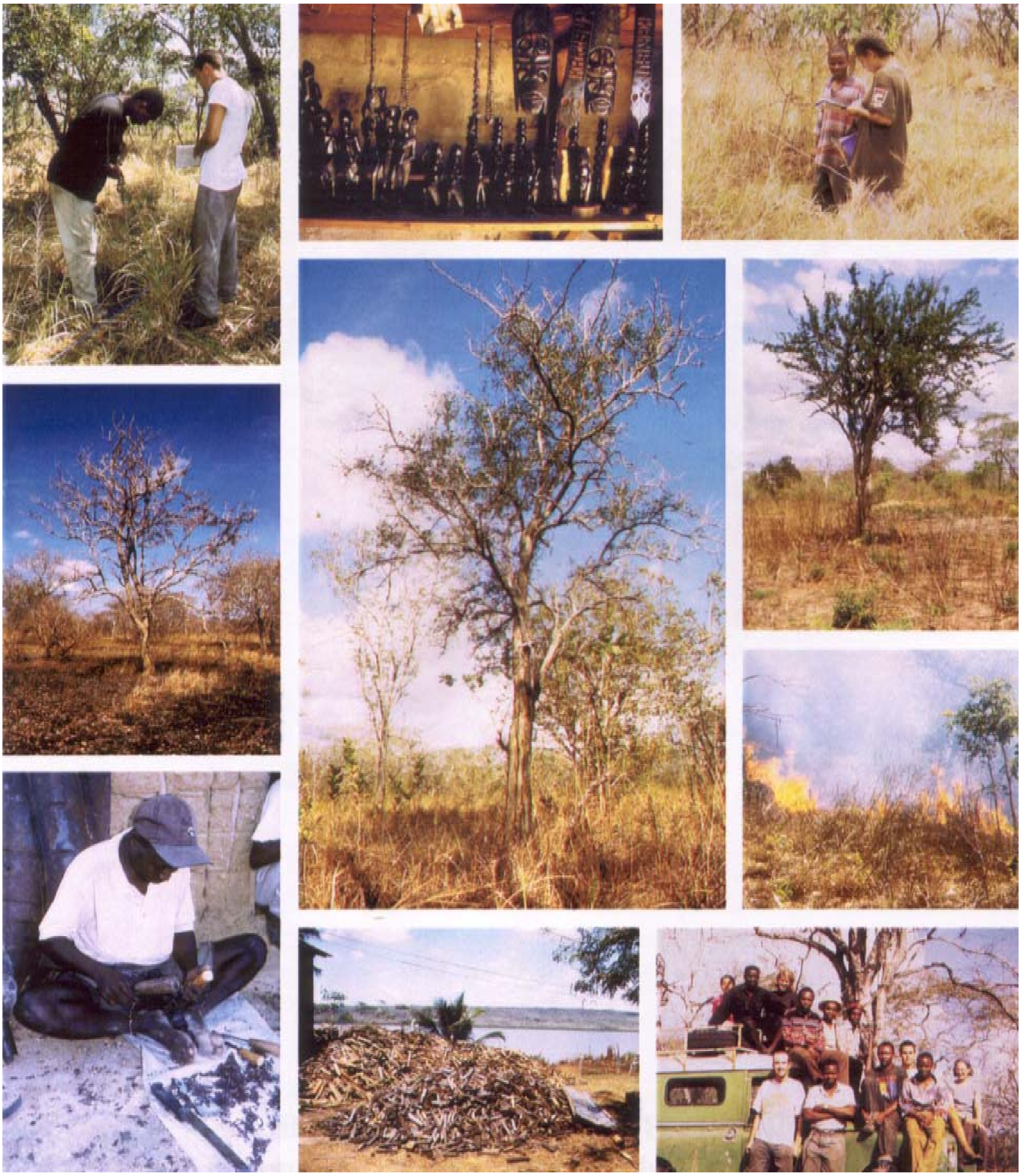
The Mpingo Conservation Project

Tanzanian Mpingo 98

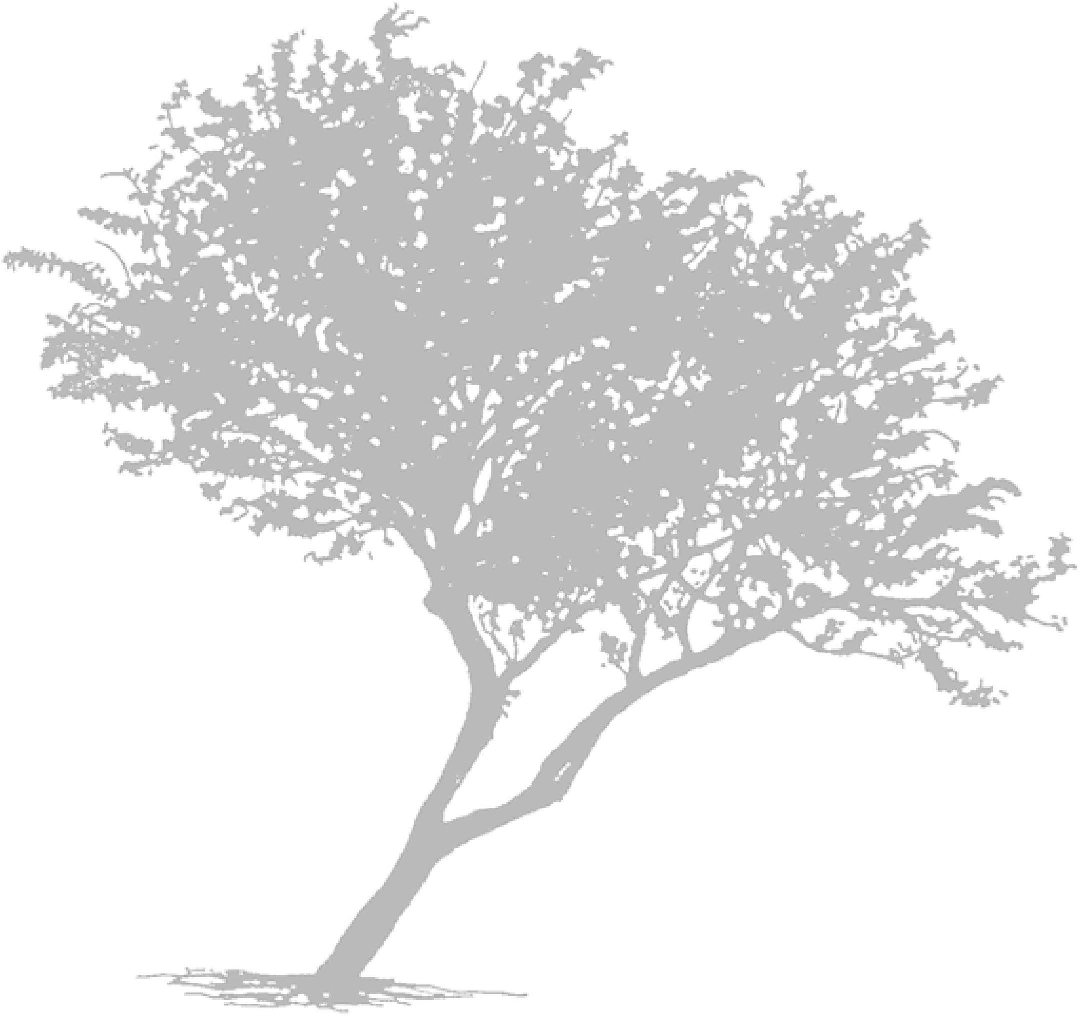
A Cambridge University Approved Expedition in association with Sokoine University of Agriculture and Fauna & Flora International

Full Report



Gregory, A-M., Ball, S.M.J., Eziefula, U.E.

Radcliffe, T., Timothy, J., Kindeketa W.J., Bevan L.J.V., Kitula, R., Chunsi, Z., Tarimo, E.



Gregory, A-M., Ball, S.M.J., Eziefula, U.E. (1999)
Tanzanian Mpingo 98 Full Report. Cambridge Mpingo Project.

With contributions from Radcliffe, T., Timothy, J., Kindeketa, W.J., Bevan, L.J.V., Kitula, R., Chunsi, Z., & Tarimo, E.

2nd edition *(no changes of substance from 1st edition)*

Summary

Introduction

Mpingo is the common (Swahili) name for *Dalbergia melanoxylon*. The tree is used to make high quality woodwind instruments such as clarinets and oboes, and it is used in traditional African carvings, especially those of the Makonde tribe. It is Tanzania's national tree, but it has a much broader native distribution covering much of sub-Saharan Africa. However it only attains harvestable size in East Africa. Kenya's stocks have been over-harvested leading to commercial extinction, and Mozambique's civil war at one time largely prevented harvesting of mpingo there. Virtually all the billets of processed timber bought by developed countries currently come from Tanzania and Mozambique. Concern has been voiced that Tanzanian stocks are in decline.

Fauna and Flora International (FFI) set up the *SoundWood* project in 1993 to protect the valuable species used to make musical instruments. It held a conference in Maputo, Mozambique in 1995 which brought together conservationists, foresters, government officials and mpingo users to discuss the current situation. It was apparent that very little research has been done on the ecology of the tree in the wild. Indeed the *Food and Agriculture Organisation* (FAO) has prioritised mpingo for research and conservation work. This work is essential if a management plan is to be formulated allowing sustainable harvesting of the tree in such a way that rural livelihoods, woodturners' crafts and export earnings are all safeguarded.

The *Cambridge Mpingo Project* was established in 1995 to conduct long term research on mpingo to provide a sound factual basis on which management decisions can be made. A previous expedition, *Tanzanian Mpingo 96* began to collect such information, but it was felt that further sites needed to be studied to provide a broader picture of the species' habitat and exploitation. *Tanzanian Mpingo 98* was set up in response to this. Our core activity was surveying 150km² of land inside and outside a forest reserve using stratified random sampling. We identified factors associated with the adult and juvenile mpingo trees and related this to the habitat's fire regime using information gathered from a series of meetings with local people. We piloted an education project in the village school, and using the techniques of Rapid Rural Appraisal (RRA) we collated data on the use of, and attitudes towards mpingo. We briefly visited additional districts in southern Tanzania, giving us a much broader picture of mpingo stocks and harvesting. Such inputs and activities would be central to any management plan, the success of which would be dependent upon local implementation.

What Tanzanian Mpingo 98 achieved

- Surveyed over 150km² of forest
- Gathered ecological data from a little studied region
- Identified over 100 tree species
- Added to the data set of *Dalbergia melanoxylon* measurements
- Increased our understanding of *D. melanoxylon* regeneration
- Investigated local knowledge and attitudes towards the species
- Calculated a figure for harvestable timber per hectare

Results

Tanzanian Mpingo 98 gathered detailed botanical and sociological data from the Kilwa District of southern Tanzania. We found no significant difference in mpingo abundance between land inside and outside Mitarure Forest Reserve. Additionally we discovered statistically similar mpingo stocks in miombo woodland, recently burnt areas and around ephemeral water courses. This supports the idea that adult and juvenile mpingo can tolerate quite a broad habitat range and so its affinities with other species are likely to be complex. We found plentiful evidence that mpingo stocks have been regenerating recently and observed no obvious gaps in the size range of mpingo. There had previously been some harvesting of mpingo in the area but abundant stocks still remain. Overall there was 1.03m^3 of potentially harvestable logs per hectare. However there are substantial difficulties in extrapolating this figure over the whole region to assess whether the rate of harvesting is sustainable.

We established that mpingo is not *per se* a valuable resource for villagers because it has restricted local uses. Villagers only gain financially from its presence if they aid commercial loggers to harvest it. The usage of mpingo is inherently inefficient due to natural faults in the wood, but there is potential for significant improvements in its efficient use by integrating the activities of sawmills and carvers. It became clear that mpingo is threatened by adverse burning regimes, illegal harvesting and deforestation. Tanzanian foresters do not have sufficient resources to manage miombo woodland effectively. Sustainable harvesting of mpingo in its natural habitat can only be achieved through understanding the tree's ecology in a wider socio-economic context.

Recommendations

- An inventory of Tanzania's mpingo stocks is urgently needed.
- Sawmills and carvers need to make more efficient use of harvested trees by integrating their activities.
- Steps need to be taken immediately to encourage early burning of miombo woodland.
- The use of miombo by villagers should be considered in decision-making.
- Mpingo in Lindi region should be protected from illegal logging and woodland clearance which will result from improved road links with Dar Es Salaam.
- Conservationists, sawmills and government foresters must work together to formulate and implement a management plan for mpingo.

The Team

British members

Steve Ball, mathematics graduate of Emmanuel College. Co-leader and Photographer.
Steve led the *Tanzanian Mpingo 96* expedition. He is a keen wildlife photographer. This was his third visit to East Africa.

Anne-Marie Gregory, plant sciences graduate at Fitzwilliam College. Co-leader and Cambridge Co-ordinator.
Anne-Marie has extensive experience of botanical research. Her main academic interests are economic botany, ethnobotany and plant taxonomy.

Lucinda Bevan, geography student at Fitzwilliam College. Treasurer and Equipment Officer.
Also taught in Tanzania in 1996. Experienced geography research assistant both in Britain and abroad.

Toby Radcliffe, ecology student at Girton College. Medical and Scientific Officer.
Toby developed our methodology. He has experience of conservation work in Britain.

Ukachi (Litty) Eziefula, biology and education student at Homerton College. Responsible for the sociological and educational aspects.
Lit spent her gap year in Tanzania and fell in love with the country. She now speaks fairly fluent Swahili and developed the expedition's links with the local community.

Tanzanian members

Jonas Timothy, Assistant Forestry Officer with the Kilimanjaro Catchment Forest Project. Tanzanian Leader.
Jonas is a keen amateur ornithologist, and active conservationist. He is a veteran expeditioner and was a taxonomist on *Tanzanian Mpingo 96.*

William Kindeketa, graduate in Forestry from Sokoine University of Agriculture (SUA).
William is now working with the Tanzanian Botanical Training Programme helping develop the skills of para-taxonomists.

Rukia Kitula, graduate in Food Sciences from SUA.
Rukia is now specialising in sociological aspects of nutrition and worked closely with Litty on the sociological aspect.

Zawadi Chunsi, privately employed forester from Moshi Region.
Zawadi has several years experience in plantation forestry.

Ernest Tarimo, amateur conservationist.
Ernest's principal concern is for the avifauna of Tanzania, and has carried out habitat-orientated work with a previous Cambridge Expedition.

Isa Kilindo, game guard employed by Kilwa District.
Said Mohamed, local retired game guard.
Paskal Ngonyani, driver and mechanic.

Contents

Part I : The Science

Literature Review

1 *The tree*

Mpingo (*Dalbergia melanoxylon*) is a member of the Papilionoideae subfamily of the Fabaceae. It is traded as 'East African Blackwood' and many names refer to the heartwood which is black in good quality timber. It is often called ebony. Indeed the word 'ebony' is thought to have originally referred to *Dalbergia melanoxylon* (Puhakka 1991) and not the genus *Diospyros* with softer, darker wood (Lovett 1987, Moore & Hall 1987) to which the word 'ebony' normally refers in modern scientific literature.

Mpingo is a small, heavily branched tree. It typically grows in patches of widely spaced individuals (Hawkins *et al*. 1996) often growing with multiple trunks. It usually only reaches a height of 4.5-7.5m but occasionally grows to 15m (Mugasha & Mruma 1983). The bole (trunk) length of harvested individuals is normally about 1.5m (Nshubemuki 1993). Old trees may have a circumference of 3m (Moore & Hall 1987) although 60-120cm is more typical of harvested individuals.

The species has a scruffy appearance; its yellowish-brown woody bark is shed regularly, possibly annually (C. Ruffo pers. comm. in Sharman 1995) when it flakes off in long strips. The twigs bear alternate long, straight spines. Young bark has a characteristic grey-white colour.

Mpingo leaves are imparapinnate with 9-13 leaflets each approximately 1.5x1.5cm which are typically notched at the apex. It is semi-deciduous, losing many of its leaves over the dry season in common with most trees of its usual habitat. The flowers are small, white, sweetly scented and grow in tight clusters. They develop into papery grey pods each containing one or two seeds (Mbuya *et al*. 1994) which are thought to be wind dispersed (von Maydell 1986).

2 *Mpingo timber*

Mpingo is considered to be "the finest of all turnery timbers, cutting most exactly and finishing to a brilliantly polished lustrous surface" (Bryce 1967). Processed mpingo blocks, known as billets, are reportedly worth up to \$18,000m^{-3} (Nshubemuki 1993). It is the preferred wood of the musical instrument trade because of its high density, fine texture and exceptional durability. By far the biggest demand is for clarinets (Moore & Hall 1987). It is also the wood of choice for local carvers, most notably the Makonde tribe. Most users prefer dark wood and only the blackest is acceptable for the manufacturing of musical instruments (Moore & Hall 1987). Traders have, since the early 19th century moved progressively south through mpingo range states (Sharman 1995).

The best quality Tanzanian timber is widely acknowledged to come from the Nachingwea district. Moore and Hall (1987) state that the most important harvesting areas are Liwale, Nachingwea, Masasi and Ruvuma River.

Several factors are thought to affect the colour of the heartwood which varies from black through a purple-tinted colour to brown (Moore & Hall 1987). For example Sharman (1995) and Luoga (1995) both state that trees growing in close proximity to the sea often have much paler brown heartwood. This means that growth rings are visible. Dark timber is thought to be produced when the tree is growing slowly. Mpingo users have found that often the timber is darker towards the outside of the trunk. Brown coloured heartwood is confusingly known as 'white mpingo'.

The wood is used in local tools where hardness and durability are important. Because the heartwood is so hard that it blunts axes, the tree is seldom cut for firewood and is sometimes left standing in fields, although it might later be killed (Ball *et al.* 1998). It is 'difficult to saw or plane and cannot be screwed or nailed without first drilling' (Moore & Hall 1987).

The heartwood is surrounded by a layer of cream coloured sapwood about 2cm thick hence another name for the tree: zebrawood (Moore & Hall 1987). In comparison with the heartwood, the sapwood is less dense. The density of mpingo can be as high as 1.3gcm^{-3}, i.e. it sinks in water, compared with 0.76gcm^{-3} for the sapwood (Malimbwi *et al.* 1998). The sapwood is significantly less resistant to termite (Moore & Hall 1987) and fungal damage (Bryce 1969). In comparison, the heartwood is resistant to biotic (Nshubemuki 1993) and abiotic agents of decay. After the tree has died the heartwood remains standing for many years (Hawkins *et al*. 1996).

Mpingo is known to be attacked by one species of boring insect, a cerambycid larva. Pinholes made by the larvae are often found in logs (Moore & Hall 1987). At sawmills any billet with a visible pinhole fault is rejected because it is indicative of a serious fault deep inside the wood. A tree with a large fault, for example caused by heart rot or fire damage cannot yield a billet sufficiently large enough to make a clarinet (Haughton-Sheppard 1958) or a bagpipe chanter (Lovett 1987). Carvers are however less dependent on top quality timber (Lovett 1987).

Mpingo is the preferred material for instrument manufacture for a number of reasons. Its natural oiliness seals the surface, prevents absorption of moisture and protects metal fittings from corrosion. Its fine grain means that the finish is beautifully smooth (Bryce 1969), it is durable and holds its tone well in different conditions.

Unseasoned mpingo is cut into cuboid billets with the approximate dimensions of the sections of the finished instrument. These are exported as ‘sets’ which make one instrument. Billets for woodwind instruments must be free from defects otherwise they will split when put on a lathe. Hence only faultless, top quality black mpingo makes up these exported sets (Hall 1988, McCoy-Hill 1993). Only mpingo from particular regions is of sufficient quality to make musical instruments (Green Umbrella Productions 1992).

Tanzania only allows the export of processed timber (Beale 1995) so the quantity of mpingo exported from the entire country is very low, averaging 42m^3 over the period 1980-1991 (Marshall 1996). Demand for musical instruments has been more-or-less static for the last few years (Krauth 1996). 90% of European trade is via five importing companies, and it is estimated that the UK’s demand at 4-5,000 mpingo clarinets per year (Beale 1995).

3 It’s uses

3.1 Musical instruments

A theoretical consideration of sound production in woodwind instruments dictates that the wood used does not affect the sound produced. ‘So long as the walls of the instrument are thick enough to be rigid—two millimetres for woods—and the inside walls are smooth, the kind of material is, for the most part, immaterial’ (Harby 1998). However ‘no professional would be seen dead playing a plastic instrument’ (quotation from a leading manufacturer in UNEP 1988). The timber species used is widely believed to affect tonal quality, see for example Burns (1999). Scientists say that this difference of opinion is largely due to the craftsmanship that goes into instruments made from different materials (Harby 1998) although wood grain size could influence the sound produced. Boosey and Hawkes’s subsidiary Buffet Crampon have pioneered the use of a composite material using mpingo sawdust to make a ‘Green Line’ of oboes and clarinets (SoundWood 1999). This sawdust would otherwise be a waste product. They face suspicion from musicians who believe that mpingo wood, rather than craftsmanship, is critical to the sound produced (Harby 1998). Currently professional musicians almost exclusively use instruments made from solid wood and it is likely to take years to change this situation.

3.2 Carvings

Mpingo is traditionally used for carving by several tribes in East Africa. The Makonde, whose tribal lands straddle the Tanzania—Mozambique border, are renowned for their mpingo carving.

Frequently Makonde families hand down their carving skills from father to son. Mozambique's civil war and the consequent low standard of living has lead to many thousands of refugees crossing into Tanzania over the last three decades. Many moved into the Dar Es Salaam region (East African Movies 1998) and established carving co-operatives there.

Several distinctive styles of sculpture have developed to represent scenes from everyday village life and more abstract work, such as Shetani spirits and other characters of Makonde folklore (Lovett 1987). Carvers also supply the tourist trade with novel items such as the Coca Cola bottles, chess sets and ash trays we saw at Mwenge Carvers Co-operative, but it is the distinctly Maasai figurines and representations of the classic safari animals which are most popular.[1] Mpingo carvings are now available in ethnic craft shops in many European and North American cities. More practical objects like tea sets are produced for wealthy Tanzanians.

Moore and Hall (1987) estimate that there are about 1500 carvers in Tanzania, most using less than $1m^3$ timber each year. The highest concentration, including around 1150 carvers, is in the Dar Es Salaam area which includes Bagamoyo, Kisarawe and the Mwenge carving co-operative. Mwenge has become a tourist attraction where visitors can buy mpingo items ranging from letter openers to two metre high carvings. Many carvings are bought unfinished from dealers who obtain them from smaller groups of carvers working in distant parts of the country.

Carvers are able to utilise a much broader range of mpingo wood than the music trade. They are able to incorporate the natural twists, turns and faults of mpingo into their work (Lovett 1987).

With the expansion of the tourist industry in East Africa the market for carvings is increasing. Even in 1987 it was appreciated that carving is an increasingly important factor in mpingo exploitation (Moore & Hall 1987). They estimate that $1500m^3$ (37%) of mpingo is used by Tanzanian carvers each year. The relative importance of harvesting for the music industry versus local usage is uncertain (Moore & Hall 1987).

3.3 Other local uses

The durability and sheer hardness of the heartwood means that mpingo is put to specialised uses by indigenous people such as all-wooden hoes[2], pestles, knife handles (Bryce 1969), supports for buildings such as granaries (Ball *et al*. 1998)), house construction (Lewis & Berry 1988) and floors for pit latrines (Olet 1996). The tree is also used by villagers as animal fodder, medicine[3], as a dye and as green manure (Sharman 1995).

3.4 The problem

Large, good quality pieces of heartwood have always been scarce because the tree is naturally twisted and branched and the wood tends to split (Lovett 1987, Moore & Hall 1987, McCoy-Hill 1993, Ball *et al*. 1998). Mpingo is known to be attacked by one species of boring insect, a cerambycid larva. Pinholes made by the larvae are often found in logs (Moore & Hall 1987). At sawmills any billet with a visible pinhole fault is rejected because it is indicative of a serious fault deep inside the wood. A tree with a large fault, for example caused by heart rot or fire damage cannot yield a billet sufficiently large enough to make a clarinet or a bagpipe chanter (Lovett 1987).

---

[1] These Maasai figures are an interesting case – produced as they are by mainly Makonde carvers working throughout Tanzania. This material is exclusively for the tourist market, partly because Muslims make up a large part of the Tanzanian population which forbids human figures. This ironic situation arose through the influence of tourism on Kenyan carvers. It is thought that the Kenyan carving industry developed after Makonde carvings were brought back by Mutisya Munge who served in the British Army in Tanzania in World War I. He single-handedly developed the Kenyan carving industry, selling to Europeans. Mpingo was originally used but local supplies were exhausted by the 1940s (Hamilton 1996) and substantial stocks only remain in Kenya's protected areas (Mbengi 1996). A market for such 'traditional ethnic' carvings has persisted and Tanzanian carvers now produce large numbers of Maasai carvings for tourists and for export to the West.

2 This is the origin of another of its names: mugembe (Moore & Hall 1987).

3 The bark, roots and leaves have all been recorded as used in traditional cures (Mbuya *et al.* 1994).

It has always been the case that the recovery rate of sawmills is low because of natural faults in the wood and decay (see for example Haughton-Sheppard 1958). Felling by carvers is usually done using an axe 20-30cm above the ground (Moore & Hall 1987). McCoy-Hill (1993) and others recommend the use of saws so that more of the trunk can be removed.

Because carvers use small pieces of heartwood and often have to carry the timber out of the bush they frequently cut smaller trees than sawmills do (Platt & Evison 1994). The largest trees do not necessarily yield the highest quantity of useable timber because they frequently have heartrot (Puhakka 1991, Malimbwi *et al.* 1998). Heartrot is apparently associated with fungal infection following fire damage (Nshubemuki 1993, Malimbwi *et al.* 1998) This fact is not always appreciated by conservationists.

When timber arrives at a sawmill it is cross-cut into 45cm lengths. It is then split along natural faults with wedges or sawn with hand or circular saws (Moore & Hall 1987, McCoy-Hill 1993). A lot of the equipment used is old and inefficient (Hall 1988). Skilled operators feed the resultant blocks through cutting machines to produce regularly shaped billets (Hall 1988). However many logs split as they dry out in the sun prior to processing (Moore & Hall 1987) and great care needs to be taken when processing mpingo (McCoy-Hill 1993). If there are any slight defects the timber will split when put on a lathe. Consequently only a small fraction of harvested wood ends up in the finished billets. Processing techniques in several sawmills are inefficient (Hall 1988, Puhakka 1991, Platt & Evison 1994, Beale 1995) with a low recovery rate.[4] This means that the output of processed billets is a small percentage of the input log volume. No-one has accurately measure the recovery rate of a sawmill; several estimates are given in Table 1 below.

Author	% Recovery Rate
Puhakka (1991)	1.2
Moore & Hall (1987)	7-25
Beale (1995)	9
Haughton-Sheppard (1958)	<10
McCoy-Hill (1993)	<10
Hall (1988)	10

Table 1. Varying estimates for recovery rate of mpingo timber.

Moore and Hall (1987) believe that 1000m^3 of trunk and large branches, which could be used by carvers, is wasted each year. We saw some evidence of such wastage in the field. The time between felling, by hired villagers, and collection was often long enough to encourage splitting of the ends of the logs as they dried in the sun. They do not know of any loggers who seal the ends of logs in the field.

4 *Mpingo's habitat*

4.1 Miombo woodland

Areas dominated by a mixture of grass and trees under a regime of approximately six wet months and six dry months are called dry savanna (Troll 1963). Jeffers and Boaler (1966) sub-divide dry savanna into several categories including miombo woodland which is considered the typical habitat of mpingo. See the International Geosphere-Biosphere Programme's Miombo Network web pages for an expanded technical definition of miombo woodland.

In miombo the trees are quite widely spaced such that their canopies do not form a complete cover. This structure is brought about by competition for water during the dry season. Grasses take up

[4] The recovery rate is the output volume of processed timber relative to the input volume of logs.

water in the upper horizons of the soil. Any water that infiltrates deeper is used by trees, which are thinned out as they grow through competition.[5]

Miombo is characterised by trees in the sub-family Caesalpinoideae especially species in the genera *Brachystegia* and *Julbernardia* (Lind & Morrison 1974, White 1983). Typically miombo trees are semi-deciduous (White 1983) meaning that they lose some or all of their leaves in the dry season depending on its severity. 'The shrub layer is variable in density, percentage cover and species composition. It is often dominated by *Diplorhynchus* and *Combretum* species' (Rodgers 1982). Miombo's structure and composition is largely maintained by periodic dry season fires. Under anthropological influence miombo can be burnt as frequently as twice a year.

Figure 1. Profile of miombo woodland. The left hand side shows habitat immediately after burning; the right hand side illustrates woodland that has not burned for a year.

The Cambridge Encyclopaedia of Life Sciences has described miombo woodland as 'arguably the most important wildlife preserve in the world…in respect of its animal and plant life alike' (Moore & Hall 1987) Buffalo, warthog, elephant, hunting dog and lion are among the species of game found in this habitat (Lind & Morrison 1974). Lind and Morrison (1974) and Rodgers (1982) estimate that approximately half of Tanzania is miombo woodland and it constitutes the single largest vegetation type in East Africa (Rodgers 1982). Miombo in Tanzania occurs at altitudes from near sea level to about 1600m (Lind & Morrison 1974) in areas with rainfall between 500-1200mm per year, where there is a single dry season (Jeffers & Boaler 1966) on infertile soil (Desanker *et al.* 1997).

At Kilwa the level of precipitation is. approximately 1000mm per year (Hansen 1996), falls on the boundary between 'wet' and 'dry' miombo *sensu* White (1983)

4.2 Mpingo's range

Mpingo grows in most countries of sub-Saharan Africa. It can tolerate a wide range of conditions which contributes to its broad geographical range. Mpingo occurs in at least seven of the eight major floristic zones in Tanzania (Nshubemuki 1994) and is found at elevations from sea-level to 1300m (Mbuya *et al.* 1994). The species occurs across the transition from bushland to woodland (Nshubemuki 1993) and can grow in soils which vary from sandy (Rodgers 1982) to clayey (Oldfield 1996). It is light-demanding and cannot regenerate under heavy cover (Oldfield 1996).

The mean maximum temperature in its range is 35°C and the minimum is 18°C with no frost (Oldfield 1996). Kilwa District has a single rainy season starting in November followed by a six month dry season. The district's climate is moderated by the stability of the ocean temperature (Clarke 1995).

[5] This process is better understood in other habitats where herbaceous and woody plants grow together.

Mpingo's Range

Figure 2. Map of Africa showing mpingo's range, and highlighting Tanzania & Mozambique.

4.3 The role of mpingo

Although quite a large body of literature is available on mpingo, botanists know little about the tree in it's natural habitat (Lovett 1987). 'The ecological importance of mpingo is virtually unknown' (Moore & Hall 1987) but the species is known to fix nitrogen (Högberg 1986) which is likely to be significant in a habitat where so much organic nitrogen is lost through combustion (Nye & Greenland 1960). This could aid mpingo to colonise shallow and rocky soils (Stockbauer 1999). *Brachystegia* and *Julbernardia* do not fix nitrogen (Högberg 1986). Other nitrogen fixing genera in miombo included *Acacia*, *Afzelia, Enteda*, *Pericopsis* and *Pterocarpus* (Rodgers 1982, Gauslaa 1989).

5 *Fire ecology*

Miombo is a habitat dependent on fire for its structure and composition (Moore & Hall 1987). Natural fires can be started by lightening, however under man's influence they have increased in frequency. All miombo plants are adapted to tolerate fire at some stage of their life cycle. However they differ in their tolerance of severe fire, for example *Brachystegia* is considered to be fire sensitive (Lind & Morrison 1974, Rodgers 1982). However miombo trees are typically thick barked and seeds may require 'cracking' by fire to allow germination e.g. *Pterocarpus* (Rodgers 1982). Fires themselves favour certain species of grass over woody vegetation. Indeed fire was used in colonial times to kill trees and so produce a grass-dominated habitat from which tsetse flies were absent (Lind & Morrison 1974).

Most young growth is destroyed by burning.[6] This includes the above-ground growth of grasses, herbaceous plants and juvenile shrubs and trees. The speed with which regrowth occurs depends on access to water. If there is rain then vigorous growth will be produced within a week. Vegetation which has access to ground water is evergreen and will not burn.

Even in quite fierce fires the juveniles of many woody miombo plants have the ability to survive underground and they quickly regenerate if fire is excluded (Mugasha 1978, Gauslaa 1989). Usually this involves re-sprouting from the roots, an adaptation known as 'die-back' which allows even quite young plants to escape death due to frequent dry season fires (Rodgers 1982). Mpingo is one species exhibiting such behaviour. Juveniles devote their resources to developing a thick root from which they re-sprout (Madoffe 1996). For their first 7-20 years typically only the below ground growth survives annual fire (Mugasha 1983). Eventually the individual can produce a sufficiently substantial stem to survive fire, or perhaps fire is absent for a few years. Then mpingo can develop into a 'pole' and subsequently a mature tree. Adult mpingo trees can be damaged by fire resulting in visible scars to the trunk. This may reduce the growth rate and wood quality (Mugasha 1996) but is unlikely to directly kill the tree.

Where there is little combustible material, flames might reach only a few centimetres off the ground, such that it is possible to walk through an approaching fire. The fire passes over within a minute. The temperature just below the soil surface is scarcely raised and shallow roots and storage organs are not damaged.

The timing of burning is important. Burning early in the dry season, when the above scenario is true, has little effect on miombo trees. Many of which would lose their leaves during this season. Later fires tend to be more vigorous. Because of the larger quantity of combustible dry material the flames reach higher and so damage more foliage. Burning late in the dry season can have a devastating effect on mpingo and the other species of miombo woodland (Moore & Hall 1987, Puhakka 1991). Fires late in the dry season are likely to be more severe because of the accumulation of dry matter (Ball *et al*. 1998), particularly grass. At the same time miombo trees are sprouting new leaves late in the dry season (White 1983)[7], and this makes them particularly vulnerable to late burning (Lind & Morrison 1974).

Heart rot is thought to enter mpingo following fire damage (Hawkins *et al.* 1996, Nshubemuki, 1993, Malimbwi *et al*. 1998) probably when the tree is young. So late burning can reduce mpingo stocks both directly and indirectly. Mpingo's heartwood does not burn easily. Dead trees are often left standing for many years (Hawkins *et al*. 1996).

6 Mpingo regeneration

Mpingo sometimes grows with multiple stems and these will develop vigorously if the largest stem is harvested. It is known to coppice[8] when the main trunk is harvested, but this ability is thought to be lost in the adult tree (Forest Division 1984, McCoy-Hill 1993). Root damage encourages mpingo to send up suckers (Sharman 1995), hence they are common in fields and on unsurfaced roads.

[6] Hence the difficulty in identifying seedlings and saplings in fire plots.

[7] At the end of the fieldwork phase of the expedition *Brachystegia longifolia* was coming into leaf with spectacular red foliage.

[8] That is re-grow stems from a stump. However, these stems can be few and variable in size which is quite different from coppicing in the British sense of producing many equally-sized stems.

Presumably logging trucks in the bush would have the same effect, and additionally logging itself may encourage the same effect.

It is not known how important vegetative reproduction is for mpingo in the wild. Hansen (1996) found that 91.1% of juvenile mpingo trees in Mitarure Forest Reserve were suckers, with only 8.9% developing from seedlings.[9] However he does not explain how he derived that figure and it is likely that even in Mitarure FR there are areas where more regeneration is from seed. Mpingo seed has a papery wing which aids wind dispersal. One would therefore not expect a cluster of seeds to settle at the same spot and germinate. *Tanzanian Mpingo 96* found very dense clusters of juvenile mpingo, forming small mono-specific stands at Mchinga (Ball *et al*. 1998). These were almost certainly suckers.

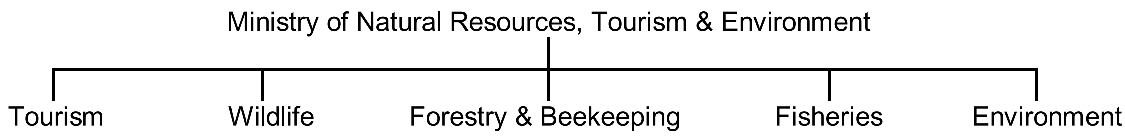
Various authors have commented on an apparent lack of regeneration. Moore & Hall (1987) for example state that 'there is virtually no regeneration of the species occurring either in natural stands or in areas where trees are being harvested.' Puhakka (1991) found an 'alarming' dearth of juvenile mpingo and big mpingo trees in Mtwara Region. Platt and Evison (1994) noted a scarcity of mpingo seedlings in Iringa. A possibly related finding is that of Hawkins *et al*. (1996) who reported that in Mikumi National Park mpingo of 5-10cm diameter breast height (approximately 16-31cm CBH) were fewer than expected.

