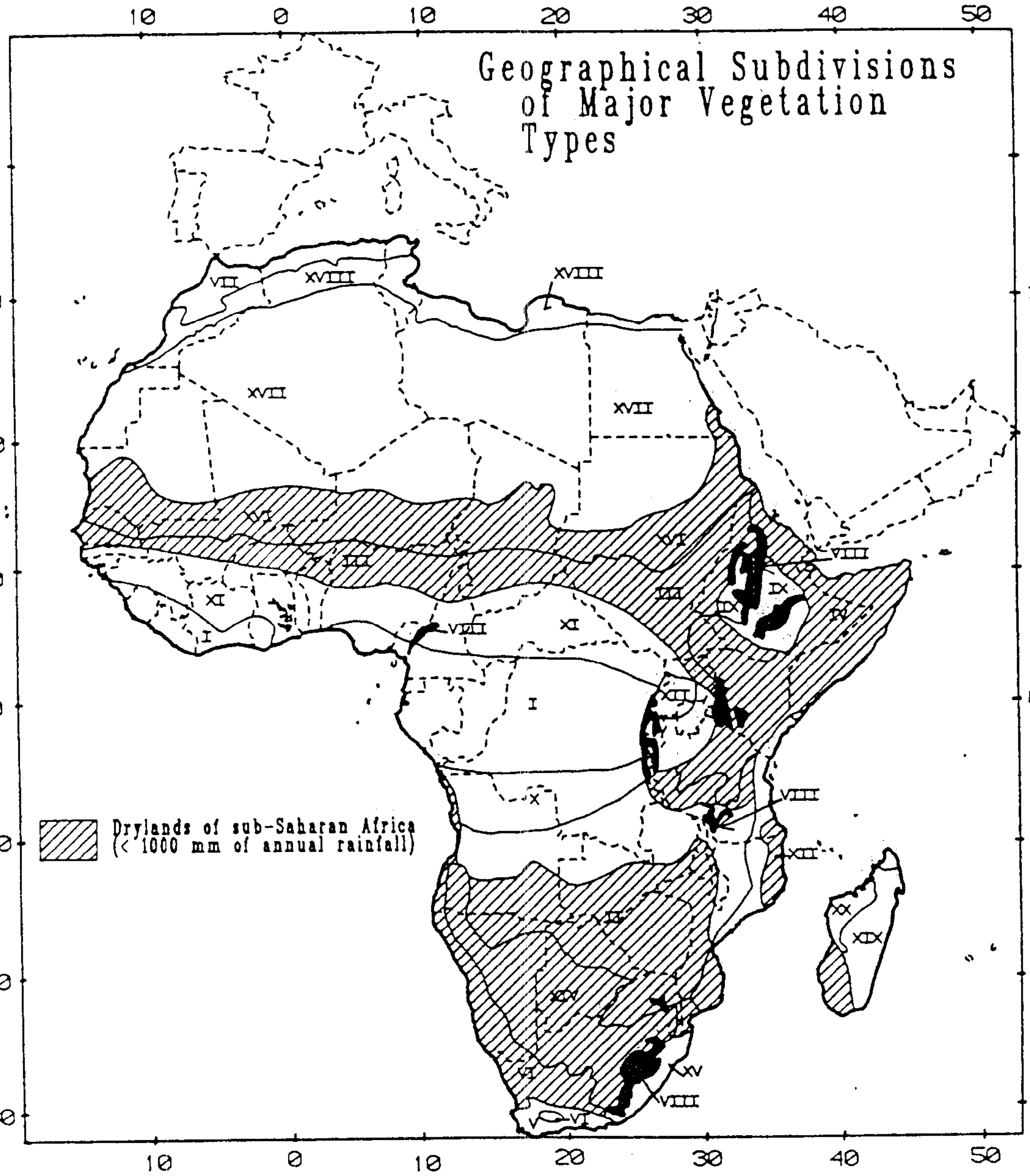
Numerous vegetation classifications exist. Some have strictly scientific origins and may be applicable at global, continental, regional, national, or local levels. Others are vernacular in origin such as *savanna, miombo, karoo* , or *mopane*. In some cases, vernacular names have been adopted and defined by ecologists. For example, *savannas* (a Spanish word originally applied in Latin America) are plant communities with a herbaceous layer dominated by grasses interrupted by trees and shrubs. In other words, *savannas* fit between true forests with a closed canopy of trees and few grasses at one extreme, and grasslands or deserts at the other.

For the purposes of this guide a classification that is Africa-wide and distinguishes vegetation types of relevance to foresters is appropriate. Fortunately, a widely accepted classification has recently been published by UNESCO (White 1983). This system, with minor modifications is adopted here. Two independent, but compatible types of classification are used. The first identifies major geographic regions of plant species distributions and transitions between them. The second is a structural classification based on relative abundance of plant growth forms (trees, shrubs, grasses) and is independent of species composition. Most locally recognized plant communities fall within this framework. Thus, it is possible to compare a *miombo* woodland in Zambia to a Sudanian dry forest in Mali. Such comparisons are of great value to determine the relevance of work done in other parts of Africa when addressing a local problem, given the relative paucity of forestry research in Africa. The use of standardized classification systems should be encouraged.

White's (1983) major geographic units (which he calls phytochoria) are indicated by Roman numerals in Figure 3. The first seven are regional centers of endemism (Box 2) on the African mainland, the last two are regional centers of endemism on Madagascar. Units VIII and IX are montane systems. The remaining nine categories are transition zones and mosaics between the centers of endemism. Of these 20 units, 10 (indicated by hatching in Figure 3) are wholly or partly in the drier regions of sub-Saharan Africa. Annual rainfall below 1,000 mm is a reasonable approximation to the drier areas covered by this guide. Most of sub-saharan Africa is thus covered by these vegetation units.

Structural formations of relevance to forestry in dry areas of sub-Saharan Africa are given in Table 1. Additional categories with little or no woody vegetation include grasslands, forblands, dwarf shrublands, deserts, urban areas, and aquatic formations such as mangroves and herbaceous swamps. Forests are relatively rare when annual rainfall is less than 1,000 mm. Woodlands and bushlands cover most of the dry lands. In most cases, woodland and bushland canopy density is not constant through time. For example, a dense bushland may be thinned to a sparse bushland as a result of elephant or livestock browsing, cutting of bushes, fire, or hydrological change. However, if these pressures are relaxed, the bushland will become denser again. Because of ever-changing landscapes, it is not useful to map vegetation structure on a continent-wide basis. Even at a national level, the amount of detail necessary in such maps is enormous.

Figure 3.



REGIONAL CENTRES OF ENDEMISM

I Guinea-Congolian
II Zambezian*
III Sudanian*
IV Somalia-Masai*
V Cape
VI Karoo-Namib*
VII Mediterranean

MONTANE

VIII Afromontane
IX Afroalpine

REGIONAL TRANSITION ZONES AND MOSAICS

X Guinea-Congolia/Zambesi
XI Guinea-Congolia/Sudania
XII Lake Victoria
XIII Zanzibar-Inhambane*
XIV Kalahari-Highveld*
XV Tongaland-Pondoland*
XVI Sahel*
XVII Sahara
XVIII Mediterranean/Sahara

MADAGASCAR

XIX East Malagasey
XX West Malagasey

* denotes areas partly or wholly in semi-arid and arid zones

Geographical subdivisions of major vegetation types are based on information provided by White (1983)

1:55,625,000
APPROXIMATE SCALE

ARD/GIS
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Table 1. Structural Vegetation Types in Drier Regions of sub-Saharan Africa (modified from White 1983 and Pratt & Gwynne 1977)

Formations of Regional Extent	Transitional Formations of Local Extent
1. **Forest**. Continous canopy of trees; ground cover sparse with few grasses.	8. **Scrub forest**. Intermediate between forest and bushland or thicket bushland.
2. **Woodland**. Open stand of trees 5m tall and canopy cover 20%; ground cover usually dominated by grasses.	9. **Transition woodland.** Intermediate between forest and woodland.
3. **Bushland**. Open stand of trees or taller shrubs between 2 m and 5 m tall and canopy cover 20%; ground cover often dominated by grasses.	10. **Scrub woodland**. Stunted woodland with small trees or intermediate between woodland and bushland.
4. **Thicket bushland**. Closed stand of trees or shrubs usually between 2m and 5m.	
5. **Low Shrubland**. Stand of small shrubs usually 2m tall, often interspersed with grasses.	
6. **Wooded grassland**. Grassland with occasional trees 5m tall; canopy cover 20%.	
7. **Bushed grassland**. Grassland-with occasional trees or shrubs 5m tall; canopy cover 20%.	

Using these classification tools, White (1983) describes the main vegetation types throughout Africa. At this level, local terminology familiar to workers in different regions or countries is introduced. Thus, for example, *Acacia-Commiphora* bushland from East Africa and *miombo* woodland from Central Africa can be placed in a continental context. Table 2 gives major vegetation types and their dominant species within geographical units and structural types of relevance to this guide.

Most vegetation types can be allocated to one of the categories in the first column of Table 1. White (1983) argues persuasively for inclusion of transitional formations in the second column. Although these formations are not extensive, they facilitate the regional classification and can be locally important components of transition zones and mosaics. Since these intermediate formations carry substantial woody vegetation, they are significant from a forestry perspective.

Table 2. Major Vegetation Types of Significance to Foresters in Regions of Figure 3 in sub-Saharan Africa. Information from White (1983)

II. Zambezian Region

There are more than 8,500 species of plants. About 54 percent are endemic. No families and few woody genera are endemic. About 25 percent of tree species also occur in the Sudanian Region including *Burkea africana* and *Isoberlinia angolensis*. Some species such as *Balanites aegyptiaca, Boscia angustifolia* , and *Commiphora africana* from drier parts have more or less continous distributions through to Sudanian and Somalia-Masai Regions. The Zambezian Region is notable for its wide range of well developed and distinctive woodlands.

***Baikiaea* forests** occur where rainfall is 600 - 900 mm, on deep sandy soils which retain moisture through most of the dry season. These dry deciduous forests are extensive on Kalahari sands in the southern part of the Zambesi basin.

***Miombo* woodlands** are the most extensive vegetation in this region. *Brachystegia* spp. are dominant, often associated with species of *Julbernardia* and *Isoberlinia*. Soils are leached, acidic, and often shallow. In wetter areas, *miombo* is secondary vegetation replacing "muhulu" forest which has been burned and/or cultivated.

***Mopane* woodlands** are widespread in the east of the region. *Chlophospermum mopane* is the dominant species. Rainfall is generally less than 500 mm and soils are varied.

Northern undifferentiated woodlands north of the Limpopo are characterized by absence of *miombo* and *mopane* dominants. They have many more common tree species including *Afzelia quanzensis, Burkea africana, Dombeya rotundifolia*, and *Terminalia sericea*.

Southern undifferentiated woodlands in the southeast of the region range in altitude from 325 - 1,000 m and in rainfall from 350 - 1,000 mm. A wide variety of trees is present including many species of *Acacia* and *Combretum*.

Chipya woodland and wooded grasslands have fire-resistant tree species as a result of frequent burning. The resulting localized communities are a mosaic of mature, degraded, and regenerating trees such as *Afzelia quanzensis, Albizia antunesiana, Burkea africana*, and *Pterocarpus angolensis*.

Itigi thicket in Tanzania and related formations in Zambia and Zimbabwe occur in drier, less stony areas with sandy soils among the *miombo*. Dense shrub cover includes *Baphia* spp., *Combretum celastroides, Pseudoprosopis fischeri*, and *Tapiphyllum floribundum*.

Kalahari thicket is a stunted form of *Baikiaea* forest about 2 m tall, which occurs in some areas of impeded drainage. Similar stunted thickets of *Brachystegia bakerana* occur in eastern Angola.

III. Sudanian Region

There are about 2,750 plant species; about one-third are endemic. No families and very few genera are endemic. Many species from the Sudanian Region occur in other dry regions of Africa. Little true forest exists and most vegetation has been modified by cultivation.

Dry forest remains in small pockets of the Sudanian Region in western Mali. They are dominated by *Gilletiodendron glandulosum* or *Guibourtia copallifera.*

Woodland types are often varied in species composition. In the wetter south, *Isoberlinia doka* is often dominant. These woodlands lack *Brachystegia* and *Julbernardia* of the Zambezian *miombo* (see above). Associated species include Sudanian endemics *Acacia dudgeoni, A. gourmaensis, Lophira lanceolata,* and *Terminalia glaucescens.* Drier northern woodlands are more difficult to characterize except that they lack *Isoberlinia.* Many species are common in other regions, such as *Acacia albida, A. nilotica, A. senegal, A. seyal, Balanites aegyptiaca, Burkea africana, Combretum* spp., *Commiphora* spp., *Dalbergia melanoxylon, Terminalia* spp., and *Ziziphus mauritania.* Endemics include *Acacia macrostachya, Albizia adstringens,* and *Piliostigma reticulatum.*

IV. Somali-Masai Region

There are about 2,500 plant species of which half are endemic. The *Dirachmaceae* (one sp. of limited distribution) is the only endemic family, but about 50 genera are endemic to the region. Many endemic species of non-endemic genera occur including 30 spp. of *Acacia,* 6 of *Boswellia,* 60 of *Commiphora,* and 20 of *Indigofera.*

***Acacia-Commiphora* bushland thickets** cover much of the region. Common *Acacias* and *Commiphoras* include *A. bussei, A. mellifera, A. nilotica,* and *A. reficiens*; *Commiphora africana, C. boiviniana, C. campestris,* and *C. mollis.* Other common trees and shrubs include *Balanites* spp., *Boscia coriacea, Cadaba* spp., *Cordia* spp., *Dobera glabra, Grewia* spp., *Lannea* spp., *Salvadora persica, Sterculia* spp., and *Terminalia* spp.

Evergreen/semi-evergreen woodlands, bushlands, and thickets occur on drier slopes at altitudes between *Acacia-Commiphora* bushlands and montane forests. Species composition is variable, but common species include *Carissa edulis, Olea africana, Euclea* spp., and *Teclea* spp.

Scrub forest occurs locally where rainfall is high for dry bushlands, but low for true forest. Examples include the Lake Manyara escarpment and northern slopes of the Western Usambara mountains in Tanzania. *Commiphora* spp. are common, associated with baobabs (*Adansonia digitata*) and candelabra Euphorbias.

VI. Karoo-Namib Region

There are about 3,500 species, more than half are endemic. One family (*Welwitchidaceae*) and about 60 genera are endemic. Few species are common to the adjacent Cape Region. Among tree species extending from the Zambezian Region are *Acacia mellifera, A. karoo, Boscia albitrunca, Euclea crispa,* and *Ziziphus mucronata*. Most of the area is too dry to support significant stands of trees and taller shrubs. Where taller plants occur, they are often succulents.

XIII. Zanzibar-Inhambane Coastal Mosaic

There are about 3,000 species, at least several hundred being endemic. Of 190 forest tree species recorded, half are endemic. Of the non-endemic forest trees, most have affinities with the Guineo-Congolean Zone. Much of the area is too wet, carrying rain forest or related formations, for inclusion in this guide.

Woodland and scrub woodland with Zambesian Region affinities occurs in drier areas.

XIV. Kalahari-Highveld Transition Zone

Although there are about 3,000 species, most of these penetrate short distances from the surrounding regions. The interior of the zone has few endemics and a poor flora. Much of this zone has very sparse, woody vegetation due to aridity and/or human modifications.

Kalahari thornveld wooded grasslands and woodlands on Kalahari sands are the most widespread vegetation types. In southern areas, *Acacia* spp. are dominant associated with *Boscia albitrunca, Dichrostachys cinerea,* and *Terminalia sericea.* In northern areas, *Acacia* remains dominant, but with more abundant, broad-leaved species such as *Combretum collinum, Commiphora* spp., and *Ziziphus mucronata.*

XV. Tongaland-Pondoland Mosaic

There are about 3,000 species; of the 500 larger woody species, 40 percent are endemic. The *Achariaceae* family has the center of its distribution in this region. About 20 genera of trees are endemic. Of the 500 larger woody species, the greatest affinity (20 percent) is with the Zambezian Region, followed by 9 percent Afromontane and 8 percent Zanzibar-Inhambane. Coastal forests and areas adjacent to the Afromontane Region are outside the scope of this guide.

Evergreen and semi-evergreen bushland and thicket are widespread where rain is inadequate to support true forest. Common and widespread species include *Azima tetracantha, Brachylaena ilicifolia, Diospyros* spp., *Grewia* spp., *Olea africana*, and *Rhus* spp. *Acacia* spp. are abundant, particularly in the north, including *A. borleae, A. caffra, A. karroo*, and *A. nilotica*. Of these, only *A. caffra* and *A. karroo* are present in the south.

XVI. Sahel Transition Zone

There are about 1,200 species of which less than 3 percent are endemic. No families or genera are endemic to the Sahel. Twenty-six percent of species also occur in the Sudanian Region, 14 percent in the Sahara Zone, and about 6 percent in the Somali-Masai Region. The northern Sahel is arid with few larger woody plants.

Wooded grasslands are widespread on sandy soils of southern Sahel. In West Africa, *Acacia tortilis* is widely dominant in association with *A. laeta, Commiphora africana, Balanites aegyptiaca, Boscia senegalensis, Maerua crassifolia*, and *Leptadenia pyrotechnica*. In Sudan, *Acacia senegal* occurs in almost pure stands.

Bushlands and thickets occur locally on rock outcrops in Sudan. *Acacia mellifera* and *Commiphora africana* are dominant. *Boscia senegalensis* and *Dichrostachys cinerea* are usually present.

XX. West Malagasey Region

There are about 2,400 species, almost 80 percent of which are endemic. About 20 percent of the 700 genera are endemic. The southwestern section of the island has less than 1,000 mm of rainfall.

Dry deciduous forest covers much of the area, species composition varying with soil. On lateritic clays, larger trees include *Dalbergia, Stereospermum euphorioides, Givotia madagascarensis*, and *Xylia hildebrandtii*. On moist, sandy soils, *Tamarindus indica* is frequent, whereas drier sands are characterized by the cactoid *Euphorbia enterophora*.

Deciduous thicket occurs in the driest areas, usually on shallow, stony soils. Tree *Euphorbias* and the endemic *Didiereaceae* family characterize this type of vegetation. Endemic *Adansonia* spp. are also present, together with species of *Acacia, Commiphora, Grewia*, and *Terminalia*.

Box 2. Endemism

An endemic species is one which is confined to a region and originated there. Regional centers of endemism in vegetation are defined as having more than 50 percent endemic plant species and a total of more than 1,000 endemic species. Regional mosaics and transition zones are between the centers of endemism and have a mixture of species from the neighboring centers of endemism. Consequently, these mosaics and transition zones have few endemic species.

Animal species have lower, but significant, levels of endemism in these regions as exemplified by ungulate and primate mammals and passerine (perching) birds in the following compilation.

Region	Plants # species	Plants % endemic	Mammals # species	Mammals % endemic	Birds # species	Birds % endemic
Zambezian	8,500	54	55	4	650	15
Sudanian	2,750	33	46	2	319	8
Somali-Masai	2,500	25	50	14	345	42
Karoo-Namib	3,500	50	13	0	112	9

(Source: White 1983, IUCN/UNEP 1986)

Biomass and Production of Wood

Few detailed inventories of trees and shrubs have been carried out in drier regions of Africa. Traditionally, foresters are interested in timber trees which make up small components of woody vegetation in African drylands. However, smaller trees and shrubs from rangelands provide most of the fuel, as firewood or charcoal, for African households. Also, forest inventory commonly estimates wood volume, but wood mass is more relevant when fuelwood is of interest.

Box 3 illustrates the type of effort required to obtain accurate estimates of biomass of one species of tree suitable for commercial charcoal in the Bay Region of southern Somalia. Until similar information is available for all species and all vegetation types, data compilations and syntheses such as Table 3 have to suffice. The table uses data from East, West, central, and southern Africa. However, its accuracy for specific local vegetation types is questionable. Many more studies of the type described in Box 4 are needed before the accuracy of these generalizations can be assessed.

More important than wood biomass is annual production of wood. Such information is essential if optimal levels of sustainable harvest are required. Yet reliable data on wood production from drier areas of Africa are much scarcer than the inadequate information on biomass.

Box 3. Estimation of Wood Biomass and Production

Reliable data on wood biomass and production in sub-Saharan Africa are scarce. Improving this data base should be a priority for forest management. Following are brief descriptions of two exemplary studies of charcoal resources.

Biomass of Bushlands in Somalia (Bird 1988)

Acacia bussei is the primary commercial charcoal species in southern Somalia. Much of the harvest is taken from Bay Region to the capital, Muqdisho. Like many plants of African rangelands, *A. bussei* branches close to the ground or is multi-stemmed. This growth form precludes standard forestry procedures of using diameter at breast height as an indicator of tree size and mass (or volume). Crown diameter was substituted as a potential predictor of tree mass. Forty-nine trees were selected following rigorous sampling procedures. A clear relationship between crown diameter and dry weight was obtained. This prediction was then validated on a further sample of 12 trees with satisfactory results. The authors emphasize that a smaller sample is inadequate for regional predictions of biomass in natural woodlands.

Crown diameter of *A. bussei* was measured in 237 sample plots throughout the region to obtain wood biomass estimates per unit area. About 5 t/ha of wood was present of which 1 t/ha (diameter 5 cm) was suitable for commercial charcoal production. An earlier, less rigorous study estimated 17 t/ha of wood suitable for charcoal. Any management intervention based on this latter estimate would clearly lead to overexploitation.

Charcoal Production in Senegal (Gibson & Muller 1985)

A common assumption in the late 1970s, that planted exotics outproduce native woody vegetation under field conditions, was the basis of the Senegal Fuelwood Production Project. Production measurements were extrapolated to justify replacing *Acacia seyal* bushlands with *Eucalyptus camaldulensis* plantations.

Subsequent careful measurements showed that the native woodlands produced up to eight times as much wood as had been assumed, whereas the plantations produced only one-fifth the expected wood. Production in the native stands was on average almost equivalent to the plantations. With simple management, *A. seyal* production is potentially greater than the *eucalyptus* despite investment of $890/ha in the latter. As with the Somali study, the importance of appropriate measurement techniques is emphasized. Unsupported assumptions should not be used as a basis of costly development projects.

A world-wide summary of wood production indicates that 2 to 3 percent of standing wood biomass is realized as annual growth on average (Art and Marks 1971). For the SADCC (Southern African Development Coordination Conference) countries, estimates range from 1 to 5 percent (Millington and Townsend 1989). In the latter study, mean annual wood production ranged from 0.2 t/ha in dry *miombo* woodlands to 3 t/ha in highland and riverine woodlands. In Marsabit District of semi-arid northern Kenya, woody vegetation is sparse or degraded in most areas. Wood production in all vegetation types reported is less than 1 t/ha (Lusigi 1984). Le Houerou (1989) reports *Acacia senegal* wood production in Sudan as about 0.05 t/ha at 100 - 200 mm annual rainfall, 0.2 t/ha at 200 - 400 mm, and 0.5 t/ha at 400 - 600 mm.

Table 3. Wood Biomass (dry weight) Estimates of Main Structural Vegetation Types in the Drier Regions of Sub-Saharan Africa (Data from Deshmukh 1989, Millington & Townsend 1989)

Vegetation Type	Biomass (t/ha)
1. Forest	35 - 250
2. Woodland	3 - 75
3. Bushland	2 - 20
4. Thicket bushland	20 - 35
5. Low Shrubland	< 1
6. Wooded grassland	2 - 3
7. Bushed grassland	1 - 2

Overall, it is safe to assume that wood production in unmanaged rangelands well stocked with woody plants rarely exceeds 1 t/ha. In the absence of human intervention, woody biomass and production decrease as aridity increases. In addition, in many regions, woody vegetation is degraded by human activities such as fuelwood collection, farming, fires, and livestock grazing and browsing.

Mapping woody biomass or production categories on a continental scale is difficult because of the scarcity of adequate data. At regional and national scales, a first attempt has been made at such an assessment for the SADCC countries (see Box 4). This pioneering study points the way for future appraisals of rural fuelwood resources in Africa.

Box 4. Regional Estimates of Fuelwood In Southern Africa

Biomass and annual production of woody vegetation has been estimated for the SADDC countries by vegetation type and administrative districts (Millington & Townsend 1989). Remote sensing data from NOAA satellites were the primary source of data used in mapping vegetation types with respect to seasonality and productivity. Secondary mapping sources were from climatic, geologic, soils, topographic, ecological, and forestry studies. Ground studies of biomass and production were used to check the satellite-derived categories. As in most of Africa, good ground data are rare. Thus the results are only a first approximation of regional biomass and production estimates. Nevertheless, they are a better basis for planning rural fuelwood management than what exists for most of the continent. Similar methods could be profitably applied elswhere.

An example of biomass estimates for Zimbabwe is given below. Notice differences between percentage of land and percentage of total biomass attributed to different vegetation types. For example, *Baikiaea* woodland covers less than one-third of Zimbabwe, but contributes more than one-half of the total biomass.

Biomass Estimates For Zimbabwe Vegetation

Vegetation	Biomass t/ha	Biomass total t x 10^6	% of Land	% of Biomass
Dense woodland	70	134	5	9
Baikiaea woodland	70	840	30	56
Mopane woodland	35	250	18	17
Intermediate woodland	20	6	1	<1
Dense bushland	20	214	24	14
Degraded woodland	11	8	2	<1
Dry woodland	9	45	12	2
Degraded bushland	7	2	<1	<1

(Source: Millington & Townsend 1989)

Ecology of Mixed Dryland Vegetation

Climatic Factors

The most important climatic variable in tropical drylands is rainfall. African lowland climates can be classified conveniently by mean annual rainfall as moist (1,000 mm), dry (500 - 1,000 mm), semi-arid (250 - 500 mm), and arid (250 mm) (see Deshmukh 1986). These subdivisions for Africa are shown in Figure 4.

