# The Miombo Woodlands of Central, Eastern and Southern Africa

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## Summary
Aspects of the environment and ecology of Miombo woodlands are described. Attention is given to the widespread nature of their distribution area and the role played by Miombo at local and national levels. A matrix of woodland-use is presented. This offers some insight into changing resource-use patterns in Miombo, and highlights the conflicts which may ensue with the adoption of certain woodland management strategies.

## Introduction
In Africa, tropical dry forests and woodlands constitute between 70 – 80% of all forested land (Murphy & Lugo 1986). South of the Equator, (5° to 25° S) Miombo woodlands are the main dry forest type in the continent, occupying an estimated area of 7 million square kilometres (Griffith 1961). Thus, Miombo represents one of the most widespread, yet compact forest types in the world. Almost 50% of the land area of both Tanzania and Zambia, and large tracts of Mozambique, Malawi, Zimbabwe, Zaire and Angola support Miombo (Fig. 1). This aereal distribution corresponds roughly to the Zambezian Floral Domain of White (1965), recognised for its floristic richness and the widespread occurrence of the tree genera *Brachystegia, Julbernardia and Isoberlinia.* Despite the widespread nature of this woodland type, its long history of exploitation and the increasing human-related pressure and needs within the countries mentioned, Miombo resource-use remains largely undocumented. The data base on inventory, silviculture,

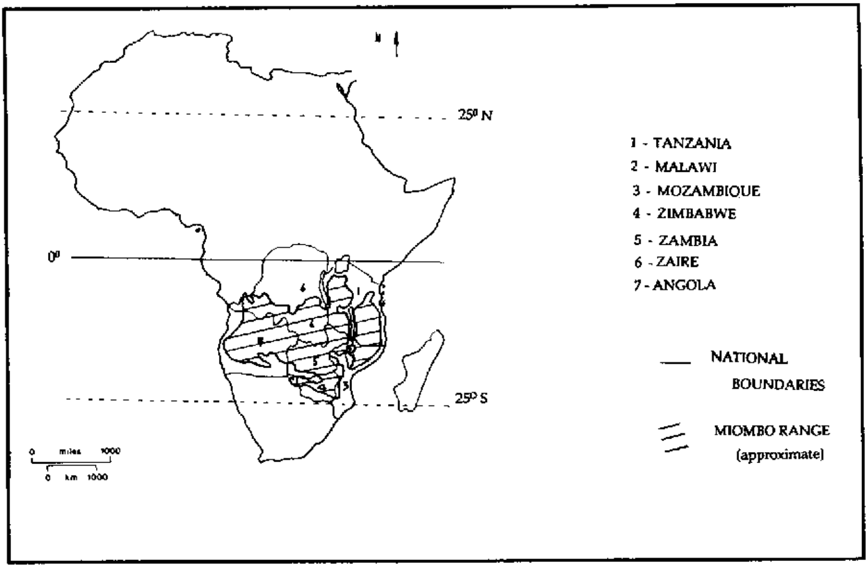



**Figure 1:** The Distribution of Miombo Woodlands in Africa.

conversion rates, and regional productivity remains scattered and discontinuous.