7 *Tanzania's forests*

7.1 Official Status

There are about 1540 Forest Reserves in Tanzania but only 30% of forested land is within a Forest Reserve (Moore & Hall 1987). In this context a Forest Reserve means reserved for forest and forestry with activities such as farming, hunting and fuelwood gathering being prohibited. Most land outside forest reserves is designated public land. This land is the chief source of mpingo for commercial loggers. For example in Nachingwea, the most important logging area, no licences are granted for logging in the only Forest Reserve, Lionja, but logging is permitted outside this Reserve.

Forest administration is highly decentralised (Moore & Hall 1987, Beale 1995). Policy direction comes from the central government:



The Forestry Division in Dar Es Salaam has direct administrative control over only the 19 forest projects considered to be of national importance and four catchment forests. Policy guidance and technical assistance are provided through regional officers, while everything is implemented at district level. District Forestry Officers (DFOs) are responsible for enforcing all forestry regulations.

[9] Hansen quotes Gauslaa (1989) as saying that in Zimbabwe almost all regrowth of the common miombo trees *Brachystegia spiciformis* and *Julbernardia globiflora* was found to be from root suckers or coppice shoots, and seedlings were quite rare.

Prime Minister's Office

- Commission for Regional Administration
  - Regional Commissioner
    - Regional Natural Resources Officer (RNRO)
      - Regional Forestry Officer (RFO)
- Commission for Local Government
  - District Commissioner
    - District Natural Resources Officer (DNRO)
      - District Forestry Officer (DFO)

In Tanzania a licence is required to fell valuable tree species such as mpingo. The District Forestry Officer issues licences for felling on public land but he must apply to central government for permission to fell inside Forest Reserves. Mpingo and ebony are the most costly species, both requiring TSh 60,000 per cubic metre (approximately $90) to be paid to central government. Additionally a fee must be paid to the district government, which in Kilwa are the same as the central government fee (Mfangavo pers. comm. 1998). The licence number must be stamped on both the felled trunk and stump, but many people report seeing stumps without license stamps (Moore & Hall 1987, Ball *et al.* 1998).

7.2 A global perspective

The destruction and degradation of the world's dry tropical forests, a category which includes miombo, has not attracted the same attention as that of the rainforests yet the extent of their disappearance and alteration is greater (Janzen 1988, FAO 1993). 'Miombo ecosystems directly support the livelihoods of about 39 million people in 7 Central African countries including some with among the lowest per capita income and the highest per capita population growth rates in the world' (Desanker *et al*. 1997). The population of this region is rapidly increasing. Tanzania's population increases at a rate of 2.8% per annum (Bureau of Statistics 1996)[10] Economic growth compounds the impact of population growth on the demand for timber and other tree products. Most unprotected forests in Tanzania have been destroyed or degraded to some extent (Puhakka 1991, Clarke 1995) and the remnant fragments are poorly known to biologists (Clarke 1995). There are mpingo populations in protected areas such as the Selous Game Reserve and Mikumi National Park (Hawkins *et al*. 1996), but the bulk of stocks lie in public land.

10 This is based on the 1988 census but 2.9% is the 1992-2000 projection given by the Instituto del Tercer Mundo (1997) so such figures can be assumed to be approximately correct.

Geographical Context

1 Southern Tanzania

The southern coast of Tanzania is among the poorest areas of a poor country.[11] It is isolated from the richer north by the Rufiji river which can only be crossed during daylight by a single ferry. This ferry does not operate at all during the wet season, and there would be little point for most of the roads are unsurfaced. Road travel is almost impossible during this time, and even during the dry season the deep ruts cause considerable wear and tear to all vehicles.

Land to the south of the Rufiji is also poor in natural resources. Miombo soil is of such low fertility that herbaceous crops cannot readily be grown commercially without fertilizing.[12] Tree crops though are successfully grown on *shambas* (smallholdings) and commercial plantations. Cashews are the main agricultural export from Kilwa District and are an important source of foreign exchange for the country as a whole.[13] Virtually all the children in the village where we stayed had visible signs of malnutrition and about half had to walk barefoot.

Kilwa district was where we conducted our primary research and thus the district we came to know best. Although it is a coastal district it stretches a considerable distance inland. The River Rufiji forms its northern border and the Mbwemburu River the southern one. After Liwale district it is the second largest district in Lindi region covering roughly 12,000km².[14] Government estimates from the 1970s state that the total area enclosed in forest reserves is 1,957km², and a further 2,194km² of public land is forested, but these figures are old and we do not know what definition of ‘forest’ was used. Observations suggest that far more than 35% of the district is covered in the sort of woodland which is the typical habitat of mpingo. The estimate of 70% forest cover provided by the District Executive Director seems more realistic. Only detailed analysis of satellite images would give a final answer.

The district is sparsely populated with about 15 people per square km.[15] Away from the coast much of Tanzania is rendered uninhabitable by tsetse flies which spread sleeping sickness.[16] Tsetse are for example, present in the unpopulated area south-east of Mbate. Thus the pressures on public and protected land which have led to their degradation in other parts of Tanzania are not as evident in Kilwa District.[17] However population is growing by 2.9% per annum[18] – in line with the national rate but faster than economic growth in the district.

[11] Tanzania is a very poor country with few natural resources. It was one of the countries highlighted by development organisations at the G7 summit in Birmingham, UK last year to illustrate the contrast between the standard of living in the wealthiest and poorest countries.

[12] Lind & Morrison, 1974; Desanker *et al*., 1997

[13] Bureau of Statistics 1997

[14] There are various estimates around 13,800km² (Bureau of Statistics, 1997 says 13,857 km²) which apparently include about 2,000km² of water cover, i.e. the sea. The government figures from the 1970s gives the land area as 11,865km².

[15] This figure is derived from the population estimate for the year 2000 given in the Tanzanian government’s Health Statistics Abstract (1996).

[16] Briggs 1996

[17] Tanzania Forestry Action Plan 1990-2000

[18] Mfangavo *in litt.* 1998

2 History of Kilwa

Kilwa was at one time a major trading centre. Kilwa Kisiwani, ‘Kilwa Island’, lies about 2km from the mainland and was an independent city port at the height of the Swahili culture (1250-1450AD). A network of such ports along the east African coast linked Africa with the Middle east and Orient. Gold and slaves from the interior were exchanged for luxury goods from the Orient. Swahili dominance was ended around 1500AD by the Portuguese in an attempt to establish their own trading posts (Instituto del Tercer Mundo 1997). However slave trading continued, and was later controlled by Omani Arabs who built a holding prison on Kisiwani. Two hundred years later the mpingo they had used to support their door frames is still in excellent condition. Kilwa Kivinji, ‘Kilwa of the *Casuarina* trees’, which at one time was the second most important slave trading post on the East African coast, became an administrative centre during colonial times (Briggs 1993). Nowadays it is a quiet fishing town. The district is currently run from the modern town of Kilwa Masoko ‘Kilwa Market’ which has government offices, a post office and a fishing port. The whole district is something of a backwater in modern Tanzania. By virtue of its history the area is predominantly Muslim and Swahili speaking.

3 Mitarure Forest Reserve

We were based outside Mitarure Forest Reserve (8°50-9°06S, 39°00’-39°10’E) about 30km inland from Kilwa. The road from Kilwa to Liwale passes through the reserve. Mitarure is the largest forest reserve in the district, covering an area of 604.8km².[19] There are thought to be substantial oil reserves in the area and there have even been test drillings within Mitarure FR.[20] These have apparently been abandoned and we saw no evidence of current drilling, neither commercial nor experimental, in the area. There is a small village, Mbate, just before the road enters the north-eastern part of the reserve.

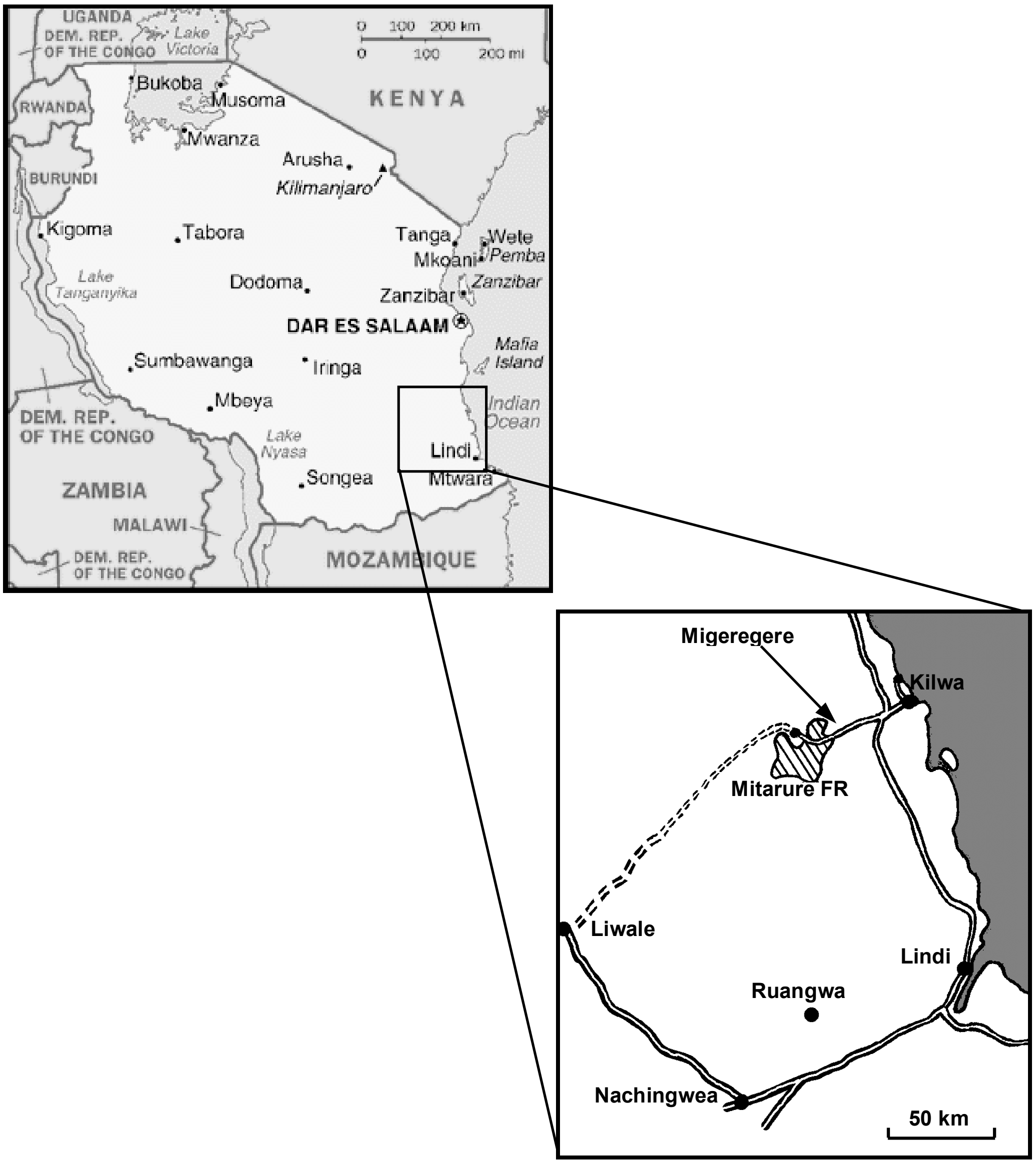
Both Professor RE Malimbwi, head of the Department for Forest Mensuration and Management at Sokoine University of Agriculture, Tanzania and MB Hansen, from the Agricultural University of Norway, have conducted research on the mpingo of Mitarure FR. It is believed that there was some mpingo felling in the reserve in the 1970s and 1980s. This timber was sold to dealers in Dar Es Salaam suggesting that it may have been destined for export. Kilwa sawmill initially (1960s-1980) used wood from the public land around Mitarure FR. In 1984 when ‘all the valuable timber in the public land’ had been extracted they were given permission to fell mpingo and other species within the reserve itself.[21] This contradicts Luoga and Hansen[22] who believe that there has not been ‘significantly exploitation’ of timber within the reserve.

[19] Mfangavo *in litt.,* 1998

[20] Ball *et al*., 1998

[21] Mfangavo *in litt*., 1998

[22] Luoga, 1995; Hansen, 1996



4 *Migeregere*

We camped on the edge of Migeregere for the duration of our fieldwork. Migeregere is a linear village along the road from Kilwa to Liwale between Nangurukuru and Mitarure FR inhabited by approximately 150 people. It is the centre for the division[23] which includes Mbate.

The village is chaired by one man who, like the majority of people in the village, is Muslim, (there are also Christians in the village). The chairman has a small mud hut which serves as an office, in the centre of the village. Close to his hut are the three to four stalls manned by young boys and women selling the only supplies available in the village itself. These included oranges, tomatoes, onions, cigarettes, matches, sweets, deep fried fish (occasionally). In addition, there is a small roadside bar/restaurant. Travelers on their way through the village would be the most likely customers.

Some 200 yards back from the road is the village school with its six classrooms and small staff room. As is standard for Tanzanian primary schools, Migeregere Primary consists of seven year groups, or ‘standards’. Parents send their children to school when then can afford to pay the fees.

[23] Divisions are the administrative level below districts. The ‘capital’ of each division will be a small town such as Nangurukuru or large village like Migeregere. These will provide administrative functions to outlying smaller villages.

Hence the ages of the primary school children can range from five to around seventeen. Migeregere Primary is poorly equipped. The standard 1 classroom is the shady area beneath a tree in the school grounds. The standard 7 classroom only has three walls, making it impossible to teach in during the rains. None of the windows have glass in them nor do they have wooden shutters and there are no doors to the classrooms. The wooden desks within the rooms rest precariously on the uneven ground which is dusty in all but two classrooms where a cement floor has been laid, so long ago, however, that it too is now extremely uneven due to wear.

The village has a dispensary which is situated about 100 yards from the centre of the village along the roadside. The service is manned by one male doctor and two female nurses. They are able to provide free malaria treatment to local people and they do stock various antibiotics. There is one bed in this dispensary. It has a door but only wooden shutters in the windows. Inside it is clean though extremely basic. There are posters on the walls about typhoid, AIDS and malaria.

Next door to the dispensary the village carpenters and repair-men are based. Furniture is made from bamboo and wood. A short way down the road is a small bar where the local ‘coconut wine’ brew is made and served.

Migeregere is devoid of both electricity and running water. The only water supply in the village itself was a steep pit which was almost entirely dried out for the whole two months we were there. What water it did contain was a murky brown colour, unsuitable even for clothes washing. Some 10 minutes drive west of the village there was a larger pit used for collection of rain water. This water would be used by people for all general household purposes (drinking, cooking, clothes washing) and also for bathing.

Methodology

The methodology was based upon the techniques of stratified random sampling, but the exact methodology was only finalised after observation of field conditions in Tanzania.

1 Plot Location

Each plot was circular with a 20m radius[24] and was marked out using four 20m ropes laid out at approximately 90°. Plots were equally divided into three categories:

- **Fire Plots** – *had clearly been burned this year.*
- **River Plots** – *contained the channel of a water course (would only contain surface water during the rainy season).*
- **Normal Plots** – *all other plots.*

The aim was to survey 120 plots in total[25] with 20 of each category inside Mitarure Forest Reserve, and 20 of each outside. They were randomly placed in a 153km² area (half inside the reserve) which lay between the 250ft and 500ft contours. Without recourse to GPS, plots could not be located exactly where marked on the map, and instead standardised walking speeds from pre-determined points along the road were used to gauge the travelling time required along a specified compass bearing. This was not very accurate but preserved the essential randomness of the sampling.

A more real problem was ensuring the correct proportions of plot categories. This was solved by taking no specific action until one category was used up, when surveying teams would be directed to continue walking until the came across the required conditions.

For each plot a general description was recorded, specifically noting plot category, vegetation composition, height of grass, ground slope, estimated number of years since it was lasted burned, the size of any ephemeral water course, and presence of termite mounds. We also took a soil sample from the centre of each plot, but unfortunately equipment failure and inadequate local facilities prevented us from fully analysing it. An attempt to grade the sedimentation with a soil 'worminess' index, but this proved unworkable in the field.

2 Tree Size Classification

Trees were classified according to their girth – the circumference at breast height – which was measured at 1.3m above the ground:

Class	Girth (cm)
Pole	$10 \le CBH < 30$
Tree	$30 \le CBH < 80$
Big Tree	$80 \le CBH < 150$
Very Big Tree	$CBH \ge 150$

Table 2. Size class definitions.

[24] Hence each covered an area of 1257m².

[25] In the end we surveyed 124, plus 38 extra sub-plots outside the reserve.

Note that these do not correspond to the definitions used by *Tanzanian Mpingo 96*.[26] In that report individuals of *pole size* where classified as *saplings*, and all other individuals were termed *trees*. The term sapling is here given a different meaning, see section 5 below. All mention of tree size groups in this report will follow the above terminology even when referring to data from *Tanzanian Mpingo 96.*

3 Taxonomy

All trees of pole size or greater were identified, and the size class recorded. No attempt was made to identify lianas, but trees were identified to species level where possible, and genus or family otherwise. The knowledge of our game guards was very important in helping identify trees, but this did lead to problems with translation of vernacular names which, unfortunately, was not always possible.

4 Mpingo Measurement

All mpingo trees of pole size or greater were measured in a number of ways:

- **Number of stems** with CBH ≥ 10cm were counted
- **Circumference at Breast Height (CBH)** of each stem was measured.
- **Height** of the tree was determined from a clinometer angle reading taken at 10m distance from the tree. Then the following formula produced the height:

$$Ht = 10m \times \tan(C°) + RH + Adj$$

where	Ht	=	Tree height (m)
	C°	=	Clinometer angle (°)
	RH	=	Height of researcher (m)
	Adj	=	Adjustment for ground slope (m)

- **Canopy Area** was calculated from two diameters, the first of which was oriented across the longest distance under the canopy, and the second oriented to be the longest distance perpendicular the first diameter. Neither diameter would necessarily pass through the trunk or any notional centre of the tree. The canopy was then assumed to be elliptical for the calculation of its area:

$$CA = \pi AB$$

where	CA	=	Canopy area (m²)
	A	=	Length of maximum diameter (m)
	B	=	Length of maximum perpendicular diameter (m)

- **Estimated Straight Length (ESL)** was defined as the length of the longest section of trunk or primary branch which was essentially straight. That is it did not have any bends or lateral twists; it did not need to be the thickest part of the trunk. This was only estimated to the nearest 0.5m.

Three important measurements of harvestability were derived from the CBH and ESL:

- **Estimated Straight Volume (ESV)** is the volume of wood contained within the section of trunk measured in the ESL. Following the calculation method

[26] Ball *et al.*, 1998

used for licensing purposes this uses the CBH to determine a cross-sectional area assuming it is a perfect circle and the trunk is uniformly thick. The figure produced gives a volume overbark. The formula used is:

$$ESV = ESL \times (CBH^2 / 4\pi)$$

Note that since the ESL is not necessarily measured at the same point as the CBH there is a tendency to over-estimate, but in practice this was not thought to have had a big effect.

- **Harvestability** is a Boolean statistic. A tree is considered harvestable if the CBH is at least 70cm and the ESL is at least 1m (which corresponds to a straight length of 75cm+ due to the estimation accuracy).[27]
- The **Harvestable Worth** of a tree equals the ESV if it is harvestable, and zero otherwise.

The attempted accuracy of measurements, estimated measurement error, and deduced estimated error of reported figures is summarised in Table 3 below.

Reported figure	Component	Attempted accuracy	Measurement error	Calculated accuracy
Girth	CBH	1cm	± 5cm	± 5cm
Height	Clinometer angle	1°	± 2°	±0.25m
	10m distance		± 0.3m	
	Researcher height	1cm	± 3cm	
	Adjustment for slope	10cm	± 20cm	
Canopy area	Max. diameter	0.1m	± 0.3m	±2.5m²
	Perp. diameter	0.1m	± 0.3m	
ESL		0.5m	± 0.3m	± 0.3m
ESV				± 18cm³

Table 3. Measurement accuracies.

The health of each mpingo was classified in two ways. Firstly the level of fire damage apparent on the outside was graded on an index of 0 – 3. Zero indicating no observable fire damage, 1 and 2 indicating increasing degree of scorching evident on the trunk, and 3 indicating severe scorching and at least some scarring of the timber. Secondly the degree of termite attack was gauged on a scale of 0 (no termite presence) to 5 (severe termite infestation, possibly more than the tree could survive). It is important to note that apart from the highest category in each classification, the grading does not necessarily imply damage to the timber. Mpingo has evolved in an environment where both fire and termites are common, and has evolved various mechanisms to prevent them penetrating the outer bark except in severe cases.

Finally for each mpingo its closest competitors of different sizes were identified: the species of the nearest pole, tree and big tree sized trees (or bamboo clumps) was recorded along with the distance from it to the mpingo (measured to the nearest 0.1m). For analysis purposes if a tree was closer than the nearest pole then it was used instead of the pole, and ditto if a big tree was closer than the nearest pole or tree; i.e. the size class here defines the *minimum* size of the competitor.

[27] These qualification requirements were selected as being a reasonable reflection of saw mill practice, see the *Investigatory Tour of Lindi Region.*

5 Juveniles Survey

Juvenile trees were classified as follows:

- **Seedling** *if height is less than 50cm and circumference measured at 20cm above the ground is smaller than 1cm.*
- **Sapling** *if bigger than a* ***seedling*** *but smaller than a* ***pole****, i.e. height ≥ 50cm or circumference at 20cm ≥ 1cm,* ***and*** *CBH < 10cm.*

Note this definition makes no reference to the source of the juvenile – whether grown from seed, sucker, or old root stock.

We surveyed juveniles by use of sub-plots, one per main plot. If juvenile mpingo could be found within the whole plot, then the sub-plots would be centred around the closest mpingo juvenile to the centre of the main plot. If there were no mpingo juveniles, but there were juveniles of other species then the sub-plot would be centred around the closest juvenile to the centre of the main plot. Failing this second condition, the sub-plot would simply be located at the centre of the main plot. Where applicable the height of the locating juvenile was noted.

Each sub-plot had two components. Inside a 2m radius all seedlings and saplings were identified (although this was frequently difficult) and counted. Then canopy cover was considered within a 5m radius; and a percentage was estimated for each contributing species. When analysing the canopy cover a dominant species was determined for each plot as follows.

A species is defined the dominant for the 5m sub-plot if:

- It has the single greatest contribution (to total cover) of all identified species.
- It contributes at least 20% of cover.
- Unidentified species account for either:
  - Less than 30%
  - Or less than 20% less than the cover for the species concerned.

If total cover was less than 20% then the dominant cover was given as '*Open*', otherwise it was defined as '*Other*'.

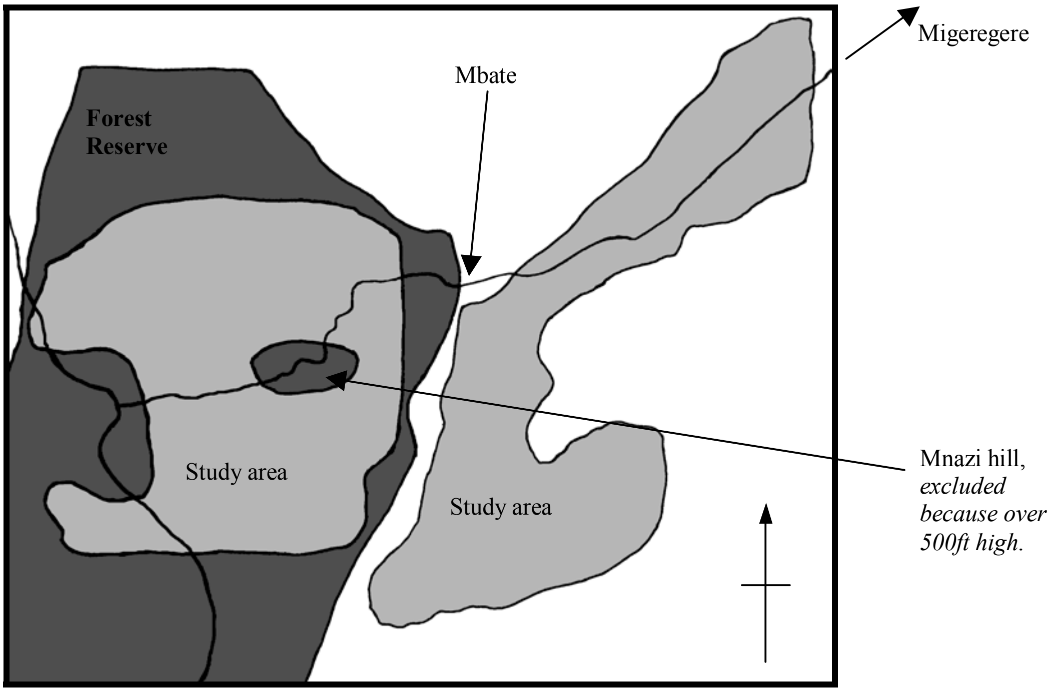


Figure 3. Layout of study site.

Habitat Description

The area we surveyed encompassed a wide variety of habitats ranging from riparian evergreen vegetation to frequently burnt grassland. Most of it however was miombo woodland. Our fieldwork was undertaken in the middle of the dry season hence any trees had few leaves and seldom did we see a tree in flower. This meant that for the purpose of data analysis we were unable to break this genus down any further than three categories (*C. apiculatum, C. molle* and other *Combretum* species).

Together we identified over 100 trees, unusually high for an undergraduate expedition. In comparison there are fewer than 40 distinct tree species native to the whole of northern Europe. Appendix I lists the woody plants growing in and around our study site. This list includes three non-native species that are growing without obvious human interference: cashew, mango and yellow oleander. The former two are widely grown on *shamba*s in the district.[28] We found huge specimens of tamarind (*Tamarindus indica*) growing 10km from human habitation. These were probably several hundred years old and support the theory that tamarind is native to East Africa rather than Asia.

Bamboo formed dense stands up to 6m high typically on the poor soil of the steeper slopes we surveyed.[29] We estimated the percentage of each plot occupied by bamboo but did not gather further data on the species. Bamboo thickets exclude most growth of tree species but adult mpingo trees are found within less dense patches and on the periphery of thicker patches. We saw patches of Combretaceous grassland 'as a zone in the catena'[30] in valleys (*mbuga*s) which support a grass-dominated flora preferred by game species. In agreement with White[31] we found that termite mounds, rocky outcrops and shade islands offer a refuge for species less tolerant of fire. We found that lianas, *Tamarindus indica* and *msagawi* were common on the huge mounds of termites but otherwise were largely restricted to the land around ephemeral water courses. By excluding fire, abandoned termite mounds support vegetation similar to White's Zanzibar-Inhambane undifferentiated forest, which we otherwise found surrounding the courses of ephemeral water channels. Adult mpingo trees were also sometimes found on old termite mounds as is thought to be particularly common in southern Tanzania.[32]

Micro-habitats such as termite mounds and narrow ribbons of evergreen vegetation covered less than a quarter the area we surveyed. The remainder was largely open woodland, but this category was by no means homogenous. There was considerable variation within the relatively small area we surveyed. For example, *Brachystegia spiciformis* and *Julbernardia globiflora* formed quite a tall canopy where many of the trees had overlapping canopies. In contrast *Brachystegia longifolia* was more abundant in the more open areas which had a lower, shallower canopy. These areas formed a patchwork on a scale of a few hundred metres, such that any one plot usually fell within one micro-habitat subtype.

We divided our plots into river, fire and normal miombo according to the dominant vegetation. The category 'river' plots includes evergreen vegetation growing where there is a high water table, in addition to riparian vegetation growing along ephemeral water channels. We intended to conduct an ordination on our data to identify the species affinities of mpingo, but unfortunately technical problems have held this up.[33] We observed that on a small scale mpingo is found neighbouring a

[28] Additionally they are a source of revenue for villagers.

[29] *Oxytenanthera abyssinica* is the lowland bamboo found in the Lindi region. It is notable for having solid stems (Mbuya *et al*. 1994). The species we found had hollow stems which made it suitable for furniture making by local craftsmen.

[30] Lind & Morrison, 1974

[31] White, 1983

[32] Nshubemuki, 1994

[33] We hope that we may be able to produce an addenda with these results at a later stage.

broad range of plants such as bamboo and lianas which are not associated with miombo woodland, as well as the typical miombo species *Combretum apiculatum*, *C. molle* and *Diplorhynchus mossambicensis*. These unusual species affinities are an artefact of our plot size, relative to that of the habitat mosaic. It indicates that mpingo trees are present in a variety of micro-habitats.

This explains some of the apparent contradictions in the literature about mpingo's habitat requirements. Detailed analysis of the soil is likely to reveal that mpingo trees growing with riparian species are in fact growing in soil quite similar to typical miombo soil but have roots sufficiently deep to reach down to the water table. These species will look very different on remote sensing data to typical miombo and so might prove an indication that mpingo stocks might be present in remote areas which are not known to foresters.

The altitudinal boundaries we chose (250-500ft) were effective in delimiting areas where mpingo grows. Above this height there is closed canopy forest with taller trees that tend to be evergreen. *Khaya nyasica* (*mkangezi*) and *Milicia excelsa* (*mvule*) are among the important timber species found here.

Rodgers[34] states that 'towards the coast the increased rainfall with less seasonality and higher air humidity and temperature lead to more typical coastal woodlands and woodland forest mosaics. *Brachystegia* disappears and there are more plants of the genera *Lannea*, *Sclerocarya*, *Tamarindus, Sterculia, Terminalia* and palm species as well as a number of *Combretum* species.'

We found all of these genera in the 153km^2 that we surveyed. *Combretum* species are also characteristic of miombo understorey so need to be removed from this analysis. *Lannea* and palm only occurred in one plot each. A higher proportion of our vegetation was of the genera Rodgers and White[35] consider to be typical miombo species.[36] Mpingo was found in both typical miombo and with the species Rodgers describes as constituting coastal woodland. However we seldom found these 'coastal' species co-existing. For example, *Tamarindus* was restricted to the dense vegetation of ephemeral water courses and termite mounds. *Terminalia* and *Combretum* despite being closely related and superficially at least, found in quite similar habitats, tended not to co-exist.[37] *Sterculia* was very infrequent but was restricted to similar areas as *Tamarindus.* We saw a lot of *Sterculia* whilst travelling elsewhere in Lindi region. *Sclerocarya* were found in the more open plots, and was not present with *Lannea*, *Sterculia* and palm.

Examining Hansen's climate data for Kilwa Kivinji compared with Nachingwea[38], it is clear there is no difference in the total precipitation or temperature and no apparent difference in seasonality or climate between these 'coastal' and 'inland' areas. However we were approximately 30km inland from Kilwa Kivinji. In a narrow, less than 10km wide, strip along the coast there was scrub vegetation similar to that at Mchinga[39] with notably more *Sclerocarya*, *Tamarindus* and palm species but with few large mpingo trees, and totally lacking *Brachystegia* species and *Julbernardia globiflora* which are characteristic of miombo woodland.[40] So while the habitat surveyed by *Tanzanian Mpingo 96* was Rodgers's coastal forest, the area we surveyed in 1998 was definitely not.

[34] Rodgers, 1982

[35] Rodgers, 1982; White 1983

[36] See *Literature Review : Mpingo's habitat*

[37] There were insufficient plots to test this statistically.

[38] Hansen, 1996

[39] Ball *et al.,* 1996

[40] Lind & Morrison, 1974; White, 1983

Characteristics of the Mpingo Population

This section presents the results of the various measurements made on the mpingo trees discovered during the course of our surveying. A total of 108 mpingo individuals of pole size (CBH at least 10cm) or greater were discovered, mpingo being present in 40 out of 101 plots surveyed.[41] The characteristics of these trees are compared here with those found at Mchinga by *Tanzanian Mpingo 96*.[42]

In doing this analysis a large number of statistical tests and correlation attempts (over 100) were performed, few of which are reported in any detail. However, the large number of tests conducted means one must be careful to reduce the significance level appropriately.[43] Thus many tests are performed in this section will be at least to a significance level stricter than 5%. Where no significance level is noted the test was performed to 5%. Many tests were performed twice – once for results obtained from plots inside the reserve, and once from outside. In order to reduce the likelihood of reporting false positive results (statistical Type I errors) it was required that both tests were consistent to the 5% level for the result to be considered significant.

However this method suffered from an artefact of the data in which only 4 trees were discovered in normal plots outside the reserve. Thus it is difficult to decide the significance of patterns which show normal plots to differ markedly from fire and river plots, as the statistical analysis will be heavily dependent on those 4 trees. Where the difference is genuine there are likely to be two separate ecological explanations for the variation (though the proximate causes may well be the same). Further research would be required to show the truth of any such speculations.

1 *Distribution*

Tables 1 and 2 summarise the distribution of the mpingo surveyed.

Plot type / *Density* (ha^{-1})	Normal	Fire	River	Migeregere overall	Mchinga
Mean density	4.3	10.7	10.3	8.5	31.1
Standard error	*8.8*	*15.7*	*16.2*	*14.3*	*45.5*
Max density	31.8	87.5	55.7	87.5	212.2

Table 4. Comparison of absolute density of mpingo for different plot types at Migeregere and also at Mchinga.

[41] A book containing data from the remaining 23 plots, all from outside the forest reserve, was unfortunately lost in the chaotic return from Migeregere. The data set is thus slightly unbalanced, but not so much as to invalidate the conclusions drawn here.

[42] Ball *et al.*, 1998 – they measured 228 individuals. All references to Mchinga refer to the results of *Tanzanian Mpingo 96*.

[43] Since, on average, one would expect one test in 20 to have a significant outcome if all the tests were performed at the 5% significance level.

Plot Type	Normal	Fire	River	Migeregere Overall	Mchinga
Percentage of Plots with Mpingo	24	53	40	40	80
Mean % of Trees	1.0	3.5	1.9	2.1	12
Max % of Trees	22	29	12	29	40

Table 5. Comparison of proportional density of mpingo for different plot types at Migeregere and also at Mchinga. The lower two lines refer to the proportion of trees within the plots that were mpingo.

A binomial model was used to test variation in distribution (mpingo presence or absence) between different plot types, but although both the fire and normal plots show deviation neither was found to be significant. An analysis of variance was used to compare the species frequency in each plot (analogous to species density), but no significant variation was found. It follows that, for this sample at least, the distribution and density of mpingo in different plots types can be considered independent of plot type. Similar checks for variation in mpingo distribution and density inside and outside the Forest Reserve show no significant differences.

No. individuals in a single plot	Corresponding density (ha-1)	No. plots	% of plots
0	0	61	60.4
1	8.0	9	8.9
2	15.9	17	16.8
3	23.9	5	5.0
4	31.8	4	4.0
5	39.8	2	2.0
6+	47.7+	3	3.0

Table 6. Comparative frequency of mpingo densities found in plots.

It is probably true to say that for most tree species surveyed in this way that if one individual is found in a plot, then there is a greater chance that second and third individuals will be found there. This follows from the fact that certain plots where the species is not found will not have conditions suited to the tree, whereas others will be suitable habitat for the tree, but chance has simply resulted in no individual growing there when surveyed. However if a tree grows in an evenly scattered distribution then it is likely that this extra factor will be very low (or, it has been speculated, even reversed if the species is highly competitive with conspecifics over areas the size of a plot). Conversely trees which grow in clusters will give rise to an even greater imbalance in proportions, as will be the case for species which frequently reproduce vegetatively.