Effects of rainfall gradients on dryland ecology are seen most dramatically in West Africa. Moving northward from the coast, vegetation zones change with increasing latitude and decreasing rainfall (compare Figure 3 and Figure 4). Thus, one moves from the moist Guinean zone, through the dry Sudanian zone, the semi-arid Sahel to the arid Sahara. On average, mean annual rainfall declines by about 1 mm for each kilometer northward.

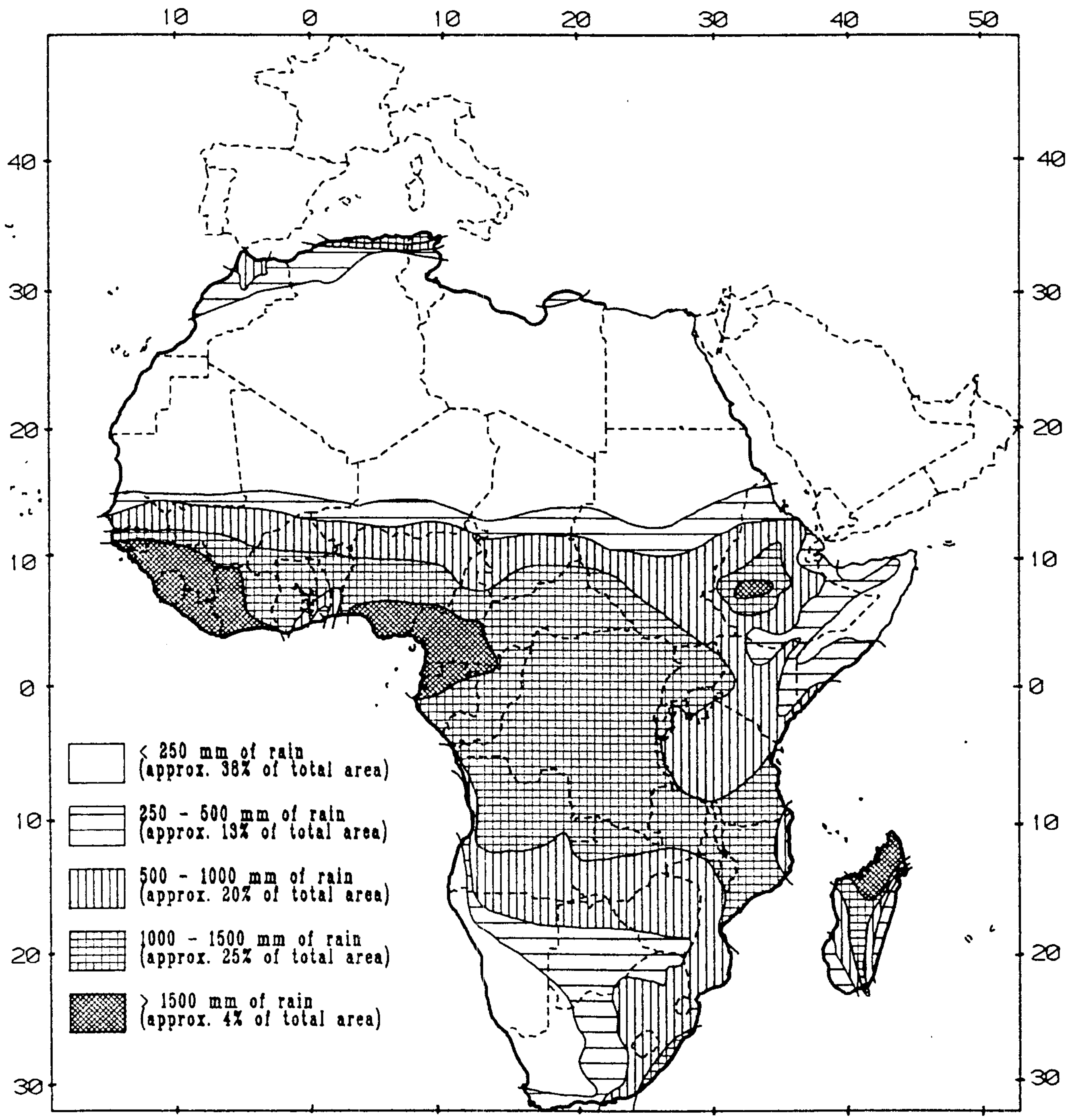
As in all dry areas, mean annual rainfall is a statistical abstraction. In most cases, rainfall close to the mean is unusual in any given year. More common are runs of several years somewhat above average followed by a year or two of drought when rainfall is substantially below average. The Sahel is an exception to this "normal" pattern in drylands. In this region, rainfall from 1965 to the present was substantially lower than in the preceding 50 years (see Box 5).

Seasonality and reliability of rainfall are also important. Most dry regions in Africa have one annual wet season and a prolonged dry season. In West Africa, the rains normally come in June to September while in Central and Southern Africa, November to March is the wet season. In equatorial regions of East Africa, there are two wet seasons in April to May and November to December with intervening dry seasons. The January to April dry season is more intense, in part because the preceding rainy season is smaller and less reliable than the April to May rains. In general, length of the crop-growing season and rainfall reliability decrease as aridity increases. In West Africa, herbaceous-growing seasons range from 15 days with annual rainfall of 100 mm, through 75 days at 400 mm, to 180 days at 900 mm. In the same region, the coefficient of variation of annual rainfall is 43 percent at mean annual rainfall 150 mm; 37 percent at 250 mm; 27 percent at 550 mm and 21 percent at 750 mm (Le Houerou 1989).

Many aspects of dryland ecology are directly proportional to rainfall. Examples include herbaceous production, biomass and production of domestic and wild large mammals, and termite activity (Deshmukh 1986). Production of wood and browse by trees and shrubs is also probably linked to rainfall although few reliable data exist. Where human disturbance is low, cover of woody plants declines with rainfall; as cover declines, so does biomass and production. However, woody cover is not only influenced by rainfall. Soil and biotic factors can preclude significant development of shrubs and trees in some environments.

Figure 4.

Rainfall Map of Africa



This map is based upon information provided by Deshmukh (1986)

1:55,625,000
APPROXIMATE SCALE

ARD/GIS
Associates in Rural Development, Inc.

Herbaceous production per unit of rainfall is substantially lower in much of West Africa than it is in East and Southern Africa with consequent effects on plant dependent animal groups (Deshmukh 1986). The same is probably true of woody plant production. Reasons include poorer soils in West Africa, less effective rainfall due to higher temperatures at generally lower elevations, and the bimodal rainfall pattern in East Africa.

Box 5. Climatic Change

Climate is not constant although long-term averages of temperature and rainfall imply that a "normal" climate can be specified. Standard meteorological statistics use the recent 30 year averages. However, climates change on several time-scales.

Short-term changes in rainfall encompass droughts and wet periods lasting several years. Such patterns are common in drier regions of the world. For example, recent droughts in Somalia occurred in 1978 and 1983. Such patterns are often thought to be cyclic, but statistically defining such cycles is notoriously difficult.

Medium-term changes, over a few decades, also occur. The desiccation of the western Sahel over the last 25 years is an unfortunate example. Such an unbroken run of dry years was unprecedented in the previous 40 years. However, 1900 to 1920 was also relatively dry. The reason for reduced rainfall over the last 25 years is unknown. Reduced vegetation cover is one suggestion. However, neither this hypothesis, nor any other, is adequately supported by the data. Such unpredictable prolonged climatic changes make natural resource planning exceedingly difficult (IUCN 1989).

Long-term changes are known from palaeoclimatic information and are predicted for the future as a result of global warming. Eighteen thousand years ago (the height of the last glaciation) aridity extended further south, such that present Sahelian-type vegetation covered the Sudanian Region. Between 9,000 to 5,000 years ago, Sudanian-type vegetation covered the Sahel. It is only in the last 2,000 years that the present climate/vegetation zonation was established (Moore 1990). If previous patterns continue, we might soon be entering a more arid phase at low latitudes corresponding to a glaciation in temperate lands.

However, the so-called greenhouse effect is leading to **global warming** rather than a new glaciation. Build-up of carbon dioxide, methane, and other gases (predominantly from industrial activities in developed countries) are the cause of this process. It is expected that mean global surface temperature will increase by 2°C by 2030. Such warming will lead to large climatic changes as present global circulation patterns are disrupted. Major grain producing regions in temperate latitudes are expected to become drier with consequent risks to food supplies. Effects in the tropics have not been assessed in as much detail. Both increased and decreased rainfall in drier regions of Africa have been predicted. All such predictions are subject to massive uncertainties. What is clear is that global climate will be affected to some degree resulting in disruptions of human activity (Abrahamson 1989).

Soil Factors

It is not appropriate to include a soil classification or map in this guide. Even an elementary description of soil groups takes many pages. Local variations in soil characteristics are often important in influencing local vegetation patterns. In other cases, apparently similar vegetation spreads over several soil types. For regional information on soils, the FAO-UNESCO (1974) Soil Map of Africa should be consulted.

Nevertheless, some general effects of soil on dry areas of African vegetation are relevant to those concerned with natural forest management. Less arid areas tend to be have leached, nutrient-poor soils while semi-arid areas have richer soils (Huntley and Walker 1982). Exception to this pattern are the acidic sands of the Sahel and Kalahari. Despite semi-arid to arid climates, these soils are low in organic matter, nitrogen, and phosphorus. Bell (1982) argues that soil nutrient status has a major influence on community structure of plants and animals when grassy formations of the Somali-Masai Region are compared with extensive woodlands of the Zambezian Region. The latter are on nutrient-poor soils often derived from granites and on Kalahari sands. Somali-Masai soils of volcanic and marine origin often are younger, more fertile soils. Bell goes on to argue that vegetation types also influence community structure of large mammal herbivores. Poor soils produce vegetation of low forage quality and palatability. In these conditions, larger herbivores (notably elephants and buffalos) are favored. These animals are physiologically better adapted to cope with low forage quality than are the smaller antelopes which are more common on soils of better quality.

Hydrological factors influence plant communities locally. For example, riverine floodplains often support closed evergreen forests even when flowing through semi-arid lands. Moisture is enhanced by surface floods and lateral sub-surface seepage. Recent alluvial soils deposited on floodplains are often richer in nutrients than surrounding areas. However, herbaceous swamp vegetation usually predominates and woody plants are scarce or absent from permanently waterlogged sites. Salinity of soils or water table also affect vegetation (Box 6).

Box 6. Vegetation Change in Amboseli

Dramatic vegetation changes occurred in Amboseli National Park, Kenya, through the 1960s and 1970s. Large *Acacia xanthophloea* trees (fever trees) died leaving depleted woodlands. Swamps also increased. Overgrazing by livestock and then elephants was blamed for loss of trees. Herbivores were not the primary cause, however. The Amboseli basin receives groundwater flows from Mount Kilimanjaro. Increased rainfall led to a rise in the water table. Amboseli is a closed basin; as a result, the water table is saline. It is this rise in a saline water table that killed the fever trees. A similar cycle has occurred previously. European explorer, Joseph Thomson, described the area as devoid of trees in 1883. The local Maasai people also record these events in their oral tradition. They speak of a treeless landscape in the mid-19th century, but that woodlands began to develop around the turn of the century (Western 1983).

Biotic Factors

Biotic interactions influencing vegetation include competition between plants, grazing and browsing animals (including livestock), and human activities such as fires, farming, and fuelwood collection. Human-related factors are dealt with in the next section.

Competition between plants is primarily for water. As woody canopy density is low in arid areas, competition for light is often unimportant. Trees, with their deeper roots are better able to reach deeper for soil moisture, but during growing seasons, shallow-rooting grasses soak up some moisture before it reaches deeper layers. Thus, for a given rainfall, sandy soils with rapid infiltration support more woody vegetation relative to grasses than clays with slower infiltration (Walker 1985).

In drylands, root systems of trees spread far more widely than the canopy (as much as seven times as far in *Burkea africana*). As a result, even apparently widely spaced trees may compete for soil moisture. Removal of trees results in increased growth rates of neighbors. However, competition is not always straightforward. In southern Africa, broad-leaved species (such as *Euclea*) establish best under the light canopy of *Acacia* spp. The broad-leaved sapling grows up through the *Acacia* canopy and eventually overshades and kills the light-demanding *Acacia* (Walker 1985). In this case, the interaction is beneficial to the broad-leaved species and detrimental to the *Acacia*.

Trees may also enhance grass growth in some situations. Soil under the canopy may be enriched with nutrients due to decomposition of leaves and deposition of dung from perching birds or mammals sheltering beneath trees. Tree roots spread more widely than the canopy. Consequently, nutrients gathered from a large area of soil are deposited as leaf litter in a much smaller area.

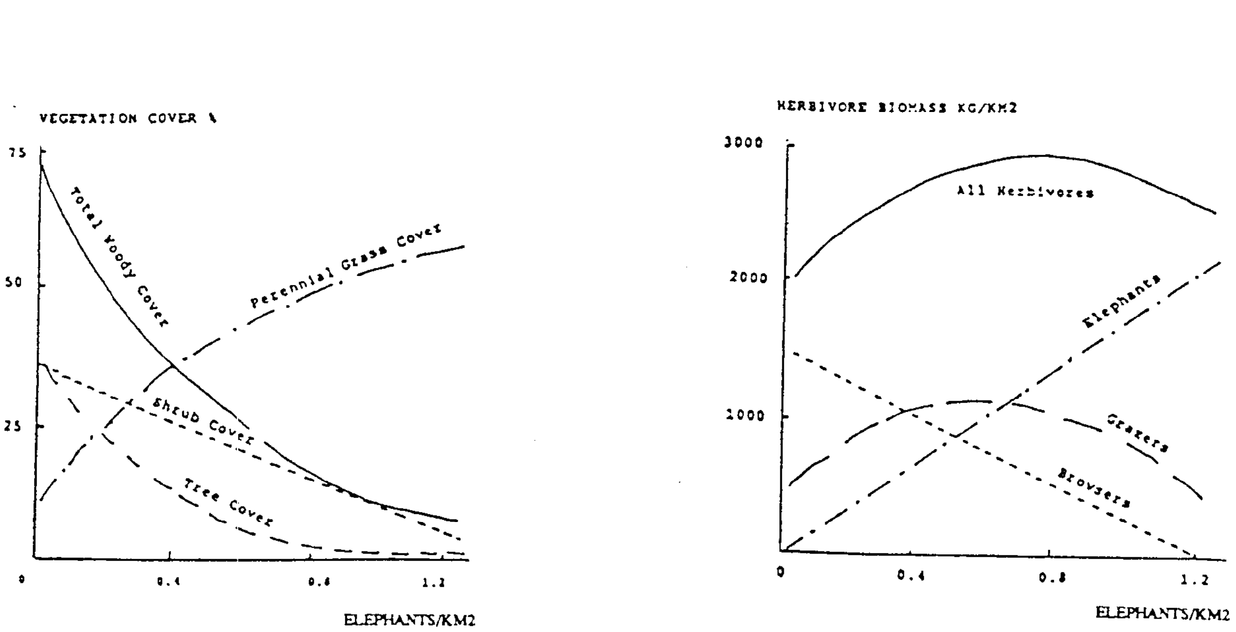
Interactions between plants and wild herbivores can be dramatic. The relative abundance of grazing and browsing species is obviously related to the relative abundance of grasses and woody vegetation. Grazers may completely remove herbaceous vegetation locally, particularly around water holes in dry seasons or droughts. Most browsers do not have such dramatic effects on mature trees and shrubs. However, they may reduce regeneration by repeated browsing of young saplings. Elephants are an exception since they can fell mature trees. In some instances, they may reduce a well-wooded landscape to a grassland (Box 7).

In their natural state, most ecosystems of dry areas in Africa are highly resilient to change; in fact, change is a normal component of their ecology. Pressures such as periodic droughts and resultant high herbivore pressure and occasional fires lead to cyclical rather than permanent change. Tree and shrub biomass is strongly biased to underground organs. If aboveground parts are destroyed, they are usually able to regenerate rapidly from sub-surface organs.

Box 7. Elephants and Ecosystem Dynamics in Kenya

Depletion of elephant populations in East Africa through poaching has received much recent publicity. An earlier controversial "elephant problem" resulting from high population density concerns destruction of trees. In some national parks, landscapes were changed from woodlands to open grasslands. Increase in grasslands led to a rise in grazer populations and a possible decline in non-elephant browser populations. In some cases, elephants were not responsible (see Box 6), but in others they were. In Tsavo National Park, Kenya, some areas were losing 2 to 6 percent of their trees annually during the 1960s. Elephant density subsequently declined markedly through the 1970s, first due to drought, then to intensified poaching. Regeneration of trees was rapid, mainly as coppice shoots. Stumps of trees felled up to 25 years previously and subsequently intensively browsed were still capable of regeneration. A computer model of vegetation cover and herbivore biomass relative to elephant density predicts the equilibrium values shown below (Figure 5). Elephants graze and browse. A high-density reduced tree cover leads to them eating more grass with a consequent decline in other grazers. Most other browsers cannot reach tree crowns and are, therefore, dependent on shrub density (Wijngaarden 1985).

Figure 5. Vegetation and Herbivore Biomass



Human Factors

Human influences should not be regarded as something alien to African ecosystems. Much of the vegetation of the drier zones has evolved in concert with human activities over thousands of years. Human foragers had similar effects to other mammals until fire became a useful tool in hunting management. They were probably used to drive large game and to attract them to post-burn grass growth. Evidence of widespread use of fire, cultivation, and livestock come from 5,000 to 3,000 years ago (Clark 1980).

At low human population densities, foraging, farming, and pastoralism do not lead to environmental degradation. All these systems had some degree of mobility so that local areas were not overused (Deshmukh 1986). Nomadic pastoralism, the most extensive land-use in African drylands, has often been maligned by development professionals. However, opinions among ecologists have shifted to recognize the effective and opportunistic use of natural resources by nomads in environments that would otherwise support few people (Box 8).

Box 8. Ecology of Pastoralism

A common assumption is that traditional pastoral systems are potentially stable at some equilibrium value of vegetation structure, range condition, and livestock density. Such a view of dryland ecology is inconsistent with rainfall fluctuations observed in these environments. A more realistic assumption is that these rangelands are non-equilibrium systems with a high degree of resilience and persistence through short-term climatic perturbations. Nomadic pastoralists exploit rangelands in an opportunisitic way and have done so successfully for thousands of years. In the absence of development interventions or climatic change, it is highly unlikely that livestock can cause widespread destruction of vegetation. Fluctuations in rainfall (and plant production) mean that livestock cannot track carrying capacity, but are usually well below it. Due to water requirements, most of the range is unused during dry seasons. Local vegetation degradation may occur near watering points, especially during droughts.

Common development interventions constrain traditional pastoral systems. Proliferation of wells and other watering points lead to increases in livestock numbers as much more of the range can be used intensively and survival through droughts is more likely. Political interventions, such as enforcement of international boundaries and creation of areas of insecurity, reduce available range. Agricultural development also takes pastoral land, often in crucial dry-season grazing lands. Finally, many politicians regard pastoralists as "backward" and apply pressure to make them settle. These well-intended policies are often the cause of land degradation resulting from livestock activities (Ellis and Swift 1988).

Fire is a powerful, low-cost management tool in rangelands. Occasional fires occur naturally as a result of lightening strikes and volcanic activity. However, most result from deliberate, accidental, or incidental propagation by people. Fires may be lit deliberately for many reasons including to influence grazing resources, clear vegetation for cultivation, concentrate hunted animals, and drive off pests or predators such as tsetse flies or snakes. Incidental fires are common where land is being cleared for cultivation. Such fires often escape into surrounding rangelands.

A fire will only spread if sufficient fuel exists. In drier areas, where tree canopies are open, grass is the fuel that carries a fire. Where grasses are sparse, as in more arid areas, or where herbaceous vegetation is grazed down, fires are infrequent. In moister areas, fires may be annual. Approximately one t/ha of grass is adequate to carry a fire over large areas. This yield of grass is equivalent to less than 200 mm of rainfall in East Africa and about 300 mm in West Africa under good range conditions (Deshmukh 1984).

Ecological effects of fire are many and various, such as the following:

- removal of herbaceous vegetation;
- stimulation of new, nutritious herbaceous growth;
- changes in herbaceous species composition;
- reduction in woody cover;
- changes in woody species composition; and
- temporary release of nutrients to the soil.

Opinions vary as to which of and whether these effects are beneficial to rangeland resources. From a forestry perspective, reduction of woody cover is obviously detrimental, but to a pastoralist with cattle, many effects are beneficial.

The extent of fire-induced changes depends largely upon intensity and frequency of fires. Hottest (and potentially most damaging) fires are late in dry seasons when grasses have dried. Therefore, cooler, early dry-season fires can be used to remove herbaceous vegetation and thereby prevent late-season fires.

Changes in species composition in areas of frequent burning lead to predominance of fire-tolerant or fire-resistant species. In the Sahel, it is thought that annual grasses have replaced perennial grasses as a result of fires (Le Houerou 1989). Most dryland trees and shrubs have evolved in response to drought and defoliation by herbivores or fire. As a result, biomass is predominantly stored underground in root systems. Therefore, regeneration potential is very high, provided shoot meristems are not damaged. A close look at apparent grasslands often reveals regenerating woody plants. This nutritious low-level browse is highly accessible to most herbivores. In this instance, optimal range management for livestock production may conflict with forestry needs.

Degradation and Conservation

Human population in Africa has doubled in the last quarter century. Such a rapid change in countries where most people are rural and poor inevitably puts pressure on natural resources. Rural peoples' basic needs for food, fuel, and housing depend upon productive land. As a result, vegetation and wildlife resources have been severely depleted, usually locally, but sometimes regionally.

These environmental pressures have led to a need for conservation or sustainable use of productive resources. At the same time, awareness of rapidly increasing human-induced extinction of plants and animals necessitates action to preserve biodiversity. Conservation and preservation are often interlinked, but not necessarily so. For example, flood recession agriculture, where crops are planted as floods recede along the edge of rivers or lakes, is potentially productive indefinitely. Riverine waters and nutrients refresh floodplains after each flood. However, floodplains often carry rare or endemic species which are destroyed by spread of agriculture.

Degradation

Three factors predominate in the degradation of these arid and semi-arid lands: need for agricultural land, need for livestock forage, and need for fuelwood. Increased population and socioeconomic changes have led to breakdown of non-degrading traditional land-uses described in the previous section. In the case of the Sahel climatic change, a prolonged desiccation described in Box 5 has been a primary cause of degradation exacerbated by human factors. In this region as a whole, as well as in some local areas throughout the drylands of sub-Saharan Africa, land degradation has resulted in desertification.

Desertification is a set of processes that reduce cover of vegetation and soil stability. Specific changes include replacement of trees and perennial grasses with small shrubs, annual grasses, and ephemeral forbs. Vegetation loss exposes soils to wind and water erosion, causing degradation and leading to mobile sands or rocky substrates. Climatic change is not a prerequisite of desertification, but the most vulnerable lands are usually in arid areas close to natural deserts. Box 9 describes land degradation in the Sahel. Due to climatic changes and infertile soils in addition to population increase and land-use change, this region is the most degraded and vulnerable in Africa. Degradation is, of course, common in other parts of Africa, but usually of more local or less drastic extent.

Demand for fuelwood outstrips supply in many areas. In West Africa, actual population exceeds sustainable fuelwood production tenfold in the Sahel and twofold in the Sahelo-Sudanian transition zone. Wood supplies almost match demand in the Sudanian zone overall and exceed them threefold in the Sudano-Guinean transition (IUCN 1989).

Similar statistics for the SADCC countries are in Table 4. With annual fuelwood demand of 1 - 2 t per person, these national statistics imply that fuelwood shortage is uncommon in central and southern Africa except in Lesotho and Malawi. However, most fuelwood gathering is a subsistence activity restricted to a radius of a few kilometers from home.

Box 9. Desertification in the Sahel

During the current Sahelian drought period of the last 25 years, human and livestock populations have more than doubled with the following ecological consequences.

Cultivation has expanded at perhaps 2 percent per year overall. Previous fallow periods of ten or more years have been reduced or eliminated altogether with a corresponding decline in soil fertility. In Darfur and Kordofan provinces of Sudan, a fivefold increase of cultivated land was accompanied by a 70 percent decline in yield. Declining yields lead to yet more land being required to support a family. As a result, the belt of cultivation moves northward into drier lands. Cultivation rarely occurred below 400 mm in Niger in the 1950s. It has now spread 150 km north to the 250 mm isohyet. Frequent crop failures leave land exposed to erosion. Expansion of cultivation also means reduction in extent of rangeland.

Overstocking by livestock is largely the result of water development and improved veterinary sevices. Animals which previously died due to drought and disease, separately or in combination, have a better chance of survival. Most pastoralists maintain as large a herd as possible so that sufficient animals survive droughts subsequently to rebuild a herd. Increased human population and improved survival prospects for animals lead to larger herds.

Effects on grazing resources are reduced ground cover and a change in species composition. In Central Mali, bare ground increased from 4 percent to 26 percent between 1952 and 1975. During a similar period, soil erosion increased by almost 30 percent and the limit of drifting sands moved 50 km southward in Chad. Species changes in the herb layer include a shift from perennial species to annuals and replacement of good forage species with less palatable grasses and forbs. Good indicators of advanced degradation are the spread of the asclepiad shrub, *Calotropis procera* and the American tobacco shrub, *Nicotiniana glauca.*

Woody plants are also depleted by human and livestock pressure. Under undisturbed conditions, Sahelian rangelands carry 5 to 30 percent woody cover representing 100 to 1,000 trees and shrubs per hectare. Reduction of around 1 percent per year since the 1950s leaves 1 to 2 percent woody cover in many areas. Species composition has also changed with spiny xerophytic plants replacing broad-leaved, more mesophytic plants. For example, species of *Acacia, Dichrostachys, Boscia, Cordia,* and *Balanites* have replaced *Combretum, Terminalia, Anogeissus,* and *Guiera* (Le Houerou 1989).