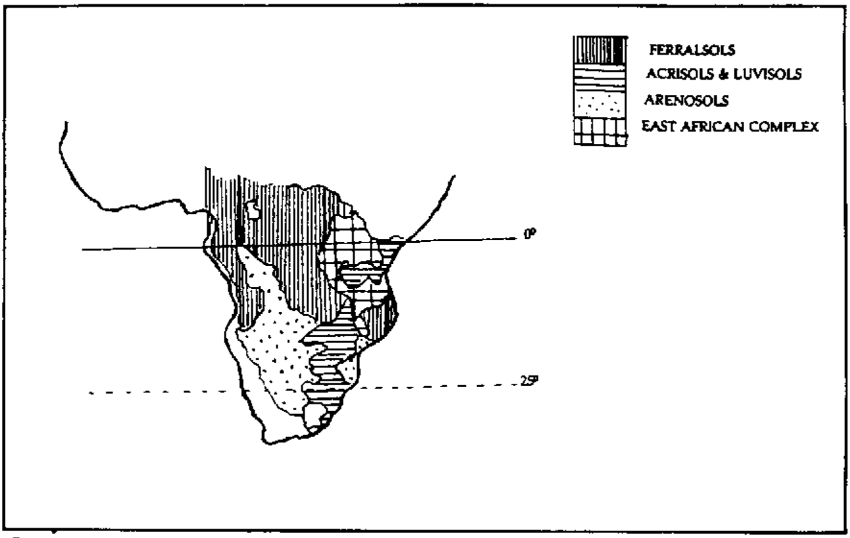
## ENVIRONMENTAL SETTING

### Climate

The natural range of distribution of Miombo woodlands falls between 5 and 25° S. This tropical position means that temperatures are high over most of the area. Thus, precipitation assumes strong significance as a key climatic factor in relation to biological productivity and land-use strategies. Menaut *et al* (1985) distinguished two eco-climatic zones for the areas in question. In the Northern Miombo block, the mean annual rainfall (MAR) ranges between 800-1200 millimetres, with a relatively long rainy season of up to five months. In contrast, the Southern block is characterised by drier climates, with a MAR range of 600-800 mm and a rainy season duration of up to four or five months. In central areas, no rainfall may occur for up to eight or nine months, with relative humidity levels remaining low throughout the dry season (UNESCO/FAO 1977). Highest temperatures are recorded in October/November prior to the rains. Ernst & Walker (1973) recorded 40° Celsius in shade and 45° C in sun-exposed areas in Zimbabwe. Mean annual temperatures vary from 18° C to 24° C, and are more closely correlated with altitude, than with latitude.

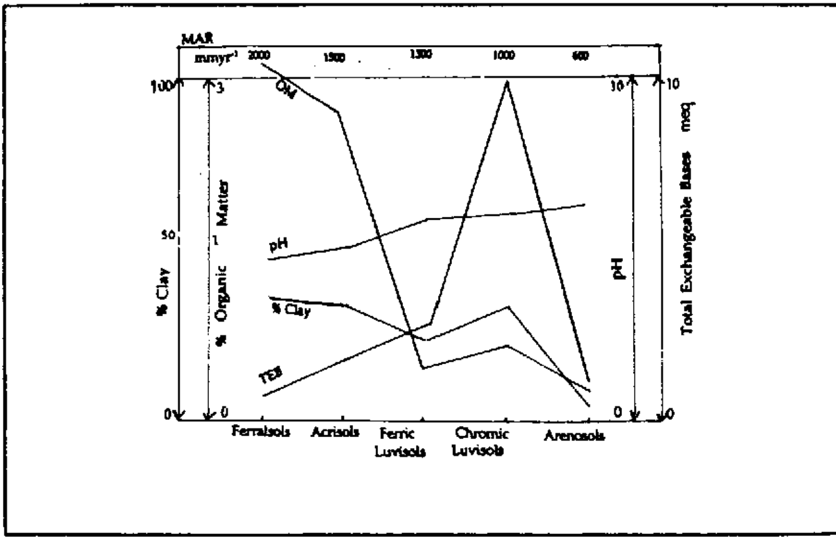
**Geomorphology and Soils**

Miombo and savanna vegetation occurs largely on the inland plateau of "High" Africa, within an altitude range of 900-1500 metres, most commonly 1200-1500 m above sea level. A granitised basement complex with metamorphic rocks ( gneiss, granites and schists) of Pre-Cambrian origin forms one important group of parent materials (c. 600 million years old). Through weathering, this substrate has been worn down. These more resistant strata now stand out as dome-shaped inselbergs amongst the plains. Alluvial sediments form a second group of parent materials, whilst in the highlands, limestone and dolomites provide the third main parent material. Over the whole plateau, chemical weathering is active throughout the year, with high leaching rates, leading to the development of




From UNESCO/FAO (1977)

**Figure 2:** The Main Soil Groups within the Miombo Eco-zone.




From UNESCO/FAO (1977)

**Figure 3:** Physico-chemical Properties of Main Soil Groups within the Miombo Eco-zone.

soils which often bear little chemical resemblance to original parent material (Okigbo 1985).

In general terms, four major soil groups, the Ferralsols, Acrisols, Luvisols and Arenosols (corresponding to the Oxisols, Ultisols, Alfisols and Cambisols of the U.S.D.A. soil classification) can be identified over the range (Fig. 2). Some physico-chemical properties of these soil groups are presented in Fig. 3. Organic matter (OM) content for the Ferralsols and Acrisols is high in comparison to the other two groups. Soil pH ranges between pH 5 to pH 6.5, with the more acid soils found in the higher rainfall areas. Clay content varies from almost 50% in the Ferralsols and Chromic Luvisols to almost zero in the Arenosols.