The following graph illustrates the case for mpingo, for which there is much anecdotal evidence in favour of it clustering markedly.[44]

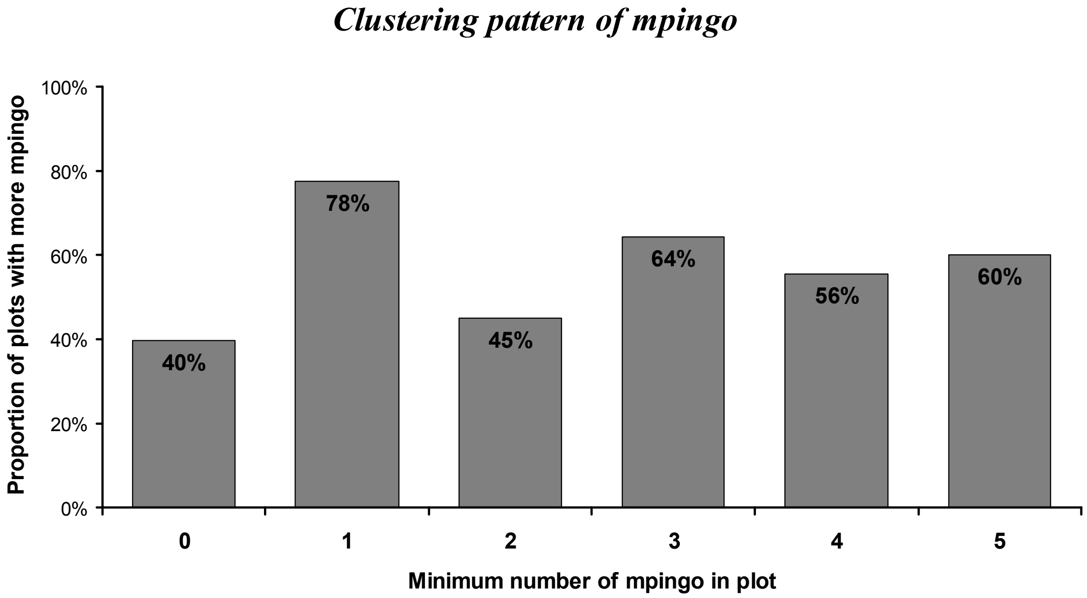


Figure 4. Relative proportions of plots with increasing numbers of mpingo individuals. Each column indicates the percentage of plots with more mpingo than given in the column label. Thus 40% of plots have at least one mpingo, and 78% of those (31% of all plots) have at least two mpingo, and so on.

There is a large jump from the 40% of all plots which have mpingo, to the 78% of plots with mpingo which contain two or more mpingo trees. Separately analysing the samples from inside and outside the forest reserve both exhibit a high degree of significance (to 1%) in the binomial test against the hypothesis that the proportions in the population are the same. However if one were to assume that half of the plots where mpingo was absent were unsuited to the species, and then considered the proportion only of those plots left, then the smaller sample of plots outside the reserve no longer demonstrates any significant change ($p > 5\%$).

Thus the importance that is attached to the first result depends on the estimation of the number of plots surveyed which were completely unsuited to the species. It seems likely that mpingo is demonstrating a tendency to cluster. However the sharp drop from the percentage in column one above to column two could be interpreted as suggesting the opposite conclusion – that the peak in column one is a chance occurrence. In the highly contrasting study area of *Tanzanian Mpingo 96* the clustering was self-evident with a substantial majority of plots containing several mpingo, and up to 60 individuals found in a single 30m radius plot. More research is required before a definitive answer to this question can be found.

In contrast to Mchinga, where mpingo was the third most common species after *Spirostachys africana* and *Commiphora sp.*, there are at least ten species/genera at Migeregere which are more abundant than mpingo. In rank order they are *Diplorhynchus mossambicensis*, *Combretum spp.* (except *C. apiculatum* and *C. molle*), *Combretum apiculatum*, *Pseudolachnostylis maprouneifolia*, *Brachystegia longifolia*, *Acacia nilotica*, *Brachystegia spiciformis*, *Julbernardia globiflora*, *mtachi*, and *Combretum molle*. Lianas were also more common than mpingo, although this could be an artefact of the one third plots which were riverine, despite this habitat making up less than a quarter of the survey area.

[44] See *Investigatory Tour of Lindi Region*

2 *Size and Stems*

The girth at breast height of the thickest stem (maximum CBH) is the best indicator of the age of a tree that can be obtained without chopping it down[45]. Many mpingo trees have multiple stems, but usually there are only one or two large ones, while the others are much smaller.

Max CBH (cm)	Normal plots	Fire plots	River plots	All plots
Mean	94	69	61	70
Standard error	*28*	*37*	*34*	*36*
Max	150	140	140	150

Table 7. Comparative thickness of stem size of mpingo to the nearest cm, qualifying requirement CBH ≥ 10cm.

Figure 5 below illustrates the size distribution throughout the whole sample and the contributions made by each plot type. It is very different from that which was found at Mchinga, where the distribution was heavily skewed towards the lower end (75% of which were poles, i.e. CBH < 30cm).

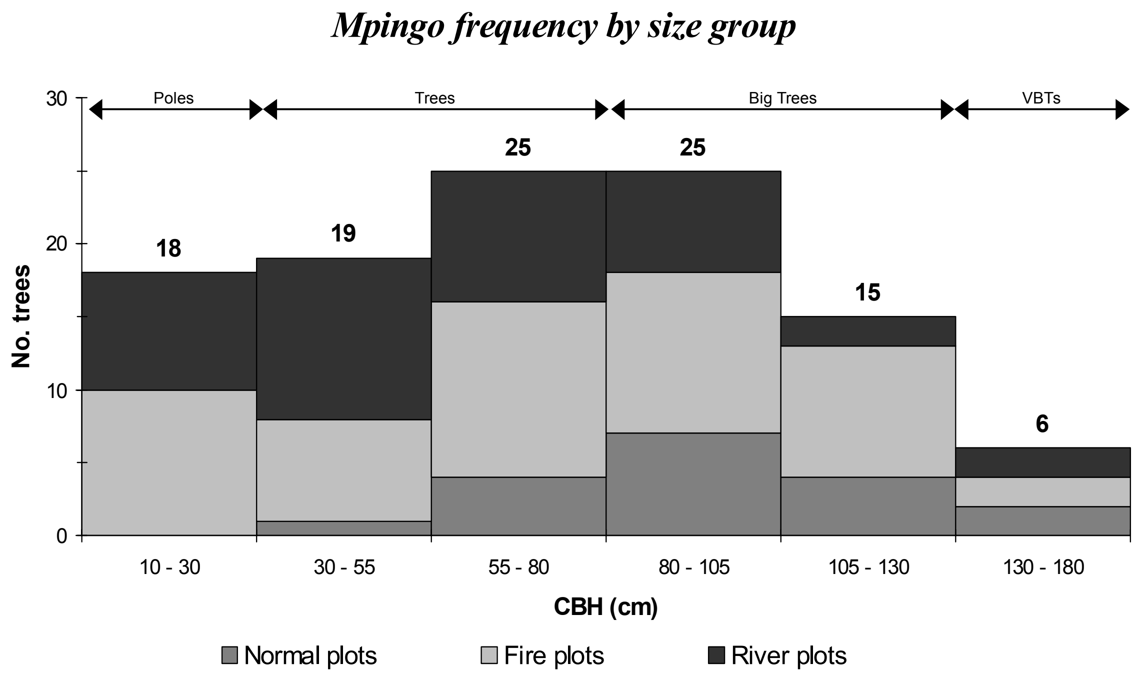


Figure 5. Contributions towards variation in size group by plot type of mpingo. Note the change in the span of size groups for the end columns. VBTs = Very Big Trees – see methodology. Two middle groups split to show extra detail.

See section 5 below for a comparison between size distribution of mpingo and other species.

Analysis of variance between plot types shows no significant variation in girth[46], but there is a significant difference ($p << 0.1\%$) between trees inside the forest reserve (mean CBH = 57cm) and those outside the reserve (mean CBH = 88cm). The data agree with the finding of *Tanzanian Mpingo 96* that there is no correlation between mpingo girth and number of trees in a plot.

[45] And even after felling since the growth rings in mpingo heartwood are hard to distinguish and generally very close together, particularly in high quality wood.

[46] Actually the overall analysis of variance produced a figure significant to 1%, but neither of the split analyses (for inside and outside the forest reserve) showed any significant variation – see the introduction to this chapter.

Other measures of tree size showed the following variation:

Measure	No. stems	Height (m)	Canopy Area (m²)	Estimated Straight Length (m)	Estimated Straight Volume (dm³)
Normal plots	1.1	11.3	36	2.4	145
Fire plots	1.9	8.4	24	1.7	86
River plots	1.2	8.5	21	2.1	97
All plots	1.5	8.9	25	2.0	100
Standard error	*1.2*	*4.1*	*20*	*1.4*	*138*

Table 8. Variation in measures of tree size for mpingo. Estimated Straight Volume, ESV = ESL x (CBH^2 / 4π), where ESL = Estimated Straight Length. Except for the final line all figures are means.

It is noticeable that apart from girth and height all the measures demonstrate a high degree of variability by the fact that the standard error is similar in magnitude to the mean[47].

A high proportion (77%) of trees had only a single stem. It is noticeable that trees in fire plots had a distinctly higher average number of stems than other trees (39% had more than one stem compared to 9% in river and normal plots), and a binomial model was used to test whether this was significant. The overall result showed significance at the 1% level, and this was supported by splitting the sample into two halves (inside and outside the forest reserve), although in this case they only demonstrated significance at 5%. This difference in significance is mainly due to the smaller sample sizes produced by splitting the whole sample. Hence one can conclude that in the population as a whole mpingo trees in recently burned areas (fire plots) are much more likely to have multiple stems (roughly 4 in 10) than in other areas (roughly 1 in 10).

Interestingly there is an even greater difference – in the number of stems per tree – to the situation found at Mchinga, where the average number of stems was 2.5 and it ranged as high as 16. Further analysis of the data from *Tanzanian Mpingo 96* showed that 57% of trees there had more than one stem. The results from Migeregere disagree with the finding in 1996 that mpingo trees were more likely to have only a single stem where there were many other trees in the plot.

Height and canopy area exhibit similar patterns to girth and all three measures are strongly correlated with one another (to 5%, repeated both in and outside the forest reserve). Both height (11.1m compared to 7.4m) and canopy area (31m² to 21m²) are also significantly greater ($p < 5\%$) for trees outside the reserve.

However the pattern is not that simple. In addition to testing those three measures for correlation, four derived characteristics were tested against each other and the three primary measures:

- Height v. Girth ratio
- Canopy area v. Girth ratio
- Cross-sectional area of trunk (α CBH^2)
- Square root of canopy area

47 This is quantified by the kurtosis statistic. CBH and height measurements display a negative kurtosis which means the bell curve is flatter than a normal distribution, while all other characteristics have relatively peaked distributions – indicated by a positive kurtosis.

Since negative values are prohibited this also indicates samples skewed to towards the lower end of the scale, with a few large individuals stretching the upper range. However, apart from number of stems (see below) and ESV (the cube root of which has a more normal character), this was not sufficiently bad to invalidate analysis of variance or regression testing as the sample size is large enough to overcome these distortions.

The definition of the height to girth ratio suggests that it should be positively correlated with height, and negatively correlated with girth, but while the latter is true, the former is not. In fact a scatter graph shows that the ratio varies between about 7 and 22 (with a few outliers beyond) irrespective of height:

Figure 6. Relationship between the Height / CBH ratio and Height for mpingo.

As for the other three derived statistics, canopy area over girth showed no correlation ($p > 5\%$) with anything else, and cross-sectional area proved to be correlated with height and canopy area, and negatively correlated with the height to girth ratio, while the square root of canopy area had identical correlations to canopy area,.

3 Harvestable Timber

The estimation of the longest straight section of trunk is new, and has not, to our knowledge, been performed before. Since a high level of accuracy was impossible, estimates were made to the nearest 0.5m only. Although values ranged from 0 to 8m, only 2 out of 108 trees had an ESL of 5m or more. ESL was not found to vary significantly between different plot types, but, unsurprisingly given the patterns of other physical attributes, trees outside the reserve were found on average to have a significantly longer straight length (2.4m) than those inside the reserve (1.7m). The ESL is correlated with the tree height, but no other physical measurements or derived characteristics in this sample.

Estimating the straight length allowed us to calculate a volume (ESV) which would be obtained were the tree harvested at the time of surveying. The mean ESV of the sample is 126 dm^3. Following previous patterns the ESV is significantly larger outside the reserve (177 dm^3) than inside (90 dm^3). As noted above ESV is so heavily skewed towards the lower end that it would invalidate any tests based up on distributions being approximately normal, but the one-dimensional equivalent (the cube-root of ESV) is much closer to normal. This proved to be correlated with girth and tree height, but no other physical characteristics, directly measurable or derived.

Based on these correlations regression analysis was performed for ESV against girth and Height based upon a cubic relationship. Girth proved to be the better predictor:

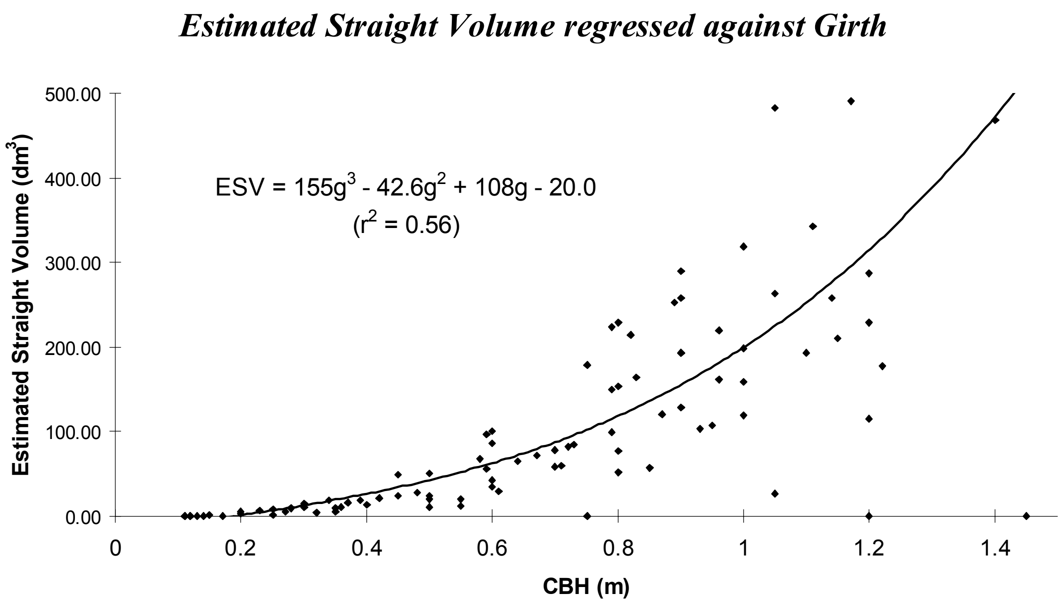


Figure 7. Cubic regression of Estimated Straight Volume against maximum Circumference at Breast Height for mpingo. g = CBH in equation of best fit.

The graph for regression against height is similar but the fit is not as close ($r^2 = 0.36$) although this is still significant ($p \ll 1\%$). The equation then is:

$$ESV = 0.112h^3 - 2.44h^2 + 35.5h - 89.1$$

where height (h) is given in metres and ESV in dm^3. Finally multiple linear regression was applied to girth and height against $\sqrt[3]{ESV}$, which produced the following equation best fit:

$$ESV = (3.88g + 0.124h + 0.154)^3$$

The linear coefficient of regression was $r^2 = 0.66$. However, in comparison to the coefficients for girth and height, the y-intercept 0.154 had a high p-value attached (0.63) and so, forcing the intercept to zero, a simpler but almost as accurate model would be:

$$ESV = (3.92g + 0.135h)^3$$

Note that a non-zero y-intercept is not necessarily a bad thing. Since only individuals of pole-size or greater (CBH $\geq$ 30cm) were fed into the model, it should not be expected to accurately predict the ESV for smaller trees, which would never be harvested in any case.

Malimbwi *et al.* found a linear logarithmic model worked best[48], and although that involved discarding data on trees with zero ESL, it also produced the highest coefficient: $r^2 = 0.90$. That produced the model:

$$ESV = 62.5g^{2.33}h^{0.46}$$

which compares to

$$ESV = 7.60g^{2.385}h^{1.409}$$

found by Malimbwi *et al.*[49] The discrepancy, which is simply one of the significance of height, but does not fall within either standard error, could be due to their consideration of all stems and branches with a minimum diameter of 20cm, which corresponds to a girth of 62.8cm or greater. Their sample size (24 trees) was much smaller.

[48] Malimbwi *et al.*, 1998

[49] This is converted from their equation of Merchantable Volume Overbark: $V_{MOB} = 0.00000198D^{2.385}H^{1.409}$, where D is the stem diameter in cm, and H the height in m.

Despite the high coefficients of regression obtained on these analyses, the 95% confidence intervals for the equation coefficients are quite wide, and so the equations are only valid for large samples, and should not be used as predictors of ESV for individual trees.

The above analysis ignores the fact that many of the trees would never be harvested in the first place, or at least not for many years. Our own research[50] has shown that sawmills prefer logs at least 50cm long, and at least 70cm in girth (though smaller ones are often taken). Since the act of felling a tree is likely to lead to some loss in straight length and also our estimate of 0.5m corresponds to an interval of 0.25m – 0.75m, we have assumed that a tree should have an ESL of at least 1m in order to be classified harvestable. 82% of trees surveyed satisfied this condition, while only 50% also had a large enough stem circumference. At this stage one cannot be sure, but it is perhaps reasonable to suggest that few of those 18% of trees which did not possess a sufficient ESL are unlikely to grow large enough in the future since the wood is non-living tissue. In contrast one might expect that, depending on conditions, a reasonable number of the 32% of trees which had a straight enough trunk but were not yet thick enough might later grow to become harvestable.

Those 50% of trees which were harvestable were found at a density of 4.2 per hectare, while the 82% which were potentially harvestable sometime in the future occurred at 6.9 per hectare. The average ESV of harvestable trees is 163 dm^3, beside which the value of 410 dm^3 per tree calculable from Puhakka's table of licences granted in 1990 in Mtwara District[51] looks rather unlikely.

Even more of interest it is possible to calculate a total harvestable volume which could be extracted from the trees surveyed, i.e. the sum of ESVs of all trees which satisfy both conditions of harvestability.

	Total harvestable volume (m^3)	**Area surveyed (ha)**	**Volume per hectare (m^3 ha^{-1})**
Normal plots	3.16	4.15	0.76
Fire plots	5.33	4.77	1.12
River plots	4.51	3.77	1.20
All plots	13.01	12.69	1.03

Table 9. Density of extractable volume of mpingo for different plot types.

It is interesting to note that although normal plots demonstrated the largest proportion of suitable trees (78%)[52], since the species was rarest there the extractable volume per hectare is somewhat lower than the other habitat types. It would unfortunately require a far larger data sample than collected at Migeregere to check whether the differences in harvestable volume per hectare are significant. These figures are well below the figure of 1.7 m^3 ha^{-1} computed by Malimbwi *et al.* for the Mitarure area, although they did include all harvestable stems and branches in their calculations.[53]

Before moving on to the next section it is also worth detailing the largest tree we found, which could certainly be taller than any previously recorded. It had a height of 19m and estimated straight length of 8m. There was a single stem of 140cm at breast height (although we did find others larger,

[50] See *Investigatory Tour around Lindi Region.*

[51] Puhakka, 1991

[52] The difference was found to be significant but since the sample was small (only 18 trees) more research is recommended before the result can be accepted as fact.

[53] Malimbwi *et al.*, 1998 – used a minimum diameter of 20cm, which corresponds to a circumference of 62.8cm.

the maximum being 215cm[54]). Canopy area was about 70m². It was found in a thickly wooded river valley and showed signs of termite infestation but no fire damage.

4 Tree Health

Various sources of damage to mpingo have been identified. This expedition attempted to quantify two of them: fire (range 0 – 3) and termites (range 0 – 5)[55], and the results can be summarised as follows:

	Fire damage	Termite infestation
Normal plots	0.22	2.06
Fire plots	1.22	2.00
River plots	0.38	1.62
All plots	0.75	1.87

Table 10. Average estimated damage by plot type.

Charts showing the breakdowns of the two sets of figures are shown on the following page. Given the classification of the different plot types the pattern of fire damage evident is hardly surprising as most of this is the result of the most recent burning. The 11 trees found in fire plots with no noticeable fire damage were generally outside the burned area in each plot (the whole of a plot did not need to have been burned for it to count as a fire plot). Due to the extreme density of the wood it has been suggested that termites are only likely to attack trees that have been weakened by fire[56], but the data does not support this. Indeed the trial plantation at Nachingwea[57] was heavily afflicted by termites, and yet is well protected from fires.

Both indicators of tree health were tested for correlation with all the physical characteristics mentioned in the previous section, but none were significant. Neither were they found to be correlated with each other, which is in agreement with the data from Mchinga. Thus it seems that damage from fire does not increase the likelihood or severity of termite attack. Finally although the variation in termite infestation across plot type are not significant, there is a significant difference ($p < 1\%$) between inside the forest reserve (average infestation level = 1.6) and outside it (average level = 2.24). However it should be borne in mind in all this analysis, that the grading scales predominantly measure surface damage only, and that a more rigorous method must be employed if the effect of these phenomena on mpingo is to be investigated more fully.

[54] This was not actually in any of the plots, where the largest found was 150cm in girth.

[55] See the *Methodology* section for more details.

[56] Ball *et al.*, 1998 suggested this could be the case at Mchinga, but there also found no evidence in favour of the hypothesis.

[57] See *Investigatory Tour around Lindi Region.*

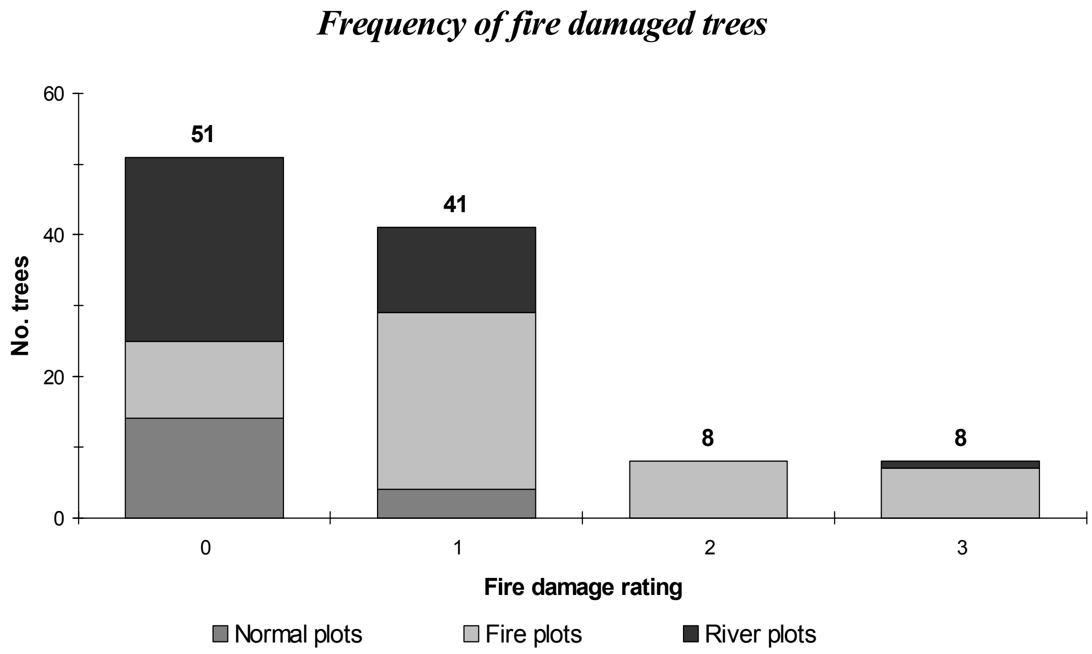


Figure 8. Frequency of different levels of fire damage to mpingo.

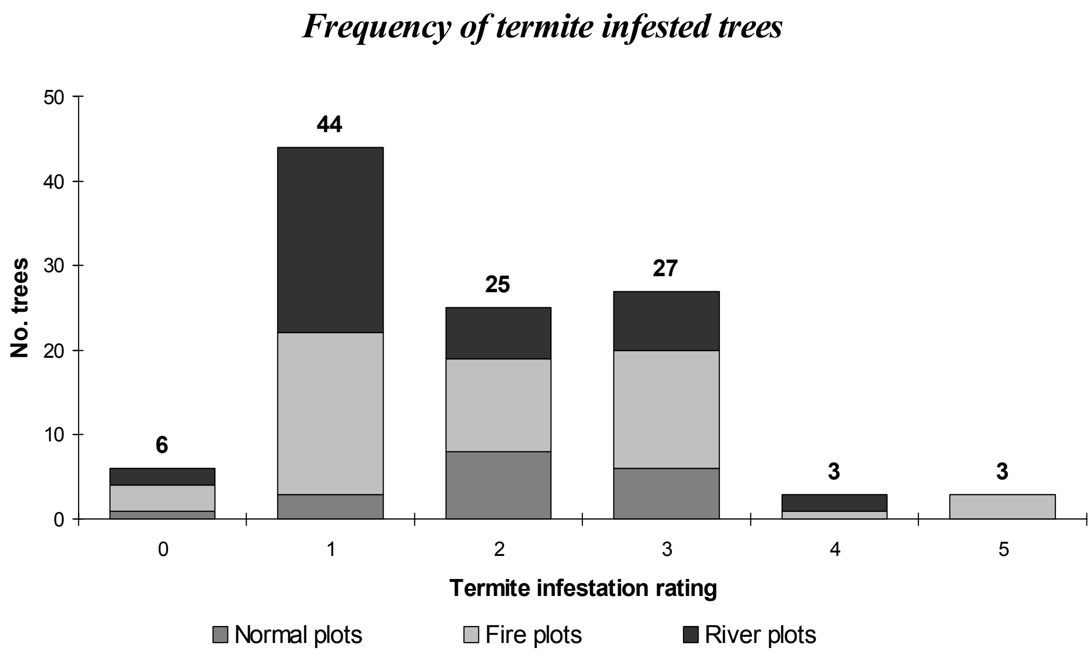


Figure 9. Frequency of different levels of termite infestation of mpingo.

5 Closest Competitors

For every mpingo tree surveyed the nearest pole, tree and big tree sized competitors (within 30m) were identified and the distance to them measured. 41 separate species and genera were differentiated amongst these competitors, although some of the Swahili names could not be translated. With this sort of diversity in a sample size of 108 trees, the competitors had to be grouped by ecological characteristics in order to analyse the data. The following species groups were adopted:

Species group	Group composition
Acacia	*Acacia spp., Enteda abyssinica*
Bamboo	*Bamboo*
Brachystegia	*Brachystegia spp., Julbernardia globiflora*
Combretum	*Combretum spp., Terminalia spp.*
Miombo understorey	*Bauhinia sp., Diplorhynchus mossambicensis, Myrica salicifolia, Ochna spp., Piliostigma thoningii, Pseudolachnostylis maprouneifolia, Sclerocarya birrea, Vanguiria madagascarensis*
Mpingo	*Dalbergia melanoxylon*
Pterocarpus	*P. angolensis, P. stolzii*
Thick forest	*Afzelia quanzensis, Bignoniaceae spp., Strychnos innocua, Tamarindus indica* & lianas
Other	*Albizia amara, Azanza garckeana, Caesalpinoideae spp., Grewia gilvifolia, Pericopsis angolensis, Pteleopsis mytifolia, Rubiaceae spp., Zanthoxylum spp.*

Table 11. Species group composition. The *Thick forest* group also included the species with Swahili name *msagawi*, while the *Other* group included species called *mkafi, mlondondo, mtachi* and *nyamwenzi*, and all unidentified trees.

The relative frequency of these species groups are given in Table 12 below.

Percentage frequency	Normal plots			Fire plots			River plots			All plots		
	Pole	Tree	BT	Pole	Tree	BT	Pole	Tree	BT	Pole	Tree	BT
Acacia	6	11	0	4	6	4	5	10	0	5	8	2
Bamboo	11	11	0	0	0	0	8	10	0	5	6	0
Brachystegia	6	6	0	4	8	20	18	15	33	9	10	21
Combretum	28	28	0	20	10	2	0	5	0	14	11	1
Miombo understorey	6	6	0	14	12	0	23	10	0	16	10	0
Mpingo	22	39	11	20	37	16	10	13	10	17	29	13
Pterocarpus	0	0	0	4	6	10	0	0	3	26	3	6
Thick forest	0	0	0	6	10	0	10	10	15	6	8	6
Other	22	0	89	29	12	49	26	26	38	27	15	52

Table 12. Relative frequencies of species group occurrence as the nearest pole, tree and big tree (BT).

In each category (pole, tree or big tree) analysis of variance was used to look for significant differences by closest competitor species group in the primary physical characteristics, harvestability and health factors of the mpingo tree. In order to maintain reasonable sample size, wherever significant variation was found (at 1% level or better) only those species groups which account for 10% or more of the total are reported here. Moreover these distinctions are only valid on a statistical basis and will not necessarily be true for individual trees. For poles the only significant variation was in tree girth:

Closest pole species group	Mpingo CBH (cm)
Combretum	91
Miombo understorey	63
Mpingo	56
All others	72

Table 13. Variation in mpingo CBH with species group of the nearest pole.

Mpingo trees whose closest competitors of pole size or greater is in the *Combretum* genus appear to have thicker stems than average, while those closer to mpingo poles or poles in the miombo understorey group have noticeably thinner stems.

For tree size competitors (CBH ≥ 30cm) significant variation was found in five characteristics: girth, height, cross-sectional area, ESV and harvestable worth.

Closest tree species group	Mpingo CBH (cm)	Mpingo height (m)	Mpingo ESV (dm^3)	Mpingo HW (dm^3)
Brachystegia	43	6.6	28	26
Combretum	93	10.1	198	196
Miombo understorey	72	9.5	131	122
Mpingo	65	8.3	107	100
All others	74	9.6	144	141

Table 14. Variation in mpingo physical characteristics with species group of the nearest tree. HW = Harvestable Worth. Cross-sectional area is not listed since it is merely an intermediate step between CBH and ESV.

All four characteristics follow the same pattern. Mpingo trees whose closest competitor of tree size is *Brachystegia* in particular, or, to a lesser extent, other mpingo are smaller than average, and hence worth less, while those close to tree-sized *Combretums* are larger than average. Mpingo close to trees in the miombo understorey group are about average size. This is possibly due to the fact that *Brachystegia* are more likely to be found at the upper end of this size bracket than *Combretums* and miombo understorey species. There was no evidence of significant variation in any characteristic according to the closest big tree.

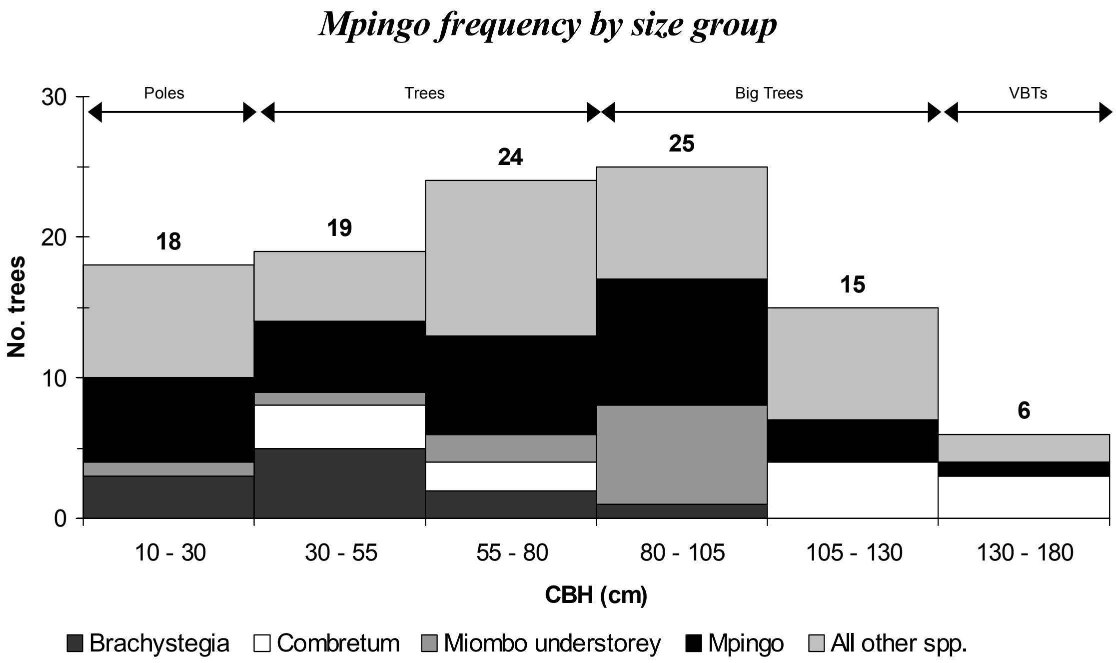


Figure 10. Frequency of mpingo size groups by species groups of the nearest tree with CBH ≥ 30cm.

The distance to the nearest competitors was tested for correlation with all the physical and health factors mentioned in previous sections. There was no evidence of a relationship with any of them except for a positive correlation between distance to the nearest tree and fire damage, which is probably linked to the significant ($p < 0.001$) variation by plot type in the distance to the nearest tree: the average distance in fire plots was 6.47m compared to 3.47m and 3.84m in normal and river plots respectively.

Distance to competitor (m)	Nearest pole	Nearest tree	Nearest big tree
Acacia	3.7	4.5	5.3
Bamboo	3.4	2.9	
Brachystegia	3.0	4.1	10.6
Combretum	2.7	6.0	0.6
Miombo understorey	3.6	4.2	
Mpingo	4.7	5.3	8.0
Other	2.9	6.2	25.5 *(see note)*
Pterocarpus	2.3	4.0	8.4
Thick forest	0.9	4.9	14.3
All species	3.2	5.0	17.9 *(see note)*

Table 15. The distance to the closest competitor for mpingo by species group and competitor size. Note where a big tree could not be easily identified within 30m, the distance was recorded as 35m for analysis purposes and included in the 'Other' species group. Blanks indicate no competitors of that size were found in that species group. Sample size is small (< 5 individuals) for many categories.

No significant variation of distance by species was discovered.

6 Seedlings & Saplings

141 sub-plots were surveyed, most of these coinciding with full-size plots, but some extra ones were done at the end to add to the data set[58]. 122 plots (87% of the total) contained at least one seedling or sapling of some species within the 2m radius, and 43 of these (30% of the total) had juvenile mpingo[59]. The juvenile mpingo were split roughly equally between seedlings and saplings. In contrast a much larger proportion (about 80%) plots at Mchinga contained mpingo.[60]

Juvenile mpingo presence was analysed by plot type and location as summarised in Table 17 below. None of the variations are significant.

	Proportion of plots with juvenile mpingo
Normal plots	21%
Fire plots	33%
River plots	37%
Outside the reserve	33%
Inside the reserve	28%
All plots	30%

Table 16. Proportion of plots with juvenile mpingo.

In addition to mpingo, seedlings and saplings from another 38 tree species and genera were positively identified[61]. This diversity is much lower than for full size specimens due to the considerable further difficulties in identifying small individuals, particularly if they are missing all their leaves. Ignoring mpingo (which was used to locate the sub-plots), the most commonly identified seedlings and saplings were in the *Combretum* genus (present in 26% of sub-plots), especially *C. molle* (10% presence) and *Acacia nilotica* (also 10% presence). Many species showed much greater tendency than mpingo to produce large clumps of seedlings with *A. nilotica*, *C. molle*, *Diplorhynchus mossambicensis*, *Piliostigma thoningii*, and *Vanguiriopsis lancifolia*, amongst others, all being found in clumps of 10 or more individuals in a single sub-plot. Mpingo counted for about 15% of all seedlings and saplings found.

In total 52% of plots contained live mpingo of any age. A Chi-squared test reveals no evidence of correlation between presence of mpingo trees and the presence of juvenile mpingo, nor there is there any correlation in the data between juveniles and the total number of trees of all species in a plot. Thus the result at Mchinga showing positive correlation for juveniles against the total number of trees of all species in a plot is only likely to be true on a small scale. In open woodland seedlings tend to be in competition with grass species rather than being crowded out by fully grown trees.

Juvenile mpingo presence is not correlated with total canopy cover, although Figure 11 below suggests that young mpingo are more likely to be found when total canopy cover is less than 40% .

[58] The same 23 plots for which the mpingo data was lost are also missing from this data set – see footnote 41 at the beginning of this chapter. The 40 extra sub-plots were fortuitously all surveyed outside the reserve, and thus the balance is redressed.