Distribution of population is more closely tied to arable soils, pasture, and socio-political factors than fuelwood supply. As a result, most SADCC countries have fuelwood shortages at local or regional levels. For example, in Botswana, almost 40 percent of biomass production is in the sparsely populated north, while less than 0.2 percent of production is in densely populated southeastern districts around Gaberone (Millington and Townsend 1989). Other restrictions on fuelwood supply include preference for certain species and conflicting demands for use of wood. In countries such as Tanzania, wood collection is controlled or forbidden over large reserved areas covering almost 15 percent of the country.

Table 4. Fuelwood Supply in SADCC Countries
(Data from Millington and Townsend 1989; Armitage and Schramm 1989).

Country	Total Biomass t/capita	Biomass Production t/capita/year	Fuelwood % of total energy
Angola	570	17	-
Botswana	1,330	45	48
Lesotho	1.5	0.2	-
Malawi	50	2	86
Mozambique	285	9	-
Swaziland	33	1	-
Tanzania	68	5	88
Zambia	390	12	25
Zimbabwe	200	6	25

Data on soil erosion by water and wind show large variations. It is clear, however, that reduction of plant cover through overgrazing, fire, or cultivation increases erosion rates. In Sahelian Burkina Faso, on a 0.5 percent slope, natural vegetation lost 0.1 t/ha of soil, cropped lands 0.6 - 8.0 t/ha, and bare land 10 - 20 t/ha due to water erosion (Kowal and Kassam 1978). Similar rates are reported from the Sudanian Region. Wind erosion is less well documented. Sand dune movements are common in the Sahel and often spread over former cultivated fields and rangelands.

Environmental change is easy to detect, but the threshold for sustained degradation of drylands is not. For example, moderate levels of grazing and off-take of wood increase production of grass and forest resources over no off-take. High levels of off-take usually cause degradation. Defining "moderate" and "high" off-take requires considerable quantitative research over many years. Variations in rainfall mean that sustainable off-take and carrying capacity are also variable. Setting off-take limits during a drought leads to under-use of resources during wetter years and a likely decline in resource production. Even if off-take limits can be defined, applying them to land-use practices of rural communities is difficult.

Sustainable Use of Natural Resources

Formulating ways of conserving biological resources is easy from an ecological perspective. Stop using them, or only allow land-use that takes sustainable yield of plant and animal products. Such a facile approach ignores the fact that rural population in Africa is increasing and that these people derive their livelihood from biological resources. Technically, environmentally sound solutions are available to most natural resource problems, but socioeconomic factors reduce or void their effectiveness. In some cases, narrowly focused technical fixes intended to enhance environmental conditions actually make other problems worse.

An example is veterinary and pastoral water development to improve livestock production causing range deterioration (see Box 9).

Development interventions that fail to take traditional land-use and other socioeconomic factors into consideration are doomed to failure. Consequently rural development programs need to be locally based. Success of a scheme in one locale or region does not necessarily mean success elsewhere even if ecological conditions are similar.

The root of African resource degradation is the rate of population growth. Unless this rate can be reduced, it is likely that resource degradation will continue or accelerate. Growth rate rather than density is the main population problem. Most African countries are not densely populated compared with other parts of the world. However, low levels of technology and investment mean that production of crops, energy resources, and livestock cannot keep pace with population increase. Slower population growth could allow time for changes in land-use to adequately supply biological resources. Population densities in the dry zones of West Africa are supportable by present crop and livestock resources if equitably distributed. With moderate inputs to agriculture, crop production could be increased by a factor of four to five times (IUCN 1989).

Rangeland management to prevent degradation is more difficult. As discussed in Box 8, traditional pastoral systems do not cause widespread problems, but current trends have led to more extensive deterioration. Localized schemes in the Sahel have met with some environmental success in small areas, but have not been economically viable. Also, destocking of project areas usually increases livestock density in surrounding lands (Le Houerou 1989).

Range management projects such as group ranches, grazing blocks, or grazing associations usually seek to confine nomadic pastoralists to a defined tract of land. Such schemes may work temporarily, but usually break down when a drought occurs and new graze and water are sought. The notion of confinement and land ownership is often introduced on the assumption that ownership confers responsible management of land. This assumption is questionable (see Box 10).

Most range-management interventions assume that pastoral systems in African drylands can be held at some equilibrium. As discussed earlier, recent ecological work suggests that these rangelands cannot be regarded as equilibrial systems. Pastoralists have several opportunistic methods of dealing with drought stress. The Turkana in northwest Kenya move over wider areas than normal in search of forage. They also trade more cattle (some of which would die anyway) for food grains. Demand for food from the pastoral system is also reduced by some people, usually those not essential to herding activities, entering temporary monetary employment. These strategies allow the Turkana to maintain their population and range resources through droughts (Ellis and Swift 1988).

A non-equilibrium model of rangeland management has recently been proposed by Westoby, et al. (1989). As with the Turkana observations, this model stresses opportunism as a rational basis of juggling grazing pressure, fires, and droughts to optimize range condition. The model employs vegetation states and transitions between them. In this way, transitions which are opportunities or hazards can be identified. In contrast to conservative grazing advocated by traditional range managers, the model suggests that, in some situations, heavy grazing or burning may be beneficial. Monitoring of vegetation states rather than stocking rates is the key to such management. As with the Turkana example, movement or slaughter of livestock may be advisable in droughts. Average livestock production is greater by varying herd size to optimize range condition, rather than maintaining constant herds at low enough density to survive periodic droughts.

Box 10. Tragedy of the Commons

Garret Hardin's statement, the "tragedy of the commons" in 1968 undertook to show how over-exploitation of natural resources is inevitable where land is communally held rather than individually owned. The basic idea is that individuals will maximize their use of communal resources since costs of overuse will be shared by the community while gains will be at the individual level. Thus there is no incentive to prevent an individual from overgrazing range or overcutting wood, since if he or she does not do it, someone else will. In contrast, ownership leads to responsible resource use. Hardin's idea is still the most frequently stated notion of relationships between resource tenure and degradation.

Increased understanding of traditional tenure structures, failures of schemes involving individual land ownership and new theoretical approaches challenge this notion. The Beja pastoralists of Sudan are split into small lineage groups (*diwab*) of 50 to 150 households, each with well-defined land rights. Each *diwab* holds an area of land, vegetation, and water sources which is collectively owned. Individuals have equal rights to use of resources. Other *diwab* recognize these rights and will only use another group's land with permission and payment of a fee. Migration to "un-owned" areas in times of ecological stress help to prevent land degradation. Thus collective tenure of land is promoted within tightly knit groups with common interests. In contrast, privatization of land into group ranches in Kenya and Botswana has not achieved the objectives of range improvement and increased livestock production.

In general, it seems that traditional tenure systems work best when mechanisms exist to learn from past experience, and participants can agree on and enforce future objectives. Most important is a fairly equal common interest in resource use and conservation. In highly stratified or heterogeneous societies, common interests do not exist.

Traditional tenure practices are often destroyed when their legitimacy is denied by governments imposing nationalization or privatization of land. It is unrealistic for modern government structures to accomodate the myriad tenure systems that have existed. However broader, decentralized approaches to resource tenure are required which recognize previous systems. Tenure systems for common land should define collective rights, vest resource conservation control with agreed objectives at the local level, and have reciprocal access agreements where necessary (IUCN 1989).

Biodiversity Issues

Biodiversity is the sum of species on earth, together with genetic variation within each species and the ecosystems they inhabit. As is well known, tropical rain forests are the richest and most threatened sites of biodiversity. However, degradation of African drylands is a significant threat to biodiversity (Box 11).

Box 11. Threatened Plant and Animal Species

Of the 21 countries in sub-Saharan Africa that have wholly or predominantly dry climates (see Figure 3), 11 have no published lists of threatened plants. This situation reflects ignorance of distribution and abundance of the flora, not an absence of threat. In 1986, only 10 of these countries had adopted the World Heritage Convention, and 11 were attempting to enforce the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

Degradation of vegetation is widespread in sub-Saharan Africa. Clearly, many species are rapidly declining in abundance and becoming more restricted in distribution. In countries where the situation is documented, many species are known to be threatened. Examples are given below.

Country	Number of species	Number of endemics	Number of endemics threatened
Senegal	2,100	32	31
Chad	1,600	49	10
Somalia	3,000	171	40
Tanzania	10,000	1,200	98
Zimbabwe	5,400	170	8

Threats to animal species such as elephants and rhinoceros are well known. However, many other less "charismatic" species are inadequately protected. For example, thirteen species of mammal, thirteen birds and four reptiles are known to be theatened in the Zambezian Region alone. Although poorly known, many more species of invertebrates are threatened (IUCN 1986, IUCN/UNEP 1986).

A significant proportion of land in most African countries is protected for conservation (Table 5). Unfortunately, the effectiveness of protection is also low in most of these countries. Many African parks were set up to conserve large mammals. Nevertheless, coverage of major vegetation types is fair. At finer scales, gaps in protected area networks are more evident. Wetlands, in particular are underrepresented. Floodplain vegetation of rivers and swamps are severely threatened due to high agricultural fertility and water management schemes. In drylands, these areas are perpetually green patches of distinctive flora and fauna and provide vital dry-season refuge for many other species.

Table 5. Extent of Protected Areas in Countries of Sub-Saharan Africa with Predominantly Dry Climates (IUCN 1986)

Country	% area protected	% area proposed	Cover of vegetation types*	Level of protection
Botswana	17.1	0	good	fair
Burkina Faso	2.5	8.3	fair	poor
Chad	0.1	11.6	poor	poor
Djibouti	0.1	0	poor	poor
Ethiopia	4.7	0.1	fair	poor
Gambia	0	0.8	poor	good
Kenya	5.3	2.0	good	fair
Lesotho	0.2	0	fair	good
Malawi	11.5	1.0	good	good
Mali	5.4	0	fair	poor
Mauritania	0	0	none	none
Namibia	8.3	0	fair	good
Niger	0.6	7.1	fair	poor
Senegal	10.2	0	good	fair
Somalia	0.5	6.7	poor	poor
South Africa	11.7	0	good	good
Sudan	1.2	6.5	poor	poor
Swaziland	2.0	0	good	good
Tanzania	12.4	1.9	good	fair
Zambia	8.4	2.1	good	poor
Zimbabwe	11.7	0	good	good

* *vegetation types from White (1983)*

For poor countries with burgeoning, land-hungry populations, conservation may appear expensive, both economically and politically. Developed countries appear to have become wealthy through exploitation rather than preservation of biological diversity. Since loss of biodiversity is perceived as a global problem, it is clear that rich countries should contribute to sharing the costs to maintain biodiversity relative to their wealth.

Protected areas are a part of the answer, but these reserves only remain viable if massive, or if surrounding lands are also managed with conservation in mind. For example, only 20 percent of Kenya's large mammalian herbivores inhabit parks (Western 1989); the remain der share rangelands with livestock and have done so for 3,000 years. Degradation of these rangelands is detrimental to both rural people and wildlife. The same arguments apply to forest resources. Loss of diversity devalues vegetation as a source of gathered foods, livestock fodder, construction materials, fuelwood, shelter, and traditional medicines.

Most prevailing economic rationales tend to exploit rather than conserve biological resources. Conservation in these terms is only justified if, for example, national parks pay for themselves (or, preferably, make a profit) by attracting tourists. However, such simplistic notions of the value of biodiversity are changing.

Proper accounting should include goods and services provided by biological resources, many of which never involve exchange of money (McNeely 1988). Examples of such goods include forest products. Services include climate, watershed, and soil maintenance. Even products reaching the market such as timber, ivory, and medicinal plants are usually grossly undervalued at the rural level where they are produced. Governments and international bodies routinely employ economic incentives and disincentives to promote policy. There is no reason why such means should not be used to promote biological conservation and sustainable land-use. Examples are given in Box 12.

Box 12. Incentives and Conservation

1. Management of *Acacia kirkii* Woodlands in Mali

Prior to 1960, woodlands in the Niger Delta were under community control. These woodlands are essential to waterbirds which in turn maintain aquatic productivity by depositing dung which is washed into the delta during floods. During the dry seasons, cattle herders grazed in the woodlands. Resource tenure was locally controlled by local fishermen and a *Dioro* (a respected local) administering pasture. In 1960, land was nationalized. Resource control was vested in a Ministry of Natural Resources which issued permits for goat browsing. It was forbidden (with support of fines) to cut live trees for fodder. However, the culprit could rarely be indentified and fines were imposed communally. An individual may as well cut fodder since he would surely be fined for someone else's transgression. Thus fines were a disincentive to good resource use. The result was degradation of woodlands.

A recent project has attempted to restore the traditional grazing control by a local *Dioro*. Woodland ownership and management is vested in local committees of goat herders, fishermen, and *Dioros*. Woodlands, birds, fisheries, and grazing grounds now seem to be effectively conserved. Community involvement is a major incentive to conservation in this case.

2. Wildlife Management in Luangwa Valley, Zambia

Safari hunting in the valley yields about $350,000 per year, but less than 1percent of this has supported local village economies; even less was used in wildlife management prior to 1983. Thus local support for wildlife protection was minimal and poaching of elephants and rhino, rampant. To reverse this situation, the national parks authority promoted local involvement in wildlife management. Wildlife committees were set up in each chiefdom. Locals were trained and employed as custodians of wildlife for each village. Income for the system was generated by culling hippos and auctioning hunting permits to safari companies. Forty percent of proceeds are for local community projects, the remainder for wildlife management. With economic incentives to protect and manage wildlife, elephant poaching dropped by 90 percent. Elephant populations are now increasing to the extent that hunting permits may be issued, considerably increasing future revenues (McNeely 1988).

Resource Assessments

One of the early steps to forest management planning is an assessment of the resource base. Forest inventory methodologies are a traditional skill taught to all forestry professionals and technicians. The applicability of these methodologies developed for the temperate forests is doubtful for the sparse tree and shrub savannahs and woodlands of the arid and semi-arid zone of Africa, both in terms of effectiveness and cost efficiency. At the same time, arid zone inventory methods have only begun to emerge[1]. This section draws upon recent experience with resource inventories in Sahelian West Africa.

Classical forest inventory techniques in the United States are based primarily on forest cover-type mapping done from aerial photographs. In the temperate zone, medium-scale (1:15840 is standard) black and white infrared aerial photographs permit an experienced photo interpreter to delineate most forest stands by the dominant species, their size classes, and crown cover. Using a variety of sampling schemes, field inventory crews then measure the diameter and perhaps the height, age, and other characteristics of each species of tree on selected sampling points representative of the different cover types. The intensity of this sampling is directly related to the perceived (and sometimes measured) diversity of the subject stands. Overall sampling intensity rarely exceeds 5 percent of the total area.

Volume tables are applied to provide unit area estimates of volumes by species. Average volumes per unit area are multiplied times the area measurements made from the cover-type maps to provide estimated totals for stands, compartments, districts, forests, and other groupings. Most of the new information obtained from a classical forest inventory is based on the cover-type map done from aerial photographs; the quality of the field inventory is less important than the quality of the air photo interpretation.

Temperate zone techniques generally do not work in dry areas in tropical Africa for the following reasons:

- **Species identification is difficult or impossible.** The species diversity of tropical dry forests, while less than that of humid tropical forests, is generally far greater than that of temperate zone forests. Stands are rarely dominated by one or two species. Furthermore, virtually all dry tree and shrub species are broadleaf deciduous or broadleaf evergreen hardwoods. For technical reasons (less variability in their spectral response), hardwood species in general are much more difficult to identify on a photograph than conifers. One can rarely identify tree species from aerial photographs.
- **Lack of leaf-on photography.** In dry areas, rainy season, leaf-on aerial photography is generally difficult to obtain because of the limited number of cloud-free days in the rainy season. Most aerial photographs are flown in the

1 See for example the proceedings of the International Workshop on: *Arid Land Resource Inventories--Developing Cost-Efficient Methods*, La Paz, Mexico, 1980.

dry season. At least a number of the trees in nearly all these areas are deciduous, losing their leaves in the dry season. Without their leaves, the height and crown cover of trees and shrubs is very difficult to discern.

- **Wildfires**. The very widespread phenomenon of dry-season fires, especially in the tall-grass savanna zone, further complicates the use of aerial photography and other remote-sensing techniques. Fire kills the leaves even on evergreen species; after the passage of a fire, the trees and shrubs remain leafless until the next rainy season. In the tall-grass savanna zone of Burkina Faso, roughly 80 percent of all forests burn every year (Hagen 1982). Furthermore, nearly all of these forests and woodlands burn within the first month and a half of the dry season during the time when most aerial photographs are flown.

- **Cost**. The cost of inventory and mensuration techniques should reflect the value of the forest resource to be managed. Aerial photography in tropical Africa is almost invariably much more expensive than in the industrialized West and the value of the forest resource is generally far less; firewood (a low-value product) is often the principal forest product. This makes the acquisition of new aerial photography for natural forest management difficult to justify. For example, if new aerial photography missions must be flown to provide the basic resource data, the cost of doing so must be considered as a factor in the cost/benefit analysis of the project feasibility. Existing photography is often relied on, but it is highly variable as to age, scale, season, and quality. The most common scales of existing photography are generally in the neighborhood of 1:40,000 to 1:70,000. At 1:50,000 scale, the smallest individual tree that one can detect with good contrast is one with a crown of about five meters in diameter; most shrubs and small trees just blend into the grey tones at these scales.

- In dry Africa, **appropriate mensurational techniques and tools have not been developed**. This is partially due to lack of interest in natural forest management until very recently and, in part, because the classical volume table correlation of diameter breast height (d.b.h.) to volume does not work well for many of the species. Most shrubs in these zones are multi-stemmed and many small trees are variable in form with branches or forks below breast height. In many areas, there are no species-specific volume tables for the majority of the local species.

- In temperate zones, small-diameter trees, tops, and branches often have no commercial value; large diameters command a premium price. Volume tables are generally developed for usable wood volumes. **Small diameters are often preferred** for fuelwood, charcoal, posts, and poles. Trees over 20 cm in diameter are often unusable for firewood with the simple, locally made hand tools most commonly used. Too often, volume tables that have been developed in these areas are based on an unrealistically high minimum diameter and include the commercially unusable large diameters.

Assessment Objectives

The most common errors in forest inventories or forest resource assessments result from a failure to define the objectives of the assessment. One must first decide what the real information needs are. Mapping, inventories, and assessments are expensive. Far too many projects have gotten stuck in the "Let's study it from all angles before we do anything" rut. The first natural forest management project in Burkina Faso, after nine years of vegetation mapping, soils mapping, inventories, socioeconomic surveys, and other studies, had not progressed beyond the cutting of dead trees. During this same time, part of the natural forests of Burkina Faso were lost to agricultural expansion.

In most parts of dry Africa, natural forest management either does not exist or is in its infancy. How to manage and assure the regeneration of natural forest types is not well known at this time. Accurate inventory data only becomes critical as one approaches the sustainable limits of the forest resource to be managed. Until forest management methods are better known and field tested, including their ability to penetrate the marketplace with their products, it will be difficult to more accurately predict realistic information needs. With limited resources, it is generally best to invest most of them in the development of economically and ecologically viable natural forest management pilot interventions, and not into exhaustive inventories and assessments.

Forest resource assessments are conducted at two general levels—broad-based, extensive inventories done for general planning purposes and more intensive assessments of specific forests to be managed or already under management. **Common objectives of extensive inventories** covering relatively large geographic areas include the following:

- provide general information on the location and accessibility of remaining natural forests; this can be very valuable in planning where to undertake natural forest management;
- provide information on the relative mix of natural forests and agricultural land, e.g., uninhabited forest, low-, medium-, and high-density agricultural use;
- provide general estimates of standing volumes of different forest products;
- provide an estimate (when compared with preexisting maps or other data) of the rate of loss or change in the forest resource base; and
- provide general information on the forest condition.

Extensive assessments give senior planners a general idea of the potentials and the problems of the natural forest resource base, but they are not of much use to the field forester charged with managing a specific forest.

Intensive assessments of forests to be managed should be designed to provide the information needed to begin management of the forest. **Common objectives of intensive assessments** of a forest include the following:

- prepare detailed maps showing the precise limits of the forest, access roads, stream courses, and other physical features;
- classify the forest by soils/landform types of homogeneous potential;
- locate fields, fallows, degraded areas, and inaccessible areas;
- estimate the standing volume of wood products by species and/or the amount of secondary products;
- estimate the type and the adequacy of forest regeneration; and
- analyze pest and disease problems, fire damage or risk, evidence of timber trespass, soil erosion, and animal damage.

What one needs to know is not a trivial matter. One obviously needs to know where the forest is. If it is a "state-owned" forest reserve, it may have been created during the colonial period. The records with the legal description may have been lost. The forest may never have been surveyed. If surveyed, the survey may have been full of errors; the survey records may not specify whether bearings are magnetic or geographic, whether they are in degrees or in grads. Boundary markers may have been lost, stolen, or moved. The limits of the forest will probably be disputed by the local people. The forest may have been partially or completely cleared for farm fields.

Natural forests that lie outside of official reserves may be the object of conflicting tenure rights between the national government, local villagers, and transhumant pastoralists. Before natural forest management can be attempted, this legal limbo must be resolved. If the forest lies within the traditional limits of a village's lands, it is probably best to legalize these limits making the villagers the forest owners. This is a crucial political issue.

Secondly, one must be able to divide the forest into annual cutting units of approximately equal potential. Normally, one wants to be able to harvest the same quantity or value of products each year. To do this, one should know the actual standing volumes and the productivity of each portion of the forest. In the long term, the sustainable harvest or allowable cut will be determined by the productivity of the forest and the management techniques employed. The productivity, optimal rotation ages, and allowable cuts will almost never be known initially, due to lack of previous experience and appropriate research. In the short term, the annual cut will be strongly influenced by the initial standing volume. Most relatively intact, unmanaged stands are "old growth" stands with low productivity and a much higher ratio of mature trees and shrubs in the larger diameter classes than a managed forest may have. The volumes, products, and species harvested on the first cut may differ greatly from subsequent cuts. Other unmanaged forests may have sections that are badly degraded where initial cuts may be much less than what could be sustainable after rehabilitation.

To estimate standing volume, one could spend years developing appropriate volume tables for the tree and shrub species in the forest and then use them to conduct a classical inventory. Alternatively, one can obtain an empirical estimate of merchantable volumes by actually harvesting portions of representative stands within the forest and measuring the volumes of products harvested. Within a year after beginning a natural forest management project, one should be in a position to conduct trials of appropriate harvesting techniques. An FAO project did this on 100 ha of the Nazinon National Forest in Burkina Faso in 1988, thus obtaining an operational estimate of harvestable volumes on which to base their planning.

There are several advantages to estimating standing volumes through early cutting trials on a natural forest management project:

- they provide operational estimates of merchantable wood volumes under different harvesting techniques and on different sites;
- they can be combined with practical training for members of the woodcutter groups being formed. This should be a money-making exercise for the woodcutters thus creating an economic incentive early in the project;
- they can serve as operational trials of regeneration success under different harvesting techniques;
- if combined with a longer-term research effort, they can eventually provide estimates of productivity under different management regimes; and
- as the cutting trials serve several purposes, the cost allocated to volume estimates is considerably less than that of a classical inventory.

Estimating the forest productivity of different soils/sites is much more difficult than estimating standing volumes. Productivity or site index is very difficult to measure because of the lack of well-defined annual tree rings that are used to age trees in temperate zones. Long-term growth studies are needed, but one cannot wait for them before beginning management activities. Standing volume or height of the dominant trees of relatively undisturbed stands may be directly correlated with site productivity, but only roughly so. Modern soils maps could be prepared, but they are of little value if the correlations between soil type and forest productivity have not been established. In dry forest areas, soil water-holding capacity determined by soil depth and texture may be the most important factor in site productivity; this can be estimated satisfactorily in the field with a soil auger, a water bottle, and one's hand.

One will generally have to begin natural forest management without good estimates of productivity. The best approach is probably to divide the forest into a very few, general soils/landform classes. As soils and landforms change little over time, this can often be done from existing aerial photographs, even if they are old and of small scale. The local people will usually have a simple soils/landform classification scheme that may be employed successfully.

If it is possible, the annual cutting units should contain an equal portion of each soils/landform class. In this way, the long-term potential of each cutting unit should be about the same, even though this potential is not well known. If this is not possible, then one should make one's best estimate of relative productivity and accept that adjustments to the cutting units will have to be made down the line, as better estimates of productivity are obtained.

Cutting unit boundaries will probably have to be changed over time, anyhow, as more information leads to a better definition of the cutting cycle or rotation age.

Assessment/Inventory Procedures

The following provides some general guidance on assessment/inventory procedures. There can be no absolute blueprint for forest inventory under arid and semi-arid conditions at this time in sub-Saharan Africa. The procedures to be followed and the methodology to be chosen, as mentioned above, are very dependent on the site conditions and on the objectives of the management plan. Proper planning at the outset is, nevertheless, essential both for efficiency and to ensure that the data and information collected meets the needs of the management plan, and importantly, includes a level of validity which, when applied, will not lead to long-term negative effects. For example, faulty assumptions about existing regeneration and its ability to withstand the pressures on the area could result in "managed" deforestation.

This example highlights the need to focus on both the quantitative and qualitative aspects of a resources inventory. The able forester or forest manager will be familiar (see discussion below on "Back to Basics") with their area of responsibility and will recognize pertinent contradictions that may emerge during an assessment exercise. In short, assessments must be built on existing familiarity with the area; local staff must routinely visit, inspect, observe (and record their observations), and be generally familiar with the forest area at the reconnaissance level.

