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Status and uses of *Oldfieldia dactylophylla* (Euphorbiaceae) in Malawi

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Abstract

Determining the status of species under use is not only important for conservation and management of biodiversity but is also critical for sustainable use of such resources. *Oldfieldia dactylophylla* (Welw. ex Oliv.) J. Léon., one of the species in the plateau miombo woodlands, has a limited distribution in Malawi and Africa. Its status in the wild is poorly known in spite of being used by local communities for a long time. Adaptive cluster sampling using randomly selected 100 x 100 m quadrats was employed to determine abundance and distribution patterns of *O. dactylophylla* in Mubanga Forest Reserve (9°45' S, 33°18' E), and interviews with key informants to profile its uses by the local communities around the reserve. Abundance was expressed as frequency of occurrence and density of trees per quadrat, and uses as reported use values. The main findings were: (1) the root is the most used part for medicinal purposes but improper harvesting methods make its use unsustainable; (2) the local communities around Mubanga Forest Reserve are willing to conserve *O. dactylophylla* because of its values but their traditional knowledge on medicinal plants is rapidly getting lost with time and is undocumented; (3) *O. dactylophylla* is rare and depicts a clumped pattern in Mubanga Forest Reserve with a frequency of 26% and mean density of 0.81trees/quadrat; and young trees dominate the population with few trees having DBH >15 cm (mean = 6.30 cm). There is need to investigate the status of *O. dactylophylla* at country level and in its geographical range; and considerations ought to be made to gazette the Mubanga Forest Reserve and initiate co-management practices in the area to conserve the indigenous biodiversity.

Key words: adaptive cluster sampling, biodiversity, co-management, local communities, *Oldfieldia dactylophylla*, sustainable use, traditional knowledge.

Contents

Introduction

Knowledge about status of a species under use in the wild is critical to its existence and sustainable use. Eilu *et al* (2004b) aptly points out that basic information about abundance, distribution and uses of tree species is of primary importance in planning, implementation and management of biodiversity. According to Peters (1994), information on abundance of forest trees is vital for the sustainable management and utilization of such resources.

Biodiversity conservation and utilization, however, calls for a multidisciplinary approach and involvement of local communities who are hosting a wealth of knowledge on values of various species for human development due to their long periods of interaction with nature (Ticktin 2004; Gemedo-Dalle *et al* 2005).

How a wild species is harvested and utilized by resource users not only has a bearing on its temporal distribution but also abundance and population structure (e.g. Byg and Balslev 2001). Furthermore, the values that resource users place on a particular species do influence their perceptions on its conservation and sustainable utilization (Cunningham 1993), although Shingu (2005) argues that those that tend to over-harvest may sometimes not become aware of the harm they are causing. This study, conducted between July 2006 and March 2007, is probably the first attempt to investigate the status of *Oldfieldia dactylophylla* (Welw. ex Oliv.) J. Léon. and its traditional uses as a way of establishing its baseline data.

Study plant and associated knowledge

Belonging to the family Euphorbiaceae, *O.dactylophylla* is a stunted tree growing up to 10 m high, with a short straight bole of up to 25 cm in diameter. Its habitat is mixed deciduous plateau woodland, often on sandy soils in "dambo" forest margins (low lying, seasonally water-logged areas) with an altitude range of 1035 – 1830 m above sea level. Usually occurring as a sub-canopy tree in *Brachystegia* woodlands, its leaves are alternate with unequal leaflets 3–5(7). It has bright yellow male inflorescence and brown female flowers while fruit is obovoid-subglobose, orange when ripe and pubescent when mature (Radcliffe-Smith 1996). The species name *dactylophylla* is a direct reference to the finger-like leaf arrangement on a leaf stalk. Three other species in the same genus namely: *O. africana* Benth. and Hook.f., *O. macrocarpa* J.Léon., and *O. somalensis* Milne-Redh., exist mostly in western and eastern Africa, although the former has a wider distribution across the larger part of Africa (Léonard 1956; Radcliffe-Smith 1996).