Most soils in the ecozone have a medium to coarse texture. This increases their vulnerabiltiy to water erosion. Rainfall intensities of up to 60mm per hour have been reported, with an erosive potential which may be up to 16 times greater than most temperate rains (Sibanda & Odra 1988). Slope factors range from 0-30% with mid-slope soil having good drainage properties. These free-draining slopes are preferred for cultivation, although they are often poor in nutrients. The removal of tree and plant cover, followed by permanent cultivation (i.e. without a fallow period), leads to high soil losses. Young (1989), for example, calculated potential losses of 255 tonnes/ha/yr for a ferric luvisol, with a 10% slope (5.7°), and a MAR of ca. 800 mm.

## WOODLAND DESCRIPTION

### Structural Characteristics

Miombo woodlands have a deciduous or semi-deciduous nature and a canopy arrangement of one to three layers. Malaisse (1978) described the woodland structure as follows:–

- a dominant tree layer of 14 to 18 metres, often over 20 m in height, and a density of ca. 65 stems/ha.
- a secondary tree layer of eight to 12 m, sometimes up to 14 m, with a stem density of ca. 80/ha.
- a shrub layer, less than eight metres tall, with ca. 375 to 500 stems/ha.

Under natural conditions, stem density and height vary considerably. Soil depth, soil texture, and the availability of moisture in the dry season are factors which determine woodland architecture. The influence of fire, clearance, felling and grazing/browsing are regarded as key factors under disturbed conditions. Variation in stem density can be quite wide, e.g. Martin (1974) recorded over 1712 stems/ha in a Miombo shrub layer in Zimbabwe. This is almost five times the figures shown by Malaisse (1978) for Zaire. Tree form may vary from small, twisted and misshapen stems, to tall straight boles. Only one species, *Marquesia macroura,* displays a buttressing habit. Mature woodlands have a canopy which is umbrella-shaped, with the crowns just touching and rarely interlocking. Depending on the degree of canopy closure, a herbaceous layer may develop. In more open sites, grass growth may achieve a height of up to two metres, with as much as 70% ground cover (Walker 1985). This is a factor contributing to the high incidence and intensity of woodland fires in the late dry season.

The canopy is far from continuous in contemporary Miombo, with gaps enlarging over time as shifting cultivation ("chitemene" in Zambia), selective felling and clearance for semi-permanent cultivation occurs. Below this level the understorey is also dis-continuous under natural conditions. The shrub layer, on the other hand, is continuous and quite dense.

### Botanical Composition.

The Family Leguminosae is the most frequently encountered Plant Family in Miombo Woodlands. The authors encountered 32 Plant Families within arborescent layers, with 25% of all genera and 22% of all species belonging to the Leguminosae (Tuite & Gardiner 1990a unpubl.). Other important Families included the Rubiaceae, the Anacardiaceae, and the Combretaceae. The floristic composition of the field layer also varies, with the Compositae, Graminaceae, and the Papilionaceae being most common. An interesting component of this field layer in both woodland and cut-over areas, is suffruticose vegetation, found usually below heights of one metre. White (1965) refers to these life-forms as the "underground forests of Africa". Suffrutices have a perennial habit, with aerial parts which die-back during the dry season, when the incidence and intensity of annual fires are greatest.

**Woodland Productivity and Yield**

Sawlog yields of 2-14m$^3$/ha have been estimated for Zambia, with fuelwood yields of 50-150m$^3$/ha (Celander 1981). In Tanzania, Temu (1979) found total volume to 5 cm top diameter (overbark), to be approximately 120m$^3$/ha, with 15-20% of the volume suitable for veneer and/or sawntimber. Up to 50% of the volume can be held by branchwood, whilst misshapen stems and short boles with wide-branching habits do not lend themselves easily to economic conversions, with the exception of charcoal and fuelwood billeting. During a survey of wood stocks for charcoal in Zambia, Chidumayo (1987) estimated a stackwood yield of 14.8m$^3$ per m$^2$ Basal area (B.A.). This corresponds to 7.74 metric tonnes oven dry weight per m$^2$ (B.A.). The rate of growth in Miombo is often quite low, and may not exceed 4m$^3$/ha/ yr. Nilsson (1986) estimated an annual growth rate of 1-2m$^3$/ha/ yr for disturbed woodlands in Tanzania. Young Miombo in Zambia was found to have an annual increment of 2.5 tonnes/ha fresh weight (= 1 tonne/ha dry weight), and an annual basal area increment of 0.5m$^2$/ha/yr (Stromgaard 1985).