[59] Note that since these sub-plots were centred about the nearest juvenile mpingo (or if absent the nearest seedling or sapling of any species) in the 20m radius plot, presence or absence are indicated over this larger area. The surveying method at Mchinga was very different: 29 sub-plots of 1m radius were placed at fixed locations within each 30m radius plot, so it is difficult to compare some of the data.

[60] 64% of plots had mpingo seedlings or saplings in one of the 29 sub-plots which together only covered 3.2% of the area of each plot. Recollections of members estimate that probably around 80% of full-size plots would have contained seedlings or saplings.

[61] See *Appendix I* for the complete list.

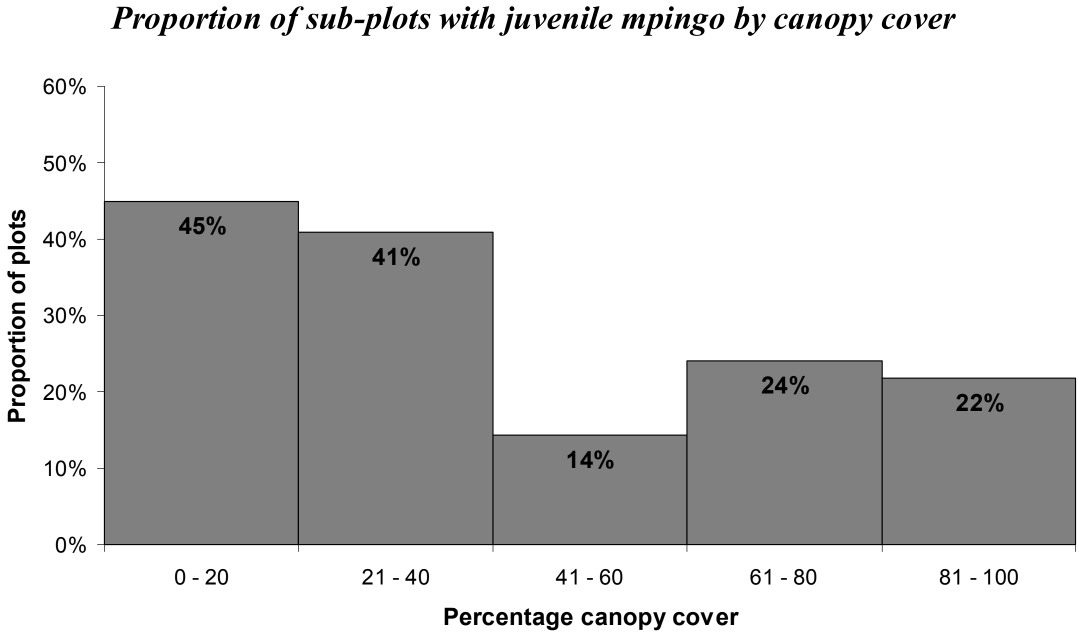


Figure 11. Proportion of sub-plots with juvenile mpingo by canopy cover in 5m radius (at least 20 sub-plots in each category).

The species of the dominant species[62] was grouped together in the same way as for the nearest species to mpingo trees above, and then the data analysed for proportion of plots with juvenile mpingo. The results are summarised in Table 17 below.

Dominant species	Number of plots	Proportion with juvenile mpingo
Acacia	5	40%
Bamboo	1	0%
Brachystegia	19	0%
Combretum	5	40%
Miombo understorey	10	40%
Mpingo	4	25%
Other	1	0%
Pterocarpus	5	40%
Thick forest	52	29%
Open canopy	39	44%
All plots	141	30%

Table 17. Occurrence of juvenile mpingo in sub-plots with different species dominating the canopy cover in a 5m radius.

For most species groups the total number of plots where they dominate is insufficient to conduct any meaningful statistical analysis, but the result of 0% for *Brachystegia* species is significant ($p < 0.001$), and only 2 of those 19 plots have no seedlings at all. Thus it is clear that while mpingo seedlings are *Brachystegia*-averse, others species do at least sprout in the shadow of these often large trees. With a larger sample size the same might well be shown for species in the *Pterocarpus* genus. The higher proportion of open canopy plots with mpingo present is also slightly significant

[62] See *Methodology* for a definition of the dominant species.

($p < 0.05$), and follows on from the previous result that mpingo presence is negatively correlated with total canopy cover.

The height[63] of mpingo seedlings and saplings differed little from that of other species:

Height (cm)	Mpingo	Other species
Min	8	9
Mean	101 ± 61	102 ± 57
Max	291	230

The smallest seedlings came from fire plots, but otherwise there was no significant variation between plot types.

[63] Only the one at the centre of each sub-plot was measured.

Local Use and Knowledge of Mpingo

Any management scheme for mpingo which is based on sustainable exploitation on a local level will depend on the support and co-operation of local people. However little is known about their current practices and attitudes, and until these are understood, and the reasons behind them, it will be very difficult to change them. To this aim a three week sociological study[64] was conducted in parallel with the ecological surveying. It focused on local ethnobotanical knowledge, current practices and general attitudes in relation to mpingo and miombo woodland as a whole. Techniques of *Rapid Rural Appraisal* were used in a series of meetings with different groups of villagers in Migeregere and Mbate. In addition a short pilot educational project was attempted at the village school.

1 Rapid Rural Appraisal

Rapid Rural Appraisal (RRA) is a collection of techniques designed to assist researchers conduct effective studies in rural areas (and particularly in developing countries) in a short period of time and yet overcome these people's natural resistance to questioning by outsiders. It is also intended to convey information about the views of a whole group in a succinct and efficient manner. The methodology frequently employs large diagrams which are drawn on the ground using natural resources such as sticks and stones. Subjects are then requested to portray information by adding markers to these diagrams to express their response to the particular questions they are asked by the researcher. A group is then invited and encouraged to discuss alternative responses to questions together and after some consideration and perhaps alterations to original positions of markers, one final group response is produced. Researchers do not need to be fluent in the local language to see the results on the diagram, and the style of answer encourages discussion within the group. The diagram enables researchers to appreciate the range of opinions that may exist, and yet still arrive at a consensus for the group.

2 Specific Methodology

2.1 Migeregere

To open this field of research an initial meeting was organised with the village chairman to whom we reiterated the purposes of our overall research and explained our intentions for this three week sociological study. He kindly agreed to liaise with villagers to make arrangements for us to meet several groups of people. These were:

- male elders (aged 40+)
- female elders
- male adults (18-40)
- female adults

The chairman attended every meeting, all of which he opened by leading the villagers in their traditional cry[65]. He followed this by informing the attendees that to follow was a brief period of questioning to which they should respond to the best of their knowledge. It was then our duty to

[64] It was shorter than the ecological component to allow the villagers of Migeregere to adjust to our presence before commencing the study. It was hoped that they would be more open in their answers if they felt they knew us a little.

[65] The chairman stands and raising on arm with fist aloft cries, "Migeregere hoya". *hoya* is an expression used to grasp attention, and is also the appropriate reply from the group. The chairman then cries, "Migeregere juu", *juu* – literally 'up' – here implies 'above'.

introduce ourselves and to explain that we were interested in their opinion and knowledge of the tree since this was relevant to our study.

Meetings such as these must be conducted with a tremendous amount of respect towards the interviewees. All meetings were conducted solely in Swahili and were led by the Tanzanian members of the team. Their understanding of the correct cultural ways to behave was of paramount importance in the success of this study. For instance only female team members attended the meetings with local women as they would be disinclined not to speak out in the presence of men. We aimed to encourage maximum participation from all groups.

The broad themes for which information was sought were:

- The phenology of mpingo (which months it is in leaf, flower and fruit).
- The animals seen on mpingo at specific months of the year.
- The calendar patterns for the logging of mpingo and also for burning and clearing village land.
- The uses of mpingo and for each use a comparison with other trees.
- The importance of mpingo in terms of its value to the local people.

Having planned to use techniques of Rapid Rural Appraisal we made preparations for the first three themes to be explained by the use of calendars, onto which the villagers could place small sticks to depict particular months. The first group of interviewees, the old men, did not respond to this with enthusiasm. We sensed that they considered it to be somewhat patronising. Furthermore it seemed that this procedure was too time consuming and therefore tiresome for them. We quickly abandoned this method and resorted to verbal questioning and answering. To determine the value of other tree species in comparison with mpingo for the uses listed of mpingo, we had prepared comparison tables for ranking . This was also shunned for its considerable time requirement. Thus we proceeded by asking for a list of their uses for mpingo and then naming one by one the uses they had given and asking them to compare each of the trees they knew of in their village, with mpingo for each use. There was constant pressure on us, enforced (in a light hearted manner) by the chairman, not to waste people’s time. The importance of mpingo was introduced as a final topic for open discussion and (as was the case throughout the interview) notes were made discretely by one team member as another addressed the villagers.

The questions were asked of each group are listed in the box.

1. In which months of the year is mpingo in
   a) leaf b) flower c) fruit?
2. Are there any animals which you associate with mpingo? When do you observe them?
3. In which months of the year do you burn and clear the land in this village?
4. How much (as a rough percentage) of the land in this village do you burn?
5. How strong are the fires?
6. Can you list the different trees you know of in this village?
7. Do you have any uses for the mpingo tree? What are they?
8. For each use given of mpingo (question 7) interviewees were asked to compare mpingo with each (in turn) of the trees given in question 6.
9. In which months of the year is mpingo cut by local people?
10. In which months do local people cut other trees?
11. In which months is mpingo cut by outsiders to the area?
12. How important is mpingo to you? How would your lives change if there was no more mpingo?

2.2 Mbate

At Mbate we conducted two meetings; firstly with a group of ten men, and then with eight women. Both meetings were semi-structured interviews. Female team members interviewed the women and one male team member interviewed the men. Prior to the interviews we outlined the questions for which we wanted answers but decided not to stick stringently to them but to follow the pattern of the conversation spontaneously. The questions followed similar themes to above, but did not include a discussion of other tree species. Instead the groups were asked about the frequency of logging vehicles travelling into Mitarure (and beyond), and their knowledge of the Forest Reserve and regulations surrounding it.

3 Results

There was considerable variation between answers given by the different groups. This impresses the need for further inquiry. Occasionally one member of a group of interviewees acted as spokesperson and at times also did most of the thinking. So answers were not always collaborative since discussion was not practised as often as desired. This makes it difficult to tell whether or not the answers are truly representative. However, some interesting findings ensued. The results are in broad agreement with those at Mchinga.

The calendar-based results are summarised in Figure 12 below. For a full listing of all the answers of different groups see *Appendix II*.

3.1 Phenology and presence of animals

The remarkably short period over which mpingo is credited as bearing leaves coincides with the start of the rains in November. Thus these answers probably refer to the time when leaves first appear rather than the duration of leaf cover which *Tanzanian Mpingo 96* reported as lasting until April – May time.[66]

Groups gave different estimates of months when the tree is in flower. This could be due to actual variation in flowering or to random answering. Three groups said that the flowers attract bees, which are then used for honey by the local people. It is unclear why exactly birds visit the tree,

[66] Ball *et al.*, 1996

some claimed that the birds simply use the tree as a resting place. Some groups reported having seen them at the same time as the bees. They made no mention of birds being in search of seeds or insects.

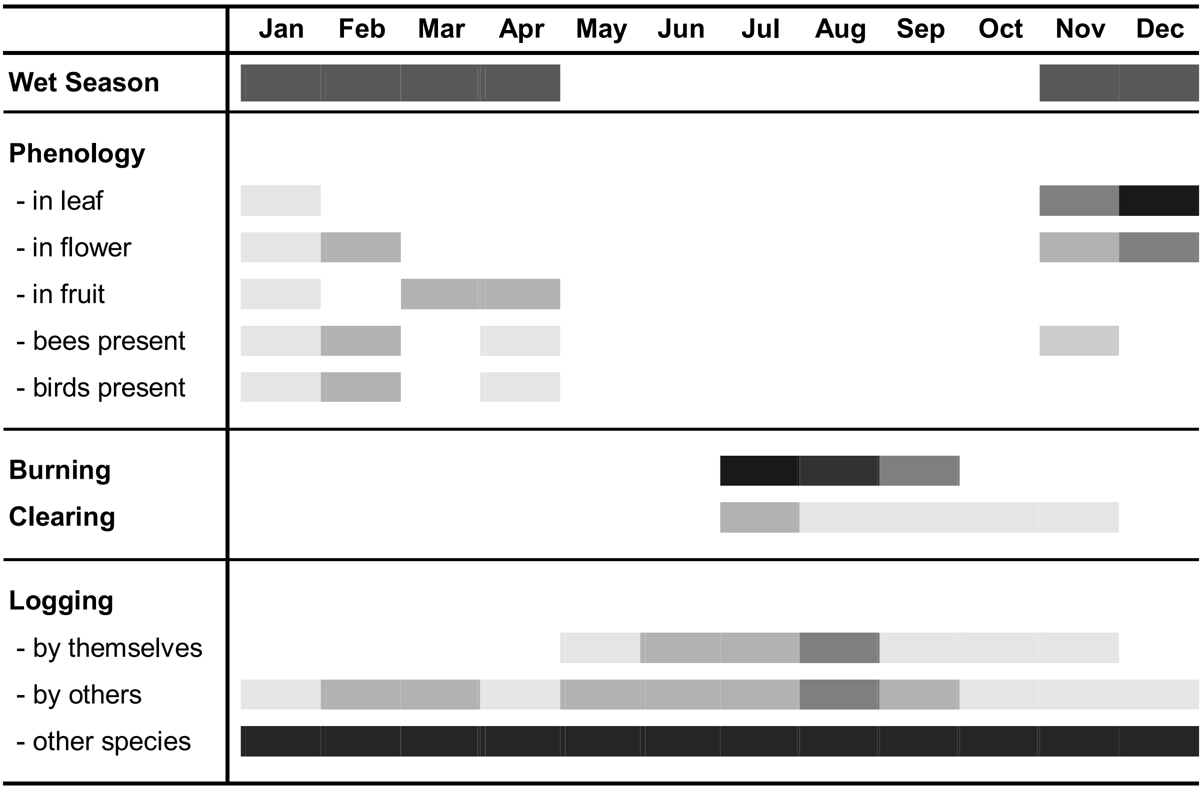


Figure 12. Calendar of RRA results for Migeregere and Mbate. Not all groups were asked every single question; the shading is relative to the total number of groups asked. Wet season illustrated for reference – it was not one of the questions. Note that continuous areas of shading may reflect different groups giving consecutive answers; only the lightest and darkest areas indicate complete consistency.

Key:

All the groups asked said that this happened during this month of the year.

Half of the .. ..

Only one .. ..

None of the .. ..

3.2 Burning

According to each group, the main point of fire burning is to ward dangerous animals (snakes, lions and elephant were mentioned) away from the places where people dwell. Answers regarding months for burning essentially coincided: fires are burnt regularly between July and August/September. However the responses to questions about clearing were far less consistent. People here appear to start both activities later in the year than at Mchinga, where clearing was reported beginning as early as April, and burning in June.[67]

One group suggested that burning only occurs on land where there is a reasonable amount of grass which aids the spread of fire. This same group said that burning normally kills some of the mpingo saplings, seedlings and all the grass. We were told that fires can be strong enough to destroy houses and whole farms, though fires of this strength are not burned every year. When the burning needs to be controlled they use a method of setting fires in strips. In the main the land is not cleared for cultivation after burning. One man from Migeregere mentioned that after burning, wood and

[67] Ball *et al.,* 1996

charcoal are removed from the areas. The male elders from Migeregere reckoned that about half the land around the village was burned each year, while the adult men said that it was about 100 acres.[68]

The information we gathered on this theme came from the male groups since, we were informed, only men go into the bush, so the women were not in a good position to judge what amount of the land is burned, nor how strong the fires can be though as far as they could tell everything gets burnt. Some women commented that only dead trees are burnt, never young ones. However, they did not endeavour to substantiate this claim.

3.3 Logging

Payment for assisting commercial loggers was cited by male interviewees as the most important ‘use’ for mpingo. However there was little consistency in the naming of the specific months when it is felled (either by themselves or by outsiders). This vagueness is in contrast with answers from Mchinga where the dry season was picked out for logging activity, and very little happening in the wet season.[69] It seems that people are unsure of when logging occurs, perhaps because it is an infrequent practice. The men of Mbate knew that Makonde people use the wood for carvings. They were sure that other people cut the tree but did not know where the wood was taken or what use the people had of it. They suggested that it might get sent to Tanga, Dar, Arusha or England.

The women of Mbate stated that outsiders log mpingo during the dry season but expressed their uncertainty as to the identity of these people. They acknowledged that lorries carrying wood pass through the village but they did not notice how many times a week this occurred and could not easily produce even a rough estimate. They remembered a small group of people who planted mpingo some 20 to 30 years previously, but were unaware of who they were. They also explained that their village by-laws determines who can cut the trees in the area, and said there are different laws for different trees. The men of Mbate are aware of the government restrictions on the chopping of certain trees in an attempt to preserve them. They mentioned mpingo, *Milicia excelsa, Pterocarpus angolensis* and *Khaya nyasica*[70], as being subject to these restrictions.

3.4 Uses of mpingo

Throughout the year villagers utilise trees in their daily lives. Everyone at Migeregere acknowledged that they have uses for mpingo. Contradictions emerged regarding the nature of this use and the comparison of mpingo with other trees for these purposes. See Table 18 below for a comparison of the different uses mentioned by each group. In contrast, though, the villagers of Mbate said the tree did not grow in close enough proximity to their homes for it to be worthwhile.

We learned one new use for mpingo timber – as toilet seat covers; otherwise a familiar list of combs, cups, plates, stools, maize pounder, chapati rolling board was given – mainly by the women.

[68] Unfortunately it was not clear as to which areas exactly each group were referring, so it is impossible to reconcile or not these figures.

[69] Ball *et al.,* 1996

[70] Plus one vernacular species name we could not translate: *mkongo*.

	Older men	Older women	Adult men	Adult women
Local uses				
Building	⑨	⑨	⑨	⑨
Charcoal	⑨	⑨	⑨	⑨
Firewood	⑨	⑨	⑨	⑨
Furniture			⑨	
Medicine	⑨	⑨		⑨
Tool Making		⑨	⑨	⑨
Outsiders' uses				
Carvings	⑨	⑨	⑨	⑨
Furniture	⑨			

Table 18. Uses for mpingo supplied by the people of Migeregere.

At home in the village, people cook using wood (charcoal is a luxury fuel). The adult women explained that of mpingo made for inferior firewood owing to its fierce flame[71] and thick, stinging smoke. *Julbernardia globiflora*, *Acacia polyacantha, Brachystegia bussei* and *Vanguiria* sp. are preferred because the smoke is less offensive and the trees are easier to cut down. Conversely, the men (whose household responsibilities do not include cooking and firewood collection, unless they are living as bachelors) stated that the reason why it was good for firewood was because of the strong flame.

Charcoal is produced for selling in Kilwa and Nangurukuru. Though the hardwood of mpingo often deters people from cutting the tree all groups stated that mpingo is the best wood for charcoal production. Other reports state that mpingo is not the preferred species for either wood or charcoal.[72] In Mchinga mpingo is used for firewood.[73] The variation may be due to personal choice over cooking particular dishes. Some preparations (such as boiling water) require a strong unattended heat. The strength of mpingo may be well suited to this and since the pot may be left unattended, the thick smoke becomes less of a problem.

The women of Mbate collect honey from the bees that search for nectar in November (when flowers are present). Though most groups mentioned that mpingo has medicinal uses none but one group of old women explained the specifics. One woman in this group claimed that the leaves of mpingo are pounded, mixed with water and given to babies to provide them with strength for growth. The doctor at the village dispensary later explained that he had never come across this. According to Mbuya the bark, roots and leaves may be used for medicinal purposes.[74]

[71] It quickly will burn through the bottom of their cooking pots.

[72] Moore & Hall, 1987

[73] Ball *et al.,* 1996

[74] Mbuya *et al.,* 1994

Use	Older men	Older women	Adult men	Adult women
Building	M	M	M	B
Charcoal	M	M	M	M
Firewood	M	M	M	J, R *
Furniture		M		S **
Medicine		M		M
Tool Making			P	

Table 19. Preferred species for each declared local use of mpingo. Key: M = mpingo, B = *Bignoniaceae cf. Markhamia*, J = *Julbernardia globiflora*, P = *Pterocarpus angolensis*, R = *Brachystegia bussei*, S = *Strychnos heterodoxa*. Blanks indicate not regarded as a use of mpingo, or no preferred species given.
*** They also mentioned two untranslatable species: *mjombo* and *mnyenye*.**
**** Plus *mzizima* – Latin unknown.**

Although mpingo was frequently listed as a first choice species for its various uses, in all cases there were equally good alternatives. Mpingo is used for interior supports in house construction[75], but adult men and women argued that *Pterocarpus stolzii* is preferable to mpingo which requires too much effort to cut. At Mbate bamboo and *Bignoniaceae cf. Markhamia* were listed as good for this purpose.[76]

3.5 Importance of mpingo to the local people

The overall attitude was that mpingo is of no great significance to the life of a typical Migeregere villager. Only those who cut the tree down for payment by outsiders expressed any potential difference to their lives should the tree cease to be present. People explained that ready substitutes existed for all the uses they have for mpingo, and that the switch would not significantly change their lifestyle.[77] Clearly local timber is very important to the people of Migeregere; however, mpingo itself is not crucial to their way of life.

3.6 The Forest Reserve

The men at Mbate saw no difference between the condition of both land and vegetation inside compared with outside the reserve. This may stem from their uncertainty of the exact border of the reserve. There are no marked boundaries and the women had never heard of the reserve being called Mitarure. They also stated that they have no knowledge of the difference between the land condition and vegetation inside the reserve as compared with outside since they do not enter it.

4 Education Pilot

When all Migeregere interviews had been completed an ‘mpingo workshop’ was planned and conducted on two successive mornings for the whole primary school. Having not spoken to children in any of the interviews, we were keen to discover how far their knowledge of mpingo extended. The whole pilot was conducted in Kiswahili; it being a primary school the level of English was low or non-existent for the vast majority of students.[78]

On the first morning we introduced ourselves to the whole school. We thanked them for their generosity, and explained what we had been doing in that time. We then taught the children two

[75] Ball *et al.,* 1996; Lewis & Berry, 1988

[76] As well as *mpweke* – also untranslatable.

[77] The adult women mentioned combs as a specific example of this.

[78] And the teachers as well.

songs.[79] Many children delight in learning songs and have the capacity to remember the words for a long time. Though it took some encouragement and several practice runs, the children eventually sang out strong and enjoyed it tremendously. Unfortunately time was a little short this morning as the whole school was on tidiness duty.

The second morning began with an interactive talk on mpingo. The children were introduced to mpingo as being the National Tree of Tanzania, something which clearly none of them were aware. When asked, the children listed charcoal, tool construction, medicine, house building and carvings as uses of the tree. They were surprised to learn that the tree is also exported and used in the construction of many woodwind instruments. A crude picture of a clarinet was drawn on the board and the method of playing it briefly described.

For the last section of the morning the children were given paper and coloured pencils and pens (which we later donated to the school) to make pictures of something they had learnt over the two days about mpingo. We had a plastic sleeve album into which we placed all their work and presented it to the head teacher of the school when we left the village.

[79] See *Appendix III*

Investigatory Tour around Lindi Region

After the completion of the main phase of fieldwork at Migeregere some of the team made a brief tour around Lindi region. We visited each of the district centres, as well as a side trip to Mtwara, talking in each place to the District Forestry and Natural Resources Officers. We also visited several sawmills and a few other places of botanical interest. The following is an account of who we met, what they told us, what else we saw and finally an attempt to summarise it all into a meaningful conclusion.

1 *Kilwa District*

See *Geographical Context* for background information on Kilwa District.

1.1 Summary of various interviews with Mr Mfangavo, DFO

Mr Mfangavo, the District Forestry Officer for Kilwa, was very helpful throughout the expedition. He was able to provide us with much of the background information on Mitarure Forest Reserve which is found elsewhere in this report. Of the many Reserves in Kilwa district only Mitarure, Kitope, Ngaranga North, Mitundumbea and Malehi are thought to have significant stocks of mpingo. Except for a small volume extracted by Kilwa Sawmill from Mitarure over 1987 and 1988 there has been no harvesting of mpingo from inside the forest reserves, and most felling takes place on public land.[80]

Mr Mfangavo provided us with monthly figures for all commercial logging licences granted since September 1982. These possibly excluded licences granted to carvers which were recorded separately – carvers can obtain a 'petty licence', sometimes on behalf of a group of individuals, to harvest small volumes – although licences for volumes as low as $0.1m^3$ were included. *Pterocarpus angolensis* was by far the most harvested tree, at least by volume, followed by *Milicia excelsa* and mpingo. The following graphs show the patterns of harvesting for the district.

[80] Note these figures do not match with those given to us by the sawmill. It seems likely that at least one other sawmill was harvesting in forest reserves during 1987-88, although possibly not in Mitarure.

Harvesting licences granted in Kilwa District 1983 - 1997

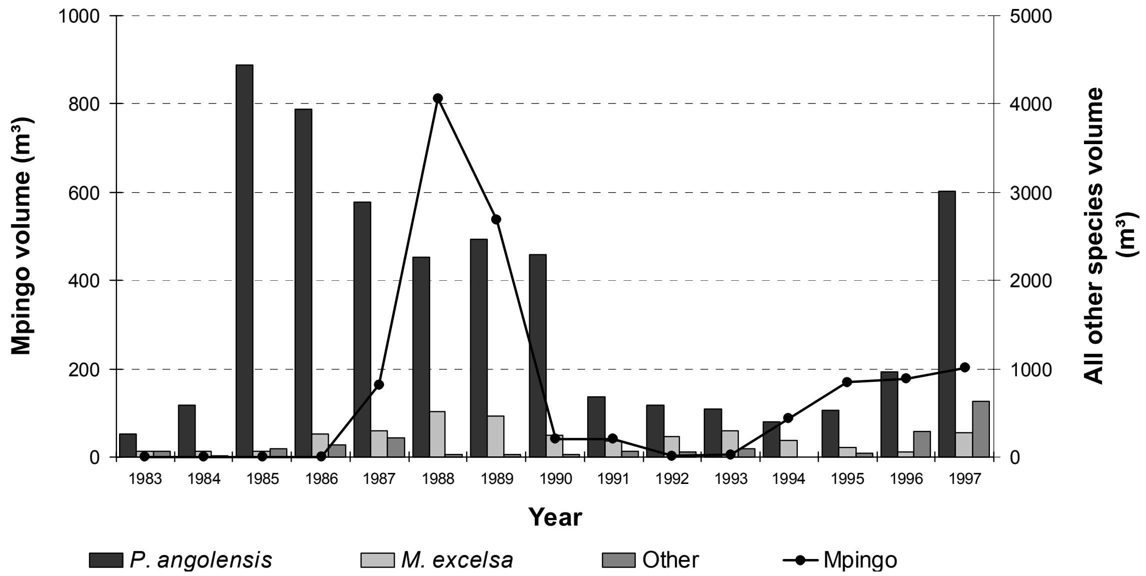


Figure 13. Harvesting licenses (volume) granted in Kilwa District 1983 – 1997 by species.

All the mpingo harvested legally between February 1987 and August 1988 inclusive (total volume 641.5m³) came from forest reserves, as did a further 23.5m³ spread over 1991-92. All other licensed extractions were from public land (including another 335m³ licensed in the last four months of 1988). We do not know why such a disproportionately large amount of mpingo harvesting was licensed over 1988 and 1989.

Extracted timber source in Kilwa District 1983 - 1997

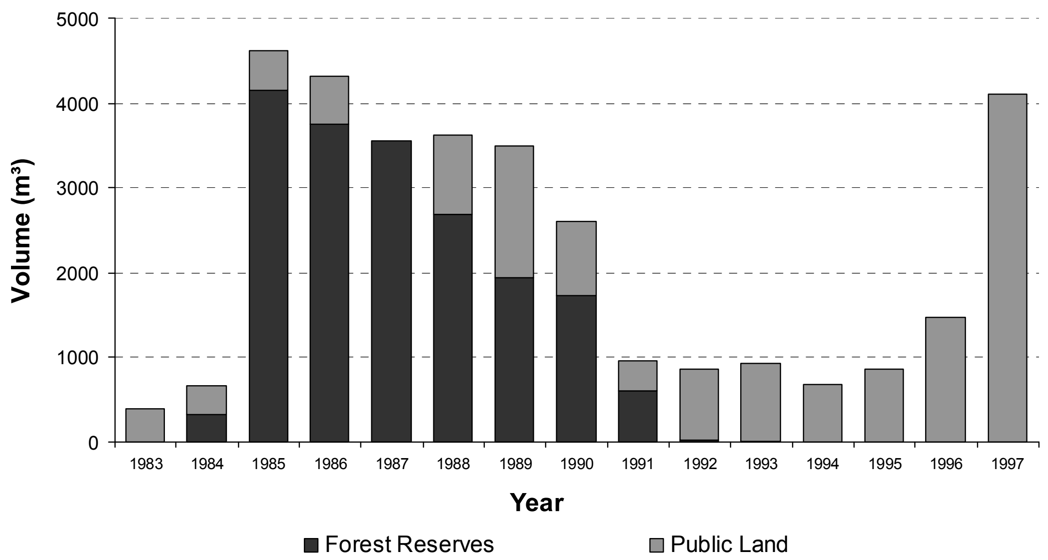


Figure 14. Source of licensed timber extractions (of all species) from Kilwa District 1983 - 1997

Examining the monthly figures demonstrates the unsurprising fact that a high percentage harvesting is carried out during the dry season.

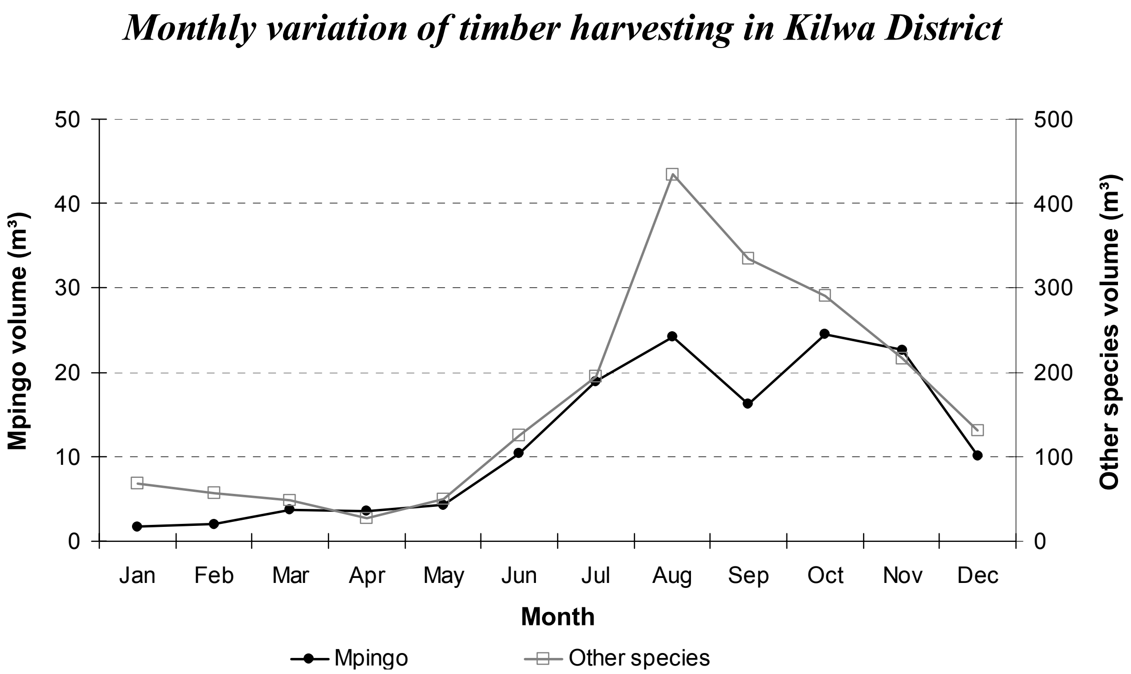


Figure 15. Monthly averages of licenses granted for mpingo and other species in Kilwa District, Sept 1982 – Aug 1998.

Encroachment is currently a problem at the Ngaranga Forest Reserves (North and South) and Ruvungu. There used to be a problem in Tongomba FR, but the clear demarcation of a boundary has solved this. Mr Mfangavo did not regard the encroachment we had seen by villagers at Mbate into Mitarure as a serious issue.

Mr Mfangavo agreed with local carvers that mpingo tends to grow in clusters. He opined that stocks had not reduced significantly over the last 10 years, although the lack of any inventory precluded a definitive answer. There are some mpingo with less valuable brown coloured heartwood around Kitope and Chumu, but most of the district's stocks possess black heartwood for which the tree is renowned. He did not think that there was much illegal harvesting in the district, and that shifting cultivation, which he identified as the biggest threat to the district's forests, caused more mpingo destruction than illegal felling for timber purposes. Fire was also a threat, and often for the purposes of clearing land or warding off wild animals. Finally he stated that charcoal made from mpingo wood was popular with local people.

1.2 Visits to carving groups near Nangurukuru

There are two groups of carvers (about 15 carvers in total) operating around Nangurukuru, one just to the north and one just to the south of the main junction.

Korndi Kasioni Mpondo and his son who share a small carving workshop just north of Nangurukuru on the road to Dar Es Salaam. Mr Mpondo explained to us that they pay an 18,000/- licence fee for every three months to have the right to fell trees in Nangurukuru division. They walk for an hour to reach the site which they are currently exploiting and then select trees with a straight trunk length of 80cm or above. They do not cut trees 'to order', but take them to their home-based workshop and begin work there. In their opinion the best place to get wood from is the from around a small village close to Nangurukuru. Mr Mpondo and his son claimed that only local people obtain wood from there and that wood is still easy to find. They explained that the areas where they get their mpingo from are very green as there is no burning in these areas. They said that the youngest age for a tree to be ready to cut was 30 years old but that a tree takes 100 years to reach full size. They described harvesting sites as having trees in clusters of 10 –15 within a large patch of forest.

The other group of carvers (situated on the other side of Nangurukuru) are of Makonde extraction.[81] They obtain their wood from the same place as Mr Mpondo. They are not experiencing any shortage of trees. Unlike commercial loggers, who only log in the dry season, they will use each tree as it is felled, and cut down another one when the previous in is finished. They will fell trees with trunk diameters[82] between 18cm and 60cm. They have no permanent customers but sell most of their produce to dealers who come down from Dar Es Salaam in the dry season. They can sell brown mpingo to some people, but generally they have to use black shoe polish to achieve the colour that most customers demand. They say they can generally tell which trees are likely to have internal faults, but this is only through long experience. They sometimes give their offcuts to their neighbours for use as firewood.

1.3 Visits to Kilwa Sawmill 3/9/98 and 14/9/98

Kilwa sawmill was established by the government company TWICO[83] in 1972. In recent years it came under partial and now full Chinese ownership, and presently trades under the name Shanrong. The major species processed at the mill are *Pterocarpus angolensis*, *Afzelia quanzensis*, *Milicia excelsa*, *Strychnos heterodoxa* (for flooring) and *Caesalpinoideae spp.* All the processed timber is sent to Dar Es Salaam from where some of it is exported. All the wood is sourced from Kilwa district. From the Mitarure area they have mainly taken mpingo and *Strychnos heterodoxa*. Mpingo used to be an important species for the mill, but not latterly, and they still have stock which they are trying to sell. In 1986-87 they harvested roughly 200m³ of mpingo, then there was no production until 1994 when they harvested about another 130m³ of the species[84], since which time they have only processed about 50m³ of that crop. Sameja Enterprises in Lindi *q.v.* used to be a major buyer of mpingo billets, but not now, and they will not process any more of their stock until they can find new customers.

We were told that Lindi Region is the best place to find mpingo in Tanzania, although there is also some in Masasi and Newala Districts in Mtwara Region. In contrast there is very little in Iringa, Morogoro (except inside the Selous Game Reserve) and Tanga Regions. There are no other companies harvesting mpingo in the same areas as Kilwa sawmill. When harvesting they will search out particular species rather than generally clearing or partially clearing an area. They often use contractors to fell the trees. There is no special treatment of mpingo compared with other species. When they do harvest mpingo they do not treat the logs specifically to avoid splitting, even though the value of split logs is much lower. It takes 3 to 6 logs to make up 1m³ of wood; output volume was estimated to be roughly one third of input. They want to employ a carver to utilise waste, which has previously just been used as firewood.