According to the species database hosted by the United Nations Environment Programme-World Conservation and Monitoring Centre (UNEP/WCMC 2006), *O. dactylophylla* appears to be restricted to a belt surrounding Angola, Democratic Republic of Congo, Tanzania, and Zambia but its distribution status in Malawi is unclear.

However, secondary information obtained from the National Herbarium and Botanic Gardens of Malawi suggest that *O. dactylophylla* is restricted to Chitipa District in the extreme north of the country. It was in this district that the first specimen in the country for *O. dactylophylla* was collected by W.E. Lewis in 1937 (specimen no. 66; Radcliffe-Smith 1996). The knowledge gap on abundance, distribution patterns and uses of *O. dactylophylla* coupled with curiosity to investigate poorly known but seemingly vulnerable plant species in marginalised forest habitats in Malawi provided the impetus for this study.

Noted among the 80 more important species of the African woodlands in the late 1950's, around which detailed research about silvics and silviculture were recommended (Griffith 1961), *O. dactylophylla* is up until now one of the species that have received relatively little attention.

In countries where *O. dactylophylla* has been known to exist, its status in the wild is either not known or has been reported to occur in very low frequencies (Mgumia and Oba 2003). In their study on the potential role of sacred groves in biodiversity conservation in Tanzania, Mgumia and Oba found that of the 68 tree species inventoried, *O. dactylophylla* had the lowest frequency.

O. dactylophylla has been reported as a remedy against a number of human ailments including tuberculosis, pneumonia, anaemia and abdominal complications (Bossard 1996). Roots of this tree species have been reported on markets in Zambia (Cunningham 1993). Local communities around Mubanga Forest Reserve have been using *O. dactylophylla* for a long time and its roots are reported to find their way to neighbouring Tanzania and Zambia (Mtambo, pers. comm., July 2005). Unless the status of a plant species in the wild and its values are known, appropriate management practices for such a species would not be developed. According to Agea *et al* (2007), establishing good knowledge of a species' ecology and uses by the local communities would provide appropriate protection for that species.

The role of traditional knowledge[1] in biodiversity conservation and sustainable use[2]

The role of traditional knowledge (TK) in biodiversity management cannot be overemphasized. Due to long periods of interaction with forests, local communities are embodied with knowledge not only about uses of plants but also "detailed knowledge of plant ecology" (Ticktin 2004). They are not only aware of local distributions and habitats for specific plant species, plant history traits and values to human uses (Fernandez-Gimenez 2000), but they also host enormous knowledge and experiences in resource management (e.g. Kristensen and Lykke 2003; Springuel 2005).

According to Byg and Balslev (2001) and Shackleton *et al* (2002), local communities, being resource users, become the first to recognise and experience changes, temporal as well as spatial, occurring in populations of species. This knowledge, if extensively and properly investigated, could be used to document and enable in the development of appropriate management and monitoring plans for Malawi's biodiversity.

A number of studies have suggested that certain traditional practices contribute to the conservation, maintenance and sustainable utilization of biodiversity (e.g. Shepherd 1992; Cunningham 1993; Mgumia and Oba 2003). Practices and/or beliefs including animal grazing, sacred groves, taboos, protection of individual species for religious and cultural practices, and use of fire have been cited. The sustainability of such practices and beliefs is however uncertain.

Several factors contributing to the loss of TK and practices, and consequent loss of biodiversity have been reported including rapid cultural change and loss of control over resources by local communities (Gadgil *et al* 2000; Lin 2005; Tardío *et al* 2005). In addition, the increase in human population pressure on limited resource bases and changes in life patterns cannot be overlooked - for slow growing, multipurpose plant species, with limited distribution become more scarce as demand increases (Cunningham 1997; Martin *et al* 2000).