In general terms, dominant tree layers are often found to represent about 35% of total B.A. When B.A. values are lower than 10m$^2$/ha, the lower layers and grass/herb strata change, leading to a wooded savanna. Endean (1962) highlighted the rate of increase in B.A. which resulted from selective cuttings, with a 110 to 120% rate of increase following the removal of one-quarter to one-third of basal area. During a study of regressive woodland succession in Zaire, Malaisse (1985) offered comparisons between the stocking levels for Miombo (15 to 25m$^2$/ha B.A.), dry evergreen forest (30 to 40m$^2$/ha) and wooded savanna (5 to 15m$^2$/ha). Some estimations for Miombo stocking levels and biomass production from various sites within the eco-zone area presented in Table 1.

**Table 1:** Productivity estimations for Miombo woodlands

| **Region** | **Woody Biomass (kg dry wt/ha)** | **Basal Area (m$^2$/ha)** | **Source(s)** |
|---|---|---|---|
| Zambia | 48,000 | 14 | Stromgaard (1978) |
| Zaire | n.a. | 15-25 | Malaisse (1985) |
| Zimbabwe | 20,000 | n.a. | Martin (1974) |
| Tanzania | | | |
| . . Rukwa | n.a. | 14 | Boler & Schiwale (1966) |
| . . Iringa | n.a. | 8 | Tuite & Gardiner (unpubl) |