1.4 Visit to Ikiwirri Sawmill 15/9/98

Ikiwirri Sawmill is owned by Mahmood International, and we were lucky to talk with the very knowledgeable Mr Suchak, the manager there, and all the following information was provided by him. The company was established in 1989 and employs about 140 people: 40 in Dar Es Salaam (where the billets are sent for finishing prior to export), 40 in the sawmill here, and 60 people felling trees in the forest. They only deal in mpingo and export mostly to London, from where it is sent all over the world. Demand for the wood is increasing but is inherently limited. Originally Mr Suchak professed no knowledge of what the wood is used for, but later on described how only the

81 We do not know Mr Mpondo's ancestry.

82 They actually said radius, but it would be a rare mpingo with a DBH of 120cm.

83 TWICO = Tanzania Wood Industries Corporation

84 These figures do not match with the figures given above for felling licenses granted in Kilwa District, where it was implied the harvesting took place. One year added on, i.e. so new dates are 1987-88 and 1995, does correspond. It seems more likely that the sawmill's records are incorrect than the District's as that is part of a larger contiguous data set.

blackest wood is suitable for the manufacture of clarinets, oboes and bagpipes. He said that Ikiwirri was the largest harvester of mpingo in Tanzania, and the mill certainly was a lot busier than the others we had visited.

The sawmill obtains all its wood from Lindi Region and Rufiji District (Rufiji District is part of Pwani Region). There is a lot of mpingo in Kilwa District and Lindi Region as a whole. The biggest trees are in Nachingwea District. Within Kilwa District taller trees are found near Majachumvi, while around Samanga and Jenga they tend to be shorter than average. There are plenty of stocks (he estimated 20 to 30 years' harvests worth) in Morogoro, Iringa and Ifakara Regions, but they are a long way from the main roads so less well known and harder to reach. 'Arusha' mpingo apparently comes from Dodoma Region. The company did try harvesting in Mozambique but the venture failed – Mr Suchak did not know why. Kenya has no significant stocks of mpingo; he is unaware of the situation in other countries.

To find harvestable mpingo Mr Suchak talks to local hunters (we gained the impression that Mr Suchak personally supervises this part of the business) because they are familiar with their local areas. He needs there to be about 3 months supply for it to be worthwhile sending in the felling team, comprising 30 to 60 cross-cutters. About 90% of the wood they use is felled by their own employees, and only about 10% is bought from contractors. The contractors they do use must be experienced loggers and the sawmill will only buy logs which meet their own tight specifications. The best logs are over 3½ft (107cm) in circumference, but in those over 5ft (152cm) heart rot is a frequent problem, dramatically reducing the amount of export quality of wood which can be obtained. They do not fell heavily fluted trees for the same reason. Mr Suchak does not permit his harvesters to cut coppiced trees because their multi-stemmed nature means that the logs are rarely very big, and often the wood is of poorer quality. He suggested that the ex-TWICO Kilwa Sawmill's current difficulties lay with the fact that in the past they have harvested indiscriminately and therefore there current stocks are of too poor quality to readily find buyers on the international market.

The sawmill did not have a problem with supplies. However they cannot harvest during the wet season, due to the impassable roads, and thus the mill is closed for this period every year, like many other operations in Tanzania. He is concerned about deforestation, but does not see it as an immediate problem because there is still so much forested land. Fire can damage the wood – we were shown examples of this – and particularly when areas are burned late in the dry season. Fire also retards, and can even kill, seedling growth. He does hear of illegal harvesting and sees the confiscated logs at checkpoints – sometimes he will buy them from the forestry authorities.

Mr Suchak believes that mpingo takes a minimum of 40 years, and up to 80 years, to reach harvestable size. He thinks that plantations would be a good idea, although it did not seem as if the company had any plans to create their own. He supports the theory that the species reproduces vegetatively from disturbed root-stock. Mr Suchak would like to see the licence cost reduced.

Experienced sawyers are vital to maximise export billet volume obtainable from logs. The financial problems of other sawmills probably lies in their inability to produce enough billets of the highest quality from the logs they receive. First of all logs are split down natural faults. Then they must be inspected for faults and quality of the wood. Ikiwirri Sawmill will reject a split log with just a pinhole-sized fault at one end because this is likely to extend most of the way through. The brown coloured heartwood can be used for carvings but is not suitable for export. It is virtually impossible to tell the colour of the heartwood before felling a tree because sometimes they are browner in the middle, but quite black towards the outside. Mr Suchak speculated the brown colour might be caused by a surplus of water[85].

After the split-logs have been sawn, the resulting billets are graded and then waxed to prevent splitting. It takes about 2 days for the sawmill to process a consignment of logs. The company

[85] One possible explanation is that high water availability facilitates rapid growth, leading to less dense and lower quality wood.

exports about 2-3m³ of billets per month and 30-40m³ over a whole year[86]. For each cubic metre of highest quality export wood, they require 20-30m³ of logs; and it can take anything from 10 to 30 logs (although averaging at the lower end of this range) to make up 1m³.

The sawmill employs two carvers to get maximum value from their waste – although it would take many more carvers to use it all. The carvings are also exported. However there is still a colossal amount of wastage. All around the edge of the mill compound was a huge pile of rejected logs and billets. We were told it measured 270 x 90 x 2ft; allowing for 50% air space this is over 2,200 m³ of waste. It cannot be used for flooring because the wood is fissile. It is not economic to turn it into charcoal, and so they are selling it cheap as firewood.

2 *Lindi District*

2.1 Return visit to Mchinga 6/9/98

Mchinga village, just 30km north of Lindi itself, was the site of the first expedition, *Tanzanian Mpingo 96*. We revisited the study site briefly to see how it had changed in the intervening two years. The main thing that struck us was how dry it was. Two years ago it had been drier than Migeregere was this year, but now the central grassland patch was almost completely dried up. We frequently stumbled over large cracks and holes in the ground which had not been there in 1996, and the grass itself was withered like hay. The puzzle was increased by the fact that across the country and region as a whole 1998 had been a far wetter year than 1996. We could only speculate that some other event had dramatically altered the local water table. Our guide for the afternoon contradicted this possibility by averring that this was the normal condition of the mini-plateau at this time of year, but we are not sure he understood the drift of the question.

Apart from this there did not seem to be a great deal of change at the site. The young mpingo trees at the edge of the grassland did seem to have grown and increased in number slightly (although this was a merely an impression), however the mass of seedlings dotted throughout the grass had not yet grown into any saplings. Our guide informed us that one or more bush fires had gone through the area both of the last two years, and we suspect this to be the reason for the lack of seedling growth. We saw the same stumps and remains of felled mpingo as before. Our guide said no-one had come up here to harvest since 1996 – not surprising given the rarity of large trees.

2.2 Interviews with Mr Mahimbo, DFO and Mr Mzui AFO 7/9/98 and 8/9/98

The first person we were able to speak to in Lindi was Mr Mzui, and Assistant Forestry Officer and in charge of the mangroves project in the district. Later on we managed to talk to Mr Mahimbo, the District Forestry Officer. They told us that there had been no large scale harvesting of mpingo in the district for several years. There once had been a lot of felling, but no longer – trees with brown coloured heartwood predominated the area's stocks. Currently the important timber species are *Pterocarpus angolensis*, *Afzelia quanzensis*, *Milicia excelsa*, *Khaya nyasica* (African mahogany) and *Pterocarpus stolzii*. We were told there are three sawmills operating in the district: Mingoyo, Sameja Enterprises and Dubai African Blackwood (although this last one turned out to have closed down). They also said that there are about 10 carvers working in the district and they procured off-cuts from the sawmills, although none of the sawmills could confirm this.

It does, though, make a convenient explanation as to why they are not paying licence fees. The foresters informed us that mpingo and *Diospyros spp*. (true ebonies) are the only trees in Class 1A of the licence system. This is the most expensive classification and licences for these timbers cost TSh 60,000/- per cubic metre. In contrast *Pterocarpus angolensis* and *Milicia excelsa* licences only cost TSh 25,000/- m^{-3}. Licence records from before 1992 had been sent to the central store in Dar Es Salaam. Since then they had only granted two licences for felling mpingo in the district: 1m³ in

[86] These figures were given to us by Mr Suchak. The monthly figures actually correspond to a yearly range of 24-36m³ and this does not take into account the fact that the mill is supposedly closed for up to six months each year.

1992 @ 20,000/- and 32m³ in 1993 @ 50,000/- (the cost of licences has risen steeply in recent years). This confirms that the harvesting at Mchinga in 1995/6, of which the foresters were hitherto unaware, was illegal. They did not perceive illegal felling to be a major problem but the above example illustrates the problems local foresters have policing large areas without adequate transport.

However they see deforestation as a major threat, and lay the blame on shifting cultivators. Thankfully there has been, thus far, little encroachment into forest reserves. Bush fires are also a big problem, and the dearth of funds for boundary clearing means that these could easily penetrate into reserve areas. Education efforts are hampered by a lack of good village government. Village leaders are not paid so it is difficult to find good people to fill the role. Many so-called leaders are not active in their job, and on occasion they have even been discovered as having died sometime ago without a replacement being sought. Villagers often see the forest as their enemy because wild animals, especially elephants, which live there can destroy crops. The use of blank ammunition in guns as a deterrent has failed as the elephants have become used to their non-lethal nature.

Finally they suggested Mipingo Division (named after the tree) as a place worthy of investigation, and having a forest quite different from that at Mchinga, with lots of *Milicia excelsa* and *Khaya nyasica*.

2.3 Visit to Sameja Sawmill 8/9/98

The manager of Sameja Enterprises Sawmill in Lindi was not present when we visited but we were able to talk to the supervisor on duty, Mr Juma Ndauka. He informed us that the mill, which is smaller than other sawmills, has been in operation since 1989. As well as mpingo they also deal in other high value hardwoods. All the mpingo processed by the mill is sent via Dar Es Salaam (previously they used Mtwara) for export to the UK and Japan. Mr Ndauka was unaware as to what use the wood is put there. He said that demand was increasing, the problem was supply – it is getting harder to find harvestable specimens. A very low percentage (he guessed 25% – well above the industry average) is actually realised as billets.

Although the mill is in Lindi they get most of their logs from Nachingwea (the area around Lionja Forest Reserve) and Ruangwa Districts, and a few from Mtwara and Masasi. This is because most of the mpingo in Lindi District itself has brown colour heartwood, though he did add that some customers actually prefer it. Typically they will have to go 15 to 30 miles from the nearest village to find a harvestable stand. The mill employs 21 people to fell trees, and does not buy logs from contractors. Production is reduced in the wet season but not completely halted. Before felling trees they will conduct reconnaissance surveys. They knock on the trunk with a small hammer to determine if the truck is suffering from heart-rot or has major faults. Heart rot is the biggest problem, affecting virtually all trees. Unfortunately there is no way to tell the colour of the heartwood short of cutting the tree down. They generally fell trunks with circumferences ranging from 2½ft to 4ft (76-122cm) – bigger trees are very rare. The trunks of multi-stemmed trees are not usually large enough; they never utilise branches.

We took a measured some of the logs while we were there. The following table summarises the results for the 35 sampled logs:

	Max. diameter (cm)	Min. diameter (cm)	Circumference (cm)
Minimum	13	5	28
Maximum	43	20	149
Mean	23	12	76
Std. error	*7*	*4*	*23*

Table 20. Measurements taken from 35 logs awaiting sawing at Sameja Sawmill, Lindi. The diameters are measured across useful heartwood (i.e. inside the bark) while the circumference was measured overbark. Maximum and minimum diameter are the greatest / shortest distances respectively across the end of the log.

Interestingly the mean circumference is on the lower edge of the preferred range, and only 43% of logs fell inside that range, with most of the remainder (54%) smaller than preferred. Only one log had a circumference larger than 122cm.

In addition we rated the size of the largest fault in each log on an improvised scale of 0 (none) to 3 (large hole >5 cm across, or equivalent). Figure 16 summarises these:

Figure 16. Frequency of different fault sizes of logs at Sameja Sawmill, Lindi.

Analysing this data produced some interesting results. Firstly there is not a significant correlation between circumference overbark and minimum diameter underbark: neither linear regression or power regression models produced anything significant (F statistic = 5.78 for linear regression model). Secondly the expected link between circumference and fault size was not much better (F = 9.40). We conclude that the logs have extremely irregularly shaped cross-sections.

We also took length measurements of a separate sample of 17 logs. These ranged from 46cm to 70cm, averaging 54cm (Std. Error 5.92cm). Hence the average volume overbark for the logs can be calculated (using the circumference) as 24dm³.

The pile of logs had been there for one day already, and Mr Ndauka estimated it would take them another 4 days to process them all. The billet sizes they produce are determined by customer requirements. Crosscuts are chosen to minimize waste. Inside the mill store room there were neat piles of billets awaiting export. We did not have time to take detailed measurements but we saw none with a cross-section large enough to make the bell of a clarinet (the broadest part).

2.4 Visit to Mingoyo Sawmill 9/9/98

Like the one at Kilwa, Mingoyo was established by the government-owned TWICO. In 1996 it was sold to Expostone. Six months after that it ceased operating. At the time of our visit they were preparing to restart operations on the 15th September 1998. We were lucky to be able to speak with a Mr Kilosa one of the Expostone managers charged with bringing the mill back to operational status.

The principal timbers with which they expect to work are *Pterocarpus angolensis*, *Milicia excelsa* and mpingo. Under the old TWICO ownership mpingo had been an important species for the mill. In contrast to timber from the other species which was generally for domestic use, the mpingo output was exported. The UK and Germany were the biggest customers, but the USA and Japan also received significant amounts. Under TWICO the mill normally only exported around 1m³ a year, but some years were much higher: in 1987 they exported 15m³. Ignoring exceptional years demand was roughly constant.

They expect to obtain mpingo wood mainly from Nachingwea and Ruangwa Districts, with only a little coming from Lindi District, due to the problem with brown coloured heartwood. Mr Kilosa said that Nachingwea has the best logs. It is becoming harder to find mpingo and they will have to go further afield than before to get it, but with good transport there should not be any great problem meeting anticipated demand. He did not consider plantations would be viable due to the long time the tree takes to reach timber size.

The mill employs surveyors to find the suitable trees; they will go up to about 5km off the road into the forest to them. Once felled, they used to have tractors to drag the logs out to the road, but now they must send their trucks into the forest. Mr Kilosa said that it was not possible to know in advance if the log was good quality. They sometimes used the hammer technique described by Mr Ndauka at Sameja, but clearly did not hold much faith in it. Apparently up to half the logs arriving at the mill have defects. They will negotiate a lower price with contractors if the logs are of poor quality. Cross-cutters employed by the mill bring better quality logs, but the contractors work harder and most of their supply is brought by them.

It generally takes 20 to 50 logs (but sometimes as low as 10) to produce $1m^3$ of exportable timber. They have separate machinery to saw the mpingo because it is so hard. Waste is used as firewood – normally given away free to employees. After cutting the billets are graded by government foresters. Only the darkest woods will meet export grade, other pieces are waste. Sometimes the mill will sell carvers poor quality logs, but not bad output or offcuts. Finished pieces can be stored for a long time before export. Indeed we saw quite a collection in one shed which had presumably been there since the mill ceased operations over a year ago. They were neatly grouped into different piles according to which musical instruments they are used to make. We took measurements:

3 Mtwara District

Mtwara Region lies to the south of Lindi Region and borders Mozambique. It is much smaller than Lindi Region and comprises only three districts: Mtwara on the coast, and Masasi and Newala inland.

3.1 Interview with Mr Kinyunyu, DNRO 7/9/98

Although we went to Mtwara intending to speak to the regional officials there we ended up talking principally to Mr Lamek Kinyunyu, the District Natural Resources Officer, as the regional officers indicated he could tell us more than they could. He said the best areas for mpingo in the district are Ngonja, Lukanda/Bandari and Chiwila (Nanyamba), although within the region Masasi has the best stocks. The most important timber species in the district are *Pterocarpus angolensis*, *Afzelia quanzensis* and *Milicia excelsa*. The only sawmill which processed mpingo wood in the district, Kilawala, is no longer in business. Despite this pitsawyers are continuing to cut the species, and most do so illegally. Illegal harvesting is known to account for far more trees in the district than licensed felling. Thus far this year there had been no applications for licences to fell mpingo, and last year only about 5 were received, yet they believe the market is increasing.

Deforestation is another big problem. The main causes are obtaining fuel and building materials, and clearing land for agriculture. He stated that population growth is low at about 1.3%. Fire is the third major threat. He estimated that between 25% and 50% of the district is burned each year. Many fires are started by people trying to scare away snakes they see slithering into the undergrowth, others for fun – a similar story to that around Migeregere. Mr Kinyunyu lacks the staff and transport to do very much about any of these issues.

Finally he said that if anyone were to come back to make a proper survey of the district he would be very happy to appoint a local forester to work with them. Raymond Ndumbalo, an Assistant Forestry Officer, assisted Ms Puhakka in her work in 1991.

4 Ruangwa District

Ruangwa District is a new district which was only split off from Lindi District in 1995. As a result any records dating from before that time must be found in Lindi – the officials in Ruangwa have only that which they need to do run the district now.

4.1 Interview with Mr Mwambi, DFO 9/9/98

As well as Mr Mwambi, the District Forestry Officer, we were also able to talk to Mr Makongo, the Natural Resources Officer for the district. They informed us that there are Ruangwa has many valuable forest timber species: *Pterocarpus angolensis*, *Milicia excelsa*, *Khaya nyasca*, *Afzelia quanzensis*, *Strychnos heterodoxa*, *Brachylaena huillensis*, *Swartzia madagascarensis*, *Afzelia bescola* and *Bombax sufi*, but mpingo is the most important. There is plenty of the species, and generally not in Forest Reserves. Harvested volumes are increasing and there is some illegal felling, but it is not perceived to be a major problem. In 1997 they told us they licensed a paltry 46.58m^3 of timber of across all species to be felled, but none of this was mpingo – they speculated that perhaps harvesters still had licenses from years prior to the district's establishment. Thus far in 1998 they had licensed a total of 25.8m^3 of mpingo to be harvested. All timber is sent to the Lindi sawmills. There are no carvers working in the district. Interestingly they said there was little deforestation in the district, although firewood collection, bush fires, and clearing of land for shifting agriculture were problems. It could be that they understood deforestation only to include clear cutting by loggers.

4.2 Visit to the trial plantation at Chinokole Village 9/9/98

Mr Mwambi and Mr Makongo later took us to see a 24 hectare trial plantation at Chinokole village. This was begun back in 1976, but had not been tended for since 1986 (as was obvious from its appearance) due to a cash shortage. Mpingo and *Pterocarpus angolensis* were the only planted species, but there was also a lot of bamboo and some trees of the *Combretum* genus. A few larger specimens had clearly existed before the establishment of the plot – this was confirmed by a village elder. The mpingo trees were irregularly spaced, with distances between individuals varying from 2m to 5m. It was suggested that the spacing is supposed to be 2.5m which is the normal planting separation for hardwood tree seedlings in East Africa. No thinning had taken place since planting, but the area was burned once a year. However there were a few obvious gaps where we would have expected trees. In measuring 30 trees we encountered 4 such gaps.

We measured the girth of each stem of those 30 trees. The number of stems per tree varied from 1 to 7, but averaged 2.7 per tree. The data obtained is summarized in the following table:

CBH (cm)	All stems	Mean stem size per tree	Max stem size per tree
Min	8	15	22
Max	69	69	69
Mean	27	32	**38**
Std. error	*13*	*13*	*12*

Table 21. Girth of mpingo stems at Chinokole Trial Plantation.

The mean maximum stem size (i.e. the average girth of the largest stem on each tree) of 38cm is important as maximum stem size is the best indicator of a tree's harvestable volume. This gives a growth rate, averaged out over the 22 years since planting, of 1.73cm CBH growth per year. There were very few seedlings or saplings present. They said the trees tended to flower around April, and bore fruit June to July time – in complete contradiction to people at Mchinga and Migeregere.[87]

5 *Nachingwea District*

Nachingwea District is inland from Lindi and Ruangwa districts and has an area of 6,115km^2. Much of the best wood is reputed to come from Nachingwea, and mpingo trees growing in Lionja Forest

[87] See *Local Use and Knowledge of Mpingo*.

Reserve (the only one in the district) have been cited as typical of inland stocks as compared against coastal stocks of Kilwa district.[88]

5.1 Interview with Mr Ungele, ADNRO 10/9/98

Mr Sefu Ungele is the Beekeeping Officer for Nachingwea District, and was the Acting District Natural Resources Officer when we visited. We spoke at some length to him and the following day we were fortunate to speak to the District Forestry Officer, who was able to clarify for us some of what we had heard. Mr Ungele was clear that there is plenty of mpingo to be found in the district. It grows plentifully both inside and outside Lionja Forest Reserve. Both the trees with lighter and darker colour heartwood are found in the district, growing interspersed with one another.

Harvesting has been occurring in the district at least since 1945, with a large increase in volumes extracted after 1980. Sameja Enterprises, Nachingwea Trading Company (NATCO) and Dubai African Blackwood Enterprises (the latter two are now closed) have harvested there in recent years, and there are also pit-sawyers and a few carvers operating, with licences, in the district. They did not think that many people are felling without licences and said that illegally felled volumes are low compared to licensed logging. All of the harvesting is occurring on public land – permission to harvest inside Lionja Forest Reserve has always been refused by the Ministry of Natural Resources and Tourism in Dar.

We were provided the following data for licenses granted in recent years to fell mpingo in the district:

Year	Volume of wood for which licenses were granted (to the nearest m³)
1993	325
1994	302
1995	41
1996	30
1997	162
1998 (to 10/9)	25

Table 22. Volume of mpingo for which licences for felling were granted in Nachingwea District since 1993. Since the dry season was nearly at an end the 1998 figure cannot be expected grow significantly.

We were told that the average size of log is $0.054m^3$. They said that the level of harvesting is small in comparison, and expressed the opinion that the district had sufficient stocks to sustain a harvest of $300m^3$ per year. There is plenty of mpingo regeneration in the forest reserve, but not so much outside it, probably due to regular fires destroying seedlings. They thought that it is becoming harder to find good trees and the harvesters are having to go further from the roads in order to find them. Other species, though, are felled more intensively than mpingo; they are *Pterocarpus angolensis* and *Albizia amara*, and stocks of both are decreasing. *Afzelia quanzensis* is also harvested in the district.

Bush fires, mostly started by hunters, are perceived as the biggest threat to forests in the district. The fires often spread into the forest reserve from the public lands. Local people are aware of the rules regulating the reserve, but the district does not have sufficient funds to maintain a clear boundary[89] around it. Deforestation is another big concern for the district officials, shifting agriculture is the principal reason for it – a result of the district's rapidly increasing population. The clearing of forest is particularly prevalent along rivers, which increases the rate of soil erosion. The

[88] Hansen, 1996; Malimbwi *et al.*, 1998

[89] It is standard practise to keep an area several metres wide around a forest reserve clear of vegetation to prevent fires spreading into the reserve.

issue has become highly politicised. Charcoal production around the town is also exerting a strong pressure on local forests.[90]

5.2 Visit to Mpingo site close to Lionja FR 10/9/98

The first place we stopped was abandoned agricultural land which is now reverting to woodland. The most striking feature of this area was the uniformity of tree size and spacing. The species present were very similar to those at our study site but in different proportions. There were many large specimens of *Piliostigma thoningii* and *Bauhinia petersiana* along with *Pterocarpus angolensis*, *Ochna praecox*, *Diplorhynchus mossambicensis* and *Pseudolachnostylis maprouneifolia*. Mpingo was quite common.

The second place we visited had less abundant mpingo. The vegetation was again broadly similar to the area we surveyed having *Brachystegia spiciformis*, *Strychnos innocua and Pterocarpus angolensis.* Additionally there was also *Euphorbia candelabrum* which was surprising given the high water availability in the area.. This site had a closed canopy which was substantially higher than previous one (12-15m compared to 7-10m).

Then on our way back was the most remarkable discovery of the day: an mpingo tree close to the road which was in full leaf, and even bearing flowers. In mid-September, at the end of the dry season, we could only speculate that it was growing above a locally high water-table. It was in the middle of a *shamba*, and the surrounding vegetation was the harvested remains of cassava. The nearest trees, at least 100m away, did not appear any greener than normal.

5.3 Inspection of Trial Plantation by Nachingwea Forestry Office 10/9/98

As noted by *Tanzanian Mpingo 96*, there is a small trial plantation of mpingo right outside the forestry office in Nachingwea, which was planted in 1979[91]. This had been weeded by scything every year up to 1996, but had not been tended since. Nor had any monitoring had ever taken place – both a result of lack of funding. 52 trees had been planted – most of them in a square grid with spacing roughly 2.5m between each tree. They were all about 6 to 7m in height. Interestingly, in contrast to Chinokole where very little termite attack was noted, there was plenty of evidence of their presence on all the trees, but we could see no damage as a result.

We measured the girth of every stem, and estimated the length of straight stem (to the nearest half metre) for all the trees in the plantation. The results are summarised below:

CBH (cm)	All stems	Mean stem size per tree	Max stem size per tree
Min	9.0	15.3	19.0
Max	62.0	53.5	62.0
Mean	28.5	29.4	35.9
Std. error	10.9	8.1	9.5

Table 23. Girth of mpingo stems at Nachingwea Trial Plantation.

Once again we can calculate a growth rate for the trees using the mean maximum stem size: 1.88cm CBH growth a year. The number of stems on one tree varied from 1 to 6, with a mean of 2.7. Table 24 summarises the estimated length of straight stem data and the resulting volumes overbark:

[90] Charcoal produces 40-80% the heat of wood but is lighter and smaller. It is especially used around larger towns of Africa (Lewis & Berry 1988).

[91] Ball *et al.*, 1998

	ESL (m)	Volume overbark of largest stem (dm^3)
Min	0.5	1.4
Max	3.0	59.7
Mean	1.8	20.6
Std. error	0.6	13.3

Table 24. Estimated Straight Lengths (ESL) of stems and calculated volumes overbark of mpingo trees at Nachingwea Trial Plantation.

6 *Liwale District*

At 36,034km² Liwale is by far the biggest district in Lindi region. However two thirds of it lies within the huge Selous Game Reserve, which covers over 50,000km², an area bigger than Denmark, and is the largest wildlife reserve in Africa, and the second largest in the world.[92] The northerly parts of this great protected wilderness are the most frequently visited, but the section south of the Rufiji (the bulk of the reserve) which mostly lies inside Liwale District is very remote. Some basic maps of Tanzania show Liwale town as having no roads going to it. The only way to reach the town in the wet season is by air.

6.1 Interview with Mr Lupogo, DFO 11/9/98

According to Mr Paul Lupogo, the District Forestry Officer for Liwale, there is plenty of mpingo in the district, mostly within the three forest reserves: Nyera, Kiperere and Lung'onya (which itself lies inside the Selous Game Reserve). This third reserve should be well protected since apparently there is no encroachment into the Selous from this district. All the district's stocks have the darker coloured heartwood preferred by harvesters. The license records had been sent to the regional office in Lindi, but there is no organised harvesting occurring at present. Apparently Dubai African Blackwood harvested between 1991 and 1994, but not since. All the trees felled were on public land, but the company had not exhausted stocks there. Mr Lupogo did not think stocks in the district had declined significantly over the last ten years, although deteriorating infrastructure did mean that it was becoming harder to harvest what was there. There are no carvers in Liwale District, and he was not aware of any illegal harvesting of mpingo. The only timber species currently harvested commercially in the district are *Pterocarpus angolensis* and *Afzelia quanzensis*, although *Swartzia madagascariensis* is also found in some numbers.

Clearing for shifting agriculture does not seem to be as big a threat to the district's forests as it is in elsewhere in Lindi Region, even though the small human population is growing fast. Most cleared land is turned into cashew plantations – we saw many along the roads. Rather than clearing established forest some of these farmers are expanding into old, disused plantations, which they are currently re-clearing. Bush fires are a major problem, but Mr Lupogo thought that they only had a small effect on mpingo regeneration.

Finally Mr Lupogo did tell us of a trial plantation of mpingo close to Kiangara, but unfortunately we did not have the time to visit it. The plantation was apparently begun in 1976, but is not tended any more.

7 *Inventory by the FBD in Dar Es Salaam*

The Forestry and Beekeeping Division of the Ministry of Natural Resources and Tourism in Dar Es Salaam has a role in providing centralised co-ordination and support to the Regional and District

[92] Briggs, 1996

foresters. In 1996-7 they sent teams down to Lindi Region to inventory the local forests. We first learned of this from Mr Mzui in Lindi, but officers from other districts also reported this when asked. However none of them had ever received any kind of report of the findings from Dar. After the end of the expedition we went to visit the divisional headquarters in Dar, where we met Mr Edwin Haule, who is in charge of Surveys and Inventories for the division. He said they had very little information on regeneration of mpingo, and that no effort had ever been put into propagation and they instead just left nature to its course. When pressed about the inventory he revealed that it had been not been completed due to the donor, the Swedish International Development Agency (SIDA), pulling out and the Tanzanian government had not released the funds for them continue. The partial data that had been collected had not been analysed – the suggestion being that there was little point unless the surveying was completed. Mr Haule would certainly like to see this done, but he did not seem to think it likely unless a new donor stepped forward. Our impression is that a new donor is not being actively sought. We asked if we could analyse the data ourselves, to which Mr Haule consented, however bureaucratic difficulties prevented us from getting it before we left Tanzania. We are still hoping that something may come of it all, perhaps with the co-operation of Sokoine University of Agriculture.

8 Conclusions

Some of the information we collected on the trip seems contradictory, while much was very fragmentary. On top of this many of the people to whom we were talking were unable to spend much time in the field so their awareness of the true conditions was often not very good. We were unable to verify much of what we were told. All of this makes it much harder to draw firm conclusions, but nevertheless there are a number of points which did arise.

8.1 Mpingo's Habitat

Apart from the narrow strip right next to the coast, which generally resembled the conditions at Mchinga[93], the natural habitat of the whole region did not appear markedly different from that at Migeregere. This is important because it means that results from there can be broadly applied with reasonable confidence across the region. The forest at Nachingwea and Liwale may have been a considerable distance inland, compared to Migeregere, and at higher elevations, but the general species composition was quite similar.

8.2 Illegal Harvesting

It has been suggested that illegal felling accounts for one half of all harvesting of mpingo that takes place each year.[94] Data are available for processed mpingo billets exported from Tanzania over the period 1980 to 1991.[95] Comparing this with the figures given above for harvesting is extremely difficult. If the Nachingwea harvest before 1993 was a sustained 300m³ per annum then it is possible to read some sense into the figures[96], but the abnormally large amount licensed in Kilwa district over 1988 and 1989 is not reflected in the exports for those years. Were the licences used up over a number of years?

We believe that those foresters who thought illegal harvesting was only a small problem, are suffering an illusion caused by their lack of transport and consequent inability to patrol their districts effectively.[97] The high cost of licences is a major disincentive against small-time operators

[93] And where few large trees, mpingo or otherwise, are to be found.

[94] Moore & Hall, 1987

[95] Moore & Hall, 1987; Marshall, 1995

[96] In addition to extrapolating demand and harvesting levels, there are a whole load more assumptions required including recovery rate, contributions from other regions.

[97] Moore & Hall (1987) also commented on apparent ignorance amongst foresters of illegal harvesting occurring in their own districts.

purchasing them. The sawmills did not corroborate the foresters' stories that carvers were obtaining their raw material from sawmill discards. Without the resources to disprove the carvers, foresters have little choice but to believe them. Even the sawmills themselves cannot be free from suspicion. All the mill managers spoke of their knowledge of illegal felling, but, predictably, denied they had any part in it. They cannot all be telling the truth. Only effective policing will provide the answer.

8.3 Sawmilling Practices

The size of the logs obtainable is clearly critical to any sawmill. We were only able to measure logs at Sameja Sawmill in Lindi but the discrepancy there between what the manager said was the size of logs they preferred, and the sizes of the actual logs they had is worrying. Only 43% of the logs there were within his ideal range, and only 14% had a circumference over 105cm which was Ikiwirri Sawmill's preferred minimum. The 10th percentile (i.e. the cut-off point such that 90% logs have a circumference higher than that) is as low as 52cm. This corroborates Mr Ndauka's statement that they are experiencing some difficulty procuring the size of logs they would like. Calculating a volume overbark for the logs we find they would need on average 36 logs to make $1m^3$ of wood before processing, compared to a range of 10 – 30 logs (and normally at the lower end) quoted by Ikiwirri. If the logs are as long as 1m (i.e. almost double the mean length of those at Sameja) then for 10 logs to make up $1m^3$, their circumference would have to average at 112cm which fits into their preferred range. The Kilwa estimate was for 3 – 6 logs making up $1m^3$ volume overbark, which at 1m long makes for an unlikely average circumference of 145 – 205cm. However if each tree were to yield several logs then 3 – 6 trees per $1m^3$ of volume overbark seems reasonable.

Others before us have commented on the inefficiencies of the milling process[98], and, while we are not qualified to speak with any authority upon such things, it is something worth discussing. Mr Suchak, of Ikiwirri Sawmill, seemed the most knowledgeable of the sawmill managers to whom we spoke, and he was at pains to stress the importance of careful selection of cutting lines at all points before and during the milling process. In contrast, from our brief visits we gained the impression that the workers employed at Sameja Sawmill, for one, did not take as much care with their cuts, and this in turn led to a lower recovery rate of billets produced. In addition Kilwa Sawmill could not sell their billets, Mingoyo had suspended harvesting, and Dubai African Blackwood had stopped trading.

We could not get an answer at Sameja for the number of logs they require for $1m^3$ of exportable material, but we did get a range of answers from the others:

Sawmill	No. logs for $1m^3$ input	Recovery rate	No. logs for $1m^3$ of billets
Kilwa	3 – 6	~0.33	10 – 20
Ikiwirri	10 – 30	0.03 – 0.05	200 – 900
Sameja	~36		
Mingoyo			20 – 50

Table 25. Summary of estimates of number of logs required for $1m^3$ of export billets. Recovery rate is the output volume divided by the input volume. The figures for Kilwa and Ikiwirri sawmills are calculated from the other two columns, and all figures, except for the Sameja one, are estimates.

The difference is staggering. One can speculate that Kilwa sawmill's billets are of poor quality (hence their inability to sell them) and that the sawyers at Mingoyo are not as skilled as at Ikiwirri. Also it is possible that the Mingoyo figure should actually belong in the first column, although this would still be inconsistent with other mills. Mr Suchak of Ikiwirri Sawmill seemed much more

[98] Moore & Hall, 1987; Platt & Evison, 1994; Beale, 1995; and others.

knowledgeable than the other managers with whom we spoke and hence we are inclined to believe his figures rather than the others.

All this points to the conclusion that while mpingo felling and processing may be seen as a lucrative business because of the high price billets command on the international market, the actual operation must be run with maximum of care and control in order to ensue profitability. There is no doubt a huge amount of inefficiency in the whole process. Even at Ikiwirri they did not appear to seal the ends of logs after felling to prevent splitting before processing at the sawmill. And the huge waste piles at Ikiwirri testify to the very low output to input ratio achievable with better practices.

8.4 Mpingo Growth Rates

The calculated growth rate of mpingo obtained from both the plantations visited agree fairly well at around 1.8cm per year increase in CBH. Within about 20 years the trees at Nachingwea had reached about 75% of the average tree height of trees encountered in our main survey.[99] However this could easily be their maximum height unless thinned – McCoy-Hill states that mature trees can range from 3 to 7.5m tall.[100] It is also interesting to note that at both trial plantations the average number of stems (2.7) is substantially higher than at Migeregere (1.5). This could simply due to poor stock, or there could be some environmental factor responsible.

The mean volume overbark of the largest stem (based on Estimated Straight Length) of each tree in the Nachingwea plantation, 20.6dm³ is somewhat lower than the average volume for logs at Sameja: 27.13dm³ as calculated from the circumference measurements. However no logs there were longer than 70cm, while the ESLs ranged up to 3m suggesting each tree could provide up to 4 logs. The ratio of average lengths indicates 3 such logs per tree. At 1.8cm per year it would take 42 years to achieve 76cm CBH, the mean circumference of logs at Sameja. Mr Ndauka said that trees with a girth over 4ft are now rare, suggesting that of those trees which do grow that big there are now very few over 70 years old. Mr Suchak's preferred circumference range of 3½ - 5ft corresponds to an age range of 58 to 85 years at this rate of growth. However it must be remembered that these rates of growth are in a plantation where fire is regulated (which is critical at early stages) and competition is only between different individuals of the same species.