In developing countries, where the human population is also fast growing, the larger part of the population lives in rural areas deriving resources from the wild to compliment its healthcare and nutritional requirements. The most widely quoted estimate of over 80% of the population derives resources from the forest (WHO[3] 2002; Schippmann *et al* 2003). In this respect, Malawi is not an exception. Over 85% of its population lives in rural areas, relying on wild biodiversity as a compliment source for livelihood.

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[1] Local or indigenous knowledge developed and informally passed on over generations
[2] Defined in this study as using a species in way that does not reduce its future potential use to humans
[3] World Health Organisation

In the health sector, for instance, Malawi's rich biodiversity has provided a wide range of plants to meet the peoples' primary healthcare requirements since the country's medical system is predominantly traditional medicine (Maliwichi 1997). Yet, little work has been done to document traditional forest-related knowledge and practices; profile species that are vulnerable; investigate status of species in the wild; and implications of traditional use on such species (Malawi Government 2004a; 2004b). The importance of documenting TK against a background of rapid cultural change threatening the existence of this realm of knowledge has however underlain international debate (Agrawal 1995; Gadgil *et al* 2000; Maikhuri *et al* 2000; Alves and Rosa 2005; Fassil 2005; Tardío *et al* 2005).

Nonetheless, not all traditional practices or beliefs have a positive contribution towards conservation and sustainable use of biodiversity. Local over-exploitation of certain plant species and use of improper harvesting methods have been associated with traditional use. Some traditional uses have been reported to cause local extinction of species or changes in population structure of plant species (e.g. Cunningham 1997; Fernandez-Gimenez 2000; Byg and Balslev 2001; Shackleton *et al* 2002; Stagegaard *et al* 2002; Ticktin 2004; Springuel 2005).

If we agree that every plant has potential medicinal values, and in tandem with the call by the WHO (2002) to integrate traditional medicine in national health systems, then it is envisaged that there will be an increasing pressure on plants with potential multipurpose medicinal values. The greatest pressure therefore will be on slow growing species, with poorly known distributions such as *O. dactylophylla*. This will especially be critical in countries where databases of important species in use and their status in the wild are non-existent or remain rudimentary.

Due to its poorly known distribution and in the light of rapid erosion of traditional knowledge, habitat loss and fragmentation resulting largely from extension of agricultural activities, and unsustainable harvesting methods that are often associated with seemingly scarce but favoured species, the population of *O. dactylophylla* might be dwindling. Agea *et al* (2007), contends that a population of species preferred by local communities often deteriorates and becomes locally extinct with each harvest. For potential medicinal plants, this becomes critical when there is a shift from household traditional use to trading the plant parts to urbanized people in need of primary healthcare (Cunningham 1993).

According to Cunningham (1993), market demand can undermine the rural resource base by causing over-exploitation of favoured but often slow growing species. Understanding how local communities utilize *O. dactylophylla* in Malawi and knowing its status in the wild would undoubtedly be instrumental both to the Forestry Department and the local communities to come up with appropriate management and monitoring practices for this species and other useful plant species in Mubanga Forest Reserve.

Purpose of study

The main purpose of this study was two-fold: to determine the abundance and distribution of *O. dactylophylla*; and investigate its traditional uses by local communities in Malawi as a way of establishing its baseline information that would contribute to its management and sustainable use.

The study endeavoured to address four specific questions namely: (1) how is *O. dactylophylla* utilized by the local communities around the Mubanga Forest Reserve? (2) what are the perceptions of the local communities in Mubanga area on the conservation of *O. dactylophylla*? (3) is there any mechanism to ensure sustenance of traditional uses of medicinal plants including *O. dactylophylla* among the youth of Mubanga area? (4) what is the current abundance and distribution of *O. dactylophylla* in the Mubanga Forest Reserve?

Assumption

The most critical methodological assumption made in this study was that the local communities would be available for interviews and willing to divulge information on traditional uses of *O. dactylophylla* especially that which they consider sacred.