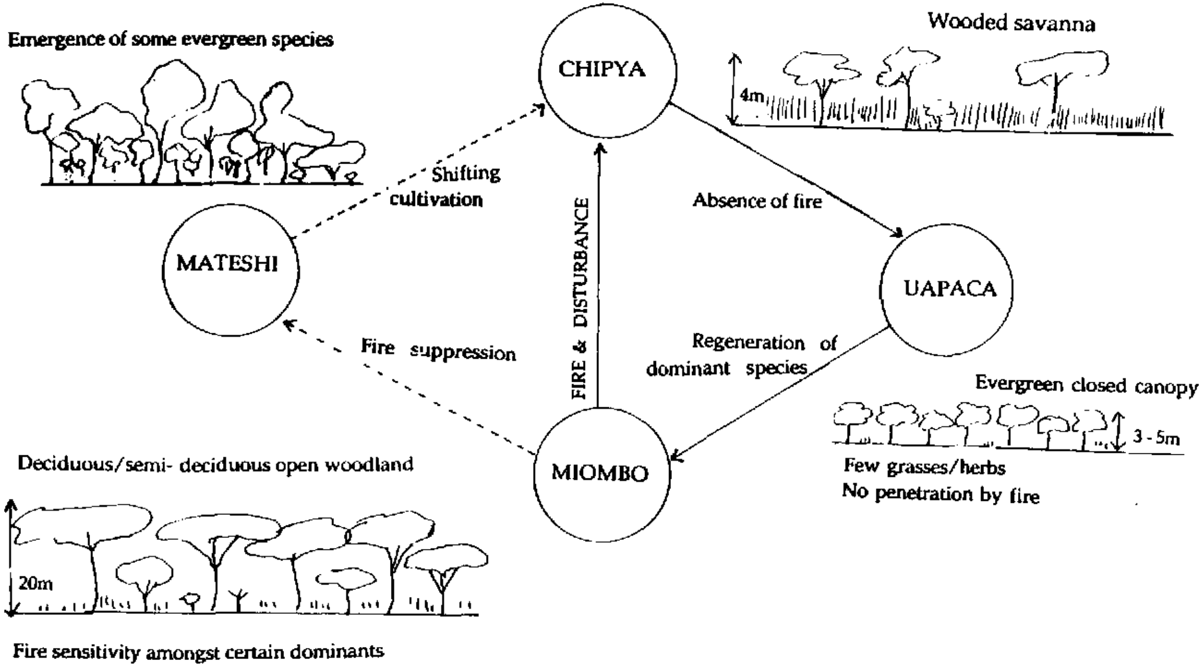



**Figure 4:** Miombo Woodland Succession.

## MIOMBO WOODLAND SUCCESSION

Most ecologists agree that Miombo woodlands represent either a fire or a climatic climax. Three or four seral stages may be recognised (Fig. 4). The Chipya stage may develop where either mature Miombo or Mateshi woodland is opened by fire or shifting cultivation (Fig.4). This chipya stage is characterised by a sparse woody component, with low stature and misshapen form. The grass/herb layer is well developed, often reaching heights of two metres. Repeated burning, overgrazing/browsing, indiscriminate heavy felling and patchy cultivation are regarded as key factors in the development of Chipya (Celander 1981). *Pterocarpus angolensis, Syzygium guineese, Diplornychus condylocarpus, Hymenocardia acida,* and *Vitex doniana* are common tree members in this seral stage. Such species display adaptations to their environment, e.g. *Pt. angolensis,* (mninga), allows its roots to accumulate over a number of seasons without aerial growth. After up to five or six years there is a sudden emergence of a shoot which may elongate up to 1.5 metres in one season. Thus, the new growth is protected to some extent, from intense grass fires. The term "pioneers" has been applied to these Chipya tree species. The term is not entirely accurate however, as they are frequently encountered in more undisturbed areas, where they show better form and attain greater heights.

The Uapaca stage develops in the absence of annual burning and generally less disturbance. It is dominated mainly by *Uapaca kirkiana,* with a closed canopy of up to five metres in height, and almost total suppression of grass/herb layers. Thus penetration by fire is prevented, allowing regeneration of *Brachystegia, Julbernardia* species and other Miombo dominants. Few authors have attempted to put a time-scale on the successional period, from Chipya to Miombo. Stromgaard (1986), in a study of the recovery of Miombo following shifting cultivation, found that after 25 years, the Miombo dominants were still absent in abandoned plots. He also found that a *Combretum* wooded savanna element looked likely to succeed the Chipya, rather than the Miombo stage.

Miombo woodlands are structurally very different from Chipya woodlands, with a canopy arrangement, stocking levels and a floristic richness not found in the Chipya or Uapaca stages. *Brachystegia* and *Julbernardia* spp. are fire sensitive when young, and retain sensitivity into maturity, when fierce, late-season fires occur. Trapnell (1959) showed almost complete loss of *Brachystegia, Julbernardia,* and *Isoberlinia* spp. under repeated burning regimes in Zambia. Regrowth was good however in early-burnt plots. In the absence of fire over prolonged periods, Mateshi, a dry evergreen forest may develop. It has a dense understorey with high numbers of small trees and shrubs, a sparse field layer, and a range of epiphytes and lianas (Fig. 4). Mateshi is rarely found as extensive woodland today, and occurs most frequently as remnants in areas where soil moisture is relatively high.

## RESOURCE-USE IN MIOMBO WOODLAND AREAS

Historically, woodland resource utilisation in these areas has been multipurpose. In areas where the levels of disturbance have been relatively low, one can still observe the diverse range of uses and products derived within a Miombo environment. Figure 5 presents a summary of the various types of uses found by the authors in North Ihowanza in Tanzania. Agroforestry techniques have been traditionally used in Miombo areas to produce staple food crops (millet, sunflower, beans and groundnuts) and to tend herds of cattle, goats and sheep. In many areas, such systems have been maintained, of which the 'chitemene' system (Zambian term) is the most renowned. The practice involves the pollarding of selected trees at 1-1.5m or more (Plate 1). Following cutting, the lop and top is piled into large heaps and later burned *in situ* to provide ash fertiliser. Depending on site productivity, this