Preliminary information that might be collected as part of the familiarization process could include the following: boundaries and boundary markers; a sense of the topography, including the existence of rivers, streams and waterholes, and special topographical features such as hills, plateaus, wetlands (*wadis*), and drainage ways; access points, roads, and trails through the area; a preliminary sense of the forest types and the predominant species; current pressures on the forest, including wildlife and livestock use patterns and vegetation responses to these pressures; proximity to population centers and villages; and a general sense of forest/woodland/range condition, including signs of degradation (laterization, soil erosion and gullies, recent fires, drought impacts). This information is important; it will provide a baseline for inventory design and enable the planner to make decisions about the level of sampling intensity and the accuracy to be sought. It is also a sound start to the kind of monitoring practices which will be fundamental to ensuring that the forest management plan, once designed, can be carried out correctly.

The first stage to planning and implementing an inventory is a basic **compilation of existing information** (surveys, records, maps) about the area. It will also be useful to review the relevant forest management experience, if any, in the area. Compiling this information first will help to identify information gaps and define the information needs to be targeted in the inventory. The distinction between gaps and needs above is intentional; wasting time and funding collecting information that cannot be effectively used or will not provide adequate returns on the investment must be avoided. The stakes are high. Too much information means higher costs which government will have a hard time justifying. In these early days of natural forest management in the dry areas of sub-Saharan Africa, the axiom must be a conservative approach. This approach must take into account the unknowns and the assumptions built into the resources assessment.

Maps are an important and extremely useful tool for forest management. Existing maps dating from the establishment or designation of the areas as a forest reserve may be adequate for management purposes or may provide a baseline for improvement and updating. Updating and verifying the accuracy of a map of a forest area to be brought under management is essential. The forest area may have been reduced in size by clearing for agriculture or from the impact of fire and grazing. Occasionally, forest areas have expanded as a result of changing land-use patterns and pressures.

Perhaps the best way to begin reviewing the utility of an existing map is to undertake a boundary survey. Good maps include compass bearings and distances for each distinct traverse along the perimeter of the forest. These surveys and the maps resulting from them are usually made using simple equipment—a compass and tape. It is neither necessary nor cost-effective to utilize more sophisticated equipment such as a transit or other more precise instruments. Without these bearings and distances, which must "close" (meaning that by following the bearings and distances, either mathematically or in the field, one returns to the point of departure), it is difficult to make an exact determination of the forest area. Properly plotted, a map can be used to determine the area by dividing it into triangles or other polygons and calculating and summing the area of each.

Scale is an important consideration in mapping. The basic forest survey map will need to be of a scale wherein the details can be adequately represented. As mentioned above, the standard applied in temperate forests is 1:15,840 (4 inches to the mile); using the metric system, the standard is typically 1:10,000 (10 centimeters to the kilometer). A map of this scale can include the essential information: boundaries, topography, forest-type information, compartment lines, roads, trails, and other special features. In all cases, a forest map should be tied into some terrain or landscape features that are unlikely to change, i.e., points along a paved road, buildings, large boulders, or something similar. At this scale, it may be necessary to have several sheets to allow facility of handling and to cover the entire forest. Where this is necessary, a full-size composite of all the sheets should be put together and displayed (at the main forest office) so that staff and visitors are able to relate areas and features with actual ground conditions.

The boundaries of the forest, including interior compartment lines as these are established, should be marked in the field. The perimeter boundary merits a more permanent marking, usually steel rods set below the ground at each compass station of the survey which can later be located by following the description. They are set below ground so they will not be tampered with. However, it is also fundamental to mark the boundary sufficiently so that anyone approaching the forest will clearly see the boundary. Paint applied to trees and/or rocks is the usual practice. This practice cannot be overemphasized, especially in cases where a high degree of popular participation by local people is foreseen in managing the forest. Without such marking it may be difficult to discern the boundaries and therefore apply usage prescriptions or hold anyone responsible for transgressions. Numerous "reserve forests" in sub-Saharan Africa have disappeared simply because local people had no practical knowledge of the existence or location of the forest.

As important as having maps, is using them. One copy of the forest map is not enough. There should be one copy, typically the original, used to make copies and safeguarded as the archival copy. Many copies should be made and distributed to field staff and others (local villagers) concerned with forest management. They should be encouraged to take them to the field and taught how to use them. Understanding and using maps is a skill. Several members of the staff should be aware of how these maps are made (using compass and tape) and be able to run lines and locate them on base maps as necessary.

These maps will always be needed for forest management; where they do not exist, they will have to be created. In some cases, existing maps prepared for other purposes by other institutions than the forest service may be available, and if of suitable scale, can be adapted and improved for management. Institutions such as the national geographic institute, the national remote sensing center, other government technical services (e.g., agriculture, livestock, water resources, land-use planning) and even commercial aerial photography and mapping services may be able to supply these needs.

If maps need to be created, there are essentially two options. Ground surveys may be feasible for relatively small forests and woodland areas of up to a few thousand hectares, especially if the vegetative cover is quite homogeneous. The other alternative is using aerial photography for developing the base maps and identifying physical features and soil/landform and vegetation units. Recent vintage aerial photography is best, but a rapid reconnaissance of the area with the photos in-hand can quickly determine if they are still usable. Map-making based on aerial photography, however, requires specialist skills; consequently, it is likely that this service will have to be carried out with assistance from others (e.g., the remote sensing/inventory unit of the forest service, some other government unit, or even commercial services).

A full discussion of this topic is beyond the scope of this document. Some points, however, are worth highlighting. Even though a specialist may be used to develop the maps, the forest manager should be closely involved, especially in assisting the others to ground-truth the map. The map production process should be planned in such a way as to facilitate the inventory that must follow it. Beyond the perimeter and linear mapping requirements, the use of aerial photography can greatly facilitate the basic forest-type designations. After identifying the different soils/landform types on the photos, these should be taken to the field to establish the correlations between soils/landforms and species association/vegetation types. A soil auger is very useful at this point to gather additional soil information. Species of particular commercial value for which there may be a subsequent need to inventory, are also identified at this point. In many cases, existing soils/landform/vegetation classifications may be applied although these need to be thoroughly ground-truthed. Once such a scheme is found acceptable, whether newly developed or adapted from past use, the forest area may be mapped. This map will also include all of the significant features.

If accurate estimates of standing volume are not necessary, and if there are no particular inventory needs for high-value species, then simple cutting trials in representative stands of each soils/landform/species association should provide adequate estimates of standing volume that can be harvested under different cutting regimes. If map units are heterogeneous, one may want to select well, medium, and poorly stocked examples to provide a range of volumes. One will probably want to limit these cutting trials to accessible stands of commercial potential. Because the number of blocks cut will probably be small, they should be selected subjectively (not randomly) to be representative of the type to be sampled.

If no aerial photography of the forest can be obtained, one will have to gather all of the data for assessing the forest on the ground. If the soils/landform/species association maps are done from old and/or small-scale aerial photography, then information on stand condition will still have to be gathered on the ground. Probably the best way to gather this information is to run systematic, parallel transects with a hand-held compass, and make observations or sample measurements at fixed intervals along the transects. Distances along the transects may be measured by pacing or with a tape. Nearly full visual coverage of most forests can be achieved if the transects are no more than 100 meters apart.

Observations and measurements along the transects must be determined as a function of the information needs previously defined for managing the forest. They should be kept as simple as possible. Some types of observations should be recorded at whatever point along the transect they occur. Examples include changes in cover type, presence of eroded areas, paths or roads, stream crossings, and fields. Other data that is to be collected as samples subject to statistical analysis should be collected at fixed intervals along the transects. In the unusual situation where appropriate local volume tables exist, one may want to perform a classic forest inventory with sample plots spaced out along the transects.

Satellite Assessment Techniques

Satellite imagery offers a new tool for extensive forest resources assessment. There are two principal types of land resources imagery currently available—the American Landsat MSS imagery and the French SPOT imagery. Both can provide repetitive, multi-spectral, small-scale, large-area coverage useful for extensive surveys. Data can be purchased as either hard-copy "photographs" or on computer compatible tapes (CCTs). It takes about nine SPOT images to cover the same area as one MSS image; the cost per image for each type is roughly the same.

SPOT imagery provides much better spatial detail than MSS imagery; a SPOT multi-spectral image is composed of picture elements (pixels) 20 x 20 m on a side while an MSS pixel is 79 m on a side. With SPOT imagery recorded after crop harvest, one can generally distinguish individual farm fields. One usually cannot with MSS imagery, but with optimal hard-copy images, one can classify areas into about four categories of forest—agriculture mix (uninhabited, low-, medium-, and high-density agriculture).

Neither SPOT nor MSS images are of much use in distinguishing directly between natural forest types by their spectral response. The use of satellite imagery for vegetation analysis is subject to many of the same constraints as is aerial photography but without the benefit of the high resolution detail of aerial photographs. Basic soils/landform units can, however, often be interpreted from satellite imagery. Soils/landform units generally correlate well with typical species associations and with forest productivity.

Satellite imagery finds its greatest use in the dry zones in simply distinguishing between forest and non-forest. Given the very rapid rate of loss of natural forest land in many dry areas, satellite imagery provides one method of monitoring this change and providing an update of approximate forest cover.

A word of caution—with satellite imagery, it is very easy to be fooled into believing that one can distinguish more than is really possible. In the Sahelian countries, the early dry season is the optimal period for obtaining imagery, but it is far from ideal. At this time, the savanna grasses are dying, and their spectral response (reflectance) varies wildly. Color composite images display a wide variety of colors for natural forest types that correspond to nothing more than slight differences in the phenological (greeness) condition of the grasses. Use of satellite imagery for vegetation mapping in dry zones must be done by a well-qualified interpreter experienced with the peculiarities of such zones. Even then, ground-truthing is almost always essential for a meaningful interpretation.

Other Techniques

Other techniques for assessing natural forest lands include low-altitude visual observations from the air, low altitude; hand-held oblique photographs; and small format, vertical aerial photography. (Box 13 discusses examples of techniques used in Burkina Faso.)

Low-altitude overflights. For a preliminary reconnaissance of large areas, or of areas of difficult access, low-altitude visual observations from a fixed-wing plane (or helicopter) can be very valuable. Flying heights of 100 m to 1,000 m above ground level are best. One should carefully plan the itinerary in advance and bring along selected topographic maps and/or aerial photographs as navigational aids. It is easiest to follow roads and stream courses wherever possible. Members of the local flying club are often willing to charter a small plane.

Observations can be most efficiently recorded directly on the maps and photographs or on clear plastic overlays with an indelible filter tip marker with a medium or fine tip. Types of information that can easily be made from the air include the following:

- the presence of fields or dwellings within the forest;
- access roads and trails used by commercial woodcutters/transporters;
- cattle trails, evidence of overgrazing or eroded areas; and
- major vegetation types and sometimes species identification.

Low-altitude, oblique, hand-held photography. Oblique photographs can easily be taken through an airplane window with a 35 mm or similar camera and are an obvious complement to visual observations. Low-altitude obliques can be a very efficient, low-cost method of obtaining the reference data needed for forest cover-type mapping, especially for large areas of difficult access. Color slides or color prints are generally most useful. When taken from 100 to 200 m above ground level, one can distinguish between shrub savanna, tree savanna, woodlands, and grasslands on the obliques. Many other features can also be detected.

As an aid to vegetation mapping, obliques are virtually useless if one cannot locate them precisely on the image or photograph to be interpreted. The oblique photos should either be taken with identifiable features such as roads, streams, hills, and buttes included or should be indexed very carefully on maps or aerial photographs at the moment they are taken. High obliques with the horizon just visible are much easier to locate than low obliques. Easily identifiable photo points can be preselected before the flight, or representative points can be selected from the air. The location and direction of each oblique should be marked on an index map as soon as possible after the photos are developed while details of the flight are still fresh in one's mind.

Small format, vertical aerial photography. Small format 35 mm or 70 mm aerial photographic systems can be highly versatile tools for vegetation and natural resource assessments (Meyer 1973). They were developed in the U.S. primarily to make it possible for the natural resource professionals in the field to plan and to execute their own aerial photography. They have been used relatively little in Africa to date, but could become very useful if natural forest management becomes a major activity.

With three basic lenses, a wide angle, a standard, and a telephoto lens, one can obtain aerial photographs that vary from about 1:2000 to 1:100,000 scale with a variety of emulsions. A window mount is available for 35 mm cameras; belly mounts are available for both 35 mm and 70 mm cameras. Small format photography is generally not suitable for precise quantitative measurements, but is excellent for qualitative information needs such as for vegetation and soils mapping.

Resource Assessment Issues

Assessments versus action. One of the principal issues regarding resource assessments concerns the amount of assessment and inventory information that is needed before it is proper to proceed on an operational scale. This has already been discussed under assessment goals where it was argued that it is generally much more important to concentrate on developing biologically and economically viable NFM techniques than to gather more accurate information. Information on the characteristics of the unmanaged forest is of far less interest than information to be developed on the managed forest. Since people are just beginning to learn how to manage the forest, it is difficult to predict what management techniques will work on an **operational** scale by doing assessments.

Who should do needed research? A second issue concerns who should conduct the research that is needed to accompany NFM development, particularly long-term growth studies to quantify the effect of different interventions. There are no international forestry research organizations presently conducting such research. National agronomic or scientific and technical research institutes generally have very uncertain, inadequate operational budgets, may lack qualified researchers, and have a poor record on applied research. The national forest services may have a much better vision of what the research needs are, but generally lack qualified researchers. Projects can generally supply the financial and human resources, but rarely last long enough to complete the long-term studies that are needed.

Assessing/quantifying non-wood forest products. There are a host of inventory/assessment techniques to be developed for non-wood forest products. How does one estimate the gum arabic production from *Acacia senegal* or the amount of fruit that can be produced from *Zizyphus mauritiana*? What is the sustainable production of bark for fiber from baobab trees (*Adansonia digitata*) or of palm fronds for basket and mats from the doum palm (*Hyphaene thebaica*).

Box 13. Selection of Priority Areas for Natural Forest Management in Burkina Faso

In 1988 and 1989, the Ministry of Environment and Tourism in Burkina Faso developed urban fuelwood supply strategies for the cities of Ouagadougou, Koudougou, Bobo-Dioulasso, and Ouahigouya with the assistance of the World Bank's Energy Sector Management Assistance Program (ESMAP). A preliminary analysis pointed strongly toward NFM as a keystone for energy supply strategies, but existing forest cover maps had been rendered useless by large-scale changes in the natural forest cover due primarily to land clearing for agricultural expansion. One could not answer the question, "Where are the forests?"

Preliminary fuelwood supply zone maps were prepared at a national meeting of provincial forestry directors; these maps were continually refined from field observations and discussions with wood transporters, district foresters, and others. A four-hour, low-altitude overflight was made over the main wood supply zones of Ouagadougou and Koudougou and over 70 high oblique, 35 mm color aerial photographs were taken from the plane. The position of each was marked on a topographic map along with other observations. The overflight strongly confirmed the need for new forest cover maps.

New forest cover maps of the supply zones were prepared from manual interpretation of 12 early dry-season 1987, 1:500,000-scale Landsat MSS color composite hard-copy images. The oblique prints complemented by field observations were used for reference data to interpret the imagery. The principal natural forest classes identified were unoccupied forest and two mixed classes of natural forest with low- and medium-density agricultural land use. Principal roads, streams, forest reserves, villages, and forestry posts were added to the maps.

It was out of the question to perform a new forest inventory on the ground; estimates of standing volume were based on results of a national forest inventory that had been done in 1982. The area of each map unit was measured with polar and electronic planimeters. High and low per-hectare standing volume estimates were based on 100 percent and 50 percent of the average standing volumes for each area from the 1982 inventory. Natural forest areas with low- and medium-density agricultural use were assumed to have 2/3 and 1/3, respectively, of the standing volumes of unoccupied natural forest. Productivity estimates were based on Clement's (1982) regression equation for Sahelian natural forest productivity (for unmanaged stands) as a function of rainfall. Post-1967 rainfall averages were used as more indicative of the extended period of drought that has prevailed.

It was found that the remaining natural forest land represents very sizable, but finite, resources, that, **if managed**, could supply a large part of the energy needs of all four cities on a sustainable basis over the next 10 to 20 years. Criteria were then developed for the selection of priority areas for NFM pilot projects. Using the forest cover maps, these criteria were applied, and priority zones for each city were printed onto the final draft of the maps produced.

Organizing for Participation

Encouraging participation of local populations in the management of natural forests is usually a complex and long-term process. The key to all efforts at natural forest management based on popular participation lies in the development of resource governance systems that make management or support for management activities attractive to a very large proportion of actual and potential users of the forest. This requires as much attention to governance institutions and management organizations as to forest management techniques. Incentives promoting forest governance and management may be both positive and negative. For instance, penalties may actually be imposed for violating regulations prohibiting harvesting of forest or products from a natural forest during closed seasons. These sanctions, if reliable, are one sort of negative incentive that may encourage users to coordinate their harvesting activities and so enhance productivity of the forest. If users enjoy enforceable rights to harvest products, or share in products harvested, these will be viewed as positive incentives if the products have consumptive use or market value.

This section discusses the problems of promoting popular participation in natural forest governance and management in terms of strategies to encourage participation, and criteria for evaluating the success of any given effort to encourage participation in forest governance and management. The section focuses primarily on institutional considerations rather than on technical ones.

Institutions, as the term is used here, are sets of rules that order human behavior, whether the rules are written or unwritten, produced by the central government or by local people, formal or informal. Organizations are one form of institution, but so are land-tenure rules and dispute resolution procedures. In this sense, land-tenure rules that people apply in a particular area make up an institution, as do the rules of a cooperative organization or a forest products market through which goods produced by a natural forest are harvested and sold. Organizations such as local moots or trial-and-appeals-level courts in the national system are also institutions.

Strategies to Encourage Participation

Participation in forest governance and management can be promoted in many ways. The range of possible strategies is quite large. One strategy might involve technicians establishing management techniques and organizations. Local people are then required to adapt their behavior to fit with the requirements of these imposed structures and techniques. At the other end of the range, a strategy stressing the importance of locally specific time-and-place information might emphasize local management organizations and techniques as the starting point for all activities. Technicians, rather than determining the entire management system, would have to adapt their approaches to these local givens. Intermediate strategies might involve combinations of local forest governance systems and management techniques, complemented by foresters' tested technical knowledge.

An important point to remember at the project design and modification stages is that no one approach can be automatically assumed to be superior to all others. Experience in a specific context and evaluation criteria established by the goals of the natural forest management operation (e.g., sustainability, efficiency, and equity) provide the only real measures of success of a given technique. However, this is of little practical use to anyone charged with designing a natural forest management operation. For this reason, the remainder of this section suggests and explores factors that the designers of governance and management institutions and management techniques should consider in proposing activities.

Various elements should be considered in trying to discover or design durable institutions for natural forest management operations. These include the character and productivity of the woodstock targeted for management; the supply/demand conditions for the forest and non-wood products it generates, or could produce; users' attitudes and practices concerning woodstock governance and management; the techniques that local people use to manage woodstocks, including slash-and-burn and fallowing; and thorough knowledge of the institutions that may be able to carry out forestry management activities or affect them.

As a general principle, it is easier for people to undertake activities that require them to learn little and rely instead on what they already know than those where they have to learn to do unfamiliar things. It is easier for people to bring to bear what they know about local time-and-place conditions if they can do so through the context of existing, functioning, local institutions than if they have to master wholly new behavior and rules of organization. In this sense, existing local institutions that are going concerns represent a very important form of social capital. If natural forest management activities can be executed through such institutions, or through institutional forms that local people know how to develop and maintain, much time, effort, and money can be saved. By contrast, to the extent that new institutional forms have to be created and mastered by forest users and others, both error and failure rates will be higher. Furthermore, local people will feel more confident of their ability to assess the risks of modifying existing institutions than through initially ill-understood, "foreign" institutions.

Authority to Govern and Manage Natural Forests

It is useful to remember that authority to initiate and continue natural forest governance and management activities is rarely centered exclusively at the local level. If anything, the opposite is true: authority is centered at the national level. In some countries, management authority has been deconcentrated to technicians—foresters—in sub-national units of the administrative hierarchy. Such deconcentration in no way ensures local people of authority over woodstocks. Local people may or may not have any say about whether a particular area of woodstock will be targeted for natural forest management. They may or may not have any authority to determine forest management rules, whether or not they have the indigenous or exogenous technical knowledge to manage a woodstock effectively.

An important first step in designing participatory governance and management institutions for natural forest parcels is to determine exactly who has what kinds of *de facto* and *de jure* authority over such activities. **The following list of issues** to be addressed is not exhaustive, but it can be assumed that failure to address the issues on the list will greatly increase the chances of a collapse in governance and management systems.

- Who controls the land where the natural forest is located?
- Who controls the woodstock (ligneous or woody materials, including bushes as well as trees) in the parcel?
- Who controls the non-wood products harvested from the parcel?
- Who uses the natural forest and for what purposes?
- Who has authority to make and change rules concerning access to and harvesting of parcel forest and non-wood forest products?
- Can local people change governance or management rules on their own initiative, or do they have to seek outside approval for changes?
- What are the transaction costs—the time, energy, and money—involved in changing different sorts of rules at different levels in the system?
- Who has authority to apply rules concerning access to and harvesting of wood and non-wood products, and how difficult is it for a guard or a co-owner of a natural forest to get assistance in applying the rules in cases of infraction?
- Who has authority to mobilize resources necessary to ensure that natural forest access and use rules are enforced reliably, e.g., policing the parcel during closed and open seasons, collecting and distributing user fees (permits, licenses, taxes), and accounting of labor, materials, and cash provided?

If local people have little authority in any of these areas, it will be difficult for them to insist that their interests be taken into account. Even if they have considerable authority in some areas, (e.g., rule making and rule application), but lack the authority to mobilize resources necessary to finance the operations of the forest governance and management units, chances of failure increase significantly. Realistic planning will be based on a close knowledge of these constraints. The most realistic in many cases may be that participatory governance and management are not possible because current policies make the costs to local people too high.

If local people do enjoy considerable degrees of authority over these issues, they can be expected, if the prospect of managing a natural forest interests them, to provide the sort of feedback and exercise the vetoes necessary to ensure that their interests are taken into account. It is also likely, where they have incentives, to help design governance and management institutions, coupled with the capacity to veto proposals considered inappropriate by those who make decisions within local communities, that known local institutions or local institutional models will be incorporated into governance and management institutions.

Dispute Resolution

Disputes are to be expected in the development and maintenance of natural forest governance and management systems. Two general problems are important in this context: who resolves disputes, and who provides enforcement when local social pressure is inadequate? To understand the importance of these issues, one must put oneself in the position of a member of a natural forest management unit. Officials, whether local/traditional, religious, civil servants or government judges, who usually decide disputes concerning the natural forest may make decisions in an impartial and equitable manner. If so, then except for the differential costs of pursuing a suit within the local area or taking it to a government office somewhere, it may make little difference who actually decides a case. On the other hand, if members of the forest governance and management unit believe that some judges are more concerned with fairness or even-handed decision-making than others, who decides a case may have a decided impact on the future possibilities for successful management of the natural forest. If members cannot themselves have a say in who decides how disputes will be resolved, they may conclude that the risks of adverse decisions are so high, in terms of losing control over the forest or its products, that they lose interest in the whole idea.

Those working with local people to design natural forest management units will want to explore these issues fully with them. If local forest users do not have clear ideas on these issues, or are reluctant to discuss them, it may be useful to suggest a range of different dispute resolution processes and options. Once local people have had a chance to consider these issues, they may want to exercise a larger say on the question.

Evaluation Criteria

Considering the designs of natural forest governance and management institutions in light of possible evaluation criteria may be a useful way of thinking about those institutions and what is necessary to make them work in a specific context. **Sustainability** is an important criteria if a goal of the natural forest management operation is to perpetuate a particular woodstock as a source of a continuing flow of benefits—goods and services. In some cases, sustainability will not be the overriding goal, for instance, because of the gradual spread of rainfed agriculture into a wooded area. Where sustainability is a criteria, it should be evaluated not merely in terms of the perpetuation of a flow of goods and services from the managed woodstock, but also in terms of the capacity of management organizations to persist over time, given the surrounding institutional context.

Existing or proposed governance and management institutions should be examined to see where they are vulnerable to break-down. Are the operational rules of management systems enforceable at a cost acceptable to members? Are the rules adopted by the governance unit for making operational rules sustainable? Can the resources necessary to make the management system work be mobilized on a reliable basis? Who will have to provide the resources? Is the governance unit self-sufficient in terms of taxing power, or does it depend on permission or authorization from other governmental units? Can disputes about the forest or its products be resolved in a satisfactory manner?

Whenever the answers to these questions are negative, or not clear, it is an indication that the institutions may be fragile. If local people do not, or will not support them, then sustainable management may be a nice idea, but it will probably not be a practical one.

Another common criteria for evaluation is **equity**. Examples exist of efforts to preserve natural forests by declaring them common property resources under a given management regime, and then limiting access and off-take rates. In the process, some individuals and groups accustomed to using the natural forest resource for various purposes may be prohibited from continuing to use the resource in the same manner. This may have important implications for sustainability, particularly if excluded former users are heavily dependent for their survival on the resource and will violate new management regulations to defend their rights or meet basic needs. The conflicts that result from these interactions may make it extraordinarily difficult to sustain the woodstock resource.

If local people and forest users think a forest management system is not fair, then they are unlikely to support it. This may mean that enforcement of use regulations, even if supported by those who benefit, may be inadequate to protect the forest. Generally, management requires "co-production" of enforcement; that is, officials cannot do the job alone, but must rely on users for assistance in making sure that everyone understands and respects use regulations. Those users who consider regulations unfair are unlikely to co-produce enforcement.

The role of women as users of forest products and as potential managers of forest products may be critical. If local men dominate local input to the design and modification of natural forest management institutions, they may well give little weight to women's concerns. If women are responsible for collecting firewood and other forest products, and find themselves excluded from former harvesting areas now under management, then they may be unwilling to cooperate in management. The consequences may be devastating for woodstock sustainability.