Materials and Methods

Site description

Mubanga Forest Reserve, approximately 1263 hectares, is one of the 21 proposed state forest reserves across the country (Malawi Government 2004c). Located at 9°45' S, 33°18' E in the southern part of Chitipa District in the extreme north of Malawi, the reserve is approximately 7 km south of the district headquarters along Chisenga-Nyika road and about 340 km from Mzuzu - the regional administrative headquarters of the northern region in the country. It was proposed a forest reserve in 1982, following negotiations that took place between government agencies and local leaders in the area from the early 1980's.

Based on the country's 1998 population projections, Chitipa District has a population of nearly 160,000 people against the country's 12 million (Malawi

Government, 1998). Like most parts of the northern region, the district has undulating hills and plateaus with high altitudes of up to 2000 m above sea level. The altitude in the reserve ranges from approximately 1228 to 1313 m above sea level.

Climate is sub-tropical characterised by large seasonal variations in temperature and rainfall with two distinct seasons. A warm wet season is experienced from November to April, during which 95% of annual precipitation takes place; and a dry season runs from May to October (although during the same period, a cool, dry winter is evident from May to August). The mean annual minimum and maximum temperature range from 16ºC to 18ºC and 24ºC to 28ºC, respectively, and mean annual rainfall ranges from 801 to 1000 mm (Malawi Meteorological Services http://www.metmalawi.com/climate/climate.php).

The vegetation in the Mubanga Forest Reserve is dominated by scrub and light forest of miombo woodland. It is a secondary forest with a smaller part of the reserve (about 205 ha) planted with *Eucalyptus* sp. to provide fuelwood and construction material while the rest is indigenous forest (Fig. 1).