[99] See *Characteristics of the Mpingo Population.*

[100] McCoy-Hill, 1993

Discussion: the Expedition's Findings

1 *The status of mpingo at Migeregere*

Although mpingo was not nearly so prevalent at Migeregere than at Mchinga, there was plenty of it about. Moreover the larger tree size meant there was a substantial quantity of harvestable wood available, even if it is brown. Mpingo density, at 850 trees per square km, was much closer to the 3,400 per square km found at Mchinga[101] than the 14 per square km in Mikumi National Park.[102] Contrary to expectations mpingo was not found to be rarer outside the reserve or in riverine plots. One might also expect the frequency of mpingo to decrease with size due to natural death and harvesting, but our results are similar to Hawkins *et al*.[103] in finding that small trees[104] are less common than expected.

In general the mpingo were in good health despite the regular fires. We did not identify the termites whose soil tunnels were on many of the trees we studied. Hence we do not know if they were a species that causes damage to living trees.[105] Some mpingo trees in the area did have clear signs of termite damage. The trial mpingo plantation at Nachingwea was heavily infested with termites. As mpingo heartwood is so hard, it is unlikely that termites prefer mpingo to other species i.e. mpingo is resistant to termite attack.[106] Hawkins *et al.* report that live trees receive damage from, but are not killed by termite damage.[107] However they are more likely to damage mpingo sapwood which will slow the tree's growth rate and so affect harvestable stocks. This would allow pathogens to enter the tree. There was no evidence of widespread disease in the mpingo trees we surveyed as has been reported for *Pterocarpus angolensis*.[108]

There were also plenty of mpingo juvenile, and it would be easy to conclude that it is regenerating well. However the relative rarity of small trees suggests that there could be a problem with seedlings maturing into poles. It is possible, though by no means certain, that the annual burnings could be the cause of this. Equally it could be a chance fluctuation or part of a dynamic cycle. With a single snapshot survey such as we carried out it is impossible to say whether there genuinely is a decrease in the success rate of juvenile mpingo. Only a long term study could answer this particular question.

2 *Mpingo clustering*

Malimbwi *et al.* review a number of examples where mpingo is reported to be growing in clusters[109], and this is commonly stated as fact by loggers and carvers in Tanzania. We found

[101] Ball *et al.,* 1998

[102] Hawkins *et al.* 1996

[103] Hawkins *et al*., 1996

[104] 10-55cm CBH, see Figure 5 in *Characteristics of the Mpingo Population*.

[105] Fungus eating termites (Macrotermitineae) which cause the most damage (Lind & Morrison 1974) were certainly present in the area. They built the huge mounds we occasionally found in our plots.

[106] Moore & Hall, 1987

[107] Hawkins *et al*., 1996

[108] African Regional Workshop 1996

[109] Malimbwi *et al.,* 1998

evidence that could support this, but it is not decisive. However we do disagree with Stockbauer's assertion that mpingo is usually found growing solitary from other mpingo trees.[110]

Mpingo's seed is light and thought to be wind dispersed.[111] If reproduction was mainly via seed juveniles might be more evenly scattered, whereas suckers will inevitably give rise to small clusters of trees from just a single parent. Other factors might explain this distribution pattern. Competition for water during the dry season forces adult trees of all species to be reasonably spaced from their nearest competitors. This distance did not have any effect on tree size on the mpingo we surveyed, suggesting that the effect is uniform, at least within this size bracket.

3 Mpingo's niche

The size of our plots was sufficiently large as to include more than one micro-habitat, as indicated by the vegetation present. In particular we saw that ephemeral water channels support a narrow ribbon of lush vegetation, surrounded by more typical semi-deciduous miombo species. Thus, although we very rarely found young mpingo plants under the heavy shade of closed canopy forest, they were frequently present close to such vegetation. Consequently adult and juvenile mpingo were recorded in river plots at statistically similar densities to those found in fire and normal plots. This observation is particularly useful in explaining the apparently contradictory views in the literature on mpingo's water requirements i.e. these apparent contradictions could partly be explained by scale.

Author	Habitat
Mugasha (1978)	Known to grow on very dry, often rocky sites (quoted in Hansen)
Engler (1895)	Best developed on moister soils with good drainage (quoted in Hansen)
Rodgers (1982)	Soil that is wet compared to typical miombo soil
Nshubemuki (1993)	Often found on dry rocky sites, common near water and will not regenerate under heavy cover
Luoga (1995)	Grows best in dry places with a low water table, none on sites with a high water table (quoted in Hansen)
Oldfield (1996)	Water demanding

Table 26. Varying descriptions of mpingo's water requirements in existing literature.

Tanzania's Forest Division note that these contrasting observations reflect where mpingo is found in Tanzania[112], which indicates its tolerance of poor soil and drought, versus the conditions in which it grows best.

Additionally because mpingo has such a broad distribution, and these water requirements are likely to be relative to the surrounding vegetation in different parts of the range, they may not reflect actual differences.[113]

[110] Stockbauer, 1999

[111] NTSP, 1998; Von Maydell, 1986

[112] Forestry Division of Tanzania, 1984

[113] We have been unable to obtain some of Hansen's references and so do not know the exact words they use and the sites to which they refer.

4 Observations on fire ecology of mpingo and miombo

Unlike most of the post-burning succession sites studied[114], our habitat was thought not to have been recently cleared for shifting cultivation.[115] Burning in the Migeregere area is carried out for other reasons.[116] In many cases there was little difference between the vegetation present in normal plots and fire plots, and that most of the normal plots we surveyed would burn easily, and it was mainly chance which had saved them thus far this year. Indeed much land was burned while we were carrying out our fieldwork.

We found shrubby species had lost more of their leaves and young stems than larger trees do. For example all the young growth of *Combretum molle* was killed by fire, leaving nothing more than a few charred stems. Consequently it was under-recorded in plots surveyed immediately after burning. This species was one of the first to re-grow, producing characteristic bright green leaves with soft hairs.

Like other miombo species, many young mpingo plants are killed by seasonal fires. We observed that sometimes the stems of *mpingo* saplings with a circumference of only about 2cm at the base, are merely scorched and rapidly re-grow leaves. But generally only a few seedlings will escape burning and so have the potential to grow to reach pole size and perhaps survive to reproduce themselves. Adult mpingo trees are probably protected from fire by their shaggy bark which shields the living tissues beneath it.

Bush fires do not occur at random. Since most are started by man[117], they will be more frequent quite close to human habitation. Fires are more frequent in the more open areas because this grassy vegetation burns easier. Repeated burning will produce a patchwork of vegetation, some of which has been burnt each year, some which has escaped burning by chance and other areas which have vegetation which will not burn i.e. termite mounds and vegetation with good access to water.

Because mpingo seedlings will die if they germinate close a their parent, or any other tree of any species[118], successive generations of mpingo will be in slightly different locations to the previous generation. If one mapped the location of mpingo in an area, of say, 1km², over many generations, the result would be a dynamic mosaic of mpingo presence. A dynamic mosaic model of mpingo is reinforced by the partly random nature of fires.

Repeated loss of juvenile foliage weakens trees making them grow more slowly and sometimes consequently losing out in competition with other types of vegetation, or even dying as a direct result of the fires.[119] This means that when the adult trees die they will not be replaced i.e. regeneration is not occurring.

Our seedling subplots did not show any significant variation with plot type, but to judge whether mpingo regeneration is prevented by frequent, e.g. annual fires, one would have to do a long-term study where burning is regulated. Thus we have no evidence to support or refute the hypothesis that mpingo seedlings are adversely affected by the fire regime around Migeregere although we believe this is likely.

We therefore agree with Hawkins *et al*. that the precise role of fire in mpingo's ecology is uncertain and needs to be clarified.[120] In particular there is a need for long-term studies of miombo to investigate the role of fire frequency and intensity on juvenile mpingo and the conditions under

[114] See for example Nye & Greenland, 1960 and Stromgaard, 1986

[115] Or probably at least not since the *Ujamaa* period of collectivisation 1973–78.

[116] See *Local Use and Knowledge of Mpingo*

[117] Moore & Hall, 1987; UNEP, 1988

[118] Mpingo is not tolerant of shade (Oldfield 1996), which is correlated will intensity of competition from trees.

[119] Lind & Morrison, 1974; White, 1983

[120] Hawkins *et al*., 1996

which they can grow vigorously enough to survive above ground. We suspect that miombo is a dynamic mosaic of patches which burn annually and patches that either through structure or chance escape burning for long enough for mpingo to reach a 'safe' size. We observed that fire ironically increases the short-term availability of fuelwood in areas of low population density such as Migeregere by burning through the stems of shrubs and young trees so that they die and their wood dries out.

There are conflicting opinions on the dynamics of vegetation succession in miombo. Jeffers (and Boaler) and White believe that miombo is a product of sporadic burning, replacing dry evergreen forest on moister and deeper soils which has been cleared for cultivation and where rainfall exceeds 1200mm per year.[121] Stromgaard however suggests that such land may develop into Combretaceous savanna rather than being dominated by the characteristic miombo genera.[122] There is a need for long term studies of miombo woodland itself, under different burning regimes, if it is to be sustainably managed.[123]

5 Mpingo Regeneration

Most of the trees we saw in the field had one dominant stem, the others being substantially smaller.[124] The carvers and sawmill owners we spoke to said that trees naturally growing with multiple stems did not attain a harvestable diameter. If this is true mpingo may biologically re-grow after harvesting, but not in a commercially useful sense. Vegetative reproduction is the most likely explanation for clusters of young mpingo we encountered in our surveying.

Seedlings will not survive if they are close to a larger competing tree. Even seedlings growing up in a relatively open area are likely to be killed by drought, competition for other resources or fire. So although it may be survival of the fittest, luck plays a bigger role than any genetic factors. Only a few seedlings will ever grow into mature trees.

Seedlings cannot grow up close to a competing larger tree, as will generally be the case where water is abundant in the dry season. Seedlings growing up in an open area are likely to be killed by drought, competition for other resources or fire. Adult mpingo trees are protected from fire by their shaggy bark. Only the few seedlings which escape burning will grow to reach pole size and perhaps survive to reproduce themselves. Fires do not occur at random. It is likely that they are more frequent quite close to human habitation and vegetation on termite mounds does not burn because there is little combustible grass. Escaping fire is not a random event. Fires are more common in the more open areas. They favour certain species of grass. Indeed fire was used in colonial times to kill trees and so produce a grass-dominated habitat from which tsetse flies were absent.[125] If regeneration from seed is important then it is likely miombo is a dynamic mosaic of micro-habitats.

Vegetatively produced individuals can grow close to another tree. They may develop if the parent tree dies or if a gap is formed by the death or destruction of another nearby tree. Young vegetatively produced plants generally have better developed below-ground growth than seedlings of a comparable age. This helps suckers survive fire. Additionally suckers have access to more stored food, from the parent plant, which help them out-compete other species. This means that a dynamic mosaic model is less appropriate if vegetative reproduction is as important for mpingo as Hansen's results suggest.[126]

121 Jeffers & Boaler (1966); White (1983)

122 Stromgaard, 1986

123 Desanker *et al.*, 1997

124 It is interesting to note that at both trial plantations we visited, at Chinokole and Nachingwea, mpingo trees averaged a significantly greater number of stems than those at our study site (both about 2.7 compared to 1.5).

125 Lind & Morrison, 1974

126 Hansen, 1996

Many authors have commented that certain size categories of mpingo were absent from the area they were studying[127], and fire is frequently blamed for this. An alternative explanation of all these results is that mpingo regeneration is naturally episodic. This is thought to be the case for the related timber species *Pterocarpus angolensis* whose seedlings are stimulated by high rainfall or fire.[128] Thus the apparent lack of small mpingo might only be transient. We feel that this phenomenon, if it occurs in mpingo, does not fully explain the lack of young growth observed over such a wide time interval by so many authors.

6 Local usage of mpingo

It is particularly difficult to estimate the volume used by carvers because they are dispersed throughout much of Tanzania.[129] It has been suggested that as much as 80% of timber is used by carvers.[130] We think that this is a substantial overestimate probably because Tanzanians are more aware of mpingo carving than of its use in Western countries.

The local Makonde carvers we met at Nangurukuru were particularly helpful in telling us some 'tricks of the trade'. They work for dealers who sell their work on to the tourist market in Dar Es Salaam. They tend to use small trees because, unlike sawmills, they have no transport and have to carry their timber out of the bush. This restricts the area from which they can harvest. On a more prosaic level, carvers frequently blacken items made from local very brown timber with shoe polish so that they assume the smooth black finish of top quality mpingo. Whilst in Tanzania we saw items made from other hardwood timber species being sold as mpingo, as has been observed in Kenya and Malawi.[131] Lovett and Puhakka believe that much of the material that carvers use is waste from sawmills.[132] We disagree with this. Even the Ikiwirri Sawmill which itself employs carvers only uses a tiny fraction of the sawmill's waste in this way.

Mpingo is seldom cut for use as charcoal or firewood because it is too hard to cut and burns with too hot a flame for domestic use.[133] It also burns with a smoky flame and characteristic tarry smell[134], probably because of sequestration of secondary metabolites into the heartwood. However mpingo wood can be mixed with material from other species to produce charcoal which burns with a cooler flame. Sawmills sometimes sell or give away mpingo waste[135] as fuelwood which is probably how such usage of mpingo became enshrined in the literature.[136]

7 The habitat

If the habitat is considered as a whole, it does not easily fit into any author's description of a vegetation type. Some authors, such as Rodgers, do not consider mpingo to be a typical miombo

[127] Moore & Hall, 1987; Puhakka, 1991; Hawkins *et al.,* 1996

[128] African Regional Workshop, 1996

[129] Moore & Hall, 1987

[130] Quoted in Platt & Evison 1994

[131] Wambua, 1996

[132] Lovett, 1988; Puhakka, 1991

[133] See *Local Use and Knowledge of Mpingo*

[134] Boulger, 1908

[135] See *Investigatory Tour around Lindi Region*

[136] Although the park rangers at Mikumi NP frequently use some of the abundant dead mpingo as firewood (Norton *pers. comm.*).

species.[137] Instead Rodgers thinks that it is more characteristic of coastal and drier savanna woodlands.

We concluded that coastal forest *sensu* Rodgers is present as a narrow strip along the southern Tanzanian coast. In places this contains little mpingo. Further inland, around Migeregere, the habitat can be broken down into subtypes which fall onto the category 'miombo'. Mpingo grows to maturity in both *Brachystegia spiciformis/Julbernardia* and *B. longifolia* dominated variants of miombo woodland and with other combinations of species.[138] Thus we do not at present find it helpful to subdivide miombo woodland.

8 Why are foresters and conservationists concerned about mpingo?

8.1 Current stock levels are not known

It is not known how much Tanzania's rapidly increasing population, economic liberalisation and improving transport links are affecting mpingo stocks. We recorded abundant mpingo in Kilwa District but appreciate that it only remains in this quantity because much of it is though to be brown and transport links in the area are poor. A complete inventory of the species has never been carried out, even in the three regions of southern Tanzania where most of the harvesting is carried out and most scientific research on the species has been undertaken.

We do need to clarify exactly what '*mpingo* problem' is being discussed. The Maputo conference highlighted the fact that there are a variety of threats to mpingo in different countries. Over-exploitation of stocks theoretically can lead to commercial extinction i.e. the situation where there are no more trees sufficiently large enough to harvest commercially. This appears to be the case in Kenya.[139] Alternatively there may be sufficient large trees but they might not be of appropriate quality, for example, if the timber is too brown. A third scenario is that the survival of the species might be threatened by changes in land management. We shall discuss each of these possibilities and their prevention.

There are sizeable populations of mpingo in Mikumi National Park and the Selous Game Reserve. Timber extraction is forbidden in these areas. This, coupled with mpingo's wide range and ability to re-grow after harvesting, means that even extinction of the species in Tanzania is very unlikely.

It has been reported that loggers are to having to travel up to 200km to find large trees to harvest.[140] This scarcity of top quality mpingo timber has long been noted[141], and as such reflects the typical distribution of mpingo, rather than being a sign of impending commercial extinction or genetic inferiority. The largest trees are usually hollow due to heart rot and frequently are unsuitable for the production of billets. Such decay is an expected part of ageing in trees and although undesirable in the context of mpingo exploitation, does not indicate that the trees' health is threatened by disease.[142] This is often not appreciated by conservationists.

Several partial inventories of mpingo stocks have been conducted but they are now out of date. There are additional factors, as yet unquantified, such as economic accessibility, wood quality and useable diameters, which vary between users and will limit how much of the total standing volume

[137] Rodgers, 1982

[138] This variety of vegetation falling within the category miombo probably explains why Hansen (1996) found conflicting descriptions of miombo soil when he reviewed the literature.

[139] Mbengi, 1996; Hamilton, 199?

[140] Oldfield, 1996

[141] See for example Bryce (1969)

[142] Alexander, 1998

can be harvested.[143] It will be necessary to evaluate the reliability of these calculations by gathering further data prior to the formulation of a management plan. Any such regime must be based on a good estimate of existing stocks and their potential for utilisation now and in the future.

Many people have voiced concern that mpingo is under threat of commercial extinction, perhaps aided by genetic degradation of the species.[144] The view was voiced at the Maputo conference that over-exploitation in Tanzania has led to a situation where trees of suitable size and form for supplying timber are becoming increasingly difficult to find, and no more than 20 years supply remains.[145] According to the Tanzanian forestry authorities (Forest and Beekeeping Division), mpingo was abundant in Tanzania until a few years ago, but recently the resource is believed to be in rapid decline. Some authorities believe that, due to increased harvesting, high quality trees have almost totally disappeared[146], while the forester John Hall stated over ten years ago that mpingo could drop below economic viability in Tanzania in twenty years time.[147] Some manufacturers have allegedly reported a decline in the quality of exported timber.[148]

Such opinions are however contentious. The manager of the largest sawmill in Tanzania believes that "there is no mpingo problem." We attempted to resolve this issue for the district of Nachingwea, where we were told an annual harvest of 300m³ was sustainable and had regularly been extracted in the 1980s. This figure seemed rather high to us for a relatively small district – Nachingwea covers only 6,115km². However before we could utilise our calculated density of 1.03m³ of harvestable wood per hectare we needed to consider various factors:

- How much of the district is forested? Perhaps 60%, but substantial deforestation could easily reduce this to 30%.
- How much of the mpingo is too brown. This is thought to be less of a problem in Nachingwea than elsewhere.
- Fire and heartrot are known to damage many trees.
- Uneconomic to harvest. Some trees might simply be inaccessible or too far from other trees to be worth harvesting.
- Illegal harvesting. Could be only half as much as licensed felling, or could be 1.5 times legal amounts.
- How representative was our study site? We deliberately picked an area where we knew mpingo was plentiful. It could have 3 to 5 times as much mpingo as the region as a whole.

These factors are summarised in Table 27 below.

[143] Moore & Hall, 1987

[144] See for example Moore & Hall (1987), UNEP (1988), Puhakka (1991), Platt & Evison (1994), Sharman (1995) and SoundWood (1999)

[145] FFI, 1996a

[146] Moore & Hall, 1987; Sharman, 1995

[147] UNEP, 1988

[148] UNEP, 1988; SoundWood, 1999

Factor	Lower End	Upper End
Area unforested	40%	70%
Brown mpingo	10%	30%
Fire & heartrot	20%	60%
Uneconomic to harvest	0%	30%
Illegal harvesting	40%	67%
Regional abundance	20%	33%

Table 27. Estimated ranges for the various factors affecting licensed harvestable volumes. Percentages given are the amount excluded from stocks as a result.

The final result of this calculation is that there could be anything from 10 to 190 years worth of stocks left in Nachingwea. Clearly at 10 years of stocks a legal annual harvest of $300m^3$ would not be sustainable, while at 190 years, sustainability looks rather more likely. However even then there are concerns about the fire regime affecting regeneration, and exactly how far population pressure is going to reduce forest cover.

The *Cambridge Mpingo Project* has conducted most of the ecological research that has been undertaken on the tree in its natural habitat and we do not believe we have enough knowledge on which to base an estimate of the magnitude of the problem. We can neither confirm nor refute the view that the species is under imminent threat of commercial extinction.

8.2 There are insufficient funds to manage Tanzania's miombo

Some of the legally harvested logs we saw at sawmills only had faint stamps on them. However, it is still likely that some of the stumps we saw in the field were the result of illegal harvesting. Kilwa District has issued petty licences for volumes as low as $0.1m^3$ of mpingo, but it is likely that carvers frequently use illegally felled material and the tiny volume used by any individual does not encourage forestry officials to intervene.

It is widely accepted that much large-scale logging is conducted illegally.[149] This means that the complexities of the licence scheme and forestry policy are immaterial for a high percentage of timber extracted. There is patchy knowledge of illegal felling. *Tanzanian Mpingo 96* found the stumps of 21 felled mpingo trees in $1km^2$.[150] No licences had been issued for the area and none of this felling was known to local forestry officials. *Tanzanian Mpingo 98* saw about 60 stumps which were probably all illegally felled. One large sawmill that Moore and Hall visited had never previously been visited by a forester due to lack of transport.[151] Loggers are better funded than the forestry officials whose job it is to police them.

Both *Tanzanian Mpingo 96* and *Tanzanian Mpingo 98* saw evidence of harvesting well away from roads and villages. We encountered a cluster of large mpingo stumps on public land 10km beyond the village of Mbate. Presumably the loggers had assistance from villagers to locate these trees. Because they are better financed, loggers are more knowledgeable about mpingo stocks than most forestry officials. Some foresters are even dependent on loggers to provide them with transport to reach parts of their district. Illegal harvesting is unlikely to disappear so long as there are mpingo trees sufficiently large enough to be sold and the price for top quality timber remains as high as it is.

When we established the *Cambridge Mpingo Project* we did not understand the realities of forestry in Tanzania today. A major focus of our expedition was looking for differences between the habitat inside and outside Mitarure Forest Reserve (FR). We rapidly realised that there was little difference, and those differences that existed are likely to be related to the remoteness of parts of the reserve

[149] Moore & Hall, 1987; Platt & Evison, 1994; Beale, 1995; Sharman, 1995

[150] Ball *et al.*, 1998

[151] Moore & Hall, 1987

and pre-existing differences in the vegetation e.g. due to altitude. There was no visible demarcation of the Reserve's boundary and many local people were unaware of the reserve's existence. Consequently land use activities such as burning are carried out without regard for forest reserve status. We found little difference between forest reserve and non-forest reserve land in respect of area burnt and forest composition.

There are two complex management structures who are jointly responsible for Forest Reserves in Tanzania. In this context it is difficult to formulate and implement forest management policies which are consistent throughout Tanzania.[152] It is evident to us that the level of protection afforded by Forest Reserve status is very low, partly because of insufficient resources.

8.3 Southern Tanzania's miombo is threatened by population pressure

Although clearing land for agriculture is a major environmental problem in Sub-Saharan Africa, substantial areas of miombo in southern Tanzania remain intact. This is largely attributable to low population pressure. However close to towns such as Nangurukuru there is a zone of tree clearing for fuelwood[153] and often also for agriculture.[154]

Improving transport links between the Lindi Region and the rest of Tanzania are having a detrimental effect on mpingo stocks. In recent years the Tanzanian government has made substantial changes to open up the country to private companies.[155] This has increased the incentives for individuals to enter the logging trade. However it is not that easy to trade profitably because of licence fees and the strict demands of instrument manufacturers. Platt & Evison state that there were six sawmills in operation when they undertook their investigation.[156] When we toured the Lindi district, Dubai African Blackwood had recently closed, Mingoyo was shortly reopening after changing ownership and Kilwa Sawmill could not find a market for the timber it harvested in 1994.

These changes to infrastructure and economic conditions have knock-on effects on the environment. Beale discusses at length how the old 'commons' system of resource management and usage by local people is being opened up to outsiders.[157] These loggers can log out an area and then move on to the next district. Local people who manage and use miombo on a day-to-day basis themselves have little use for the mpingo they contain and have no ownership rights over the trees.

Every form of land ownership has its disadvantages. For example, Forest Reserve status disenfranchises local people who know what resources they contain and that these resources are apparently being wasted.[158] This encourages villagers to exploit such resources in breach of the law.[159]

8.4 Current burning practices are detrimental to trees

We suspect that a significant proportion of the miombo woodland we surveyed is burnt each year. Under such a harsh burning regime, and particularly if burning is towards the end of the dry season, grass becomes a more important component of the vegetation as tree seedlings are killed each year.

---

[152] Beale, 1995

[153] We learned that fuelwood usage is dependent on population density and prosperity. Nangurukuru uses predominantly charcoal, Kilwa relies on both charcoal and wood (including illegal use of mangrove) and Migeregere almost exclusively uses wood.

[154] Coming out of Liwale on the Liwale-Nangurukuru road large areas of abandoned cashew plantation are being reclaimed. We saw that various species, including mpingo, had been ring barked in order to kill them to stop them competing with the cashew trees.

[155] Instituto del Tercer Mundo, 1997

[156] Platt & Evison, 1994

[157] Beale, 1995

[158] Beale, 1995

[159] It also incidentally gives rural people a bad impression of 'conservation'.

Eventually this will remove trees from the vegetation to leave a grass-dominated habitat with a few fire-resistant shrubs.[160] This effect will not be evident to those who start fires.[161]

Apart from natural fires caused by lightning strikes, people will start fires for a number of reasons:

- Clearing land for cultivation
- Hunting
- Scaring off dangerous animals
- To create fire breaks
- For fun

Professor Malimbwi of Sokoine University has stated that adult mpingo trees 'do not appear to be fire resistant'.[162] However this is in comparison with other miombo trees, not with the species familiar to Western conservationists. We saw evidence that adult mpingo trees can survive damage from bush fires and continue to grow. However no-one knows how fire affects mpingo relative to its competitors and this must be a priority area for future research.[163]

Moore and Hall found that there is virtually no regeneration of the species occurring in either natural stands or in areas where trees are being harvested.[164] In the Migeregere area we found plentiful evidence of mpingo regeneration and during our trips to other sites in the Lindi region we saw juvenile mpingo. We found no gaps in the size range of mpingo, in sharp contrast to work done in Mikumi National Park.[165] However we do not know what the long term effects of continuing the present late burning regime are, and so believe that lack of mpingo regeneration is probably a localised problem. Malimbwi *et al.* believe that fire control is an important component of mpingo conservation.[166]

9 *The prospect of plantations*

The main reason that mpingo has been neglected as a commercial plantation tree is the general assumption that the rotation age for this species is as long as 200 years.[167] However several authors have recently questioned this figure and believe that the species can be 'readily grown' in plantations.[168] Some of this variation in rotation time i.e. time taken for the tree to reach maturity, may partly be because the largest trees are not necessarily the best and the harvested size varies between districts and sawmills.[169]

---

160 Lind & Morrison, 1974; Moore & Hall, 1987; Desanker *et al*., 1997

161 Ironically, burning increases the amount of readily available fuelwood by burning through the trunk of young trees.

162 Malimbwi *et al.,* 1998

163 It is worth noting that most of the trees now being harvested will have germinated in very different conditions (at least in terms of human influence) in the first quarter of this century.

164 Moore & Hall, 1987

165 Hawkins *et al*., 1996

166 Malimbwi *et al.,* 1998

167 Nshubemuki, 1993

168 Moore & Hall, 1987

169 Puhakka, 1991; Malimbwi *et al.,* 1998

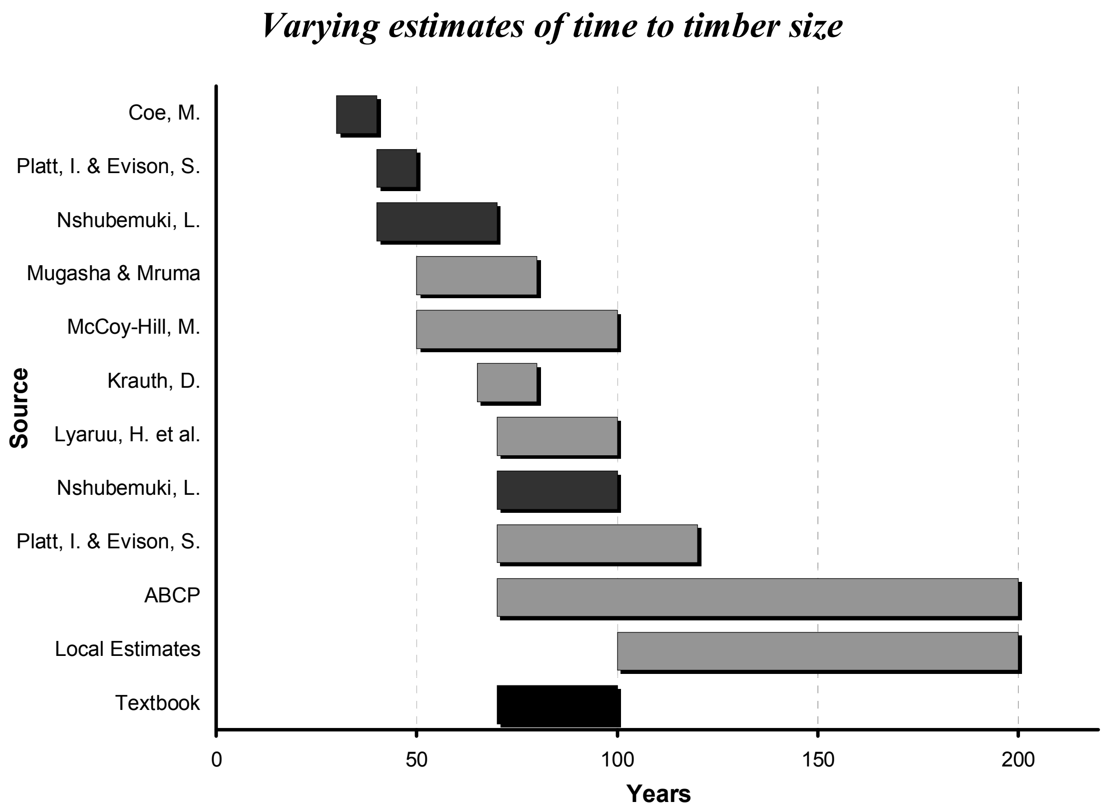


Figure 17. Different estimates of time to harvest for mpingo. Darker shaded bars indicate estimates for plantations. The bottom bar shows the standard textbook figure for age of harvestable hard wood timber trees (of any species) in East Africa. We suspect this is the origin of the much quoted range of 70-100 years.[170]

It is likely that mpingo grows best in richer, moister soil than that where it is usually found growing in the wild.[171] In such conditions it would have a shorter rotation time than it has in the wild. It is particularly interesting to note that the textbook estimate for the rotation time of tropical timbers is 70-100 years. This suggests that the opinion previous given by foresters as to the rotation time for mpingo might merely be a general figure, rather than one based on detailed study of the species.

Trial plantations have been established at several sites in Tanzania[172] which suggest that under favourable conditions mpingo trees can grow quickly enough to potentially justify investment in them.[173]

The profitability of a plantation depends on the tree's growth rate (and thus rate of increase in value) relative to interest rates. In a developing country such as Tanzania, interest rates are generally high. The Tanzanian government has managed to bring inflation under control in the last few years, but there is still much uncertainty as to Tanzania's prospects for economic growth in the future. The musical instrument industry would demand economic stability if it were to invest in plantations to safeguard its supplies.

---

[170] Sources of data are: Malcolm Coe (*pers. comm.* 1998): 30-40 years, Platt & Evison (1994): 40-50y in plantations, Nshubemuki (1994): 40-70y, McCoy-Hill (1993): 50y+, Mugasha & Mruma (1983): 50-60y on good sites & 50-80y on bad sites, Krauth (1996): 70y, Nshubemuki (1993): 70-100y, Hawkins *et al.* (1996): 70-100y, Platt & Evison (1994): 70-120y in natural forest, ABCP (1999): 70-200y, Nshubemuki (1994) quotes foresters saying up to 200 years.

[171] Forest Division, 1984

[172] Nshubemuki, 1994; Mugasha & Mruma, 1983

[173] Sebastian Chuwa has established a mpingo nursery at Moshi under the auspices of the African Blackwood Conservation Project. This aims to raise mpingo seedlings until they are large enough to withstand fire and seasonal drought (ABCP 1999).

The trial plantations at Chinokole and Nachingwea offer us clues as to how quickly mpingo can grow in favourable conditions. Extrapolation suggests that the tree would not attain harvestable size until at least 42 years, and 58 – 85 years would be required for larger logs. These estimates might even be too short, if, for example the growth rate slows as the tree gets larger, or too long, because the plantation had not been thinned. On the other hand, better stock and care might reduce this growing time.

Foresters do know more about the silviculture of setting up plantations because there have been several well designed trials. Mugasha gives details of one successful field trial where the original vegetation was very similar to the area we surveyed.[174] In such trials vegetative propagation was found more successful than growing from seed. Additionally it ensures that the plants are from good stock i.e. the parent tree has strong, upright, straight growth. Ideally stock for the next generation would come from the best timber trees of the present generation.

Some conservationists are concerned that because the best trees are used, only the genetically inferior survive to reproduce. Although this is a valid concern, a number of details suggests that the effect is likely to be small:

- Mpingo begins flowering long before it is big enough to harvest.
- Other than straightness, there is no effective way to assess the quality of a particular tree without cutting it down. Thus genetically inferior specimens suffer the same fate as better specimens.[175]
- Harvesting might actually encourage the rootstock to send out suckers, as root damage does. This potentially could produce a large number of trees, all with the same genes for producing quality timber.

Not enough is known about the genetics of plant species such as this, which are capable of both vegetative and sexual reproduction, to assess their potential implications on mpingo timber supply. Additionally, any potential problem of lowering the quality of mpingo stocks is long-term. We believe that there are more immediate threats to Tanzania's mpingo.

However we were told by several different people that mpingo trees growing quickly, or near water (which may amount to the same thing), produce paler i.e. undesirable heartwood. This could be a major problem in plantations. To our knowledge no-one has researched this. Similarly the high number of stems per tree evident at the Nachingwea and Chinokole plantations requires investigation.

In conclusion, the establishment of mpingo plantations is economically risky, and is not guaranteed to reduce the levels of harvesting wild trees.

[174] Mugasha, 1983

[175] Some areas are renowned for their good or poor quality stock. However, within a patch, there is no reliable technique for selecting top quality heartwood. Characteristics such as twisting are readily visible, but in our experience, localised in occurrence.

Conservation: the Way Forward

1 *Sustainable management*

At the Maputo conference in 1995, the possible inclusion of mpingo in CITES was discussed, but the consensus opinion was that the species is not threatened over a sufficient proportion of its range to warrant this. Many aspects of mpingo trade, such as tourists exporting carvings and local use of mpingo, would be excluded from CITES. Furthermore, CITES listing would not protect mpingo from adverse burning regimes or agricultural expansion.

Mpingo is however ideally suited to be conserved through sustainable exploitation, rather than be preserved, by preventing it from being used. Mpingo's cultural significance, as Tanzania's national tree and its importance to musicians make it an interesting species for conservation intervention.[176] The challenge to conservationists and foresters therefore is to design a management scheme to achieve this aim. To do this we must understand both the local and international markets for mpingo. It has the potential to become a flagship species for Tanzania by providing an income which allows the whole miombo ecosystem to be conserved through traditional management practices.

Successful management practices are dependent on much more than simply understanding a species' ecology. We must understand the processes which drive its utilisation.

The sociological part of the expedition gathered information on local attitudes towards mpingo and its habitat. It is essential to understand how rural people use and manage public land. Ideally local people will play an important role in managing woodland resources. The ideal management plan for mpingo would safeguard local livelihoods by allowing long-term exploitation of mpingo in a sustainable way. 'If wildlife does not pay its way, it will simply be replaced by something that does'.[177] Sustainable use of woodland resources has an 'opportunity cost'[178] to Tanzania, by forsaking short-term financial gains, in favour of long-term benefits.