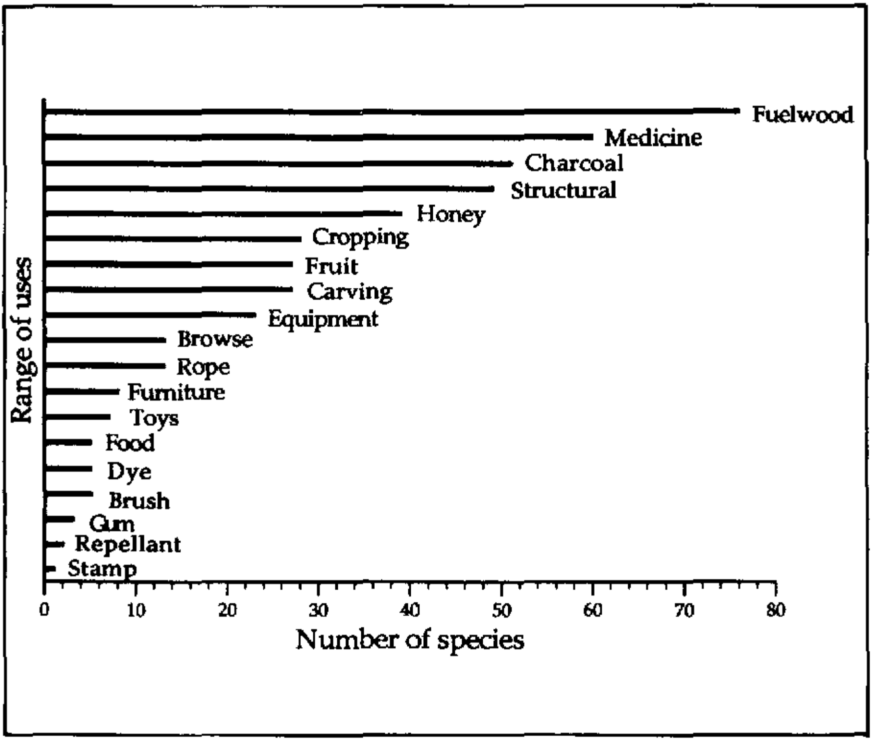



Figure 5: Tree Species Utilisation in Miombo Woodlands (south Tanzania).

**Plate 1.** Pollarding of Miombo trees prior to cultivation.

**Plate 2.** Kiln used for firing bricks.

**Plate 3.** *Pterocarpus angolensis* D.C. retained in farmland.

form of cropping may continue for up to 4-6 years, when the site is then abandoned, allowing pollard and root sucker regeneration to continue. The interval between abandonment and repollarding varies, but may be up to 7-8 years.

The value of Miombo coppice as potential browse is receiving increasing attention. In areas where the dry season may extend over seven to eight months, both browse and shade are valuable resources. Regrowth brings foliage to within easy reach of cattle, goats and sheep. Woody vegetation flushes as early as July or August, providing browse for up to six months or more, before the rains begin. By October, coppice regrowth in burnt or cleared areas may account for up to 30-35% ground cover (Lawton 1968). The importance of certain species in terms of protein and mineral content is highlighted in Table 2.

**Table 2:** Crude Protein and Mineral Content % of Browse

| Species in Miombo (%) | Crude Protein | %Ca | %P | %Mg | %K |
|---|---|---|---|---|---|
| Julbernardia paniculata | 12.38 | 0.70 | 0.24 | 0.25 | 1.50 |
| Strychnos cocculoides | 15.50 | 0.27 | 0.26 | 0.29 | 1.85 |
| Syzygium guineense | 11.50 | 0.28 | 0.20 | 0.41 | 1.8 |
| Brachystegis longifolia | 12.13 | 0.48 | 0.19 | 0.27 | 1.18 |
| Anisophylla boehmii | 10.63 | 0.12 | 0.17 | 0.28 | 1.07 |
| Albizzia adianthifolia | 29.13 | 0.20 | 0.35 | 0.20 | 1.66 |

Source: Lawton (1968)

(Source: Lawton (1972). meq. No. of Species Source(s) Figure 5 5)

There is a high dependency on natural woody formations for energy in this ecozone, both for domestic and industrial purposes. Fuelwood and charcoal are the cooking and heating materials for rural and urban sectors respectively. Tanzania, in particular, has a high wood energy requirement, with an estimated 95% of all wood harvested being used for energy (Mnzava 1985), and a per capita consumption of 1.5 to $2m^3$ annually in the central regions (IRADEP 1987; Ahlback 1988). The conversion of fuelwood to charcoal for urban centres has become a lucrative market in many areas, with high demand on the one hand, and attempts to control the rate of conversions by the forest authorities on the other. The conversion process dissipates between 20% to 60% of the heating value of the original material (Lewis & Berry 1986), but produces a lighter product which smokes less, is easily transported and is suited to the metal stove used by urban households. The drying process used for important cash crops such as tobacco, tea and coffee relies on wood raw material for energy. It has been estimated, for example, that up to four hectares of fully stocked Miombo may be required to cure one hectare equivalent of tobacco in central Tanzania (IRADEP 1987). On a smaller scale, local enterprises such as brew-making, fish-smoking, sunflower oil production and brick-making derive their energy source from natural woody vegetation (Plate 11).

The exploitation of *Pterocarpus angolensis* (Mninga) for commercial purposes was formerly one of the main activities pursued by forest authorities in these regions. It is the timber species which attracts most attention for export and local joinery purposes (Groome 1966; Breithenach 1973). It has been managed under a crude selection system based on fixed diameter limits, representing between 5-10% of the total growing stock, but providing up to 60% of all sawlog yield (Parry 1966). Its large-scale artificial regeneration however, has confounded silviculturalists to date. Natural regeneration, in woodlands and on farms (Plate III), is encouraged by farmers and foresters alike. There is much concern however, about the age-class distribution of this species, with sawlog and pole-sized Mninga now becoming scarce in many areas. Its trade names include "mninga", or "muninga" (Tanzania), "mukwa" (Zambia), and "mulombwa" (Zimbabwe).