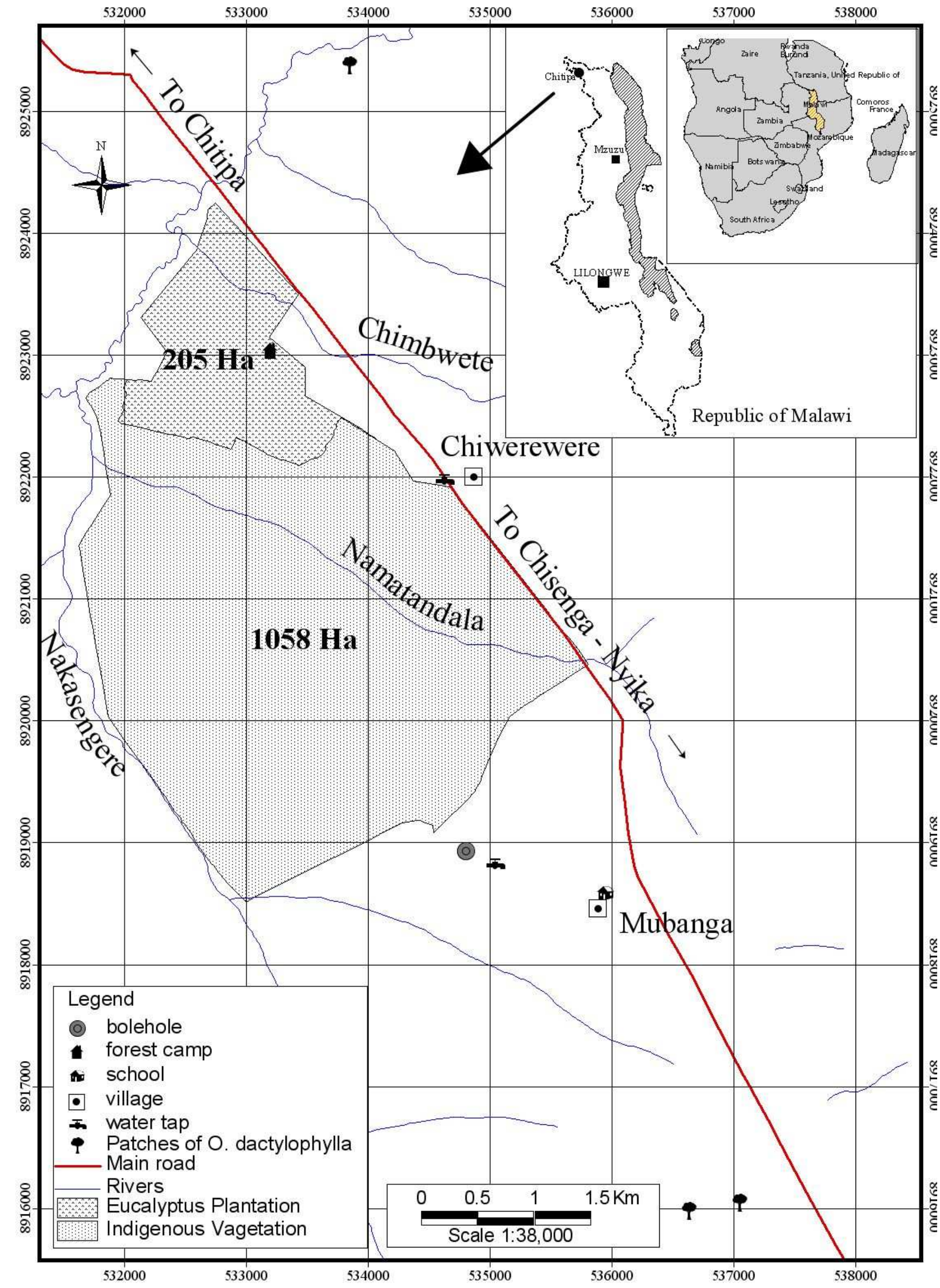

Fig. 1. Mubanga Forest Reserve in Malawi

The reserve is surrounded by a culturally rich local community with over 15 spoken dialects owing to the district's ethnic tribe diversity that include *Bandiya*, *Bemba*, *Lambya*, *Mambwe*, *Namwanga*, *Ndali*, *Ngonde*, *Sukwa*, and *Tumbuka* among others. They mainly belong to two main villages namely Chiwerewere to the north and north-east, Mubanga to the south and south-west; a smaller village, Namuyemba is to the western side of the reserve. Like the majority of rural Malawians, the local communities around the Mubanga Forest Reserve practice subsistence agriculture on small land holdings of less than 1 hectare per household comprising of six persons on average. Their main crops include tobacco, groundnut, millet, maize, field bean, cassava, and fruits such as pawpaw. Livestock include pigs, cattle, goats, and poultry. Their income is mainly generated from sales of either farm produce particularly tobacco, groundnuts, millet and livestock; or fire wood and charcoal.

Preliminary survey

A reconnaissance visit to the reserve was done in July 2006 to seek prior informed consent (PIC) from the district assembly, the district forestry office, local leaders (village headmen) and their subjects. Both the study objective and methodology were explained to the local authorities and rapport was established with local communities, courtesy of assistance from two agricultural extension staff in the area, Messrs Lewis L. Lwinja and Petros M. Mulenga. The two assistants were trained on how to administer a questionnaire. Furthermore, four test questionnaires were conducted together with the two assistants as a way of complimenting the training exercise and checking some flaws in the questionnaire; responses from this exercise were not included in the analyses.

A preliminary forest survey was also conducted and showed that the official map obtained from the District Forestry Office was different from the ground map. A few check points using a Garmin® etrex legend Global Positioning System (GPS) receiver revealed that negotiated forest boundaries had been encroached over time. A new map of the reserve (Fig. 1) was therefore drawn following the current reserve firebreak with assistance from two forest guards, Messrs M. Silweya and K. Mumba. It was observed from random walks in the reserve that *O. dactylophylla* was scarce and depicted somewhat an aggregated pattern where it was found.

Research design and data collection

The study was divided into two parts, ethnobotanical and forest surveys generating both qualitative and quantitative data.