Communities such as Migeregere are dependent on the surrounding public land to supply them with fuelwood, building materials, medicines and food. Additionally, groups such as carpenters and bamboo furniture makers use raw materials from woodland to earn a living. Mpingo is not *per se* a valuable resource for them. Because of its hardness, local people use mpingo for only a few specialised purposes. Other species are far more valuable to them. Currently Migeregere villagers only gain financially from the presence of mpingo when they act as guides and loggers for sawmills. This situation must be changed if mpingo is to be sustainably managed. Once such a plan is in operation, revenues from trade in woodland products should be sufficient to maintain it.[179]

In carrying out our fieldwork and writing this report we have become aware of how incomplete our knowledge of mpingo's situation is. We do not fully know the extent of stocks, harvesting and inefficient use of mpingo. Without being able to quantify these accurately we cannot tell whether or not the current rate of harvesting is sustainable. Our expedition addressed the question of current stocks and habitat requirements in the $150km^2$ of land we surveyed. Extrapolating this over the whole of the Lindi Region though is fraught with difficulties; but it seems likely that if current and predicted trends in logging and deforestation continue, then at some time in the future stocks will run out.

[176] Moore & Hall, 1987

[177] De Alessi, 1999

[178] Barbier *et al*., 1994

[179] UNEP, 1988

Mpingo's case is not thought to be as desperate as that of other valuable tropical species.[180] For example we heard no evidence of mpingo roots being dug up for carving as has previously been reported in Tanzania and Kenya.[181] This means that there is time to adopt management strategies before the situation becomes critical.

There is a global trend away from woodland management by distant authorities towards community management of woodland resources by local people.[182] Tanzania is a signatory of the Rio Treaty which gives local people a say in managing their environment. Sustainable woodland management does not necessarily conserve the relative composition of species within it.[183] Care will have to be taken, for example through enrichment planting[184], to ensure that mpingo continues to be produced in sufficient quantities. Community woodlands and mpingo cultivation are not incompatible.

Even when the forest is cleared, isolated mpingo trees could be left standing in *shamba*s. Their roots are sufficiently deep, so competition with herbaceous crops is minimal. The tree will over several decades attain harvestable size. Ideally the farmer could then sell it and retain the licence fee.

It is easy to be misled into believing that mpingo is an ideal candidate for community management. However there are a number of practical problems. First, successful community management projects usually involve species which provide economic returns over a short time scale e.g. the *tungya* scheme for teak management in Myanmar.[185] Poor people can only be expected to conserve mpingo if there is something in it, financially or otherwise, for themselves.[186] For example the promise of a substantial monetary sum for their grandchildren's generation, i.e. the rotation time for mpingo, is unlikely to stop their generation late burning. So revenue from mpingo harvesting must be supplemented by other shorter term sources of income.

That said, there are encouraging signs of success with other forest types. A scheme first piloted in Singida Region, and now being trialled on a larger scale in Kilimanjaro Region, allows the village council to keep part of the licence fee from timber extraction. This money can be put back into the local community, e.g. to improve health and education facilities.

If public land is to be managed by local people they will have to face some tough choices. To leave harvestable mpingo growing for another decade, the opportunity cost is the revenue forgone. This might be sufficient to build a clinic for example. Alternatively, if many communities decided to let loggers in, the quantity of mpingo timber on the world market would increase and its unit value decrease. Once a management plan for sustainable exploitation is in operation, the revenue produced should be sufficient to maintain it. However the initial start-up funds would have to be supplemented by aid organisations and Western musicians.[187]

An alternative mooted by Beale is that long-term logging concessions are given to companies to encourage sustainable management practices.[188] Similar schemes in South America though have not led to efficient resource usage because high interest rates mean that the logging contract is virtually worthless and regulation is virtually impossible.

---

[180] UNEP, 1988

[181] Moore & Hall, 1987 and Hamilton, 1996

[182] Stockbauer, 1999

[183] Newton, 1997

[184] Enrichment planting is the supplementation of a natural population by externally raised material. The aim is to produce more of a particular valuable species whist retaining the integrity of the ecosystem.

[185] McCoy-Hill, 1993

[186] Platt & Evison, 1994

[187] UNEP, 1988

[188] Beale, 1995

2 Improving the efficiency of mpingo use

In the more immediate future there is a need to reduce the extent of illegal harvesting. The Tanzanian government does not have the resources to police the current licensing system.[189] Conservationists cannot remedy this situation. What we can do is reduce the financial incentives for illegal harvesting by helping people who earn their living from mpingo to make more efficient use of the tree.

Many authors have noted how inefficient current usage of mpingo is. Moore and Hall for example conclude that, 'there is little co-ordination or integration between carvers and sawmills which leaves significant volumes that could be economically utilised by the other.'[190] Ideally carvers and other users of small volumes of timber would not harvest trees themselves. Instead they could use rejected logs from sawmills i.e. wood which are unlikely to yield an export quality billet. Ikiwirri Sawmill already has a similar small scheme in operation. If carvers did not have to pay, or paid only a nominal amount for such material then they would be unlikely to fell trees themselves. This could dramatically increase sawmills' recovery rates.

The introduction of common-sense sawmill practices could dramatically improve some sawmills' efficiency. These include not storing logs in the sun and sealing the ends of logs with wax, both of which discourage splitting. Hall discusses sawmilling in some detail and gives suggestions as to how this process could be improved.[191] He noted that sawmills themselves would welcome investment in better machinery.

Moore and Hall concluded that current milling techniques do not treat mpingo as though it is a valuable resource.[192] We believe that this is true, partly because through illegal logging mpingo is not as valuable as it should be.[193] If necessity is the mother of invention, and if mpingo stocks decline, then sawmills will have to use mpingo timber more efficiently if they are to trade profitably. We need to work with sawmills, not against them. Frequently sawmills know more about mpingo than foresters do.

3 What can be done

We feel that there is an urgent need to reinstate an education programme which warns rural people of the dangers of late burning. Malimbwi *et al*. concluded that there is 'no immediate danger to classify mpingo as an endangered species providing fire control is enhanced as an important conservation measure.'[194] Previously the Tanzanian government financially supported early burning. Currently it produces posters to emphasise the damage that burning can do to trees. If an incentive scheme of some sort could be reintroduced, any problems with tree regeneration would be greatly ameliorated.

As yet, foresters do not know the ideal burning regime for this habitat. Foresters and conservationists have identified mpingo as a priority for further research.[195] It is possible that as

[189] Moore & Hall, 1987; Puhakka, 1991; Platt & Evison, 1994; Beale, 1995

[190] Moore & Hall, 1987

[191] Hall, 1988

[192] Moore & Hall, 1987

[193] One group of carvers we met have a sizeable mpingo offcut continuously smouldering for use as a cigarette lighter.

[194] Malimbwi *et al*., 1998

[195] Mugasha, 1983; Oldfield, 1996; FAO database, 199?

little as 2 years of fire protection may allow juvenile mpingo plants[196] to grow strong enough to survive fire.[197]

An education programme would be particularly important if some form of local management was implemented. If farmers could grow mpingo in their fields, perhaps as an animal-proof boundary (as mpingo is reportedly used by Maasai farmers), and gain financially when the trees are harvested , this would be a great incentive for mpingo conservation. In a pioneering project Sebastian Chuwa set up 31 youth clubs in northern Tanzania. Here he teaches children about conservation and encourage them to set up a tree nursery to raise native species.[198] We ourselves piloted an education project for schoolchildren to emphasise how important miombo trees are to them.

Working with the supply side of the mpingo trade will never on its own solve the 'mpingo problem'. It was remarked at Maputo that 'the fact that there are multiple problems for this species suggests that multiple solutions are needed'.[199] Mpingo users also need to adopt practices which conserve the tree.

Many Western musicians would be prepared to pay a premium, or 'conservation tax' for instrument made from sustainably produced mpingo.[200] This is one of the ideas behind the *SoundWood* project. *SoundWood* supports instrument manufacturers who want to use timber from sustainably managed sites. Additionally, tourists might be easily persuaded to pay a little extra for carvings as a 'conservation tax' to support conservation[201], but there would be considerable difficulty in enforcing this outside the big carving co-operatives.

4 The need for an inventory

While in Tanzania we spoke to many foresters and sawmill owners who had conflicting views on the mpingo situation. In particular, we do not know whether the current rate of harvesting is sustainable. Our calculations show that there are so many unknown factors which effect useable stocks that the only way to assess harvestable timber would be to conduct a large-scale inventory.[202] Such an inventory would be a major undertaking given the size and remoteness of mpingo stocks.[203]

The Miombo Network of researchers interested in this habitat have proposed using data from satellites which has been collected under other initiatives.[204] This might be a cost-effective way to obtain such data, but its interpretation is likely to be difficult. There will still be a need for 'ground truthing' expeditions to survey vegetation and mpingo stocks to be able to analyse this data. In particular, we have seen how heterogeneous miombo woodland is and do not fully understand the species affinities of mpingo. Furthermore, this is unlikely to tell us whether or not the mpingo is good quality timber. Despite these caveats, we think this line of research could prove useful and should be followed as a matter of priority.

---

[196] This might also protect other trees such as *Pterocarpus angolensis*, whose hardwood timber is extracted in much larger volumes than mpingo is. *Pterocarpus angolensis* is probably incapable of vegetative spread (WCMC 1998), hence its regeneration niche might be narrower than mpingo's.

[197] Platt & Evison, 1994

[198] ABCP, 1999

[199] FFI, 1996b

[200] Beale, 1995; Ball *et al.*, 1998

[201] Ball *et al.*, 1998

[202] Moore & Hall came also came to this conclusion in 1987.

[203] The Lindi region, where the majority of harvesting occurs, covers an area of 66,000km², which is equivalent to 27% of the whole area of the UK. Remaining mpingo stocks have survived partly because of their remoteness (Puhakka 1991, Moore & Hall 1987).

[204] Desanker *et al.,* 1997

5 Improved communication links threaten the whole ecosystem

As noted above, current levels of exploitation may not be quite as threatening to the tree's future as previously suspected. However the big proviso in this statement is the qualifier 'current'. Desanker *et al*. predict that rapidly growing population and improvements to infrastructure will lead to massive changes in land use and vegetation cover throughout the miombo region in the coming decades.[205] Southern Tanzania by virtue of its remoteness and poor infrastructure currently has a low population density which protects mpingo.[206] This is however likely to change in the near future.

The government of Tanzania is, at the time of writing, building a bridge across the river Rufiji. At present access to the south-eastern part of Tanzania is controlled by the Rufiji ferry. This restricts traffic during the dry season, and is inoperable during the wet, when the roads are also impassable. Once the bridge is built (target completion date sometime in 2001) the government plans to upgrade the whole road from Dar Es Salaam to Mtwara, thus solving the region's isolation. Moreover harbours at Lindi and Mtwara have also recently been dredged, increasing their ability to operate as realistic points of export.[207]

This will have two major effects on mpingo stocks. Firstly, it will become much easier to harvest them and transport the finished product back to the capital. Accessible parts of Morogoro, Iringa and other regions have already been mostly harvested out as a result of this effect – transportation problems are cited as a major factor limiting sawmill output.[208] Under-resourced foresters would find it impossible to regulate harvesting on this scale.

Secondly, immigration from the relatively crowded north to the less populated south will cause a large rise in the rate of land clearance. This is perhaps why the Tanzanian government predicts a massive population explosion in the region.[209] We cannot tell how much forest will remain in 10-20 years time.

Hence we can shortly expect a major increase the two most significant threats to mpingo stocks. It is very difficult to predict how big this increase may be, but it cannot be ignored in any long term planning for the future of the species. It also gives urgency to any measures which could be taken towards the conservation of mpingo.

6 Conclusions

The future of Tanzania's mpingo is uncertain. It is threatened by many social and environmental factors in its native habitat. These problems cannot be easily solved, even with substantial funding. However, without careful management this valuable resource may be lost, and instrument manufacturers may be forced to look elsewhere for their timber.

The problem for everyone is to strike the right balance between resource usage and conservation. If mpingo can be sustainably managed then it could be a key factor in the development of rural southern Tanzania. To achieve this aim, we must act now to assess the current situation and the best way forward. We have 5 key recommendations:

- An inventory of Tanzania's mpingo stocks is urgently needed.
- Sawmills and carvers need to make more efficient usage of harvested trees by integrating their activities.

---

[205] Desanker *et al.,* 1997

[206] Moore & Hall, 1987; Platt & Evison, 1994

[207] At present most exports go through Dar Es Salaam.

[208] Moore & Hall, 1987

[209] In 1996 the Ministry of Health predicted a 258% increase in the population of the Lindi Region over 5 years.

- Steps need to be taken immediately to encourage early burning of miombo woodland.
- The use of miombo by villagers should be considered in decision-making.
- Forests in Lindi region should be protected from illegal logging and woodland clearance which will result from improved road links with Dar Es Salaam.

Mpingo is not yet an urgent case. Our aim should be conservation rather than preservation, but we need to act now before that is no longer possible.

Part II : The Realisation

Plant Taxonomy

Little research has been undertaken on the taxonomy of *miombo* plants since colonial times and most comprehensive floras (taxonomy books) date from this period. However for some plant groups such as the Fabaceae (pea family), classification from the family to species level has been revised since then. This generates difficulties when attempting to use books together.

As a consequence of the three factors outlined above, plant taxonomy was difficult and time-consuming. None of us had experience of either compiling formal descriptions of plants or creating a field herbarium. This task could have been done more effectively if it was the sole job assigned to particular people. As it was, we all had other demands on our time.

Our game guards, Said and Isa, had detailed knowledge of the area's flora and aided us by supplying names in local languages. On our return to Britain these were looked up in lists of vernacular names (Bayard Hora & Greenway 1940, Burtt 1953) and compared with our descriptions of the specimens in the field. One problem with this system is that there are so many languages spoken in Tanzania it would be virtually impossible to produce a complete list of vernacular names. The same name may be used for different plants in different parts of the country. For example *mpilipili* is Swahili for *Schinus molle*, a tree introduced from Peru. However our specimens of *mpilipili* were certainly not this well-known species. Folk classification makes different distinctions to scientific classification.

Said and Isa were mystified as to why we spent so much time debating the identity of *Combretum* trees, since all 70 species in the genus are locally known as *kingonogo* because individual species do not have specific uses.

We had to identify dozens of trees using just their bare, sometimes burnt, branches. For diverse genera, such as the *Combretum*s with 70 species recorded in Tanzania alone, this was virtually impossible without fertile (flowering) material. The District Forestry Officer loaned us a small field key to the difficult genera (Burtt 1953). We found, albeit rather late in the expedition, that this was very useful for the genera e.g. *Combretum*, it includes. Our knowledge of difficult groups such as this developed through the course of the expedition. Some, such as *C. ternifolium*, have distinctive vegetative characteristics but others are virtually impossible to identify without flowering material.

Introduced trees such as *Delonix regia*, *Azadiracta indica* tend not to be grown outside of the district centre, Kilwa. In the bush there are only native species. Thus when one of our books translated *mkuliungu* as *Terminalia catappa*, we were sceptical. The closest specimen of this species that we knew of was in the yard of Kilwa sawmill. We later discovered that *mkuliungu* refers to all *Terminalia*, not just this highly distinctive exotic species.

Our *modus operandi* meant that Isa and Said did not work together after the first few days of fieldwork. This meant that we spent many hours scratching our heads trying to distinguish between *mtondo*, an abundant compound leaved tree, and *mchenga*, another equally abundant compound leaved tree. We eventually deduced that they were in fact the same species, Isa's group calling the tree *mtondo* (the Swahili name) whereas Said's group named it *mchenga* (its Mwera name). Neither knew the other's name for the tree. This is not to mock Said and Isas' contribution, such linguistic eccentricities are abundant in British plant nomenclature. Rather, it highlights the importance of working as a team and using the diversity of expertise within the team to accomplish more than any one person could achieve alone.

We would advise anyone carrying out similar work to start creating field herbaria at the earliest possible opportunity, including full descriptions of the specimens and adequate plant material. Allow yourselves plenty of time in camp to discuss specimens together and use reference books. Finally, double-check your material and produce a complete species list at the earliest opportunity on your return.

Logistics

1 Dates of the Expedition

30th June	British Advance Party arrives in Dar Es Salaam
7th July	British Main Party arrives in Dar Es Salaam
10th July	Main Party take bus to Kilwa
12th July	Rest drive down to Kilwa in Landrover
15th July	Establish camp at Migeregere
23rd July – 4th Aug.	Liaison trip to Dar Es Salaam, Morogoro & Mikumi
2nd Sept.	Strike camp at Migeregere, return to Kilwa
3rd Sept.	Main Party returns by bus to Dar Es Salaam & disperses
4th – 15th Sept.	Journey around Lindi region
29th Sept.	British Members return to UK

1.1 British Advance Party

Steve Ball & Toby Radcliffe

1.2 Liaison Trip

Steve Ball

1.3 Group travelling around Lindi region

Steve Ball, Anne-Marie Gregory, Jonas Timothy, William Kindeketa, Paskal Ngonyani

2 Exchange Rates

Costs below are given in Tanzanian Shillings. During our time there the exchange rate was approximately:

GBP £1 = TSh 1080/- or USD $1 = TSh 660/-

However the rate was appreciably worse in Kilwa where we only got about TSh 580/- to the US Dollar. The old National Bank of Commerce there has been replaced by a branch of the National Microfinance Bank (an entity spawned by the partial break up of the NBC). This new bank is not generally in the business of providing foreign exchange hence the poor rate.

Inflation is a big problem, especially in Dar Es Salaam, and it is likely that even costs in hard currency will increase substantially in the next few years. We found that prices, for accommodation particularly, had gone up significantly since the 1996 expedition.

3 Transport

3.1 Travel to and from Tanzania

Four of the British members flew to Dar Es Salaam from London Heathrow by *Gulf Air*. The fifth British member flew with *Emirates* on a discounted ticket obtained through the British Airways Assisting Conservation scheme.

3.2 Public Transport within Tanzania

The long distance buses in Tanzania are far from safe but there is little alternative when travelling between major towns. The prices going out from Dar were generally more expensive than when returning to Dar. It was also bizarrely possible to do some routes cheaper by splitting the journey into two rather than completing it in one go, even though one was using the same service.

The buses which go direct from Dar to Kilwa leave from the outskirts of Dar. So to avoid the considerable inconvenience of transporting us and all our out there we took the buses which leave from the central Morogoro Road bus station bound for further south (Nachingwea, Masasi, Newala or Mtwara) and got off at Nangurukuru. These buses took around 9 hours to get to Nangurukuru and cost about TSh 9,000/- (we were generally successful in refusing to pay the excess baggage charge for backpacks). Pick-ups regularly ply the route from Nangurukuru to Kilwa from early in the morning to dusk, and cost TSh 500/-. To do the reverse journey one was faced with the choice of taking the 6 a.m. bus from the market in Kilwa, or the buses leaving Nangurukuru around 8 p.m. which had come from further south (there would always be space on at least one). The early morning service from Kilwa went through direct to Dar Es Salaam, whereas the buses coming from the south had to wait overnight at the ferry across the Rufiji – which does not make for a very restful night. However until the last couple weeks of the expedition, the early morning departure was only serviced by a couple of old *Toyota DCMs* which are not very comfortable or reliable. These are being replaced by bigger, safer buses making it a more attractive option. Prices were approximately for TSh 5,000/- for the 15 hour trip.

Within Dar Es Salaam the local mini-buses, called *Daladalas*, were used as often as possible. They are reasonably frequent and for only TSh 100/- or 150/- per ride they are cheap. Going to and from the airport, at night, and occasionally when speed or security was of the essence we took taxis. A taxi around town generally cost TSh 2,000/- whereas one to the airport was about TSh 5,000/-. However people arriving at the airport should be aware that it is hard to avoid the government approved price fixers who demand TSh 10,000/- for a taxi into town.

3.3 The Expedition Landrover

Hiring a Landrover was the task that caused the advance party most difficulty, and it was not until after the rest of the expedition had assembled and departed on the bus for Kilwa that arrangements were finally completed. The vehicle which we had hoped to use needed repairs that took longer than feasible. So instead, with the assistance of Abdallah Juma, a local contact, we located an alternative: a tired and battered Landrover which, after heavy bargaining, we agreed to hire for TSh 6,000/- (£5.55) per day. It was far from the quickest vehicle on the roads – it had a maximum speed of about 60kph – but it was fine for our purpose, and, when compared with rates of $60+ per day from the top garages in Dar, it was excellent value for money.

We also hired the services of the Landrover's regular driver, Paskal Ngonyani, also an excellent mechanic, for the duration of the expedition. Initially he was assisted by Daniel Seif, but after a few weeks Ngonyani took on those duties as his sole responsibility, which he discharged admirably.

We experienced a number of mechanical difficulties with the vehicle over the course of the expedition, but thankfully all were within Ngonyani's ability to fix. The most serious incidents were the four occasions when one of the wheels fell off due to old, stressed bolts being used. On other occasions we had steering problems, a persistent oil leak, and starter motor malfunctions. The age of the vehicle demanded a high level of general maintenance, but until the tour around Lindi region at the end, the vehicle was not used so intensively that this could not easily be provided. Given the state of the roads we were lucky not to be faced with a leaky radiator until the final section of the return to Dar, and we were able to limp close enough in to get taxi for the very last bit.

Fuel is not cheap in southern Tanzania where there is a large mark-up over prices in Dar (TSh 550/- and upwards per litre compared with TSh 400/- in Dar). We were therefore very grateful to receive sponsorship in kind from BP Tanzania. This took the form of an arrangement to obtain free petrol from the filling station in Kilwa over the latter two thirds of the expedition.

3.4 Road Quality

Approximately half of the road between Dar Es Salaam and the Rufiji is sealed, but south of there most of the of the roads are unsurfaced. When we first drove down the road had not been long open after the end of the wet season – one of the wettest for many years. Massive floods at the beginning of the year had wrecked particular havoc either side of the Rufiji river, completely washing away long stretches of the old road. Commendably, by the time of our return, most of the damage had been repaired and a flat road raised a couple of metres above the flood plain once again stretched from the ferry crossing to the town (and the start of a stretch of tarmac) north of the river. Presumably when the bridge is completed a more permanent road will be put in place either side of the river, in the meantime people arriving at the river after 6 p.m. must wait until 8 a.m. the next day to take the ferry.

The Kilwa to Nangurukuru road is good, but the 15km from there to Migeregere was perhaps the worst stretch of road along which we had to travel. Two bridges had been destroyed in the floods earlier in the year and the rest of the way was badly broken up. A hardy vehicle was essential and even once we knew every inch of the way it would still take us 45 minutes to drive it. Of the other roads around Lindi region those between Kilwa and Lindi, and Migeregere and Liwale were the worst – both were frequently rutted and we struggled to average over 25kmph along them. Most of the road from Lindi to Mtwara was actually surfaced and the bridges were being repaired at the time thanks to Japanese funding. All the roads become impassable during the wet season effectively cutting off the whole area for 6 months of the year.

4 Accommodation

4.1 Dar Es Salaam

The team stayed at the *Safari Inn*, on Band Street just off Libya Street, for virtually the whole time we were in Dar. It is one of the best hotels for security at a reasonable price in the city centre. For a twin room fitted with a fan and hot shower the normal price is TSh 9,600/- per night, but we negotiated a small discount to 9,000/- a night. The price includes a basic breakfast, and the place is always clean.

4.2 Kilwa

Whenever we had to spend a night in Kilwa we stayed at one of the two guesthouses there owned by *Mjaka Enterprises*. *Mjaka* on the main road had a restaurant attached and had single rooms for TSh 2,000/- to 3,000/- for self-contained, and twins for TSh 3,000/- (communal bathroom). At *Mjaka II* there are only self-contained singles available, but at the cheaper price of TSh 2,000/- per night. All rooms in both guesthouses have fans and mosquito nets. Mosquitoes were always plentiful anywhere in Kilwa, but the management at both would fumigate your room free of charge each night if asked. There are a variety of places to eat around Kilwa, all serving much the same standard menu.

4.3 Morogoro

All the British members visited Morogoro at different points, and stayed in different places. The *New Tegetero Hotel* in the centre was reasonable at TSh 4,500/- per night for a single. The included breakfast was impressively good, but the bar behind the hotel could generate quite a lot of noise in the evenings.

5 Equipment

5.1 Camp equipment

Tents were brought from the UK. All were lightweight tents made from synthetic materials, chosen mainly for price. Previous experience had shown that the biggest wear comes from zip failure and insect attack, which is nearly impossible to combat, so we chose tents which were reasonably roomy and featured mosquito-net windows, but otherwise were basic models. The climate in Tanzania during the dry season means the tents were not required to have any great ability to withstand harsh weather. We had four 2/3-man tents (which were occupied by two people each), plus we borrowed a 3/4-man tent (which housed 2 or 3 people) and a 1-man tent used for food storage. This usage of a tent for food storage was an idea carried over from Tanzanian Mpingo 96, but did not prove very successful and we would recommend a few rodent and insect proof strong boxes as a far better solution, even though they are less mobile.

British expedition members supplied their own sleeping and personal gear; some blankets were purchased in Dar Es Salaam for the use of Tanzanian members. Other camping equipment brought from the UK included a large flag to indicate occupancy of the toilet, some cutlery, our medical kit *q.v.* and powered Walkman speakers which meant we could enjoy some communal music – a great morale booster.

Everything else was purchased either in Dar Es Salaam or Kilwa. The following is not an exhaustive list:

Bought in Dar Es Salaam:

Cutlery
Plastic bowls and mugs
2 Large cooking pots & 2 Frying pans
Chapati board & roller
Kettle
2 Buckets & 4 Washing-up bowls
8 Jerry cans (20l each)
3 Pangas (machetes) & 2 Kitchen knives
2 Charcoal burners

Bought in Kilwa:

2 Kerosene lamps
6 more 20l Jerry cans
4 Bamboo seats and table
3 Woven mats

Most equipment purchased in Dar Es Salaam was bought in Kariakoo market. The bamboo furniture was obtained from a local craftsman in Migeregere.

5.2 Scientific equipment

Borrowed from Cambridge University:

1 Compass
2 30m measuring tapes
2 3m measuring tapes (we took stiff ones, but simple sewing tapes are better, and one each makes for no problem measuring CBHs)
2 Clinometers (the devices we took were actually slightly different from the basic clinometer and used a spirit-level style balance to achieve maximum accuracy, however the simpler model used on Tanzanian Mpingo 96 is easier to use and hence more suitable since the overall accuracy of the final height measurement is limited by other factors)
1 Gallenkamp pH stick and calibration solutions

Borrowed from Dar Es Salaam University:

1 Compass

Formaldehyde

Bought in UK:

Sample-size plastic bags
Secateurs
Trowel

Purchased in Dar Es Salaam:

Coloured rope (to lay out plots)
Cheap paper to press botanical samples
Yellow paint and brush

6 Supplies

Breakfast was usually one or more of *maandazi* (like savoury doughnuts), camp-baked bread and *chapatis*. Lunch and dinner were based around the staples of rice and *ugali* (a stiff porridge-like base made from maize flour and water). The topping for one of these meals each day would use beans, and the other anything from *nchicha* (similar to spinach), okra (ladies-fingers), peas and chickpeas as we happened to obtain them. The sauce for the topping generally included plenty of tomatoes and onions, and sometimes coconut milk too. A vital ingredient for keeping these meals varied was the small stock of herbs and gravy granules we brought with us from the UK combined with the excellent array of spices we could obtain in Dar and also Kilwa.

The vast majority of our supplies (including drinking water) were obtained from Kilwa. The drive to Kilwa took about 1¼ hours each way, although vehicle breakdowns did occasionally lead to considerable delays (once over a day). Because of the water situation we had to make the trip every two or three days. Luckily we could obtain water suitable for washing from a water hole about 10 minutes drive down the road to Mitarure forest reserve – we usually stopped to fill a few jerry cans on the way back to camp from fieldwork.

The market in Kilwa is not very large but it does have all the basics. The only commodity of which they seemed to regularly run out was oranges, and on these occasions we could find what we needed from stalls selling them to passing buses in Nangurukuru. Occasionally local people from the village would bring fruit to our camp to sell.

We avoided changing money in Kilwa as much as possible. As noted above the rates were considerably poorer and frustratingly the whole process took much longer. Anyone considering working in Kilwa should aim to change as much of their money as possible in either Dar Es Salaam or Lindi. The supply trips were also used to send and collect post – we were lucky to be able to use the District Commissioner's post box. The Post Office also provided the primitive telephone service, which was thus only available during office hours. The line to Dar was of very poor quality and one often struggled to make oneself understood.

7 Camp Details

7.1 Location

The camp was located on the edge Migeregere village so that we caused minimum interference to the lives of the local people. The camp was situated about 100 metres from the road in a grove of mango trees, which provided much appreciated shade.

7.2 Layout

The tents were arranged in an arc, facing inwards, under one of the mango trees. In the centre of this arc was the main sitting area, which was eventually furnished with a couple of large logs, three mats and four bamboo chairs for sitting on, and a bamboo table. All of these, with the obvious exception of the logs, were bought at inexpensively from local craftsmen and women.

The cooking area was situated a little way from the edge of the mango tree's canopy. We had two charcoal burners, but more often just cooked over a small fire as firewood was plentiful. A shallow pit could be used as an oven (hot coals would be buried under and around the sides of the pan, and a few more put on the lid). A much bigger pit was used to burn all organic waste – a task performed regularly so as not to attract rodents. Other waste was buried in another pit a bit further away.

For hygiene reasons the toilet was located behind a tree about 30 metres downwind from the camp, although after the second pit was filled up we had to find another suitable tree. The shower area was situated close by.

A firebreak was cleared and burned around the main camping area. This proved its worth when a fierce bush fire dramatically swept through the area towards the end of our stay. This fire removed much of the cover around camp and necessitated moving the shower area considerably further from camp in order to preserve people's privacy as much as we could. The firebreak also provided some protection against snakes, as they could not come so close to the camp without breaking cover. For the same reason the paths to the toilet and shower areas were always kept reasonably wide. This is fairly effective since their principal prey, small rodents, also like to keep to the cover.

8 Modus Operandi

8.1 Camp duty

Two people were always left in camp in order to prepare the days food and maintain the camp. This was a full day's work, involving rising at 5:45am to ready tea and breakfast. After the rest of the team had departed, preparations for lunch were begun (sorting beans and rice etc.). Later on they had to prepare tomorrow's breakfast and then cook supper.

8.2 Field work

The rest of the team would leave for the field around 7am. They would normally be driven some distance down the road in the direction of the forest reserve, and would then split into two groups, each including a game scout and one taxonomist, and head off through the bush to the day's plots, navigating by compass. We generally carried enough oranges for one each to keep us going until around 1pm when usually fieldwork would be completed for the day, and we would return to camp for lunch. Sometimes, however, we would take a larger selection of fruit and some bread/*maandazi* with us as a packed lunch and stay out until about 4pm. This working schedule was used particularly for plots which were a long way from the road and thus would allow us to complete several without having to make the long walk more than once.

When not on the extended field schedule the afternoons were used for analysing the soil samples, bird watching, provisioning trips to Kilwa, camp improvements and clothes washing etc. All the sociological work was carried out during afternoons. The evenings were spent relaxing, and preparing for the next day. The team generally retired to bed at about 9pm each night. We worked from Monday to Saturday. Each person rotated through a system, doing time in the field and in the camp. Sunday was a rest day.

Health & Safety

1 Pre-Expedition Preparations

1.1 Advice

Advice on all medical aspects of the expedition was given by Cambridge University Occupational Health Service (OHS) at Fenners, Gresham Road, Cambridge (tel. 01223 336590). Their role in ensuring that we suffered no major health related incidents on the expedition is acknowledged with gratitude. Valuable information was also gleaned from reports of previous expeditions to the area, and from our individual doctors.

1.2 Training

The Expedition's Medical Officer attended the Wilderness Medical Training Course, run by the RGS. Additionally two other team members held first aid awards.

1.3 Medical Equipment

The bulk of the Medical Kit was purchased from the Cambridge University Occupational Health Service (OHS), including all prescription drugs and emergency aid equipment such as bandages, needles, dressings etc. The more common items of the medical kit, such as painkillers and bandages were purchased from pharmacists and supermarkets in the UK.

The kit consisted of:

- IV Kit, syringes
- Dressings – absorbent lint, open weave bandages, Steri-strips etc
- Dihydrocodein
- Rehydration powders
- Immodium
- Hydrocortisone cream (Efcortelan)
- Caladryl cream
- Fansidar and quinine sulphate (2 courses of these anti-malarials)
- ANTIBIOTICS:
  - Norfloxacin (400mg)
  - Tinidazole (500mg)
  - Erythroped A (500mg)
  - Tetracycline (250mg)
  - Ciprofloxacin (250mg)
  - Augmentin
- Suncream (factors 25 and 10)
- Micotil (fungicidal powder)
- Paracetamol
- Piriton
- Betadine antiseptic paint

In addition, each expedition member was advised to bring their own small first aid kit containing any extra medication they were likely to need, including a small supply of aspirin, suncream etc., to avoid placing excessive demands on the main medical kit.

1.4 Immunisation

All British members of the expedition were fully immunised before departure against yellow fever (certificate required for entry into Tanzania), typhoid, polio, tetanus, meningococcal meningitis, hepatitis A, and rabies. The majority of vaccinations were obtained from each member's own G.P. surgery and paid for by the expedition.

1.5 Prophylaxis and the Malarial Risk

The whole team took advice from their GP and the O.H.S. on the risks of malaria, and began taking prophylaxis for the advised time before departure. Tanzania has the added risk of having some chloroquine resistance strains, and so the recommended prophylactic was mefloquine (Larium), but choice of prophylaxis was personal, and only one member of the team used mefloquine. The other four members took proguanil (Paludrine) and chloroquine in combination, having weighed up the risks against the possibilities of side effects. The Tanzanian members of the team had lifelong exposure to malaria and relied on their acquired resistance to infection.

As treatment, two courses of quinine sulphate and Fansidar were also taken for cases in the field.

Great emphasis was placed on prevention of mosquito bites. The tents we purchased had inbuilt mosquito nets. Ample supplies of insect repellent were carried. This included traditional knock down insecticides, DEET and *Mosiguard* (lemon eucalyptus oil). We were lucky in the fact that the area we were camping in was relatively mosquito free, having little surface water anywhere in the dry season. However, risk was greater in towns, especially Kilwa Masoko, where mosquito nets were often either absent or unreliable, and there were many mosquitoes.

1.6 Blood Group Assessment and Medical Histories

All team members gave summaries of their medical history as relevant to the expedition and information on their blood type, for potential blood transfusions within the group. Medical information and next of kin were supplied for each individual to our contacts in Tanzania upon arrival.

2 Expedition Phase Precautions

2.1 City Phase

In Dar Es Salaam and any other major town, the close proximity to hospitals made precautionary measures much less important. However, at all times, at least one member of the group was in possession of a small medical kit, containing essential items, such as syringes and needles; which could be used in any hospital visited if necessary, basic antibiotics for easily diagnosable and treatable ailments, and wound dressings.

2.2 Field-Work Phase

The full medical kit was available in camp, with a lesser kit being taken out to the field in case of emergency, in the Land Rover

The nearest hospital was about an hour and a half's drive away in Kilwa Kivinji i.e. well within reach if there was an emergency which could not be dealt with in camp. This was encouraging in trying to quench the fear of death by snakebite. The presence of a village dispensary prevented local people from asking for medicine from us.

3 Medical Problems

3.1 Malaria

Three of the British members and one Tanzanian fell ill due to malaria, one of whom was taking Larium as prophylaxis. Two of these were quite mild cases. All were diagnosed infected with malaria by a blood test at either the hospital in Kilwa Kivinji, or, in once case, at a hospital in Morogoro. We only brought two courses of quinine sulphate and Fansidar with us from the UK, so the latter two malarial patients had to be treated with just quinine sulphate, which is readily obtainable from hospitals and some dispensaries. We would recommend that anyone planning a similar expedition should bring sufficient malaria cures to treat at least one third of the team.

3.2 Gut Infections and the Water Supply

Several cases of gut infection and diarrhoea occurred, both mild and quite severe. Mild cases, which did not last long, were simply treated with fluids sometimes supplemented with rehydration solution. The more severe cases included one case of a gut amoeba, but the other cases were difficult to diagnose and tended to disappear quickly, after courses of Ciprofloxacin, rest and fluids.