**Conflicts in Miombo resource-use.**

A range of woodland resource-use policies are implemented within the Miombo eco-zone. Some strategies aim to improve land productivity through conversion to an alternative vegetation or crop type. Other approaches attempt to protect and maintain the woodlands through reservation. In drier regions particularly, Miombo woodlands and surrounding savanna are designated as wildlife parks, ultimately boosting vital tourist industries. Local utilisation of the woodlands has historically been of a multi-purpose nature, and is still maintained on a small-scale throughout the area.

A matrix of Miombo Woodland Resource-Uses is presented in Figure 6. It has been prepared on the basis of a number of years spent by the main author in Miombo woodlands in Tanzania. There are 18 options presented in this matrix. Each option can be found within Iringa Region where Miombo is the dominant woody vegetation found. Although there is

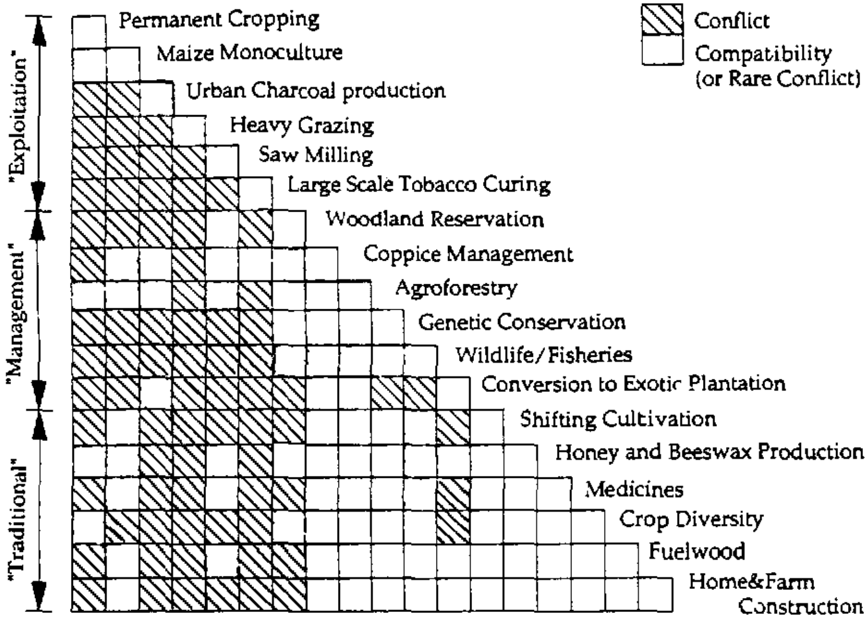



**Figure 6:** Possible Conflicts in Miombo Woodland Resource-Use.

a certain amount of subjectivity involved in defining conflict/compatibility, it is thought that useful insights may be gained from its inclusion. In the matrix, three groups of woodland resource-use strategies are presented, under the terms "exploitation", "management" and "traditional". Each strategy has been assigned six realistic options. "Exploitation" implies mismanagement, indiscriminate felling, no replacement, or conversion of woodland to other use. Saw-milling has been included due to the widespread depletion of Mninga stocks during such operations. The term "management" has been used to include a range of options which are viewed favorably by forest policy-makers. Options such as reserving woodland areas, coppice management, agroforestry, genetic conservation, wildlife/fisheries and conversion to exotic plantations have each been promoted in different areas. A "traditional" strategy on the other hand, reflects a more historical approach to resource-use in these areas. It also implies a less intensive utilisation of the natural resource base, allowing for example, a restoration period (fallow) during food production through shifting cultivation, or encouraging mixtures rather than monocultures in cropping. The "traditional" approach is above all, based on a multi - purpose utilisation of woodlands and related resources.