Another group very likely to be marginalized by natural forest management efforts are pastoralists. Their forest-use patterns must be taken into account, and provision made for their continued use. Measures may also be required to share the burdens of reduced access to forest forage, if some areas are placed off-limits on a temporary basis. Involving pastoralists in designing forest governance and management operations may complicate the process considerably. On the other hand, pastoralists may be extraordinarily good co-enforcers of management regulations since they have a continuing interest in maintaining woodstock on the ground where their animals can get access to it.

Another common criteria is **efficiency**. Efficiency in resource use can be measured in several ways. Two of these are frequently used. The first evaluates inputs required to achieve a given level of output--the amount of time, effort, and money invested in managing a natural resource to achieve a given output level of goods and services. Another approach to measurement holds the input level-time, effort, and money-constant and measures the output achieved through different combinations of management techniques, organizations, and institutions.

When one remembers that most rural Africans survive on a fairly narrow margin, it is clear that efficient governance and management systems may be sustainable and therefore attractive to users. Those same people may simply not be able to afford governance and management systems that are inefficient and require additional resources to achieve the same ends. For this reason, it is essential that local users offer their ideas on how to design management systems that will be efficient in local terms. If it is clear that innovations that increase system efficiency are welcomed, local people may become quite helpful in creating natural forest management systems over time that not only are sustainable, but leave them much better off.

Economics and Natural Forest Management

Technical, biological, and sociological prescriptions for the local environment are cornerstones for natural resource management. Many technically correct projects and activities in sub-Saharan Africa have failed or simply not been able to get off the ground because a third component, the economic aspects of the project, was not properly considered.

Economic and financial analyses are tools for examining the costs and benefits associated with natural resources management activities. When properly implemented, they can be a powerful investment planning instrument for the natural resource manager. These analyses can help establish a process whereby the manager can see what, how many, and when inputs will be required. In addition, a general view can be established early in the planning process of the expected benefits from the natural resources activity—what the quantities of benefits are apt to be, and when they will occur. With this information, decisions about the investment of project resources can be made more wisely and planning with the local population will be better focused with more realistic expectations.

In a larger context for the policy analyst and the government decision maker, a more rigorous economic framework will help to reveal weaknesses in the current natural resources policy. Too often, for example, forest products are undervalued leading to excessive exploitation, forest degradation, and often deforestation, meaning a loss of economic value to the local community/region and environmental damage. When these products are undervalued, it also means that there are insufficient returns to the local population and there is little or no incentive to be proper stewards of the resource. As a result, the degradation of the resource continues with little hope for amelioration or compensation.

Because data collection in developing African countries has often not been an exact science, the information used in economic and financial analyses of natural resource management activities is, at first, only relative and will probably only reflect orders of magnitude. As the natural resource manager gains more experience and the data becomes more refined, the benefits and gains for the local population can be more predictable.

At the very least, economic and financial analysis can provide a context whereby the resource manager can make decisions to more efficiently allocate costly inputs to the activity (or among activities) to maximize benefits. To be successful, natural resource management needs to have economic analysis as an integrated component from the time that the activity is conceived and as an integral part of the local population's management plan as it assumes control of the activity.

Past use of economic data. Too often economics has been applied to natural resource activities only as an evaluation tool, or in the classical accounting sense, to keep track of project-related expenditures. Under these circumstances, the emphasis on the activity's costs is often skewed toward the initial start-up expenses. These include direct investment expenditures such as satellite imagery, land-use mapping, resource inventory, and project office construction which are necessary to provide the technical grounding and infrastructure for the long-term management of the resource. However, little attention or weight is given to the recurrent costs associated with the activity. Fuel consumption of the motorcycles used by extension agents, camels required to patrol the forest being managed, the labor needed to collect grass seed and then plant it on hand-constructed water-catchments are all examples of costs that can occur repeatedly as an activity continues.

Project experience indicates that these latter costs are usually only presented as estimates prior to the start-up of a particular activity—the costs of actually doing the activity over time remain unknown. Accurate record keeping and monitoring of such costs often show large differences between what has been estimated and the real costs. Information on these recurring activities is critical as they represent the minimum costs necessary to maintain the activity. In combination with benefits from the activity, it is the local population's ability/desire to carry the burden of these recurring costs that usually determines whether or not the activity is sustainable and therefore successful.

Resource managers generally find project activity benefits more difficult to calculate and measure than the costs. Because they are dependent on biological and management processes, benefits from activities don't usually begin until several years after the project has started. This often means that project managers/planners need to rely on estimates based on similar experiences and circumstances that have happened elsewhere. Actual outputs from the activity are also likely to be different from the predictions. However, real and experiential data on the land use on the site, environmental conditions, and the local economy can help the resource manager to predict a range of benefits that may result due to these activities. Accurate records of production data and monitoring systems to detect changes can assist the manager in determining whether the activities' estimated benefits are indeed the real ones.

The objective of this section is to provide the resource manager with a framework and guidelines for getting the best information possible on the costs and production benefits associated with NRM activities, and to underscore the importance of data sources and record keeping. The emphasis of the section will be on financial analysis, including how costs are allocated and benefits accrue to a natural resource activity(ies). The mechanics of the analyses are illustrated with examples from ongoing projects and activities.

Economic analyses are also important for the natural resource manager to understand—particularly as projects are part of a larger program, or as government policy impacts on the way local populations make decisions about particular natural resource activities. These issues will be discussed briefly at the end of the section and at specific points in the text to illustrate how a particular national program affects a given activity.

Putting Some Basic Parameters In Context

"How much does it cost?" "Will the resources expended doing the activity be outweighed by the benefits to the local community?" These are common questions asked of and by resource managers concerned about the worthiness of a particular activity.

A natural resource management activity is most apt to be successful if it is "economically viable." This basically means that the benefits that can be obtained from doing the activity outweigh the costs. For the local people participating (whether as individuals or as a cooperative entity) in the activity, this means that there is something in it for them. In order to provide their labor to plant trees, cut fuelwood, or keep their sheep and goats from grazing in an area they traditionally use, they must realize compensation that is worth more than the time and effort they contributed to plant trees, or cut fuelwood, or the difficulty caused them by having to go further in search of fodder for their animals. The basic perspective is local. Natural resource management activity costs and benefits need to be examined from the perspective of the people who are involved in and stand to absorb the production trade-offs, and ultimately, to benefit from the activity.

Some management activities, such as fuelwood harvesting, incur direct costs like labor, but bring almost immediate returns if there is a nearby market. Site restoration activities done to reduce erosion and/or increase range productivity, may require, in addition to direct labor and material procurement costs, some type of investment inputs from the local community. This investment might be in the form of grazing rights that are foregone because the treated area is off limits to domestic livestock. It might be the collection of traditional forest products from the zone is banned for a specified period while the area is being rehabilitated via natural regeneration or enrichment plantings.

Longer-term investments might be required of the local population in instances where trees are planted. In this situation, traditional activities on the site may be limited and eventually curtailed in order to protect the new investment (trees that are planted). Regardless of the investment period, local people must be convinced that the opportunities and traditional benefits that they have been asked to give up will, be outweighed by the benefits that they will receive as a result of their investment sacrifices.

Natural resource management activities with the most immediate benefits are the ones generally preferred by local villagers (see Box 14). If the benefits are substantial, the surplus could be sold to support the costs of the activities that have benefits that will accrue later on. To the farmer, when the benefits occur are often more important than how much they are.

Keeping the local perspective also means that changes and adaptations to technical approaches may also have to occur. Making modifications to an alternative which might change the costs, or result in a different level of production, are certainly more acceptable if it means the difference in getting villagers to participate in an activity.

Box 14. The Andropogon Incentive

Fulani villagers in Niger did not hesitate to work on microsite restoration within the boundaries of a natural forest even though it meant contributing hours of hard physical labor constructing earth berms and planting perennial grasses and tree seedlings. The earth berms were to capture and hold water for the trees planted behind them; the grasses were to help stabilize the berms. The planted trees, although indigenous to the area, were intended as enrichment plantings and as biodiversity insurance. In three or four years, they were expected to begin providing the local population with dyes, medicinal products, and animal forage.

It was the grasses, however, that provided the Fulanis with the incentive to participate. The grass, *Andropogon gayanus*, had all but disappeared from the area and for the Fulanis it is one of the most important resources in their culture. The primary use is for woven mats which are used in constructing walls and roofs of their houses, and for protection when eating, sitting, or sleeping on the ground. Because of the village's proximity to Niamey, the capital, the *Andropogon* is also a traded commodity that could provide cash for families. In this instance, the benefit was direct and almost immediate with the first harvest coming within a year of planting.

Current management calls for continued planting (by clump or direct seeding) of the grass in all of the forest's compartments. (In addition to natural seeding, residual clumps, if not grazed too heavily, would expand over the site.) After the first year's experience, local villagers were excited about continuing the management activity in anticipation of the benefits they will receive from it (Dennison 1990, Hopkins 1989).

A good example is when farmers on the Central Plateau in Burkina Faso were presented with a water-harvesting technique by a local project (Wright and Bonkoungou 1984). In order to slow down erosion on farmers' fields, the initial technical prescription called for earth and rock bunds to be built on contours across the site, often irrespective of field ownership or boundaries. Farmers became familiar with the technique and gained confidence in it through the demonstration process. The rate at which they adopted the technique increased, however, when they learned that the project was not rigid in the prescription. Spacing between the bunds varied, as did the number on a field. Most villagers chose to construct the barriers field by field rather than on a larger unit (such as a watershed). These adaptations are probably reflective of their intuitive judgement about the amount of labor they wanted to expend versus the probable increases in production from their fields. The farmers also chose to build a few barriers widely spaced in a field rather than building them in one portion of their field. With this technique, they were able to reduce erosion on the entire plot. In subsequent years, they were observed to increase the number of bunds in their fields until the desired spacing was attained.

The widespread adoption of this modified technique throughout Burkina Faso seven years after its introduction is extraordinary. Farmers have adapted the principle to conform to their own immediate labor and material constraints, and many villagers are reporting benefits of more grain production, richer topsoils, and less erosion (McKay, et al. 1990). In the more severely degraded areas of the country, bi-laterally funded projects and rural extension services use the technique as a cornerstone in conjunction with other land/resources management activities (Denev, et al. 1990).

In addition to costs and activity benefit information that need to be monitored are other extraneous local factors that can't be measured, but are also important in any financial and economic analysis. Villagers, farmers, missionaries, personnel from other projects, and others can all provide valuable information about past land use, the rate of environmental degradation in an area, or whether a certain part of a forest has religious significance. These and other types of **qualitative** information are not directly measurable, but they may have an impact on what activities can be undertaken, or what modifications might need to be considered to properly manage the resource.

Assessing Management Activity Inputs and Costs

Getting the price for hand tools that need to be purchased to do site restoration or enrichment planting on a natural forest site is a comparatively easy task for the resource manager. Knowing how many of them will be needed to accomplish the work effectively, and how often they will need to be replaced is not. Similarly, obtaining the daily wage for a laborer to work on an activity is also relatively easy to get or to calculate. Determining how much work the person can do in a day for each task is more difficult. Each of these processes are necessary parts of understanding the true costs of an activity. To present an accurate picture, the resource manager needs to define all the inputs required to do an activity and provide cost estimates for each input. Box 15 illustrates a sample checklist of some inputs that might be associated with natural forest management activities. This section discusses a number of important points that need to be considered when assessing management inputs such as those in the sample checklist. Emphasis is also given to the importance of developing a monitoring system to track the costs attached to each input unit. Several examples are included to illustrate these concepts.

The preliminary inputs that are required to initiate a NRM activity (or activities) are usually the most costly in the financial sense. Often these are one-time inputs (some of these are listed in the first column in Box 15) and are usually (and properly) borne by a donor and/or the government. Other direct investment inputs, that are often administrative in nature, such as vehicle purchases and staff training, are also usually paid for by a third party. Although these are real costs of operating and running the project for which the natural resource manager is responsible, they will not be considered in this discussion. It is the inputs that will be required over the long term that must be met consistently with local resources if the activity is to be sustainable. These are the recurrent costs and are the primary focus of this natural resource management cost discussion.

Actual costs for doing a particular activity can vary from site to site. Earth "banquettes" (contour ridges) reinforced with rocks will have different costs depending on how far the rocks have to be moved, and whether they are carried in by hand or transported on a donkey cart. More stability (at an increased cost) is added when grasses and trees are planted on and behind the banquettes. If the costs are recorded per unit area (e.g., per hectare) variation is also apt to occur depending on the activity being implemented. The numbers of banquettes required, for example, to stabilize a site against erosion, is a function of the site's slope (more are needed on steeper slopes). In another situation, microsite variations often result in different natural densities of tree species which will affect how much of a replenishment planting is needed, or the rate at which a woodcutter can remove fuelwood. Both of these, the type and degree of difficulty of the activity being done, and the rate of application (the number of times, or the quantity) per unit area have direct effects on the costs and benefits of the activity.

Box 15. A Sample Checklist of Some Forest Management Inputs*

PRELIMINARY COSTS		IMPLEMENTATION COSTS		
Material Purchases	**Administrative**	**Protection**	**Improvement**	**Local Integration**
Satellite imagery Aerial photography Office construction/furnishing Vehicles **Labor** Forest boundary demarcation Imagery/photo interpretation & mapping **Administration** Villager/farmer meetings Staffing	Office, structures maintenance Training programs Labor services for: -- forest resource inventory** -- management plan preparation --annual work plans -- road construction and maintenance Staff salaries -- controller/woodyard manager -- extension agent -- forest manager -- support staff Vehicles, general -- purchase -- fuel/maintenance ***possibly a preliminary cost*	Forest guards -- salaries -- housing -- vehicles --vehicle maintenance Fencing Fire lane construction and maintenance -- hired labor -- fire-fighting tools	Central nursery -- construction -- foreman salary -- worker salaries -- materials purchase -- seed collection Fertilizer purchase Grass seed purchase Miscellaneous tools Heavy equipment rental Labor services for: -- work crew foremen -- tree planting--microsite improvement (Vs, diguettes, stone dikes, etc.)	Local Integration Extension agent(s) salary(ies) Local market surveys Local management group operation

*** Not all inputs are appropriate or necessary in all circumstances*

When costs are monitored it is also important to note the assumptions that are used to calculate them. For example, the cost of constructing banquettes may be recorded as 200 francs per meter. It needs to be stated, however, whether or not the banquettes are totally constructed from materials present at the site, or if construction materials are carried in. If they are brought in, transport is an additional cost to the activity that has to be accounted for. The same is true for the subtle difference of "trenching" the banquettes. Building the banquette directly on the soil surface requires less time and is hence less costly than the recommended practice of first digging a shallow trench along the contour and then building the banquette in the trench.

Maintenance and repair costs associated with the activity also should not be neglected by the resource manager in his analysis of an activity. In the example just given, the simple banquette constructed directly on the soil surface is apt to wash out more often, thus requiring more labor time and higher costs to repair than the sturdier banquette that had the higher initial construction costs. Table 6 illustrates some parameters used in estimating costs of banquette construction on the Dogon Plateau in Mali.

Table 6. Labor Cost Parameters for Earth and Rock Banquettes on the Dogon Plateau, Mali

Inputs	Raw materials on hand	Raw materials not on hand
Material provided by mining & transport	--	2.7 m/day
Rate of construction[1]	30.0 m/day	30.0 m/day
No. meters needed per hectare(ha)	300	300
No. labor days/ha	10	142
Daily labor rate[2]	135 FCFA[3]	135 FCFA
Total construction cost/hectare	1,350 FCFA	19,170 FCFA
Maintenance labor	8 days/ha/yr	8 days/ha/yr
Recurrent cost	1,080 FCFA/yr	1,080 FCFA/yr

Adapted from: Christophersen 1988b

[1]Construction includes locating contour lines, digging shallow trenches, placing rocks, and sealing spaces in the banquette with dirt.

[2]These are dry-season rates which are 30% of the rainy season rate.

[3]Exchange rate (Oct 90): 250 FCFA = 1.00 US Dollar.

Table 6 also shows that in the instance where raw materials need to be brought to the site, most of the labor time is in the mining and transport of the rock. This brings up another cost factor that the manager needs to be aware of when conducting natural resource activities with the local population: labor availability. In the Dogon Plateau example, 142 days of labor will be required for every 300 hectares that need to be treated with banquettes. If the work is done during periods when labor is plentiful, this should not be a problem. If it is the men who traditionally do this type of activity, and they are elsewhere in search of more gainful employment during the dry season, or it is close to the planting season, alternative plans may have to be made. (Alternative plans might include paying them a little more to prevent them from searching elsewhere for work; hiring laborers from outside the local area; or perhaps even paying the women to do the work if tradition allows it.) Labor constraints and costs play a predominant role in the planning of most participatory natural resource management plans. Input analyses (such as the one in Table 6) allow the resource manager to see where his cost constraints will be in the management process so that plans can be made accordingly. Box 16 examines another example of labor cost calculations associated with a natural resources management alternative that calls for enrichment plantings in the forest, and annual maintenance of the plantings.

Protection of the resource is another important recurrent cost component common to most natural resource management plans. The degree and intensity of the protection varies on a case-by-case basis. Perimeter fencing around a resource is probably the most intensive, and often ineffective, type of protection. The other extreme is where the only control or guarding done is that carried out by the local people. The latter situation requires a considerable amount of understanding about resource management on the part of the surrounding villagers, and an equal amount of cooperation from everyone with an interest in the resource. In the initial stages of the management process, this approach to protection will probably require considerable time (a cost) on everyone's part, and negotiating skills on the part of the resource manager.

Protection activities in practice today usually lie somewhere between the two extremes. In Burkina Faso, a woodcutter's group informally guards natural forest land that it works on, informing the authorities when someone harvests wood without the required permit. Consequently, most of the fuelwood cut from this forest is done legally, with a cutting tax being collected by the forest service. Unfortunately the tax collection is about the extent of the government's involvement in this instance. There is still no management plan for the forest and the woodcutter's group is operating without a cutting plan and without guidelines for protection and regeneration. Their annual removals probably surpass the annual growth of their forest (Catterson, et al. 1990).

In the Nazinon National Forest, in another part of Burkina Faso, more intensive protection is conducted under a management plan. In this instance, most of the activity is focused on protection against the serious wildfire problem in the grass and shrub savannah zone where the forest is located (Soto Flandez and Dilema 1989). Management staff in this instance are concerned with the number of special crews that need to be trained (and retrained) in firefighting and prescribed burning. Other major protection cost items that need to be considered include the construction of firebreaks and firetowers located throughout the forest. In addition to the manpower/staffing costs associated with the protection activity, special firefighting tools and equipment (including periodic replacement) also are important inputs that have to be included in the forest manager's cost analysis of the activity.

In Niger on the Guesselbodi National Forest, fire does not pose the same threat to the resource that it does at Nazinon; consequently, protection inputs and costs are different. Box 17 illustrates the protection parameters required for Guesselbodi, where the primary objective

Box 16. Hypothetical Inputs for an Enrichment Planting in a Natural Forest

A natural forest management alternative calls for maintaining and increasing the biodiversity of tree species growing on a 2,400 ha forest. An enrichment planting activity using local species grown by a local nurseryman is planned to accomplish this objective. Tree planting can only be performed by men in the month of April and it is done on the whole area in the first year of management. Weedings and thinnings of the planted species are conducted by women in January in all subsequent years.

Tree seedlings required:

The tree seedlings, planted at 12 m x 12 m spacing, can be obtained from a private nurseryman at a cost of $0.07 per seedling which includes delivery to the site.

1 ha = 10,000 m^2

No. seedlings required/ha: 10,000/12 x 12 = 70 trees/ha

Total cost/ha = $0.70 x 70 trees/ha = $4.90/ha

Total seedling cost: $4.90/ha x 2,400 ha = $11,760.

Planting labor required:

Men can dig holes and plant 50 seedlings per day. Labor costs for men in the month of April are $1.25/day.

No. days/ha = 70 trees/50 trees/day = 1.7 man days

Total cost/ha = 1.7 man days x $1.25/day = $2.18/ha

Total planting labor cost: $2.18/ha x 2,400 ha = $5,232.

Maintenance labor required:

Women can weed one hectare of enrichment plantings in four days. The labor cost for women in the month of January is $2.00 per day.

Total cost/ha = 4 days x $2.00/day = $8.00/ha

Total maintenance cost per year: $8.00 x 2,400 ha = $19,200

Total Estimated Cost in the First Year: $36,192
Total Estimated Cost in Subsequent Years:$19,200

Additional costs may be incurred if it is assumed that seedlings which die in the first one or two years are replaced. Maintenance costs would remain the same; seedling and planting costs would occur in subsequent years and would be proportional to the number of seedlings replaced. (Christophersen 1989).

Box 17. Protection Inputs at Guesselbodi

"A management program without effective control is doomed to failure," state forest managers of Niger's Guesselbodi National Forest. Forest guards are seen as a necessity to insure the continuation of management activities. Their salaries represent a recurrent cost that should eventually be paid from revenues generated from the sale of the forest's products. How many guards are needed, and what are the costs associated with their being a part of the management process at Guesselbodi?

The number of guards needed depends on the physical characteristics of the forest, the mobility of the guards, the extent to which the local population understands and respects the forest protection policy, and the number of animals (in domestic herds) that are in the area. The Guesselbodi forest is about 5,000 ha in size and divided into 10 parcels, roughly equal in area. Guards, employed two per parcel, patrol an area for a minimum of three years following a management activity (microsite restoration, enrichment planting, harvesting, etc.). The guards at Guesselbodi are from outside the region and live in dwellings in the forest constructed and maintained by the forest cooperative. Camels, which are replaced every six years, are the mode of transport for the guards. Conceptually, the annual (recurrent) inputs for this particular protection configuration are shown below for one management cycle (rotation) on the forest.

	Year									
	1	2	3	4	5	6	7	8	9	10
Input type				— Quantity required —						
Guard	2	4	6	6	6	6	6	6	6	6
Lodging	1	2	2	2	2	2	2	2	2	2
Camel purchase	2	2	2				2	2	2	
Camel saddle	2	2	2			2	2	2		
Saddle repair	2	4	6	6	6	4	4	4	6	
Camel care	2	4	6	6	6	6	6	6	6	6

The unit costs associated with each of these inputs are estimated as follows:

Guard salaries/benefits	35,000 FCFA/month
Dwellings (construction,replacement, repair)	100,000 FCFA/year
Camel purchase	150,000 FCFA/each
Camel saddle w/each camel	15,000 FCFA/each
saddle repair	5,000 FCFA/yr (when not new)
Camel care	
health maintenance	20,000 FCFA/yr
salt, misc. forage	15,000 FCFA/yr
	35,000 FCFA/yr

The estimated annual costs of the protection activity are obtained by multiplying the quantity required in each year by the unit cost of the input. The total estimated costs for the protection actvity at the Guesselbodi forest are illustrated in the cost cash flow table below.

	Year									
	1	2	3	4	5	6	7	8	9	10
Input	— 000 FCFA —									
Forest guard	840	1680	2520	2520	2520	2520	2520	2520	2520	2520
Lodging	100	200	200	200	200	200	200	200	200	200
Transport (camels)	300	300	300					300	300	300
Camel saddles	30	30	30					30	30	30
Saddle repair		10	20	30	30	30	20	20	20	30
Camel care	70	140	210	210	210	210	210	210	210	210
Estimated total cost	1340	2360	3280	2960	2960	2960	3280	3280	3280	2960

The estimated total cost represents the cost of the protection activity estimated for each year. They are only reflective, in this example, of the first ten years of management. As the population surrounding the forest becomes more involved with management activities, there should be less of a need for guards and subsequent costs would be lower (Heermans, et al. 1987).

has been rehabilitation of the degraded soil, range, and forest resources on this area close to the capital city of Niamey.

In many instances, the actual costs required of an activity are not known by the resource manager, they are inadvertently left out, or the actual costs are later found to vary considerably from the initial value that was established. Most important is a thorough understanding of the activity and a good data recording system that will allow the manager to fill in these data gaps as soon as the information becomes available. In many instances, interim values which represent the manager's best estimate under the circumstances, will suffice until better values become known.

Estimating Natural Resource Management Activity Outputs and Benefits

Questions such as: "What is the volume of fuelwood on this particular forest?" or How much fuelwood can the villagers cut each year without depleting the forest's capacity to maintain itself?" and perhaps, "What would be the annual forage production on this village's rangeland if it were better managed?" are all representative of the dilemmas confronted by resource managers as they try to make estimates about what managing the resource will (hopefully) do to improve yields.

Seeking the answers is also often one of the reasons for undertaking natural resources management projects. In any case, estimates about project outputs (benefits) are usually more difficult to obtain than those for the input side of the equation. In most sub-Saharan African countries, forest and rangeland management are relatively new concepts and production and yield data are frequently not available. There are, however, a number of alternatives and output/benefit proxies that can be explored by the resource manager.

Experiences in the Sahel (Christophersen 1989; Dennison, et al. 1990; Soto Flandez, et al. 1989) have used three different types of sources to obtain output and yield information: documented and undocumented research, and break-even analysis. Research data on crop and rangeland yields, biomass inventories, and wildlife population censuses from other studies can be used if they are similar to the management alternative being considered. These will usually be extrapolations, however, and will serve only as a first approximation for the resource manager. Site differences, annual climatic variations, and individual preferences for implementation procedures will all cause outputs to vary. As is mentioned elsewhere in this Guidebook, this paucity of "hard data" should not hinder the management process--the fundamental schemes should be implemented; the output and benefit "guesstimates" can be modified as they become available.

Other sources such as monitoring reports on projects, experienced resource technicians, farmers, and others intimately familiar with the site can be invaluable sources of non-documented yield information. The resource manager should always keep in mind that these data are primarily first-cut approximations that can be used to guide the analysis and the decision making. Being aware of the logical range of values that are possible under the existing conditions is also valuable and can be used as parameters in the sensitivity analyses (discussed later).