Water drank in the field was collected from Kilwa Masoko every two or three days, rather than attempt to purify the poor quality local standing water. The water was iodised to begin with, but due to one team member's under-active thyroid, some of it was also boiled. However we were told that the whole town of Kilwa uses this pump because it is recognised as being of exceptional purity. After several 'accidental' events when this thirsty team member drank, with no adverse effects, water which was neither iodised nor boiled the team decided to stop iodising the water and to drink it unpurified. There was an element of risk to this, but bearing in mind that drinking iodised water for prolonged periods is not recommended, we decided it was a small risk worth taking.

3.3 Infections and Miscellaneous

Infection often progresses faster in tropical climates, and indeed any minor wounds or scratches tended to produce pus within hours. One team member also developed skin abscesses when plasters were used to dress minor wounds.

One member of the team had a knee injury, which manifested itself in the field, but was actually a repetitive strain injury acquired through excessive sport in the UK. It was diagnosed in Dar Es Salaam as simply requiring rest. At the same time this unfortunate individual had a cyst removed from her leg, caused by an infected insect bite that was treated poorly in camp. The bite had been covered by a plaster – this had not been pointed out in any training course or medical guide book, but plasters in the tropics are a very bad idea! After this event, gauze and other loose fabric dressings were used entirely to cover any kind of wound or cut that needed attention.

Another member of the team developed a small tropical boil, also through an infected bite, which was treated with ease at the end of the trip at the Aga Khan hospital in Dar Es Salaam – by far the best hospital which we visited during our stay in Tanzania.

Another team member had difficulties with her ankle, due to walking too much in the bush, but the swelling and pain cleared up after ten days complete rest.

3.4 Sanitation

A toilet pit was dug about 20 metres from camp, behind a cover of vegetation, which was then filled in and another dug about every two weeks. The pit design was basic: a hole about a metre deep, and about 0.5m square. Then, poles were placed over the top, with an access hole, to provide a platform for use. A wash area was also built, where team members could wash in privacy. Again it was about 20 metres from camp, and well out of sight.

Food waste was burnt in the rubbish pit daily to prevent the attraction of flies, or rodents, which would in turn attract snakes.

4 Safety

4.1 Large animals

Two armed game guards were hired, to protect the team both in camp, and more importantly, in the bush during survey work, when one guard would stay with each survey group. Lions, elephants and buffalo were all present in the area of our camp and survey work, but we came in contact with none. The game guards were a reassuring precautionary measure. Baboons were frequently seen around camp but never posed a threat.

4.2 Snakes

Black mambas and puff adders were sometimes seen near camp and, once, in camp. On no occasion was anyone attacked. All team members were both aware of the threat and the advice not to provoke attack. On one occasion when several young cobras were found in camp, they were killed using machetes.

4.3 Spiders and Scorpions

Many spiders were found around camp, especially soon after the campsite was cleared, when several huntsman spiders' burrows were uncovered. These poisonous spiders tended to either run at you or hide in bags etc when discovered. We quickly became wary of them and any seen were killed using machetes and their holes dug up.

Scorpions were also found at the campsite, but precautions such as shaking out boots and bags (as for spiders) prevented any stings. One person at camp was stung by a scorpion, which had crawled into his trousers during the night. The unfortunate victim was a visitor to our camp, and apparently the sting was painful for several weeks. There is no effective cure for scorpion bites, but painkillers were used when necessary. It took about four weeks for the pain to completely disappear.

Part III : Appendices

Appendix I : Species Lists

This list includes all positively identifiable species seen in the area surveyed.

1 Trees

Latin name	Vernacular name	Notes
Acacia campylacantha	*mhungo*	
Acacia nilotica	*mhungo, muhungu, myenye*	common
Acacia polyacantha	*mkwanga*	
Acacia senegal		
Acacia xanthophloea	fever tree	used to treat malaria
Adansonia digitata	*mbuyu,* baobab	upside-down tree
Afzelia quanzensis	*mbangbakofi, mbangofi*	valuable timber
Albizia amara	*mtanga*	
Albizia other spp.		
Anacardiaceae spp.		
Anacardium occidentale	*mkorosho,* cashew	cultivated
Antidesma venosum	*kikulo*	
Apocynaceae sp.		
Apodytes dimidiata	*mgulugae*	
Balanites aegyptiaca	desert date	fruit edible
Bauhinia petersiana		distinctive foliage
Bignoniaceae cf Markhamia	*mtandawala, mtarawanda*	
Bignoniaceae other spp.		including liana spp.
Bombax sp.		distinctive foliage
Boscia sp.		
Brachystegia bussei	*mgeregere, mjerijeri*	same name as the village
Brachystegia longifolia	*miombo,* basswood	same as the habitat
Brachystegia spiciformis	sometimes called *miombo*	
Caesalpinoideae other spp.		
Cassia singueana?	*mhunja*	
Cassia spp.		
Combretum apiculatum	*kingonogo*	common
Combretum binderanum	*kingonogo*	this diverse genus is difficult to
Combretum hilderbrandtii	*kingonogo*	identify without flowers or fruit
Combretum molle	*kingonogo*	common
Combretum schumannii	*kingonogo*	
Combretum ternifolium	*kingonogo*	
Combretum zeyheri	*kingonogo*	
Commiphora pilosa	*mpome, mklola*	
Cordia cf monoica	sandpaper tree	leaves used as sandpaper
Dichrostachys cinerea ssp. cinerea		
Diplorhynchus mossambicensis	*mtogo, mutomoni*	leaves used as cigarette paper

Latin name	Vernacular name	Notes
Ehretia sylvatica	*mwaria*	
Elaeodendron stuhlmannii	*kiguruka*	
Enteda abyssinica	*mjanda*	
Euphorbia candelabrum		
Euphorbia sp.		distinctive succulent
Fernandoa magnifica		
Ficus spp.	*mkuyu*	very diverse genus
Flagellaria guineensis	*mteda*	
Grewia gilvifolia		
Grewia dif't spp.	*mnunje*	
Heeria reticulata	*mkala*	
Hibiscus schizopetalus		beautiful red flowers
Hymenocardia ulmoides	*mtete*	
Hyphaene compressa	*mikumi,* doum palm	gives name to National Park
Julbernardia globiflora	*mchenga, mtondo*	
Kigelia cf africana	*mtandi, mfungutua,* sausage tree	English name refers to fruit
Lannea sp.	*mtumbu*	
Markhamia cf obtusifolia		
Mangifera indica	*mwembe,* mango	cultivated
Mimosoideae spp.		
Myrica salicifolia		
Ochnaceae sp. cf *Brackenridgea zanguebarica* & *Ochna praecox*	*mnungamo*	
Ochna different sp.	*mnungamo*	
Pericopsis angolensis	*mwanga*	
Piliostigma thoningii	*msegese,* camel's foot tree	distinctive foliage
Pseudolachnostylis mapronuneifolia	*msolo*	common
Pteleopsis mytifolia	*mnepa*	common
Pterocarpus angolensis	*mninga, mtumbati,* bloodwood	important commercial timber sp.
Pterocarpus stolzii	*mtumbati bonde, mninga maji*	commercial timber sp.
Rhus natalensis		
Ricinodendron africanum	*mtondo*	
Rubiaceae spp.	*mwambala*	
Sclerocarya birrea	*mng'ongo, mgongo, kimbinga,* marula	Amarula drink is made from the fruit, fruit widely eaten
Sterculia appendiculata	*mjale*	huge tree
Stereospermum sp.		very showy pink flowers
Strychnos innocua	*mdongadonga, mtongatonga, mnguyanguya*	common
Strychnos cocculoides	*mdongadonga, mtongatonga,* monkey orange	English name refers to fruit which are yellow when ripe
Strychnos heterodoxa	*mpangapanga*	

Latin name	Vernacular name	Notes
Tabernaemontana sp.	*mkoko naimba*	
Tamarindus indica	*mkwaju, tamarind*	huge tree
Terminalia brownii	*mkuliungu*	
Terminalia sp.	*mkuliungu*	
Thevetia peruviana	yellow oleander	naturalised near village
Trema orientalis		
Vanguiria sp.	*mtopetope, mtopeta*	common, fruit edible
Vanguiriopsis lancifolia	*mwambala*	
Vitex cf doniana	*mfuru, mfulu,* black plum	
Ximenia americana	*mpingi*	fruit edible
Zanthoxylum chalybeum	*mjatari, knobwood*	not possible to separate these species in the field
Zanthoxylum holtzianum	*mjatari, knobwood*	

Botanical notes
Brachystegia bussei is locally known as *mjerijeri*, pronounced the same as the village we stayed at, Migeregere. Often English towns and villages are named after trees, even if there is just one of those trees in the area. There were a few specimens of *B. bussei* to the south of the village. We did not investigate whether the village was named after the tree.
The name *mpangapanga*, which we managed to identify on our return *as Strychnos heterodoxa* is also used to describe a very different species, the succulent *Euphorbia candelabrum.* We had been told that *mpangapanga* is used for flooring. This highlights the fact that identifications need checking, particularly if they involve vernacular names.
The vernacular names are mostly in Swahili and Mwera, with a few in a variety of languages which were supplied by our counterparts. In some of the vernacular names e.g. *mfulu* (*Vitex doniana*) the 'l' is interchangeable with 'r,' as is common in Swahili. Another example is that the village where we were based is usually called Migeregere but our letter of introduction to the village elders was addressed to Migelegele.

Taxonomic notes
1. In early plots *Vanguiriopsis* is recorded as a *Rubiaceae* sp. It is indeed in this family but had not at that stage been fully identified.
2. Some plants recorded as *Zanthoxylum* are probably *msengere*, both are semi-deciduous, having compound leaves and prominent corky protrusions on their branches. We have not succeeded in discovering the Latin name of *msengere* which is surprising given its distinctiveness and abundance.
3. Many lianas were recorded simply as 'liana sp.', and no further attempt at identification was made.

We also encountered the following vernacular species names, which we could not translate:

Vernacular name	Notes
Kilimanembo	climb this to escape elephants!
Kimbinga	used as a poison
Mchonda	
Mchumbu	
Mdaa	
Mkafi	
Mandalima	
Maramunda	
Marangangewa	
Marati	charcoal used to smelt iron
Mkundekunde	
Mlondondo	
Mngamba	
Mngarangara	
Mnyamwezi	
Mparakacha	
Mpeke	
Mpera pori	fruit edible
Mpichi	

Vernacular name	Notes
Mpilipili	
Mpweke	
Mpwepwe	
Pasama including *mngwaya*	
Msagawi	common
Mselekete	
Msengere	distinctive corky ridged bark
Msondoka	
Mtabwe	
Mtachi	
Mtatu	
Mteda	
Mzabibu	

Taxonomic notes

4. Pasama is thought to be the English name for a compound-leaved tree. It became apparent that we were using pasama to describe a heterogeneous group of species, many were in the Bignoniaceae, but it probably included different families. We tried to avoid using the name in later plots preferring to give the family where possible.
5. Unidentified plants where recorded as such in our raw data and omitted from most of the analysis.

2 Seedlings

Acacia nilotica
Other *Acacia spp.*
Albizia amara
Other *Albizia spp.*
Antidesma venosum
Azanza garckeana
Bauhinia sp.
Bignoniaceae sp. cf Markhamia
Brachystegia longifolia
Brachystegia spiciformis
Brachystegia thoningii
Combretum apiculatum
Combretum molle
Combretum schumanii
Other *Combretum spp.*
Commiphora pilosa
Diplorhynchus mossambicensis
Enteda abysinica
Ficus spp.
Grewia gilvifolia
Other *Grewia spp.*
Heeria reticulata
Hibiscus spp.
Julbernardia globiflora
Kigelia cf. Africana
Myrica salicifolia
Ochna spp.

Pseudolachnostylis maprouneifolia
Pterocarpus angolensis
Randia Taylorii
Rhus natalensis
Rubiaceae spp.
Sclerocarya birrea
Strychnos innocua
Tamarindus indica
Trema orientalis
Vanguiriopsis lancifolia
Vitex cf. doniana
Zanthoxylum spp.

Plus the following species only identified by Swahili name: *mdaa, mngamba, mparakacha, mpilipili, msagawi, mselekete, mtachi,* and *mtatu*.

3 Birds

Latin Name	Common Name
Acryllium vulturium	Vulturine Guineafowl
Anthreptes collaris	Collared Sunbird
Anthus novaeseelandicae	Richard’s Pipit
Aquila wahlbergi	Wahlberg’s Eagle
Buccanodon olivceum	Green Barbet
Bucorrus leadbeateri	Ground Hornbill
Campethera nubica	Nubian Woodpecker
Centropus superciliosus	White-browed Coucal
Ciccaba woodfordi	African Wood Owl
Cinnyricinclus leucogaster	Violet-backed Starling
Collandrella cinerea	Red-capped Lark
Coracias abyssinica	Lilac-breasted Roller
Coracina pectoralis	White-breasted Cuckoo Shrike
Corvus albus	Pied Crow
Corvus splendeus	Indian House Crow
Cossypha heuglini	White-browed Robin Chat
Dendropicos fuscescens	Cardinal Woodpecker
Dicrurus adsimilis	Drongo
Dryoscopus cubla	Black-backed puffback
Erythropygia quadrivirgata	Eastern Bearded Scrub Robin
Francolinus shelleyi	Shelley’s Francolin
Hirundo abyssinica	Striped Swallow
Hirundo atrocaerulea	Blue Swallow
Kaupifalco monogrammicus	Lizard Buzzard
Lamprotornis corruscus	Black-breasted Starling
Laniarius ferrugineus	Tropical Boubou
Lanius melanoleucus	Magpie Shrike

Latin Name	Common Name
Leptoptilos crumeniferus	Marabou Stork
Lonchura cucullata	Bronze Mannikin
Macronyx ameliae	Rosy-breasted Longclaw
Macronyx croceus	Yellow-throated Longclaw
Merops pusillus	Little Bee-eater
Merops superciliosus	Madagascar Bee-eater
Milvus migrans	Black Kite
Nectarinia chalybea	Southern Double-collared Sunbird
Numida meleagris	Helmeted Guineafowl
Phyllastrephus fischeri	Fischer's Greenbul
Phoeniculus cyanolmelas	African Scimitarbill
Ploceus nigricollis	Black-necked Weaver
Ploceus cucullatus	Spectacled Weaver
Pogoniulus bilineatus	Golden-rumped Tinkerbird
Poicephalus cryptoxanthus	Brown-headed Parrot
Prinia erythoptera	Tawny-flanked Prinia
Prionops plumata	Straight-crested Helmeted Shrike
Prionops retzii	Retz's Red-billed Shrike
Psalidoprocne holomelaena	Black Roughwing Swallow
Pyconotus barabatus	Yellow-vented Bulbul
Pytilia melba	Green-backed Pytilia
Stephanoaetus coronatus	Crowned Eagle
Streptopelia capicola	Ring-necked Dove
Tchagra australis	Brown-headed Tchagra
Tchagra senegala	Black-headed Tchagra
Terathopius ecaudatus	Bataleur Eagle
Tockus alboterminatus	Crowned Hornbill
Treron australis	Green Pigeon
Turaco livingstonii	Livingstone's Turaco
Turaco porphyreolophus	Violet-crested Turaco
Turtur chalcospilos	Emerald-spotted Dove
Turtur tympanistria	Tambourine Dove
Uraeginthus cyanocephalus	Blue-capped Cordon-bleu

4 Animals:

Latin Name	Common Name
Alcelaphus lichtensteini	Liechtenstein's Hartebeest
Bdeogale crassicauda	Bushy-tailed Mongoose
Bitis arietans	Puff Adder
Canis sp.	Jackal sp.
Caphalophus sp.	Duiker sp.
Cercopithecus aethiops	Vervet monkey
Civettictus civetta	Civet

Latin Name	**Common Name**
Connochaetes taurinus	Blue Wildebeest
Crocuta crocuta	Spotted Hyena
Dendroaspis polyepis	Black Mamba
Equus burchelli	Burchell’s Zebra
Galago sp.	Bushbaby sp.
Hippotragus equinus	Roan Antelope
Lepus sp.	Hare sp.
Loxodonta africana	Elephant
Lycaon pictus	African Hunting Dog
Panthera leo	Lion
Panthera pardus	Leopard
Papio cynocephalus	Yellow Baboon
Paraxerus palliatus	Bush Squirrel
Phacochoerus aethiopicus	Warthog
Potamochoerus porcus	Wild Pig
Rhynchocyon cirnei	Giant Elephant Shrew
Synceros caffer	Buffalo
Varamus albigularis	White Throated Monitor Lizard

Appendix II : RRA Data

Months when phenomena or activity occurs	Migeregere				Mbate	
	Male elders	**Female elders**	**Male adults**	**Female adults**	**Men**	**Women**
Phenology						
- leaf	Nov-Dec	Dec-Jan	Nov-Dec	December		Nov-Dec
- flower	November	December	February	Jan-Feb		Nov-Dec
- fruit	April	March	April	March		January
Animals present						
- bees	November	April	February	Jan-Feb		November
- birds		April	February	Jan-Feb		
Burning	July-Sept	July	July-Sept	July-August	July-Sept	July-August
Clearing	July-August	July	never	never	Sept-Nov	September
Logging						
- local	May-Nov	June-August	v. rarely	August	never	never
- outsiders	May-Dec	Feb-June	August	Jan-March	July-Sept	
- other species	Jan-Dec	Jan-Dec	Jan-Dec	Jan-Dec		

Blanks indicates no opinion was expressed or the question was not asked of that group.

Appendix III : Songs used in Education Pilot

One works as a short round:

Pandeni miti kwa wingi, itawasaidia baadaye.

(which translates as)

Plant many trees, it will help you later.

The other, written by two members of the team, is about mpingo specifically:

Mti wa mpingo, mti wa mpingo, Uko kijijini Migeregere, Feida zake tunazijua; Ya kwanza kuni, pili mkaa, Tatu vinyage, nne majengo, Mti wa mpingo, mti wa mpingo.	*Mpingo tree, Mpingo tree In Migeregere village. We know its uses; First wood, secondly charcoal, Third carvings, forth building Mpingo tree, Mpingo tree.*
Kwenye mpingo vitu vitatu; Kuna majani, maua na matunda. Mti wa mpingo una wageni, Mara mbili kila mwaka; Nyuki wanaenda kwenye maua, Kwa sababu ndani kuna asali. Ndege nawaopia wanatembelea, Kwa sababu ya mapumziko.	*On Mpingo are three things; There are leaves, flowers and fruit. The Mpingo tree has guests, At two times each year; Bees go to the flowers, Because of the honey inside. Birds also visit the tree, In order to perch.*
Mti wa mpingo, mti wa mpingo Uko kijijini Migeregere.	*Mpingo tree, Mpingo tree In Migeregere village.*

Appendix IV : Accounts

Received	**£**
Cambridge Mpingo Project Reserves	2,700.00
Personal Contributions	2,500.00
Plant Sciences Prize	1,308.46
Shell Grants	1,000.00
Cambridge Commonwealth Travel Bursaries	1,000.00
Cambridge Expeditions Fund	700.00
Royal Geographical Society (RTZ fund)	500.00
Girton College	300.00
Barlow International	250.00
Marlow Buyers	250.00
Lindeth Charitable Trust	250.00
Mary Euphrasia Mosely Trust	175.00
Other	357.00
TOTAL	***11,290.46***

We must also thank BP Tanzania for providing us with free fuel, worth over £400, for the latter half of the expedition.

Pre-expedition Expenditure	**£**
Flights	2,306.00
Insurance	515.00
Medical	611.59
Visas	200.00
Research Permits	935.14
Tents	320.00
Miscellaneous Equipment	77.40
Photography	159.74
Brochures	150.00
Administration	275.00
Financial	75.37
TOTAL	***5,625.24***

Field Expenditure	**£**
Equipment	129.08
Accommodation	726.04
Provisions	532.27
Public Transport	335.84
Vehicle Hire	366.67
Petrol & Oil	430.19
Counterpart Wages	1,968.06
Medical	103.10
Other	97.90
Currency Exchange Losses	236.04
TOTAL	***4,925.19***

Post-Expedition	**£**
Photographic	60.00
Administration	70.00
Report	595.00
TOTAL	***725.00***

GRAND TOTAL	***11,275.43***

The figures for post-expedition are estimates. Any surplus will be returned to the *Cambridge Mpingo Project* central account.

Appendix V : Acknowledgements

We would especially like to thank Guy Norton and Dawn Hawkins, of Anglia Polytechnic University in the UK and the Animal Behaviour Research Unit in Mikumi National Park, Tanzania for all their help, guidance in support for the Cambridge Mpingo Project.

Our heartfelt thanks Mr. Mfangavo, the District Forestry Officer, the District Commissioner, and the rest of the officers of Kilwa District who assisted us during the expedition. And also to the people of Migeregere village who so generously welcomed us and made us feel at home during our time there.

Thanks to our patrons Acker Bilk, Prof. Nick Shackleton of Cambridge University and Mark Collins, Director of the World Conservation Monitoring Centre.

Others to whom we owe a large debt of gratitude are:

Prof. Rogers Malimbwi, *Dept. Forest Mensuration, Sokoine University of Agriculture*
Abdallah Juma and James Lesckary, *Arusha Region*
Paul Nnyiti, *Wildlife Conservation Society of Tanzania*
Mr. Nguli, *Commission for Science and Technology (COSTECH), Dar Es Salaam*
The District Natural Resources and Forestry Officers at Lindi, Mtwara, Nachingwea and Liwale
Dr. E.J.V. Tanner, *Department of Plant Science, University of Cambridge*
Niall Marriott, *Consultant on the Soundwood Project, Fauna & Flora International*
Nigel Winser, *Director, Royal Geographical Society*
Shane Winser and Louise Rettie, *Expeditions Advisory Centre, Royal Geographical Society*
Sara Oldfield, *Global Programmes Director, Fauna & Flora International*
Bruce Godfrey, *Cambridge University Print Service*
Lorraine Perril, *Cambridge Occupational Health Service*

And thank you to all the many people too numerous to mention who helped us out at little moments of crisis, or provided some unexpected generosity. We could not have done it without you.

Appendix VI : Bibliography

- **African Blackwood Conservation Project** (1999) ABCP newsletter, annual report no.2. Red Rock, USA. http://www.blackwoodconservation.org.
- **African Regional Workshop** (1996) Conservation and sustainable management of trees, project workshop held in Harare, Zimbabwe, July 1996
- **Alexander, K.** (1998) Hollow ring. 21st November 1998: 63. New Scientist, London
- **Ball, S.M.J., Smith, A.S., Keylock, N.S., Manoko, L., Mlay, D., Morgan, E.R., Ormand, J.R.H. & Timothy, J.** Tanzanian Mpingo 96 Final Report. Cambridge Mpingo Project.
- **Barbier, E., Burgess, J., Bishop, J. & Aylward, B.** (1994) The economics of the tropical timber trade. Earthscan, London.
- **Bayard Hora, F. & Greenway, P.J., ed. Burtt Davy, J.** (1940) Check-list of the forest tress and shrubs of the British Empire no. 5: Tanganyika Territory Part I. Imperial Forestry Institute, Oxford.
- **Beale, D.** (1995) Tree! What tree? An ecological economic approach to producing a sustainable mpingo trade (*Dalbergia melanoxylon*). A dissertation presented for the degree of Master of Science, unpublished. University of Edinburgh.
- **Boulger, G.S.** (1908) Wood: a manual of the natural history and industrial applications of the timbers of commerce. Arnold, London.
- **Brenan, J.P.M. & Greenway, P.J.** (1949) Check-lists of the forest trees and shrubs of the British Empire no. 5 Tanganyika Territory Part II. Imperial Forestry Institute, Oxford.
- **Briggs, P.** (1996) Guide to Tanzania, Bradt Publications.
- **Bryce, J.M.** (1967) The commercial timbers of Tanzania. Tanzania Forest Division, Utilization section, Moshi.
- **Bryce, J.M.** (1969) The commercial timbers of Tanzania. Ministry of Agriculture & Cooperatives, Forestry Division, Dar Es Salaam.
- **Bureau of Statistics** (1997) Tanzania in figures 1996. United Republic of Tanzania, Dar Es Salaam.
- **Burns, C.** (website as at 01/08/1999) African blackwood and blackwood substitutes. http://kendaco.telebyte.com/cburns.
- **Burtt, B.D.** (1953) A field key to the savanna genera and species of trees, shrubs and climbing plants of Tanganyika Part II. The species of the more important genera with general index. Government printer, Dar Es Salaam.
- **Chitera, S.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995, Opening Address-Mozambique: 5–7. Fauna & Flora International, Cambridge, UK.
- **Clarke, G.P.** (1995) Coastal Forest Research Programme: Status reports for six coastal forests in Lindi Region, Tanzania. The Society of Environmental Exploration and University of Dar Es Salaam.
- **De Alessi, M.** (1999) Law of the jungle. New Scientist 8th May 1999:51.
- **Desanker, P.V., Frost, P.G.H., Frost, C.O., Justice, C.O. & Scholes, R.J. eds** (1997) The Miombo Network. Framework for a terrestrial transect study of land-use and land-cover change in the miombo ecosystems of Central Africa, IGBP report 41. International Geosphere-Biosphere Programme, Stockholm.
- **East African Movies Ltd.** (1998) Makonde Sculptures. Dar Es Salaam: 22–23, East African Movies, Dar Es Salaam.
- **Fauna & Flora International** (1996a) The proceedings of the Maputo workshop, 6–9th November 1995. Introduction: 2–4. Fauna & Flora International, Cambridge, UK.
- **Fauna & Flora International** (1996b) The proceedings of the Maputo workshop, 6–9th November 1995. General discussion: 26. Fauna & Flora International, Cambridge, UK.
- **Fauna & Flora International** (1997) SoundWood: 5.
- **Fauna & Flora International** (1999) SoundWood: 7.

- **FAO** (1993) The challenge of sustainable forest management, what future for the world's forests.
- **FAO** (1999) State of the World's Forests.
- **FAO** (199?) Database of threatened trees. Pages withdrawn from website (www.fao.org).
- **Forest Division** (1984) Trees for village forestry. Ministry of Lands, Natural Resources & Tourism, Tanzania.
- **Gauslaa, Y.** (1989) Management and regeneration of tropical woodlands with special reference to Tanzanian conditions-a literature review. LIDIA vol. 2 no. 2–3. Agricultural University of Norway, Aas.
- **Green Umbrella Productions** (1992) Mpingo, the tree that makes music (post production script). Green Umbrella Ltd.
- **Hall, J.E.** (1988) A report on a mission to analyse the sawmilling practices of the mpingo wood industry in Tanzania with a collection of small grant proposals aimed at the conservation of the mpingo resource. Unpublished report to UNEP, Nairobi.
- **Hamilton, A.** (1996) Kenya's wood-carvers face uncertain future. http://www.panda.org/news/features/8-96/story1.htm.
- **Hansen, M.B.** (1996) Natural regeneration of *Dalbergia melanoxylon* in south-east Tanzania. A thesis submitted in partial fulfilment of the requirement of the degree of Cand. Agric. (Forestry), unpublished. Agricultural University of Norway.
- **Harby, K.** (1998) Unsound reasoning. Scientific American: 278: 20–21.
- **Haughton-Sheppard, P.C.** (1958) A note on African blackwood – *Dalbergia melanoxylon*. Empire Forest Review 37.
- **Hawkins, D.M., Lyaruu, H.V. & Norton, G.W.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995. Status of *Dalbergia melanoxylon*, Tanzania: 44–51. Fauna & Flora International, Cambridge, UK.
- **Högberg, P.** (1986) Nitrogen-fixation and nutrient relations in savanna woodland (Tanzania). Journal of applied ecology 23:675-688.
- **Instituto del Tercer Mundo** (1997) The World Guide 1997/8. New Internationalist Publications Ltd., Oxford.
- **International Geosphere-Biosphere Programme's Miombo Network (**website as at 01/08/1999). http://miombo.gecp.virginia.edu.
- **Janzen, D.H.** (1988) Dry tropical forests: the most endangered major tropical ecosystem. In Wilson, E.O. & Peter, F.M. eds. Biodiversity. National Academy Press, Washington DC.
- **Jeffers, J.N.R. & Boaler, S.B.** (19??) Ecology of a miombo site. Lupa North Forest Reserve, Tanzania. I: Weather and plant growth 1962-64. Journal of ecology 54:447-463.
- **Kafwa, D.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995. Assessing the demand: 14–15. Fauna & Flora International, Cambridge, UK.
- **Krauth, D.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995. Assessing the demand: 12–14. Fauna & Flora International, Cambridge, UK.
- **Lewis, L.A. & Berry, L.** (1988) African environments and resources. Unwin Hyman, Boston.
- **Lind, E.M. & Morrison, M.C.S.** (1974) Rangeland in East African Vegetation. Longman Group, London.
- **Lovett, J.** (1987) Mpingo – the African blackwood. Miombo 2:3
- **Lovett, J.** (1988) Tree of the month: *Dalbergia melanoxylon*. Guill. & Perr. Swara 10(2): 27–28.
- **Luoga E.J.** (1995) Economic utilization of African Blackwood (*Dalbergia melanoxylon*). Field inventory report, unpublished. Sokoine University of Agriculture, Morogoro.
- **Madoffe, S.S.** (1996) Forest protection, Part II: Fire ecology. Lecture handout, Faculty of Forestry, Sokoine University of Agriculture, Morogoro.
- **Malimbwi, R.E., Luoga, E.J., Hofstad, O., Mugasha, A.G. & Valen, J.S.** (1998) *Dalbergia melanoxylon*: Is it a threatened species. Unpublished report.

- **Marshall, N.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995. Assessing the volume of trade: 16–22. Fauna & Flora International, Cambridge, UK.
- **Mbuya, L.P., Msanga, H.P., Ruffo, C.K., Birnie, A., Tengnäs, B.** (1994) Useful Trees and Shrubs for Tanzania. Regional Soil Conservation Unit (RSCU), Swedish International Development Authority (SIDA).
- **McCoy-Hill, M.** (1993) Mpingo (East African Blackwood) *Dalbergia melanoxylon*. An outline, background and working plan with a view to the regeneration of the species, its utilisation, grading and marketing and earner of export revenue. International Tree Foundation, Crawley Down, UK.
- **Mfangavo, M.** (1998) Notes on the woodland resources and licences issued by Kilwa District. Personal communication.
- **Ministry of Health** (1996) Health Statistics Abstract. United Republic of Tanzania, Dar Es Salaam.
- **Moore, K. & Hall, J.E.** (1987) Report of a mission to assess the management and conservation of *Dalbergia melanoxylon*, or the mpingo, in Tanzania. Unpublished report to UNEP.
- **Mugasha, A.G.** (1978) Tanzania natural forest silviculture research review report. Tanzania silviculture technical note (new series) no. 39. Forestry Division, Ministry of Natural Resources and Tourism.
- **Mugasha, A.G.** (1983) The effects of planting seasons, different planting materials and weeding methods on early performance of *Dalbergia melanoxylon* at Kwamarukanga, Korogwe, Tanzania. Silviculture technical notes no. 43. Ministry of Natural Resources and Tourism, Silviculture Research Station, Lushoto.
- **Mugasha, A.G. & Mruma, S.O.** (1983) Growth of *Dalbergia melanoxylon* in natural woodland and trial plots in Tanzania. Tanzanian. Tanzanian silviculture technical notes (new series): 59
- **Mugasha, A.G.** (1996) Silviculture in the tropical natural forests with special reference to Tanzania. Lecture handout, Department of Forest Biology, Sokoine University of Agriculture.
- **Newton, A.C.** (1997) Sustainable use and the conservation of tree species. Unpublished report for WCMC/IUCN SSC project, Conservation and sustainable management of trees. World Conservation Monitoring Centre, Cambridge, UK.
- **Nshubemuki, L.** (1993) *Dalbergia melanoxylon*: valuable wood from a neglected tree. NFT highlight Sept 1993: 93–95. Nitrogen Fixing Tree Association, Hawaii.
- **Nshubemuki, L.** (1994) Recent progress in silviculture research on *Dalbergia melanoxylon* in Tanzania. In Westley, S.B. & Roshetko, J.M. eds. *Dalbergia*: proceedings of an international workshop. Nitrogen fixing tree research reports, special issue.
- **Nshubemuki, L.** (1996) The proceedings of the Maputo workshop. Status of *Dalbergia melanoxylon*, Tanzania: 42–43. Fauna & Flora International, Cambridge, UK.
- **Nye, P.H. & Greenland, D.J.** (1960) The soil under shifting cultivation. Technical communication 51. Commonwealth Agricultural Bureau, Harpenden, UK.
- **Oldfield, S.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995. Status of *Dalbergia melanoxylon*: 30–38. Fauna & Flora International, Cambridge, UK.
- **Olet, E.D.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995. Uganda: 39–40. Fauna & Flora International, Cambridge, UK.
- **Platt, I. & Evison, S.** (1994) In-country investigation into the state of knowledge about the conservation and cultivation status of mpingo (*Dalbergia melanoxylon*) in Tanzania with notes about Mozambique. Unpublished report of Fauna & Flora International, Cambridge, UK.
- **Puhakka, M.** (1991) Inventory of *Dalbergia melanoxylon* (mpingo) in the Mtwara region: present state of resources and perspectives for its sustainable use in the future. Project report of the Turka-Mtwara Friendship Association.
- **Rodgers, W.A.** (1982) East African ecosystems and their conservation. In Huntley, B.J. & Walker, B.H. eds Ecology of Tropical Savannas. Springer-Verlag, Berlin.
- **Sharman, H.** (1995) Investigation into the sustainable management of a tropical timber tree species, using *Dalbergia melanoxylon* as a case study. A dissertation presented for the degree of Master of Science, Unpublished. University of Edinburgh.

- **Stockbauer, B.** (1999) A review of the literature supporting a rationale for mpingo conservation. Unpublished report on the African Blackwood Conservation Project website. http://www.blackwoodconservation.org.
- **Stromgaard, P.** (1986) Early secondary succession on abandoned shifting cultivator's plots in the miombo of East Africa. Geografiska annaler 70B: 363–374.
- **United Nations Education Programme** (1988) Don't stop the music. Save mpingo. Unpublished report, Nairobi.
- **Treeroots Network Social Forestry Report** (1993) Focus on Trees 2(1): *Dalbergia melanoxylon*.
- **von Maydell, H.J.** (1984) Trees and shrubs of the Sahel: their characteristics and uses. GTZ, Eschborn.
- **Wambua, S.** (1996) The proceedings of the Maputo workshop, 6–9th November 1995. Assessing the demand: 14. Fauna & Flora International, Cambridge, UK.
- **White, F.** (1983) The vegetation of Africa. A descriptive memoir to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa. UNESCO, Paris.
- **WCMC** (1999) Threatened trees database: *Pterocarpus angolensis*. Under http://www.wcmc.org.uk/cgi-bin/SaCGI.cgi/trees.exe.

Appendix VII : Contact Details

Cambridge Mpingo Project

The Cambridge Mpingo Project exists to facilitate long term research into *Dalbergia melanoxylon*, concentrating on obtaining quantitative data on the ecology of the tree and the impact of exploitation. It is committed to a substantial research programme conducted through two principal means: regular student expeditions from Cambridge University, and secondly by funding on-going research at other times of the year by Tanzanian students and foresters. *Tanzanian Mpingo 98* was the second expedition from the project. At the time of writing the third expedition is approaching the end of its fieldwork phase; and the project is consulting with FFI and others to determine the best way forward.

Cambridge Mpingo Project
27 Rollscourt Avenue
Herne Hill
London SE24 0EA
United Kingdom
Tel: +44 – (0)20 – 7274 – 4134
Fax: +44 – (0)87 – 0052 – 7005
Email: mpingo@sbcomp.demon.co.uk
Web: www.sbcomp.demon.co.uk

Fauna & Flora International (FFI)

Fauna & Flora International, founded in 1903, is the world's oldest international conservation charity. Its mission is to safeguard the future of endangered species of animals and plants through action based on sound scientific principles. FFI has members in over 100 countries and its programmes offer creative and innovative solutions to conservation problems. They involve and empower local people, ensuring that conservation gains for threatened species are sustained into the future.

The Soundwood Project was established to promote the conservation of numerous valuable hardwoods about the world which are endangered by high rates of exploitation to supply raw materials for the manufacture of a whole range of musical instruments. Mpingo is just one amongst many species which are threatened in this way.

Soundwood Project Officer
Fauna & Flora International
Great Eastern House
Tenison Road
Cambridge CB1 2DT
United Kingdom
Tel: +44 – (0)1223 – 461471
Fax: +44 – (0)1223 – 461481
Email: info@fauna-flora.org
Web: www.ffi.org.uk