A study of the matrix highlights a number of points. An "exploitation" strategy leads to extremely high rates of conflict. Heavy grazing, large-scale tobacco-curing and urban charcoal production are highly incompatible options. These three options are seen as the least compatible of all options in the matrix. The adoption of a "management" strategy on the other hand, reduces conflict considerably. Coppice management and agroforestry become the two most compatible of the options presented. Coppice management however, may not be compatible with permanent cropping (i.e. annual field crops), nor with heavy grazing. Agroforestry systems cannot support heavy grazing, nor can they be maintained in sites where large-scale indiscriminate felling is carried out. Both options however, can accomadate integrated systems for the production of charcoal. Agroforestry also has potential in areas where permanent cropping or maize monocultures are prominent. Conversion to exotic tree plantations and reservation of natural woodlands are the only two "management" options which conflict with those of a more "traditional" nature. Such options as shifting cultivation, honey harvesting, local fuelwood collection and the other "traditional" practices in the matrix, are compatible, both with each other, and with six of the eight "management" options presented. It is also suggested from the matrix that permanent cropping, maize monocultural practices and saw-milling, may be compatible with certain "traditional" options.

**Discussion**

Given the obvious potential conflict which results from the adoption of certain strategies, one must question why they are pursued? Due to the extent and speed with which land degradation and resource-use depletion occurs, it is hardly surprising that questions are now being asked about the sustainability of certain "exploitation" options. The suitability of certain woodland "management" options, such as reservation of woodland and exotic tree plantations, is less frequently questioned. As both options find wide favour within the areas in question, they are worthy of closer scrutiny. There is little doubt that both production and protection forestry each play vital roles in national economies. Large-scale plantations form a basis for wood raw material production and wood processing industries. Watershed management, wildlife management, genetic conservation and the promotion of tourism are facilitated through the gazetting of forest and woodland area. However, in the drier Miombo areas, plantation forestry based on exotic species has met with little success. A MAR of 800mm or less is quite marginal for many of the fast-growing species which are popularly promoted, whilst rainfall variability tends to increase along drier margins. The nutritional poverty of soils in many parts of the ecozone is a second limiting factor (Allen 1986), as are the losses which may ensue following termite attack, or wildlife/livestock encroachment.

The socio-cultural aspects of woodland management have been largely omitted from forest resource development in eastern and southern Africa. Publicly owned tracts of land have provided sites for plantations and to a lesser extent, woodland reserves. Such land may have been formerly organised through the laws of traditional tenancy, where grazing, fuelwood collection, honey harvesting and shifting cultivation systems were maintained by groups and individuals. A replacement by forest plantations, (now administered by the Forest Authorities) does not meet the needs of local communities. The situation may be further exacerbated by a lack of consultation with the rural communities involved. Thus, encroachment and damage in young plantations may result.

In comparison, agroforestry and woodland coppicing systems have been highlighted as having potential in Miombo woodland management. The former system is being researched in Africa by ICRAF (International Council for Agroforestry Research), ILCA (International Livestock Centre for Africa) and ICRISAT (International Crops Research Institute for Semi-arid Tropics). As agro-forestry has been a security measure adopted by farmers in these areas for long periods of time, this research is highly appropriate and hence can be expected to meet with early successes. The potential for Miombo tree species in farming systems has not yet been taken on-board, despite the high level of natural regeneration of tree species in farmland (Tuite & Gardiner 1990b, unpubl.). Failure to give adequate attention to the pastoral communities and to the vital economic role played by the livestock sector would be a grave mistake. As noted above, excessive grazing conflicts with almost all other land-uses within a Miombo environment. It is possible however, that the live-stock carrying capacity of woodlands and savannas are exceeded because of the replacement of former rangelands by dispersed and inadequate alternatives.

The potential for improving Miombo woodland productivity through coppice management has not been documented. From a silvicultural point of view, Miombo tree species coppice prolifically. Local fuelwood harvesting relies on this property, yet there are no large-scale Miombo fuelwood projects based on coppice management! This system does not rely on high initial investment in growing stock, but it does require a management work plan. It is tempting to add that a Coppice with Standards system could also evolve, where certain trees are retained for sawlog and veneer purposes.

The two outstanding demands placed on contemporary Miombo arise in the agricultural and energy sectors. Human population growth rate in sub-Saharan Africa is estimated at approximately 3% per annum (Harrison 1986). The rate of urban growth may be seen as one of the most significant of all demographic factors within the eastern and southern regions e.g. 7% in Zambia per annum, which is one of the highest in Africa. As this trend continues, so too does the pressure exerted on natural woody vegetation and its multiple uses and products. Within their eco-zone, Miombo woodlands are a very large part of the total resource base of seven developing countries. Policies which lead to conflict in the use of this resource result in widespread ecological problems. Such policies reflect also a lack of understanding of the role and functioning of the ecosystem itself, and an unwillingness to recognise the inherent value of more traditional and sustainable systems in the former use of this woodland type.

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