Finally, break-even analysis can be used to get an idea of what outputs from an activity need to be in order to justify all the activity's costs. Christophersen (1989) finds this to be the most practical approach if there are no data on yield responses to specific activities. For a natural resources management alternative that is promoting the production of *Andropogon* grasses, the resource manager will need to determine how much grass will need to be produced to justify the investments required (e.g., seed collection, clump propagation, site preparation, planting, protection). The yield estimate obtained is then compared with local knowledgeable people who are asked to give their best estimate about how much the yield of *Andropogon* will increase as a result of doing the activity. The more their estimates exceed the calculated break-even yield figure, the more likely it is that the activity is probably within the range of feasibility.

Table 7 presents data for a hypothetical situation where villagers are trying to decide whether it is worthwhile to invest in a donkey and cart to haul fuelwood to the local market. The table illustrates the types of information required by the resource manager in order to conduct a break-even investment analysis. Figure 6 presents the investment analysis of these data allowing the manager to explain to the villagers the amount of fuelwood they would need to cut given current prices.

Table 7. Cost, price, and physical input assumptions for a hypothetical fuelwood marketing investment.

Producer costs		
GOBF cutting tax	300	FCFA/stere
Woodcutter labor	600	FCFA/stere
Coop operating fund	210	FCFA/stere
Managment fund	500	FCFA/stere
Subtotal	1610	FCFA/stere
Transport costs		
Delivery labor	1000	FCFA/day
GOBF transport tax	300	FCFA/load
Other fixed costs		
Cart (1.5 stere cap.)	80000	FCFA/unit
Donkey	30000	FCFA/unit
Maint.(cart + donkey)	83000	FCFA/year
Monitor/guardian	25000	FCFA/month
Retail prices		
Official (Ouagadougou)	4320	FCFA/stere
Market (Ouagadougou)	7000	FCFA/stere
Harvestable wood		
Standing volume	3.0	m3/ha
Commercial fuelwood	1.5	m3/ha
No. steres/m3	3.2	steres/m3
No. steres fuelwood	4.8	steres/ha
Quantity harvestable	1.0	steres/manday
Miscellaneous		
No. cart trips	1.0	trips/day
Cart capacity	1.5	steres
Max no. delivery days	200	days/year
Monitor/guard worktime	12	months/year

Source: Dennison et.al 1990.

Marketing Costs		
Producer price	1610	FCFA/stere
Transport cost	1200	FCFA/stere
Total	2810	FCFA/stere
Investment Costs		
Donkey	30000	FCFA
Cart	80000	FCFA
Subtotal	110000	FCFA
Recurrent Costs		
Monitor/guard	300000	FCFA/yr
Maintenance	83000	FCFA/yr
Subtotal	383000	FCFA/yr
Total investment cost	493000	FCFA

Market Prices		
Official retail price	4320	FCFA/stere
"Unofficial" retail price	7000	FCFA/stere
Gross profit/unit		
At official prices	1510	FCFA/stere
At "unoffical" prices	4190	FCFA/stere
Fuelwood required to amortize investment in one year:		
At official prices		
493000 FCFA/1510 FCFA/stere =	327	steres
At "unofficial" prices		
493000 FCFA/4190 FCFA/stere =	118	steres
Area needed to produce required fuelwood:		
At official prices		
327 steres/4.8 steres/ha =	68	ha
At "unofficial" prices		
118 steres/4.8 steres/ha =	25	ha

Figure 6. Investment Analysis Used to Determine Fuelwood and Land Area Inputs

Source: Dennison et al. 1990

Data already available to the resource manager allows these types of analyses about the expected benefits from management activities. There are, of course, many variables that will influence outcomes, but they at least allow decision makers to get a feeling for benefit orders of magnitude associated with a given activity. A slightly more complex example of a 10,000-ha block of natural forest under management in Burkina Faso provides a glimpse of the potential. This sample forest is managed for urban fuelwood. It could yield as much as almost 300,000 steres over a 15-year rotation. This amount of fuel in today's retail market in Ouagadougou is worth 1.2 billion FCFA (Catterson, et al. 1990).

For this order of magnitude analysis, inventory data from satellite imagery was gathered and applied to information from other sources to calculate yield over a range of possible forest growth scenarios. An assumption about the level of annual removals for fuelwood was made and the overall value of the forest resource was calculated using established fixed prices for fuelwood. The benefits analysis from the exercise is presented in Figure 7. A range of possible cash benefits from the natural forest management activity is listed for the individual woodcutters, their cooperative, their forest management fund, and the government (as potential tax revenues).

Thus the analysis gives the manager an approximation (the accuracy depends, of course, on how good the data are and the validity of assumptions) of the benefits that might be expected for the villagers involved in the management. Based on how the total producer price for fuelwood is divided, it also gives an estimate of how much will be available for future forest management activities. Finally, it provides an incentive for the government by giving a rough approximation of what it would stand to gain from tax revenues if management were undertaken. The same study (Catterson, et al. 1990) also illustrated the potential benefits from natural forest management in a slightly different manner using the same data. Table 8 presents fuelwood yield and employment data from a managed forest in Burkina Faso to illustrate a more macroeconomic view about NFM's contribution to the local economy--one of the important steps in convincing any government to support natural resource management activities.

Outputs from resource management activities (forage produced in a cut-and-carry system, yield in animal units, fuelwood cut, etc.) can be monitored in the same manner as the activity inputs (illustrated above in Box 17). In order to develop a feeling for output cycles, increasing and/or decreasing periods of productivity on a given land unit, the manager should record the annual values (in most cases just an estimate) associated with each output in a spreadsheet (table) format. By applying the appropriate market values to each unit, the annual benefit for each output can be estimated. Natural forest management benefits for the Tioudawa forest in western Niger are discussed in Box 18 and portions of the output and benefit tables are provided as examples.

ESTIMATED BENEFITS

	Accumulated totals: Productivity Scenario			Net Present Value Analysis: Low Productivity Scenario, Discount rate =			Medium Productivity Scenario, Discount rate =			High Productivity Scenario, Discount rate =		
	Low	Medium	High	10%	15%	20%	10%	15%	20%	10%	15%	20%
15-yr volume cut (steres)	256000	292960	312000									
Avg. cut/ha/year (steres) over 15-yr period	25.6	29.3	31.2									
	--- 000 FCFA ---			--- 000 FCFA ---			--- 000 FCFA ---			--- 000 FCFA ---		
Total woodcutter salaries	156160	178706	190320	74926	56243	44049	83547	61974	48023	87988	64927	50071
Total management fund	156000	146480	156000	61414	46101	36106	68481	50799	39363	72122	53219	41042
Subtotal	312160	325186	346320	136340	102343	80155	152028	112773	87387	160110	118146	91112
Total fuelwood tax	76800	87888	93600	36849	27660	21663	41089	30479	23618	43273	31931	24625
Total cooperative fund	51200	58592	62400	24566	18440	14442	27392	20319	15745	28849	21287	16417

TECHNICAL/BIOLOGICAL ASSUMPTIONS

Total forest area	10000	ha
Forest cover class	N	
Rotation age	15	
Avg. compartment size	667	ha
Avg. standing volume	12.5	m3/ha
Compartments cut/year	1	
Standing volume cut	50	percent
Steres fuelwood/m3	3.2	steres/m3

Productivity Scenarios (m3/ha/yr)

Low	Medium	High
0.50	0.83	1.00

REVENUE ASSUMPTIONS (OFFICIAL PRICES)

610	FCFA/stere to woodcutters
500	FCFA/stere forest management fund
300	FCFA/stere for the fuelwood tax
200	FCFA/stere for the cooperative fund
1610	FCFA/stere total producer price for fuelwood
4320	FCFA/stere, retail price in Ouagadougou

Figure 7. Potential fuelwood benefits from one 15-year rotation in a 10,000 ha managed, natural forest.

Source: Catterson et al. 1990

Table 8. Production, employment and finance data for the natural forest management example, the first compartment.

Production		
Area of the compartment	660	ha
Average standing volume, m3	12.5	m3/ha
Average standing volume, steres	40	steres/ha
Prescribed fuelwood harvest	20	steres/ha
Total harvest of the compartment	13200	steres
Employment		
Daily fuelwood production	2	steres/day
Days required for harvesting	6600	person-days
Work days, full employment	200	person-days/yr
Total employment, harvesting	33	people/yr
Wages/Finance		
Woodcutter salary	610	FCFA/stere
Daily average wage, woodcutter	1220	FCFA/day
Average annual wage (200 days/yr)	244000	FCFA/yr
Per capita GNP, Burkina Faso	57000	FCFA/yr
Rural wage, daily rate	850	FCFA/day
Total harvesting wages	8.052	million FCFA
Protection and Improvement Activities		
Management fund rate	500	FCFA/stere
Total management fund collected	6.6	million FCFA
Labor/commodity breakdown for protection/improvement	75%/25%	
Labor monies available for protection/improvement	4.95	million FCFA
Potential person-days of labor, ptotection and improvement	5280	person-days
Cooperative Operations		
Cooperative fund rate	200	FCFA/stere
Total cooperative fund collected	2.64	million FCFA
Contributions to the Local Economy		
Wage labor, harvesting	8.052	million FCFA
Wage labor, protection/improvement	4.95	million FCFA
Total wages	13.002	million FCFA
Total employment potential	12420	person-days

Source: Catterson et.al. 1990.

Box 18. Natural Forest Management Benefits at Tioudawa

The results of the 1988 fuelwood inventory on the Tioudawa forest (about 8,000 ha) indicate an average standing volume of 6.3 steres per hectare. The current growth rate calculated using the inventory data, is about 1.0 steres per hectare per year. Due to the degraded state of the land, all wood is assumed to be used as fuelwood, no service (construction) wood possibilities are anticipated. The growth rate on the forest areas brought under management (800 ha/yr), with guard protection and controlled cutting, is expected to improve annual growth to 1.5 steres/ha/yr. If trees are planted, 1.8 steres/ha/yr are expected to be added to the growth rate. Annual removals are to be equal to the annual productivity (i.e., 1.0 steres/ha for the first cut, and 1.5 steres on the subsequent cuts with no tree planting).

Range production, although much more dependent on precipitation than woody biomass, is expected to begin yielding commercial quantities after the parcel is closed to grazing for three years. Without management in good rainfall years, range managers predict that 1,000 kg/ha, of which 350 kg is exploitable as forage or hay, can be expected. Three alternatives (intensive, intermediate, and extensive) are proposed which include grass planting. The intensive and intermediate options will plant grass on the arms of man-made water microcatchments established as part of the forest's rehabilitation program and on bare soil areas mulched with branches. The extensive alternative is limited to sowing seed among the branches laid down following a cutting operation to mulch the bare soil.

Grass yields (based on findings in similar ecological zones) for the intensive and intermediate alternatives is 1,600 kg/ha of stalk material and 400 kg/ha of forage based on an average density of 800 plants/ha. Under the extensive alternative, yields are expected to be only about 800 kg/ha of stalks and 200 kg/ha of forage.

Based on these data, the forest manager calculated the fuelwood and grass yields. The output table shown below illustrates the estimated yields for the first eight years that the forest would be under management. The areas under management are cumulative. After ten years, all of the forested area will be under management, the second rotation of fuelwood cutting would begin, and the expected yield would also increase according to the assumptions. Areas that can be planted to grass under the intensive and intermediate alternatives are limited to 300 ha. Under the extensive option, only 25 ha/year are treated, up to a total of 300 ha on the forest.

Estimated Fuelwood and Grass Yields
Tioudawa Forest, Niger

Output	Year							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Total forest area managed(ha)	800	1600	2400	3200	4000	4800	5600	6400
Fuelwood harvested(steres)	800	800	800	800	800	800	800	800
Grass								
Intensive alternative								
Total area (ha)	50.0	100.0	150.0	200.0	250.0	300.0	300.0	300.0
Hay (tons)	17.5	35.0	52.5	72.5	92.5	112.5	132.5	152.5
Stalks (tons)	32.5	65.0	97.5	177.5	257.5	337.5	417.5	497.5
Extensive alternative								
Total area (ha)	25.0	50.0	75.0	100.0	125.0	150.0	175.0	200.0
Hay (tons)	8.7	17.5	26.3	31.3	36.3	41.3	46.3	51.3
Stalks (tons)	16.3	32.5	48.7	68.7	88.7	108.7	128.7	148.7

Revenues to the forestry fund (used to defray the recurrent management costs on the forest) from the sale of wood will include the cost of the permits sold to the woodcutters (40 FCFA/stere) and 75 percent of the profits from the wood sales to the transporters. The village's forest management cooperative will buy the wood from the woodcutters at 850 FCFA/stere and sell to the transporters for 1,500 FCFA/stere. Thus, for each stere sold the forestry fund will receive a total of 528 FCFA.

Grass and hay permits are sold by the cooperative and are calulated at 4 FCFA/kg (4,000 FCFA/ton). Net profits from these permits are divided equally between the cooperative and the forestry fund. Permit holders are free to sell what they gather at whatever price the market will bear.

Applying these revenue figures to the expected annual outputs produces the following estimated benefits flow table for the first eight years that the Tioudawa forest is under management. Revenues for the forestry fund and for the cooperative are substantial. Individual earnings cannot be calculated because it is unknown how much of the grass which is cut is sold. Total annual benefits to villagers will at least exceed 648,000 FCFA which they stand to gain from woodcutting activities.

Box 18 Continued . . .

Estimated Fuelwood and Grass Benefits
Tioudawa Forest, Niger

Benefit	Year 1	2	3	4	5	6	7	8
	— 000's FCFA —							
Fuelwood								
Woodcutters	648	648	648	648	648	648	648	648
Forestry fund	422	422	422	422	422	422	422	422
Cooperative	130	130	130	130	130	130	130	130
Grass								
Intensive alternative								
Grass collectors	?	?	?	?	?	?	?	?
Forestry fund	100	200	300	500	700	900	1100	1300
Cooperative	100	200	300	500	700	900	1100	1300
Extensive alternative								
Grass collectors	?	?	?	?	?	?	?	?
Forestry fund	50	100	150	200	250	300	350	400
Cooperative	50	100	150	200	250	300	350	400
Totals								
Intensive alternative								
Villagers	?	?	?	?	?	?	?	?
Forestry fund	522	622	722	922	1122	1322	1522	1722
Cooperative	230	330	430	630	830	1130	1330	1630
Extensive alternative								
Villagers	?	?	?	?	?	?	?	?
Forestry fund	472	522	572	622	672	722	772	822
Cooperative	180	230	280	330	380	430	480	530

Source: Obermiller, C. 1989.

Pricing outputs from a resource management activity is almost always a difficult task. Having ready markets for products from forest, range, and water resources certainly makes the task easier, but more often than not the resource base is usually quite distant from the consumers that require its products. This market dilemma for products with established (real) value will often determine whether an activity should be undertaken. Without real values (monetary benefits) participation and stewardship commitment from the local population is potentially nonexistent. Resource managers should also do their best to inform themselves about any unique attributes or natural resource products that could be used to justify management activities.

Without tangible benefits, natural resource management activities will usually have to rely on support (subsidy) from sources external to the activity site. In this instance, nature resource management becomes more of a strict policy issue, outside the realm of the current discussion. Intangible values, both as costs and as benefits, are briefly addressed at the end of this chapter.

The Mechanics of the Analyses

The previous pages have listed suggestions for collecting input, cost, output, and price data that is relevant to particular natural resource management activities. Input and output tables have illustrated a systematic manner for tracking this information and cost and benefit flows were applied to help the resource manager determine where resource constraints might lie.

This framework, however, is simply that, a skeleton. More revealing information about management activities comes with the manner in which the resource manager and the decision makers view the data. Once the cost and benefit flow tables have been completed, the bottom lines of each are combined to give a net value (positive or negative) for each year the activity is being evaluated. This line of values, the cash flow, begins to show NRM planners the efficacy of their efforts. It is the framework, or the model, that details all the inputs and outputs associated with the activity that is important. Once these have been constructed, they can be entered into a computer software spreadsheet program (there are numerous possibilities) for the actual analyses.

With and without analysis. It is also important for resource decision makers to have an idea of what the resources use (or outcomes) are estimated to be without implementation of the natural resource activity. A separate framework will be needed for this scenario. These two frameworks, conducted over the same time period, are the basis for the "with and without analysis". The time period used by the analyst will usually be fixed by the most important variable in the management process. With forest management, for example, this is usually the rotation period, or cutting cycle. (For the Sahelian forest management examples illustrated in this chapter, rotation is usually in the vicinity of 15 years.) This also means that the "without" framework for the forest management example will also have to be carried out over the same time period.

Sensitivity analysis. In order to "fine tune" his/her predictions, the resource manager should also look at the effects to the cash flow that are made by variations in the framework data. One example of this was given in Box 18 where an extensive and intensive system for increasing grass yield was examined. This type of analysis that examines how "sensitive" the bottom line is to input, output, cost, and price changes is fairly easy to do if the analyst is using computer spreadsheet software.

When conducting a sensitivity analysis, there are two points that should be heeded. First, change and observe only one variable at a time until a "feel" for the data is obtained; then experiment with more than one change at a time. This procedure helps to guard against confounding and will also help the manager to understand which inputs and outputs are the most critical in the management process. Second, where comparable situations exist, the same sensitivity analysis needs to be conducted on the "without" model.

A numbers game. To facilitate the comparison even further, financial and economic analysis can often be relegated to a simple comparison of two numbers. It is important, however, that resource managers and other decision makers recognize that they are comparing two apples and not one apple and one orange. The numbers most frequently used are Net Present Value, or Worth (NPV), Benefit/Cost Ratio (B/C), or the Internal Rate of Return (IRR). For all practical purposes, they are mutually exclusive. The decision makers will want to compare the NPV values from the with and without analysis, or the IRRs from those two models, but not the NPV with the IRR. Also, in order to compare values between alternatives, time periods and major assumptions about the variables need to be the same. (In general, NPV figures are more easily calculated and compared with other NPV's from alternative activities. Due to this, they are more in favor in the analysis of NRM projects. IRR values are often calculated as well to fortify the decision making process.)

Each of these variables, readily calculated with spreadsheet software, is essentially the cash flow collapsed into one number. In order to do this logically, however, cash values for each year in the analysis have to be put on an equal basis using a discount (interest) rate. The choice of a discount rate is a very controversial subject, but a necessary one when evaluating the investment of resources (time, labor, materials, money) in natural resources management.

Choosing a low discount rate will generate a higher (and thus more favorable) NPV figure than a high discount rate. A high rate can be equated to placing a high priority to what is happening at the present, or in the very near future. In developing countries, farmers focus on the present and fit into this group. Christophersen (1988) notes that the implicit discount rate that a (Sahelian) farmer places on making changes (such as allowing some of his land to be used for tree planting) is quite high because (s)he is reluctant to change from something which they know works to something that is less sure and probably won't bring any return at all until further in the future.

Because of this uncertainty regarding a discount rate, a range of values is used. Decision makers, including farmers participating in the management activities, can then make their choices based on their perceptions of the importance of change. It should also be added that real discount rates, which remove inflationary factors, should be included in the range of possible values. (Most basic economic texts illustrate how the real rate is calculated.)

Other alternatives. In addition to the standard with and without comparisons, the resource manager should also expand the "with" model by examining other alternate activities. These could also be considered as a variation on the sensitivity analysis theme, but are slightly more elaborate than simply varying values. In the alternative analyses, whole activities may be substituted to examine their effect on the NPV. When the manager is operating against a fixed set of marketable outputs, an alternative analysis allows an examination of a range of possible inputs.

Ranking. By exhausting the range of possible management activity alternatives, the manager makes the analysis more realistic. More information is pulled together that is a reflection of all the possibilities: biomass production, watershed management, soil conservation, wildlife habitat and production, and rangeland productivity. Each activity will carry a different objective and each of these can be weighted according to a decision maker's priorities. This process gives a more unbiased analysis and gives credence to other analytical criteria in addition to the financial and economic numbers. Pooling the weights given by each decision maker allows a ranking for each of the activities. Christophersen (1988) presents a clear discussion on multiple-use objectives in natural resources management.

The Bigger Picture

Natural resource management needs to be as cost-effective as possible at the local level. If villagers and farmers have a vested interest in the outputs, and they can realize a tangible gain for their efforts, they are more likely to become stewards of the resource.

Management, however, is also more than being remunerated for direct inputs; it also should entail long-term rewards for wise use of the resources--and for natural resource (environmental) management, this is particularly so. Protection is a key component in this scheme and will often require more than just the local benefits to pay for the recurrent costs of conducting the necessary activities to safeguard the resource.

Prevention, as noted by Panayotou (1990), is often far more cost-effective than rehabilitation ("an ounce of prevention is worth a pound of cure"). Once excessive damage to the resource happens, it is usually not worthwhile to try and return it to its original productive level. The costs, in these instances are higher, and the effectiveness lower, and the vested interests that have accompanied the land-use changes are more difficult to change.

It is for these reasons that the economic costs associated with prevention and rehabilitation activities in natural resource management have to be shared by governments and donors alike. Unfortunately, benefits from environmental protection programs either fail to value, or undervalue environmental resources, except for their immediate commercial value, thus again undervaluing the overall return on the investment. It is for these reasons, investment in the environment--in ensuring proper management of natural resources, similar to that in education and infrastructure, often require public sector support.

Managing the Forests

Once the preliminary studies have been completed, the planners are now faced with developing a management plan and establishing a mechanism by which it can be carried out and monitored. The process by which a given forested area is converted from an unmanaged public territory (domain publique) to a common resource base to be exploited and maintained within the framework of a well defined, participatory[2] management scheme generally involves three major steps:

- an agreement in principle by the government to allow a local user group to have control over a particular territory;
- the organization and training of a local user group; and
- the preparation and acceptance of a legal management document to define the policies and management strategy by which the forest will be exploited and maintained.

Management Objectives

Early on during the initial surveys and studies of the area in question, it is likely that discussions will arise between the authorities and the local user groups about the problems being encountered there and the potential solutions. These discussions should give rise to a further discussion about the objectives of the management plan. The local population is likely to wish to optimize the use of the forest in terms conducive to their own real economic gain. Government will be interested in securing the principles of sustained yield and multiple use so as to optimize the productivity of the forest over the long-term. Brokering the mix of management, utilization, and conservation will be challenging but not impossible. Local people often understand and lament the disappearance of natural forest areas as keenly as anyone else, both from an economic as well as a cultural perspective. There may also be a struggle over the actual emphasis to be given to the management interventions, whether, for example, to produce firewood, timber, fodder for animals, non-wood forest products, or a combination of all of these.

In some instances, however, there may exist a basic underlying difference of opinion among the various groups and/or the forest service planners. Many of the mistakes that have been made in the past in the forestry sector could have been avoided if a proper study of supply

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[2]This document does not assume that all future management of the natural forests and woodlands of arid and semi-arid Africa has to be undertaken through a participatory approach. It is also reasonable to consider that in some countries, the more traditional approach, i.e., forest service management of a national reserved forest employing labor for the various activities with benefits accruing directly to the government, is also feasible. The real challenge and the real opportunity lie, however, in managing those areas still relatively intact but under pressure from surrounding communities. If through a participatory approach, the government can harness the resources of the communities, the recurrent costs for forest management will be smaller and the impact greater, both in terms of impact on the land as well as impact on socioeconomic development.

and demand had been carried out before implementation was begun. For example, many of the industrial fuelwood plantations that were planted throughout the zone are now marketing the trees as poles rather than fuelwood. Poles are in high demand and will yield a higher financial rate of return on the investment (Christophersen 1988).

Similar examples can be drawn from early natural forest management exercises. At the Guesselbodi Forest outside Niamey, the main objective of the management plan at the beginning of the project was to produce fuelwood for the urban marketplace in Niamey. As grasses began to regenerate in many of the protected areas that were being cut for fuelwood and planted with seedlings, the local people began to show as much interest in the grasses as the fuelwood. They repeatedly requested permission to begin to exploit the growing fodder resource. A simple market analysis was carried out and it was determined that the grasses were in high demand and actually worth more than the fuelwood. As a result, the management plan was altered to further promote the regeneration of perennial grasses and valuable browse species which are oftentimes the only source of fodder during the dry season.

In general, there is a need to broaden the concept of forest management to include a wider array of forest products, including both grazing and the other secondary products that are used in the local households and frequently sold in the marketplace. The preliminary analysis and discussion of management objectives and the studies of demand that must accompany it should include women, local medicine men, and others who are constantly harvesting a wide variety of secondary forest products. In some cases, the secondary products may be as important as the wood products. For example, an entire local economy may be based on the production of baskets and fiber mats, on honey or on the production of a particular herbal medicine or remedy. The management options best suited to those forests that are well known for the production of non-wood products, clearly will have to be tailored to accommodate the user group that has traditionally harvested and marketed these products.

Conversion or Management

A common mistake that continues to be made by planners with regard to the treatment of these modestly productive dry forests and woodlands is to invest huge sums to clear the existing vegetation with heavy equipment and convert them to agricultural production. In many cases, these schemes have failed and often exacerbated the degradation. Similar efforts to convert these woodlands to exotic plantations is now very much frowned upon in forestry circles in dry Africa. It has been demonstrated that given the relatively high cost of such plantation establishment and the modest yields, such efforts will rarely succeed in areas with less than 800 mm of annual rainfall. The expansion of the agricultural frontier is likely to continue even in dry Africa, e.g., in the areas along the White Volta River in Burkina Faso and the Niger River in Niger which have been freed of "river blindness" disease. Attempting to resist the inevitable in these areas by insisting on their continued existence as forest reserve will sap the political strength and credibility of the forest service and distract it from the real job at hand of managing the forests on the more marginal lands whose evident long-term vocation is forestry.

Reclaiming degraded forest areas is a viable option but will require a substantial initial investment to restore the vegetation and soils. In economic terms, such projects are rarely cost-effective; however, they are being implemented more and more within the framework of relief programs and around refugee camps where they provide a useful focus for food for work programs. Such efforts typically involve labor-intensive soil conservation measures such as check dams or micro-catchments as well as planting trees and grasses. They may also be justified as desertification control measures, keeping the sand out of villages or irrigation infrastructure or as part of catchment restoration efforts.

Land reclamation projects may also be carried out in former agricultural areas. For example, large areas of savannah woodlands in the Sudan were cleared for mechanized farming of sorghum and many were subsequently abandoned as a result of the soil degradation after only a few years of extensive farming. Some of these areas are now being successfully direct-seeded with *Acacia senegal* in anticipation of the future production of gum arabic. In addition, past work has shown that it is possible to restore the large, abandoned tracts of farmland in the northern Sahel (less than 200 mm of rainfall) simply by protecting them from livestock and fire.

Although land reclamation projects are justified in certain contexts, planners should realize that, at this stage in the development of natural forest management as a sector strategy, they should not be given high priority, if only because they will draw down the capabilities to address threatened but intact forests elsewhere that may then be lost to deforestation. **Given the limited amount of resources (human and financial) available for natural forest management in dry Africa, planners should initiate management schemes in the remaining intact forests before investing in costly land reclamation exercises on highly degraded sites.**

Organizing the User Groups

It is essential that all groups who have an interest in the area to be brought under management be contacted and have a voice in the organization. One common problem with participatory management in dry Africa is the difficulty of including nomadic groups. If these herders have traditionally used the forest area as a forage reserve, every effort should be made to contact them during the organizational process. Similarly, women are often neglected or left out of meetings at the village level even though they have a strong vested interest in the forest as a source of domestic fuelwood and other secondary products both for food and medicine.

Once the various user groups have been identified, work should begin to establish a formal, unified entity to be recognized by the forest service as the participant group charged with the responsibility for implementing the management plan. One approach that has shown success is that being used by the Cooperative League of the United States (CLUSA) in Niger. Their basic strategy involves the placement of a full-time cooperative extension worker to live among the villagers who will participate in the management scheme. The extension worker is instructed to organize discussion groups within and between the various user groups and to act mainly as a facilitator and observer and later as a trainer. The overall desired effect of this approach is that the organization of the participant group should evolve as a consequence of the meetings at the local level rather than being imposed from outside in a top-down approach.

Another interesting aspect of the CLUSA approach is that the villagers are to a large extent responsible themselves for financing the costs associated with the setting up and the functioning of the organization. The services of the extension worker are provided with project monies through the relevant government service. This avoids creating a dependency syndrome and forces the group to begin to make conscious decisions about financial management. Whatever approach is adopted, it is essential that the idea of financial autonomy be instilled and reinforced from the beginning. Project-related financing, either from the government or from an external donor, may be available for the enterprise, but this should not be used to subsidize the functioning of the group. If the area is well chosen (i.e., there are adequate resources to begin both exploitation and management operations from the outset), the group should have no problem financing their early activities from the harvest proceeds. In severely degraded areas, a parallel but separate track to finance rehabilitation may be necessary, financed by the government or the donor, in order not to burden those least able to afford it with the costs of these operations.

In most cases, the expertise required for this type of extension work will not be available at the local level. Accordingly, a full-time worker must be recruited and trained for these positions. Training should emphasize cooperative extension or small business development methodologies rather than the mechanics of forest management. Advice and assistance in the realm of forestry management should be supplied by the forest service as its contribution to the process of participatory management development. In selecting the extension personnel, care should be taken to find individuals who are familiar with and sensitive to the cultural environment, and who will see their role as gaining the trust and confidence of the local population.

The "Back-to-Basics" Approach

As a point of departure, this document postulates that the most essential feature of management capability is a deep interest in and knowledge of the forest area in which one is working. This is what the profession of forestry is all about and it provides the most pertinent basis for planning and implementing forest management. A well-managed forest will require proper mapping, boundary marking, compartment designations, regular monitoring, excellent supervision, and above all, comprehensive and well-informed record keeping.

There can also be **no proxy for a genuine field orientation if forest management is to improve**. Forest management staff must spend a good deal of their time in the forest familiarizing themselves with actual conditions and knowing what is happening there. Their observations, and those of their subordinate staff (and in the case of a participatory management arrangement, of the local user group personnel), must be dutifully recorded. It is this intimate knowledge of the forest and the qualitative observations made in the field which supplement the traditional inventory and site data which is much more static, in sharp contrast with the natural systems it depicts. This direct knowledge of the day-to-day conditions and operations will validate the basic premise of forest management--that someone is in control and knows what is going on.

As mundane as it might seem, a lack of this field orientation is often the cause behind bad policies and poor implementation of otherwise sound management prescriptions. Unless the fundamental knowledge is there, in future years, it may be difficult to reconstruct the actual variables of management or silvicultural practices one seeks to replicate. Regrettably, this happens more often than not. Was there a small fire that went unobserved and unrecorded? Did local people, exercising traditional usage rights, harvest minor forest products, fuel-wood, or poles, or graze their animals in the forest thereby changing the stand structure? Inventories provide the baseline; observations provide the understanding of the forest as the dynamic system and all its elements.

This approach, involving **frequent and regular field visits** by management staff to the forest under their care is also perhaps the **best basis for understanding the pressures on the forest from the surrounding peoples and communities.** Viewing their activities first-hand may aid the forestry personnel in developing a proper sense of perspective about their presence and their needs. Seen from a distance, it is easy to chastise local people for damaging the forest; seen close at hand, one recognizes that often they are only trying to meet their own needs--often the most basic ones--for food, fuel, shelter, and a dignified livelihood. **Contact will promote familiarity and open channels of rapport, communication, and understanding for which there is no substitute.**

It is not hard to imagine, however, that institutional and bureaucratic structures and systems in the forest service may not promote or even encourage the field orientation as an appropriate behavior pattern among its forest management personnel. It may take concerted and deliberate steps to overcome this issue. Field personnel should be chosen with this in mind. There is also probably a need for appropriate incentives, whether they be tangible or intangible, to promote the fieldwork orientation among local staff. Forest management may be taught in school and in books; it is learned, however, in the forest. It is recognized worldwide that the best-managed forests are in the hands of the most competent and well-informed field foresters.

Traditional Management Systems

The most important lesson to be learned from traditional management systems is that the community management of forest resources is possible if the right social unit is self-selected, and the objectives of the management plan widely understood and the benefits equitably distributed. In addition, the principles of social control and product distribution encoded in these systems can be successfully incorporated in the expanded management framework (Pelinck and Campbell, n.d.)

Although the above was written as a result of work that was carried out in the hills of Nepal, it holds equally true for traditional management systems in the arid and semi-arid areas of sub-Saharan Africa. The people who are charged with the organization of the participatory management group should inquire about existing or remnant past traditional management systems. Even if the traditional management system is not functioning at present, there are often village elders who know how the system operated in the past.

In the Central Rangelands of Somalia, for example, the traditional system continues to function and has been integrated into a World Bank-funded range rehabilitation and management project. During a previous phase of the project, a large portion of which was funded by USAID, anthropologists found that the entire central range is divided into traditional range territories known as "deegans". Each deegan is governed separately by a committee of elders who have authority to settle disputes and dictate how the rangelands are to be used within and between deegans. Given the recent decline in the quality and quantity of the rangeland due to increased population pressure and drought, the project is testing a variety of improved range management schemes to expand upon but retain the original framework of the traditional management system.

It is also important that people involved in the project, be they expatriates or government personnel from outside the traditional cultural context, strive to develop a keen understanding of the system rather than to suggest replacing it with a system with which they are more familiar. Each traditional system is guided by cultural and religious beliefs which are often incomprehensible to an outsider but are the foundation upon which the system functions. Typically, each traditional system works well under its own conditions but none provides a blueprint or single model that is applicable to all (Messerschmidt 1985). Although, as in the case of Somalia, there are remnants of traditional management systems in other parts of Africa, a lot remains to be done to learn how these systems function and if they can be expanded upon given the increased pressures put on the limited resources and the relatively rapid decline of the resource base.[3]

Group Organization and the National Development Plan

The organization of the user group must be carried out within the context of the national development plan and adopt a strategy that is consistent with the policies and ideologies of the central government. For example, in some countries, the cooperative movement has been relatively successful and is a key element of the development plan. In others, cooperatives have not faired as well and are not well supported. In such situations, there are often village associations or similar organizations that should be consulted and included in all phases of the management program. Whatever form the organization takes, be it a cooperative or a forestry association, it is essential that the organization be officially recognized and have an elected committee to govern it and act as the liaison between the group and the government. The organization should develop a document of its own with an organizational chart and

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[3]This is an extremely complex topic beyond the scope of this document. For further insights into the topic, please refer to two recent documents: *The Socioeconomic Attributes of Trees* by John Raintree, FAO/ICRAF publication, and *Local Knowledge and Systems of Natural Resource Management in Arid and Semi-Arid Africa* by Maryam Niamir, FAO/SIDA Forest, Trees and People Program.

by-laws describing the goals, permitted and proscribed activities, basic operating precepts, and the financial management system.

Training the User Group

The village extension worker(s) should be responsible for designing a training program that is consistent with the goals of the management interventions and the overall plan, including the realization of the objectives specifically put forward by the people themselves. In many areas of sub-Saharan Africa, farmers and herders have had previous experience with village cooperatives, credit unions, or some other similar collective activity; as a result, they will be familiar with the basic concepts, organizational procedures, and simple methods of financial management. In other areas, it may be that the extension worker will find little previous involvement by villagers in collective activities and the training program will focus on the basics.

One of the most successful training techniques has been to organize trips for a group of key individuals to visit other forest management schemes that are already functioning. Given the scarcity of existing natural forest management working models, it may be necessary to coordinate such training exercises between countries. These can be extremely difficult to organize and may require up to a year of preparation from the time that the idea is accepted in principle to the time the trip takes place. Past experience, however, has shown that this type of training is well worth the investment. One drawback of this system is that the training coordinators often assume the role of teacher instead of facilitator. This can be avoided if the goals of the training exercise are thoroughly discussed and understood by all before the trip is undertaken.

The need for certain types of specialized technical training may be identified early in the project or later on as the management scheme evolves and more activities are undertaken. For example, the group may wish to begin a honey production operation or create an artisan workshop but do not have the expertise. This type of expertise can generally be found in the country. Periodic refresher training of the village extension workers should also be built into the program. Such training might consist of seminars or workshops among peer colleagues to review their common experiences and find out what has been working best in other areas.

The Basic Agreement

The previous sections have already demonstrated that there is significant potential for the management of forest resources and, in particular, through the application of a participatory management scheme involving rural people living in villages adjacent to the forests and woodlands. In order to enter into an arrangement of this nature, the rights and responsibilities for the management activities should be duly recorded in official documents. The primary purpose of these agreements is to ensure the equity of the arrangement and promote the efficiency of the management process.

A **basic agreement** between the user group organization and the government, typically the forest service, should be established for each such organization. Failure to respect this basic agreement could lead to the suspension of the contractual rights and responsibilities. These rights could include, but would not necessarily be limited to the following:

- the harvest of fuelwood (or other products) in the forest will be done in accordance with a predetermined management plan (see next section);
- the forest service will assist the user group organization in obtaining the necessary permits;
- the organization will be free to allocate work and responsibilities, as well as the benefits, among themselves;
- there will be a third-party resolution of disputes (an ombudsman function) between the user group organization and the representatives of the government;
- non-destructive traditional uses of the forest (grazing, collection of herbs, medicines, etc.) including the privilege to allocate or share these rights with other local people, will be respected; and
- the user group organization will maintain the right to negotiate the producer prices with transporters and commercial entrepreneurs.

Equally important, this agreement will also prescribe the responsibilities of both parties to the arrangement, and could involve the following:

- an overall agreement to safeguard and maintain the resource base to ensure its continued productivity;
- an adherence to the prescriptions of the management plan regarding both the timing and import of the activities; and
- a willingness to renegotiate the terms and conditions of the basic agreement subject to the results of the periodic monitoring of the management process.

It should be obvious that these arrangements must and can only be prepared as a function of the actual technical, biological, and socioeconomic situation of the forest and the people organized to manage it.[4] This basic agreement leads to the second and more operational tier of documentation essential to a participatory management scheme--the forest management plan.

Preparation of the Forest Management Plan

The forest management plan constitutes the working guidelines for management operations. The plan is usually accompanied by a survey map of the forest, background records collected during the preliminary studies, and other pertinent data that may exist for the area under

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4A more comprehensive treatment of these relationships and the range of possibilities and issues to be considered in structuring them can be found in "Options for User-Based Governance of Sahelian Natural Resources" by Thomson, et al.

consideration. Previous forest management schemes in the Sahel and elsewhere in sub-Saharan Africa have often not been implemented because of their demand for inordinate amounts of background and baseline information. Today, a more confident approach to forest management is emerging. Fuelwood, which is the major product being optimized in the dry forests of the continent, has less of a time constraint and is less exacting in terms of product specifications than a higher-value product such as a sawlog.

There are, however, **certain technical issues associated with forest management in the arid and semi-arid areas that require resolution**, such as achieving a **high percentage of natural regeneration or good growth from a coppicing system**. These requirements should not paralyze action. Over the short-term, the forest management plans prepared for pilot management exercises should be simple to implement and achieve, be of low risk, and err on the conservative side in terms of safeguarding the resource base. The rotation age employed should be at the high end of the range of estimates. The amount of standing volume removed in the first harvest should be relatively light to ensure good site cover and to promote regeneration.

The preparation of the management plan will be led by the forest service technician(s) in collaboration with the representatives of the local user group. Other implicated services such as the agriculture and livestock authorities in the area, and perhaps the agents of the cooperative promotion service should participate to the degree that they will be affected by the scheme. It is the responsibility of the forest service extensionist and the representatives of the local user group organization to ensure that all villagers who may ultimately be affected by the management scheme be given the opportunity to voice their opinions on the policies, plans, and activities.

One of the basic assumptions of this document is that rural people, organized into forest management user groups or cooperatives, will recognize the inherent opportunity of developing their activities into a viable rural enterprise. Income generation and employment in the local area, for user group members and other village residents, should help to convince all concerned that managing forests will be to their collective advantage.

It should be noted as well, however, that rural people consume significant amounts of fuelwood and other forest products to meet their basic needs. Management planners must be concerned and attentive to **the potential of impact of forest management on rural demand**. There is reason to believe, for example, that per capita consumption of fuelwood in the rural areas is higher than in urban areas. In the villages, fuelwood is essentially a free good collected on foot by women and children from field trees, fallow lands, and nearby forest areas. Because it is not a commercialized product, there is little incentive for fuel conservation. In times when there is not enough wood, crop residues and animal dung are burned as substitutes. Villagers normally do not buy wood transported in from surplus areas. If adjacent areas of forest and woodland are put under management, random fuelwood collections will have to be discouraged. There will be some concern at the village level among those not directly participating in the user group organization, that such a trade-off might have a negative impact on the lifestyles of those rural families so affected. If this issue is fairly and logically discussed within the villages, it is likely that an understanding will emerge that such will not be the case for a number of reasons.

First, harvesting and other management activities will generate significant amounts of wood that will not be commercialized. Market preferences for specific dimensions and species mean that smaller (or larger) sizes and non-preferred species will be left in the forest. Local people should be encouraged to collect these remnants for family consumption, thus yielding secondary benefits to the local area. It is also unlikely that the entire forest area within the fuelwood collection radius around a village will be included in a management plan; some areas will remain as open access and could be additional sources of supply.

Perhaps more to the point, rural villagers throughout the continent are being encouraged to plant trees on their farms in order to take advantage of the synergistic effects of trees and agriculture in semi-arid environments. Trees planted in agroforestry configurations, along field margins, as windbreaks, or intercropped, can help ameliorate the harsh extremes of climate, providing better growing conditions for the companion crop plants. These trees can and will produce a variety of products including fuelwood for domestic consumption, thereby alleviating some of the demand on adjacent woodlands. Therefore, in many areas where population pressures are high, **the forest service will be well advised to promote and facilitate a community or agroforestry based tree planting program in parallel with the natural forest management activities**. Because of the concentration of personnel and know-how in the area, these should be relatively easier to initiate.

Regular meetings during the preparation of the management plan, as well as after it has been accepted and implementation begun, are essential to keep up a dialogue and maintain the local consensus necessary for successful and effective management. It is precisely this dialogue which constitutes the fundamental component of the extension program, ensuring that there is a two-way flow of information among all concerned with the effort.

Contents of the Management Plan

It would certainly be difficult to describe the exact model of a management plan that is best suited for all forests. It will vary greatly according to the objectives of the participants and the choice of management prescriptions for each area. Its overall complexity will be governed by the current practices in the country, the size of the area, and the number of people involved in the user group organization. Figure 8 provides an outline of a typical forest management plan geared to the participatory management approach endorsed by this document.

The following sections will follow this format, more or less. The discussion, however, is drawn from a review of several existing management plans and is intended as guidance rather than dogma. There is, nevertheless, one axiom that is an essential prerequisite to the preparation of management plans of this type. The general tendency for management planners in many countries, especially those attached to donor-funded projects, is to produce a complex document that is oftentimes much more sophisticated that it need be. **The forest**

Figure 8. Some Major Elements of a Management Plan

Basic Information

Name of the Forest/Title of the Project

Participants

Plan Prepared by ___________*; Approved by* _________

Date

Period covered by the Plan (operating years)

Background Information

Location of the forest/map/topography

Area, with compartment detail

Past use

Local conditions affecting the forest

Intended utilization of outputs

Background on participatory management agreement

Forest Situation

Type(s) of forest with areas/percentages by type

Stand history/condition

Stocking information by compartment

Growth and yield information (as available)

Actual Management

Objectives of the management plan

Restrictions and special circumstances

Cutting methods/regulation

Rotation/cutting cycle

Regeneration plan

Protection plan

Rehabilitation/restoration plan (if any)

Grazing plan

Secondary products management

management plan should be clear, concise, and written in a style and language that is comprehensible to the people who will be responsible for its implementation.

Basic Information

This section as the outline in the figure suggests, is fairly straightforward. It should include: the name of the forest and/or the user group organization and if relevant, the name of the project sponsoring the activity. This section should also list the individuals responsible for the implementation of the plan including both the forest service personnel and the user group. As there is likely to be a long list of participants in the user group organization, the list given at this point is that of the responsible individuals only; the full membership list should, however, be included as a vital appendix to the plan. It is also vital to document the names of the individuals who participated in the preparation of the plan and those who approved it. The relevant dates of preparation, approval, and the duration of the management plan should also be recorded. Much of this information can typically be recorded on **a standard face sheet** that could be developed in-country to facilitate the storage and retrieval of the most pertinent information, in which case, other information of a statistical nature might also be included.

Background Information

In general, any pertinent information that was compiled during the course of the preliminary study phase of the forest management planning should be included in this portion of the document. The location of the forest should be recorded at a level of accuracy that, if necessary, could be used to settle any juridical disputes that might arise in the future. For example, if the forest in question was included in a cadastral survey, this should be so recorded (see earlier suggestions about checking on the veracity of the survey instruments).

A copy of **the basic map of the forest** should be part of the management plan. It should show the boundary of the forest and existing boundary markers, villages, roads or trails, rivers or streams, waterpoints or waterholes, and important topographical features. This particular map should be at the largest scale available; a minimum of 1:10,000 is suggested. Note: this map should be a copy and the original should be safeguarded. Often, it is also useful to have the maps certified as true and correct by the survey crew and the forest service authorities under whose jurisdiction the forest falls. Additional maps showing such details as vegetation or soils, or compartment boundaries, should also be included in the management plan but need not be at the full scale of the original version; reductions, if such are possible, could suffice.

Depending on the intensity of the preliminary studies and the amount of information and data generated at that time, it may or may not be necessary to include all of the background details in the management plan. Additional data contained in the reports and survey information should, however, be carefully archived and protected, often with backup copies sent to the forest service for storage. It is necessary to provide a good general description of the forest both in physical and historical terms. The latter is particularly important as it may lead to future conclusions about management options (i.e., the present stand is the result of certain factors which it is possible to replicate through management to achieve the objectives of the plan). Such a description should include the following:

- a general description of the vegetation, soils, and wildlife;
- an historical account of the forest and its past use, gleaned if necessary from village elders who may be the repository of local knowledge;
- a description of the primary and secondary forest products typically available from the area; and
- a brief analysis of local conditions which are likely to affect the forest, i.e., traditional usage rights, the incidence of fire, the influx of nomads and their herds, the local grazing patterns, and similar information.

The most important part of the background information relates to the arrangements that have been agreed upon for the participatory management approach. There should **be an overall statement of the agreed goals** of the undertaking, not to be confused with the more specific and activity-oriented objective statements contained in the section on actual management. For example, cutting the forest for fuelwood on a sustained-yield basis to be marketed in a nearby urban area is a goal. Constructing x kilometers of access roads is a finite activity that would be described in the work plans. This particular section might also highlight some of the **policy determinations and agreements** that are of special importance to the management of the forest. For example, it may be the intention of the managers to use prescribed burning as a technique to control forest fires whereas in other areas, this practice is still not permitted. As a general rule, it is better to include as much detail as necessary in this section to ensure that the rules and regulations regarding the use and management of the forest are thoroughly understood, especially if the case in point is a pilot operation applying many innovative activities. This will serve as a buffer against needless disputes either within the user group organization or with the government authorities.

A section on **administration of the forest** will describe how the management plan is to be implemented in terms of the roles and responsibilities of the different participants, the user group and the forestry authorities. Until recently, the government, and typically the forest service, has taken sole responsibility for managing the forests and the relationship between the local forest staff and the local users is uncomplicated. The forest agents enforce the law as defined in the national forestry code and the users either abide with it or suffer the consequences if caught breaking the law. As governments begin to accept the idea that local participation is appropriate and new management arrangements and responsibilities are introduced, this relationship will become more complicated. It is a vitally important part of the achievements of the pilot activities and should not be taken for granted. New management arrangements must be fully described and documented.

Under the new arrangements, the basic role of the forest service is to participate in and support the development of the management plan, providing technical assistance, training, and trouble-shooting where necessary. They will also monitor the implementation of the plan to assure that the local user group is following the prescriptions specified in the plan and that these are leading to the achievements of the desired objectives. The forest service agent may also be called upon to settle disputes where these occur among the members of the user group and/or with other members of the community. The burden, however, of protection, control, and surveillance of the forest is in large measure the responsibility of the user group itself. The user group also accepts to implement the management plan according to the signed prescriptions contained therein. The implications of these new arrangements are far-reaching. For example, the user group may be granted authority to issue user permits and control the accounting system at the local level. Also, the new approach offers an incentive for local user groups to control the exploitation of the forest because they are the primary beneficiaries. **A simple organizational chart** depicting all the parties involved may be a useful addition to this section.

Until now, there has been little need to develop **financial management systems for forestry at the local level** since all of the proceeds generated from the sale of the user permits are returned to the central treasury or a centrally administered forestry fund. As decentralization becomes more accepted, however, it will be necessary to redefine financial management and develop systems that allow a portion of the proceeds to remain at the local level to pay for the recurrent costs of management and thus provide an incentive to the local user groups participating in the management scheme.

Although the idea of decentralizing the control of funds generated from the exploitation of forests is relatively new, several working models have been developed in East and West Africa which should aid future undertakings. The Zimbabwe Trust in Zimbabwe and the Kalahari Conservation Society in Botswana are two examples: NGOs in these countries have initiated schemes whereby villagers living in the vicinity of National Parks participate in the operation and management of the highly lucrative safari businesses which normally are run by private expatriate companies in cooperation with the Ministry of Tourism. Another example is in Niger, where the government has granted several local user groups exclusive rights to harvest and commercialize fuelwood and fodder in the National Forests of Guesselbodi, Gorou-Bassounga, and Baban Rafi.

In all of the above models, the system by which the funds are received is different. For purposes of illustration, however, the following paragraphs will outline the financial management system which is being employed at Guesselbodi in Niger.

Guesselbodi, a national forest of 5,000 hectares is located 30 km from Niamey. A cooperative established in 1987 originally focused on fuelwood exploitation but has expanded its activities to include the sale of hay, straw, and grazing permits. The forest cooperative has been granted exclusive authority to sell user permits from a centrally located stocking center within the forest. The stocking center is essentially in charge of buying and selling fuelwood and hay harvested by card-carrying members of the cooperative, who are directed by forest guards to designated parcels to be exploited. The number and type of permits that are sold are determined by the local forest agent in collaboration with the cooperative. The fuelwood and hay are sold for a profit through the stocking center which is managed by trained cooperative members. Accounting books are maintained and audited regularly by cooperative officers and the local forest agent.

At the end of each fiscal year, 25 percent of the profits are allocated to the cooperative and 75 percent are deposited in a forestry fund to be used to pay for the recurrent costs of management, mainly the salaries of the forest guards. Other costs of management could be included if deemed necessary and as profits increase (Heermans, et al. 1987).

To date, the forestry fund has not begun to pay for any of the recurrent costs of management, which continue to be paid for with project funds. This is due to the fact that there is no mechanism within the Nigerian administration set up to handle such a fund. This should serve as a lesson for the future: a schedule should be established at the beginning of a development project to assure that the forestry fund be institutionalized and functioning within a reasonable timeframe.

The key to the success of participatory forest management is that all parties involved receive a fair share of the revenues. At Guesselbodi, there are over 90 woodcutters who are paid as soon as they bring their product to the stocking center as opposed to working for a middleman and waiting until the end of the month or longer. The Government is satisfied because the forest is being patrolled regularly by forest guards, and more important, the forest is being exploited according to sound management principles as defined in the management document.

Whoever controls the administration and financial management of the forest, be it the user group organization, the forest service, or both, it is necessary to emphasize the importance of developing a good system of record keeping and an archive to store annual reports, studies, and other vital documents. This means that proper facilities must be constructed, and that key personnel be trained in basic organizational skills.

Information on the Forest Situation

This section of the management plan contains the basic technical information on the forest itself which will be used as a basis for the selected site-specific interventions on the forest. It will include information on the bio-physical makeup of the forest: the distribution of the different forest-cover types, if any, accompanied by the type map; notes on the topography, with a topographical map; climate data and records of recent weather, including precipitation patterns and temperature averages and any special phenomena of note; relevant data on geology and soils pertinent to forestry practices, including any information on particular issues such as erodability, laterization, or the presence of degraded areas; phenology of the important tree species; and stand history and condition data and information.

This section will also include the available information on stocking obtained during the reconnaissance inventory or field observations. Where available, information on growth and yield of the principal species and products may be included here. In reality, a good deal of information could be recorded in this section but, in many cases, it will be difficult to compile or will be absent due to the limited experience with forest management in dry Africa. Part of the goals of any pilot forest management exercise should be to expand the relevant and practical information baseline.

Management Work Plans

The final main section of the management plan will contain the bulk of the information regarding the intended activities to be employed in managing the forest. Here again, depending on the breadth of experience in the country, this can be more or less developed. There are three basic questions to answer in the process of determining an appropriate range of management options: what, when, and how? (Christophersen 1988). There is as yet a considerable lack of information and data in the field of natural forest management in dry Africa regarding the technical and economic feasibility of the various options available to the forest manager. Nevertheless, it should be possible to formulate a preliminary technical package that fits logically with the management objectives and the particular circumstances of the forest. The following sections will discuss the most common forest management options being employed in the field to date in arid and semi-arid sub-Saharan Africa. The options address certain technical and social issues that have recently been brought to light as a result of implementation.

Cutting Regimes

This discussion on cutting will focus on firewood and construction timbers, which are the two most important wood products extracted from these forests today.

Cutting as a management tool remains an ambiguous concept in most countries of dry Africa. Presently the cutting of live trees is still viewed as one of the primary factors contributing to desertification and is forbidden by law except by special permit for individual trees. As a result, firewood harvesting is limited mainly to gathering dead wood which, in turn, has left many forests with an abundance of over-mature stands that have passed their optimal age of exploitation. If such forests are properly cut **and protected**, however, there is a real probability of significant regrowth from coppice shoots and suppressed younger growth responding quickly to a reduction in competition for light and water. For cutting to be recognized as a viable and necessary management tool, it will first be necessary to dispel the notion that all cutting of live trees is bad. Governments must be enlightened to the fact that not only is pre-commercial and commercial cutting beneficial in terms of increasing the available flow of wood products, but is necessary to maintain the overall health of a forest.

The cutting schedule that is best suited to a particular forest will depend on the forest type, the site quality, market criteria, and the management goals. Removal of dead wood and over-mature trees are almost always justified as part of any harvest plan. The critical question is what percentage of the remaining stand can be cut without compromising the capital of the forest. In other words, how will the forest respond to the cut in terms of growth from coppice and regeneration. Although there has been very little work done on this subject in the academic sense, there is a wealth of knowledge in the traditional context among woodcutters who have always depended on coppice stands for firewood and construction timbers. In any case, even though tree species in arid Africa have demonstrated a remarkable ability to coppice after a cut, it is better that cuts remain conservative until more experience is gained. Conservative cuts are also more readily accepted in countries where the cutting of live trees on a large scale has never been practiced. A general rule of thumb employed in several forests in the Sahel that are being cut for fuelwood and poles is to cut no more than 50 percent of the standing volume after dead wood and over-mature trees have been removed.

Rotation Age and Cutting Cycle

It is important to differentiate between a rotation and a cutting cycle. The rotation, a term usually used in even-age management practices, is the predetermined time period during which it is intended to cut over all the trees in a forest, and corresponds to the optimal age at which to cut a tree. The rotation age is a function of technical, economic, and financial considerations. The cutting cycle, on the other hand, usually refers to uneven-aged management (selective cutting), the form of management usually implemented in African forests. It is the period that is allowed to elapse between cuttings on the same area.

A cutting cycle is a fraction of the rotation. It is the time period required for overall growth to accumulate in sufficient volume after logging to warrant a return to an area. The cutting cycle is dependent on the percent of the original stand removed, the diameter and age of the stand, and the rate of growth of the residual stand after cutting (Recknagel, et al. 1926).

Given that the cutting cycle is dependent on the growth rate of a particular stand, and there is little available data on growth of most African species, foresters will have to estimate cutting cycles based on observation and discussions with local woodsmen. Some work has been initiated in Niger and Burkina Faso that will provide preliminary guidelines for several different forest types (Rene, et al. 1988 and Alegria 1988). Similar studies should be initiated in other forest types throughout the dry zone.

It is important to recognize that there is a considerable amount of variation of age and species within these forest stands. This should not affect the determination of a cutting cycle, however, because the cutting cycle is based on cumulative stand growth, not on the time it requires for one tree to mature after a cut. For example, at Guesselbodi in Niger, which is dominated by *Combretum* species, the cutting cycle is 10 years while the time that it takes for a Combretum tree to reach maturity after a cut has been estimated at between 14 and 20 years depending on the species. Again, the cutting cycle at Guesselbodi has been estimated based on observations of stands that were cut in the past and on intuition. It may be adjusted as more experience is gained.

The cutting cycle can also be used to calculate the number of management compartments to be treated during a complete rotation cycle. For example, a relatively conservative cutting cycle of 20 years was chosen for the Nazinon Forest Management Scheme (FAO) in Burkina Faso. The total number of hectares to be cut is approximately 20,000 which means that 20 compartments of approximately 1,000 hectares each will be cut over a period of 20 years. At Nazinon, the cut is supervised by selected individuals known as "monitors" who have been trained to direct woodcutters according to a prescribed cutting regime. The "monitors" are also responsible for assuring that the wood cutters remain within the boundaries of the compartment to be cut for any given year of the rotation.

Management compartments are not only useful with regard to cutting, but greatly facilitate management of the forest so that different areas may be designated, located, and easily recognized both on the ground and in maps of the forest. In addition, the division of the forest into management compartments facilitates record keeping on a regular basis.

Sustained Yield

Sustained yield as defined by the U.S. President's Advisory Panel on Timber and the Environment is "the yield that a forest produces continuously at a given intensity of management" (Clawson 1984). Although the concept of sustained yield has been and continues to be the basis for sound, long-term management practices of forests, there are several issues that should be brought to light regarding the practical application of sustained-yield management in the African context. First, many of the forests in this zone are characterized by unmanaged over-mature stands of trees that should be cut to allow for regeneration and increased growth from the coppice. Over what period of time should this process take place? What should be the balance between growth and cut during this conversion period?

Not cutting more than the annual growth is certainly a worthwhile goal, especially in regions where the forest capital is diminishing. At this time in dry Africa, however, the specific application of sustained-yield principles remains highly idealistic and moot given the lack of management experience and the reasons for the rapid rate at which forests are disappearing. This is not to imply that foresters cannot adhere to the concept of sustained-yield management in a general sense. It is quite realistic to assume that foresters and local woodsmen will be able to develop annual cutting policies using good judgement and common sense; perhaps not adhering to sustained yield as defined by western foresters but adequate and appropriate to the African context.

Other Site Enhancement Techniques

A primary consideration in a sustained-yield, multipurpose forest management plan focused on optimizing site productivity is to maintain adequate stocking. This means that there should be a sufficient number of live trees of the desired species that will either regrow from the stump shoots following a cut (coppicing), or that will provide sufficient quantities of viable seed which will allow natural regeneration of these species.

In some instances, depending on the condition (the health and stocking levels) of the existing stand of vegetation, it may be necessary to conduct activities which will enhance the possibility for natural regeneration to occur. Some of the management activities that might be considered are illustrated in the following list.

- *Timing of the Harvest Cut*--it may be advantageous to time the harvest cut to coincide with the maturity and seed dispersal of the preferred species.
- *Seed Trees*--in order to guarantee a source of seed, it may be necessary to leave seed or "mother" trees standing throughout the area.

- *Site Preparation*--soil scarification methods, or similar work, might be required in some cases to enhance the germination environment for seeds of certain species.
- *Timber Stand Improvement*--under certain conditions, it may be necessary to carry out additional cutting to remove large, unproductive, or non-commercial tree species, or to clean out dense thickets of overly abundant smaller stock.
- *Reforestation*--in certain situations where there are areas of extreme deforestation, or denuded sites, small-scale reforestation may be justified to increase the overall stocking of the forest or to improve/ensure species biodiversity.

Enrichment Planting

Enrichment planting is employed to upgrade an existing forest to increase biomass and improve the biodiversity by adding more species of trees, grasses, and shrubs. It does not involve the removal of existing vegetation; planting occurs within and around existing pockets of vegetation.

Although once considered a necessity, enrichment planting is more and more becoming a luxury due to the high cost of producing, planting, and caring for the seedlings. It is usually the most costly of all the inputs to consider. The cost of enrichment planting can be reduced by decreasing the density of seedlings per hectare and concentrating the planting only in areas of the forest where the existing tree cover is the most sparse.

Direct seeding of trees is far less expensive than planting seedlings, but is somewhat problematic in upland areas of the lower rainfall zones (less than 600 mm). Direct seeding of perennial grasses, however, has proven to be a highly cost-effective means to upgrade the quality of the range and to stabilize eroded soils as well as provide other secondary forest products such as thatch.

One common mistake linked to enrichment planting programs is to limit the nursery production to species which seem most likely to succeed based on evaluations of the growth and vigor of species that make up the forest today, with little consideration for what existed in the recent past. One of the goals of an enrichment planting is to maintain/augment the biodiversity of a forest by planting a wide variety of species. Efforts should be made to determine the species that have recently disappeared from a forest due to overcutting or browsing. Many such species disappeared as a result of their high commercial value, not because of drought or any major change in the ecosystem. If given a chance, many such species can be reintroduced into the forest to improve biodiversity as well as increase its commercial value.

Fire Protection and Management

Although foresters continue to regard all fires as harmful, they are employed in the traditional context by herders, farmers, and hunters: the herder, to promote regrowth of vegetation; the farmer, to clear fields and eliminate harmful parasites; and the hunter, to flush game and clear views for hunting.

The most frequently cited harmful effects of fire are linked to the alteration of vegetative types. In some cases, the negative effects of fire are quite obvious and the resulting losses are felt by all user groups. For example, certain fires that occur late in the dry season are so intense that all of the herbaceous ground cover is lost leaving the area denuded. If such a fire occurs in an area that is dominated by soils with a high clay or silt content, the result is increased runoff, which may lead to serious soil erosion problems.

While it is inaccurate to say that the use of fire is totally good or totally bad, the general attitude among foresters in dry Africa is that fires are bad and should be prevented at all costs. This attitude is a carryover from colonial times and has led to the development of costly fire prevention schemes such as the construction of firebreaks which are, for the most part, ineffective and extremely expensive to maintain. Most of the firebreaks that were established 20 years ago are not maintained today and are barely recognizable. In spite of this, new tractors and bulldozers are still being bought to construct new firebreaks, and firetowers are still being erected.

The question remains: when and where is fire control justified? One cannot yet generalize on the issue of fire for the entire arid and semi-arid zone. In the more arid areas which are characterized by annual grasses and sparse vegetation, fire is obviously not as serious a problem as in the higher rainfall zones. In many areas where rainfall is higher, the entire bush is burned annually in spite of monumental campaigns by the forest service and the government to prevent fire. Many people are beginning to realize that "the war on fire" is being lost.

In light of this, the question remains: is fire control justified at all or should fire be accepted as a fact of life? One answer being put forth by an increasing number of foresters is that efforts should continue to convince people to burn early as opposed to later in the dry season. Total fire prevention should also continue to be attempted when carried out within the framework of a management scheme to protect cutover parcels designated for regeneration. Most foresters agree that such protection is necessary to allow for the development of young trees. However, questions remain regarding the period of time that such protection is necessary.

New Approaches to Fire Control

Work is presently being introduced in several countries to test other methods of fire control that may be less expensive and more appropriate to Africa than what has been done in the past. These include: educating the masses through mass media campaigns, training local fire brigades, prescribed burning, and controlled grazing schemes. For example, at the Dinderesso Forest in Burkina Faso, forest managers negotiated contracts with local herders to graze their animals in designated areas to reduce the herbaceous matter which, if left, would fuel harmful late dry-season fires. The herders benefited from the good-quality pasture and the project was able to reduce the fire hazard.

Prescribed Burning

Prescribed burning is an alternative approach to prevention but requires planning and some knowledge as to how a particular vegetation type will respond to a burn. Most trees, shrubs, and perennial grasses of the dry zone are fire-tolerant and will resprout from the stem base. Annual grasses will generally regenerate from seed. Some species are obviously more fire-tolerant than others, however, and prescribed burning programs can alter the composition of the bush by burning early or late in the dry season. Late fires burn much hotter and favor regrowth of fire-tolerant species. Early fires, on the other hand, burn "cooler", favor less fire-tolerant species, and are often employed by foresters to eliminate dry herbaceous matter which could fuel more harmful late season fires.

Fire should be viewed within the context of a particular ecological or cultural setting and treated accordingly. The most logical place to start is by asking villagers and herders about their attitudes toward fire, and if it has been employed within the framework of the traditional farming or herding system. If so, why and how? Often, villagers will state that prescribed burning is useful under certain conditions but they have abandoned the practice because it is now forbidden by law. At the Gorou-Bassounga Forest in Niger, for example, farmers and herders traditionally burned the forest as soon as it would ignite after the end of the rainy season. The herders benefited from the regrowth of the perennial grasses and the farmers claimed that the fires eliminated a certain parasite that was harmful to their crops. Both of these groups were dismayed by the government's decision to stop all bush fires.

In order to demystify fire, foresters and other environmental scientists must first convince authorities that fire can be used under certain conditions if applied by local specialists and for well-defined reasons. This is often easier said than done, however, and may require that the debate be deferred to research or that authorities be invited to visit other countries where prescribed burning techniques are being successfully employed.

Range Management

Foresters and range managers have always worked apart from each other and continue to do so although each is concerned with the rational harvesting and maintenance of trees, shrubs, and grasses. There are several reasons for this, some of which can be traced to the European structures and practices upon which present day African institutions have been modeled. Unlike in the United States, where the U.S. Forest Service regularly employs range management specialists, range-related problems in Africa are addressed by the livestock services which are generally directed by veterinarians. These services work apart from the forest service and have traditionally ignored natural vegetation. Some livestock services have now begun to accept becoming more involved with range management vis-a-vis herbaceous vegetation, but they are not involved with woody vegetation which often provides the only source of good browse during the dry season.

Another reason, however, is that many range management projects have been carried out in what is deemed as the "true pastoral zone" characterized by low rainfall, sandy soils, and inhabited by nomadic and semi-nomadic herders. Because of the sparse tree cover, such zones are generally of limited interest to foresters.

Recent studies that were carried out in Mali have shown that these lower rainfall zones are not usually subject to overgrazing due to the resilient nature of the vegetation, the relatively fertile soils, and the fact that nomadic herders are able to move from a pasture before it becomes overgrazed. The same studies have shown, however, that animal production to the south of what has traditionally been labeled as the "pastoral zone" is jeopardizing the precarious nitrogen balance and that overgrazing is causing serious soil erosion due to the fragile nature of the soils in the higher rainfall zone (Bremen 1983). Furthermore, it is generally recognized that many areas outside the "true pastoral zone" have higher animal density populations in terms of the number of animals per hectare even though much of the land is cultivated.

It is ironic that livestock projects continue to be targeted for zones where past projects have discovered extremely efficient indigenous herding systems (Maliki 1981). In the meantime, areas further south, within the agricultural zone, continue to be overgrazed resulting in extensive soil erosion and serious conflicts between farmers and herders. Fulani herders from the northern Sahel who have migrated to northern Nigeria, Benin, Togo, and Ghana are virtually at war with local authorities and farmers. In some areas of Benin, the Forest Service is authorized to shoot cows belonging to "the strangers from the north", a scenario reminiscent to the range wars of the American West.

Range management/livestock development projects in general have produced few, if any, successes and are highly criticized for the introduction of techniques that have upset the balance between the number of animals and the carrying capacity of the ecosystem. For example, the introduction of vaccination programs has tended to greatly increase the size of the herd. In many areas, mechanically powered tubewells were drilled without consulting the traditional authorities and made accessible to all comers. The overall result has been an increase in herd numbers, a decrease in pasture, and an erosion of traditional management practices (World Bank 1985).

Grazing Schemes

The employment of a particular grazing scheme implies that an individual or group has authority to control the manner by which animals are permitted to graze a given area. In the past, traditional grazing schemes were implemented by pastoralists who had jurisdiction over the movement of animals and water rights in a designated area. Today, although there are still areas of dry Africa where traditional grazing rights are recognized, in most areas, there is little control over the range and herds are allowed to wander freely.

Grazing schemes can be separated into two broad categories: continuous and rotational. Continuous grazing involves the determination of a fairly conservative stocking rate for a given area on which animals continuously graze. Although it is generally recognized that individual animal performance is best when continuous grazing is properly applied, the main drawback to this system is that it can lead to over-use of certain preferred species and under-use of potentially valuable species (Barnes 1979).

Rotational grazing involves the division of a range into sections that are rested during the same season over a period of years. This system is particularly useful where the range is degraded. Much research has been carried out regarding the use of rotational grazing all over the world and the results are remarkably conflicting. It is generally agreed, however, that rotational grazing schemes are quite beneficial in restoring deteriorated ranges but are seldom superior to continuous grazing in range which is in good condition (Walker 1979).

Given that many of the remaining natural forests are degraded due to severe overgrazing, it will be necessary to introduce schemes to restore the range by greatly reducing the number of animals or totally excluding animals from particular ranges until such time that it is deemed safe to allow controlled grazing or continuous grazing by a defined group (Perrier 1990).

In the Central Rangelands of Somalia, herders employ a continuous repeat-seasonal system whereby certain areas are grazed during the same season each year. At the same time, however, herders have set aside "seasonal range reserves" which are not grazed during the beginning of the rainy season in order to allow certain species to reestablish themselves on a periodic basis. In addition, "famine reserves" have been set aside to be grazed only during drought years.

In view of the variety of grazing schemes that are available as management options, and the disagreement among range managers as to which type is best suited for what conditions, it will be necessary that new, innovative approaches be tried and tested over a number of years in different forest types throughout the arid and semi-arid zone and that these serve as models for other forests. In any case, most will agree that the key to any success will be to adopt approaches whereby the pastoralists truly control the utilization of forage and water. Also, studies have shown that pastoral societies are very heterogenous and any attempt to organize a group must be flexible and accommodate the differences in household goals and resource availability (Perrier 1990).

Stocking Rates

The optimal number of animals that can be grazed in a given area is usually determined as a function of the carrying capacity of the vegetation and the critical level of stocking beyond which weight gain per head decreases. In Africa, where the carrying capacity of the vegetation is directly linked to the amount of rainfall of any given year (which may vary between years by 500 percent or more), it is difficult to calculate fixed stocking rates. However, one can calculate a conservative stocking rate for an average rainfall year and adjust it according to the condition of the range.

Initially, this may require that a range inventory be conducted by a range management specialist to determine the quantity and quality of available pasturage for an average rainfall year. Results from the inventories can be used to determine the number of animal units as a function of available dry matter.

Another option is to develop a set of criteria by which forest guards would be able to judge the quality of the range and adjust the stocking rate accordingly. Yet another option is to employ local herders who are extremely capable of determining the quality of the range by observing the appearance of certain indicator species. When their herds begin to graze on these species, the herder knows that it is time to move to another pasture.

Whatever method is used to determine the initial stocking rates, it should be recognized that these figures are only estimates, and that the true grazing capacity can be determined only by stocking with the estimated number of animals and observing the results (Stoddart, et al. 1975).

Protection and Control

The science of range management involves the exclusion of animals from a certain area (protection) or limiting the number of animals allowed to graze a designated area (control). This is usually done with fences, guards, or both. However, given the high cost of fencing in Africa and the vast areas involved, fencing does not appear to be a realistic option except on commercial ranches.

The main burden of controlling herds should become the responsibility of the people who are using the range. This can only occur if these same people have been involved in the design process of the management scheme and have formally accepted it. Forest guards will always be necessary, but they can be effective only to the extent that the local population supports the program.

If guards are used, they should be given the authority to impose fines on owners of animals that have illegally entered a protected area. Guards should be instructed to capture animals as opposed to chasing them away and hold them in stockades until fines are paid. This system is quite commonly employed in the traditional context whereby farmers are paid damages by the owners of animals that have destroyed crops.

Grazing Permits

Once the stocking rate has been determined, who shall have access? Under what conditions? The most obvious way of controlling the number of animals on a parcel is through the sale of grazing permits. If tree cutting is to be controlled by permits, why not do the same for pasturage? Although ranchers in the U.S. have been paying for the use of the range in National Forests for a long time, this concept is foreign to Africa but should not be eliminated as a management option. There are viable lessons to be learned from the American Southwest where community grazing schemes involving the sale of grazing permits have been functioning for many years on both public and private lands among American Indians in New Mexico (Eastman, et al. 1987).

Fodder Banks

Although the production of dry-season fodder in the form of hay or silage is not a common practice in Africa, it has been shown that people are willing to pay for good quality hay or the right to cut it. People have not been involved in creating dry-season fodder banks, primarily because pasture was relatively abundant in the past, especially perennial grasses which can be grazed during the dry season. Given an overall increase in pressure on the existing range, accompanied by a deterioration in the quantity and quality of the range, the concept of establishing dry-season fodder reserves becomes more appealing.

Rehabilitation of the Range

As already mentioned, many of the forest areas of the dry zone have been severely overgrazed and the range has deteriorated to the point that some rehabilitation intervention becomes desirable. The intensity of a range rehabilitation program depends on the condition of the range and available resources. In many forests, the range will rehabilitate itself once the pressure of the livestock is removed. More degraded areas will require additional inputs.

The condition of the range can best be evaluated by the quality and quantity of the vegetative cover and soil stability. Rehabilitation programs should focus on reestablishing perennials that may have existed in the past but are less frequent today due to uncontrolled grazing. Both Senegal and Niger have introduced programs to reestablish *Andropogon gayanus,* which is highly valued as fodder and also as a source of thatch. Seeds are collected from the families that cut the grass for thatch and the seeds are sown late in the dry season.

Mechanized methods of range rehabilitation which are quite popular in the southwest U.S. include scarification of the surface and direct seeding using tractors or bulldozers. While such methods are very efficient, they are generally not recommended for Africa at present due to the high initial investment and the high cost of maintenance. Labor-intensive programs are not only more practical but provide employment opportunities to local villagers and herders during the dry season.

Agriculture in the Forests

Many of the remaining forests in Africa, gazetted and ungazetted, are inhabited by farmers, some of whom have traditional farming rights and others who are there illegally. It is not uncommon to find entire villages of farmers or former herders who were forced to relocate from lower rainfall zones during drought years and are making a new start in forests that are cut and burned to make room for agriculture.

For the forest manager who is confronted with this situation, there are approaches to consider. One is to simply tell the inhabitants to leave the forest. Sometimes this is done by force with little prior notice and sometimes efforts are made to relocate the villagers onto uninhabited lands outside the forest. At Nazinon in Burkina Faso, for example, all of the farmers that were commanded to leave the forest were relocated to other farms outside the forest. In addition, the project paid for the installation of several wells to provide water for the new villages. The project has initiated an effort to direct seed trees on the former agricultural lands (approximately 10 percent of the forest area).

Another approach is to negotiate "agricultural contracts" with the farmers, which essentially are leases that permit farmers to cultivate designated fields in the forest as long as they abide by the terms of the lease. The duration and terms of the lease are negotiated between the forest managers and the local farmers. For instance, in the beginning, it may be preferable to lease the lands from year to year and include a token fee. Also, the lease may include clauses which obligate the farmer to practice certain agroforestry or soil conservation techniques.

If farmers are permitted to remain in the forest, it is recommended that they be concentrated onto one or several parcels designated for agriculture as opposed to having them scattered throughout the forest. This greatly facilitates surveillance of the forest and assures that no further expansion occurs outside the designated area(s).

There are several reasons why, in most cases, the second approach is preferred:

- in many forests, farmers are well established and have no other fields to go to;
- in some instances, farmers are simply reclaiming fields that were taken from them when the forest was originally gazetted during colonial times;
- most of these forests have never been properly patrolled and boundary markers were removed long ago which meant that some farmers may have entered the area from outside and settled within the forest without even knowing it; and
- the highest land-use potential of fertile areas within the forest is agriculture, not silviculture. Why not farm it?

The agricultural contract approach is not only more humanitarian but maximizes the economic potential of a forest area and promotes good will with local farmers. It demonstrates to the local population that the management program is being developed to optimize benefits from the forest which are in their best economic interests. In addition, it provides the forest manager with an opportunity to demonstrate the effectiveness of proven agroforestry or soil conservation techniques that could be included in the lease agreement.

For example, in the Gorou-Bassounga Forest in Niger, farmers were allowed to remain in the forest as long as they protected and maintained a certain number of trees per hectare that were raised in a central government nursery and planted by workers with the farmer. The choice of species was discussed beforehand with the farmers who opted for either *Adansonia digitata* (baobab) or *Parkia biglobosa* (nere) trees. Farmers were granted exclusive harvesting rights to the fruits and leaves from the tree which are sold in the market as condiments. They are not, however, allowed to cut the trees without authorization.

Soil Conservation/Watershed Management

It is difficult to justify the high cost of labor-intensive soil conservation programs on forest land unless carried out with a specific goal in mind or within the framework of an integrated watershed management program that is within or adjacent to the forest. For example, sand dune stabilization may be justified if a dune is directly threatening a field or a village. Gully erosion control is justified if gullies are threatening roads or adjacent agricultural land.

Watershed management projects that focus on labor-intensive soil conservation works often ignore the main cause of the deterioration of a given watershed which is overgrazing. Oftentimes, all that is needed to restore and maintain a watershed is to control the number of animals. In any case, all watersheds within or adjacent to the forest should be delineated and addressed in the management plan.

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