Ethnobotanical survey

Interviews using a semi-structured questionnaire were used to obtain ethnobotanical information from the local communities around the reserve. Purposive and snowball (network) sampling techniques (e.g. Tongco 2007; Soehartono and Newton 2000; Giday 2001; Stagegaard *et al* 2002; Simsek *et al* 2004) were used to select sample units for interviews.

Since the purpose was to obtain as much insight into the uses of *O. dactylophylla* as possible, and recognizing that traditional knowledge (TK) is more concentrated in the elderly (e.g. Maikhuri *et al* 2000; Giday 2001; Letšela *et al* 2003; Gemedo-Dalle *et al* 2005; Springuel 2005; Tardío *et al* 2005), and that vast knowledge about forest trees is in individuals that spend most of their time in forests (Stagegaard *et al* 2002; Letšela *et al* 2003; Gemedo-Dalle *et al* 2005), only key informants were interviewed (e.g. Soehartono and Newton 2000; Giday 2001; Stagegaard *et al* 2002; Martin 2004; Fassil 2005; Garcia 2006). Key informants have been reliable in providing information on plant uses (e.g. Gustad *et al* 2004; Garcia 2006; Tongco 2007), though at times they have also provided misleading information or have tended to be secretive (Maikhuri *et al* 2000), rendering the whole purpose of interviewing useless.

In spite of certain shortfalls such as bias stemming from "intrinsic behaviour" of the interviewer (Frankfort-Nachmias and Nachmias 1996) and formal relationships between the interviewer and respondent (Richards *et al* 2003); and its inability to capture seasonal changes in the use of natural resources such that "some important plant species may not be captured if the study is conducted within a short period of time" (Stagegaard *et al* 2002), the open interview method was chosen because of its strengths. The technique has a high response rate and draws out supplementary information from respondents apart from enabling the researcher control the whole process (Frankfort-Nachmias and Nachmias 1996). In addition, Stagegaard *et al* (2002) suggest that the technique provides a measure of level of resource use, of which this study was also striving to establish.

Two focus group discussions were held in the two main villages to select key informants. They involved village headmen, elders and agricultural extension workers. Informants were grouped into the following broad classes: (1) local traditional healers or herbalists; (2) the elderly (both men and women >51 years) and/or knowledgeable; (3) charcoal makers and/or fuelwood collectors; (4) woodcarvers and/or carpenters; and (5) livestock herders and/or hunters. Informants were contacted and arrangements were made when to conduct the interview. Furthermore, informants in each category were requested to link the researcher to other individuals in the community that qualified to be in the designated classes (e.g. Richards *et al* 2003). Apart from increasing the number of informants, this snowballing was also a way of verifying the inclusion of some informants in the designated classes.

A total of 66 informants (44 males and 22 females, their ages ranging between 20 – 90 years) were interviewed. Though the interview questionnaire was written in English, it was translated in *Tumbuka*, the language in which the interviews were conducted. Where respondents were uncomfortable with certain terms in this language, they were allowed to answer in their mother tongue and the translation was ably handled by Messrs Lwinja and Mulenga. *Tumbuka* is probably the common language in the northern region of the country and is also understood by most of the populace around the Mubanga Forest Reserve. It was learnt that *O. dactylophylla* is locally called *Nabonga*, a name that originates from the *Tumbuka* language, literally translated as “thank you” (Mtambo, pers. comm., July 2005).

The interview mainly evoked responses to the following areas: (1) knowledge of *O. dactylophylla* and how it was acquired; (2) uses of *O. dactylophylla*; (3) plant parts used, mode of preparation and storage; (4) harvesting (where collected, how and when including whether some harvested parts are traded); (5) perceptions on importance of *O. dactylophylla* in the area; (6) observed changes in the population of *O. dactylophylla* including factors causing such changes; (7) perceptions on the conservation of *O. dactylophylla*; and (8) knowledge transfer to the youth and perceptions on the attitudes of the youth towards TK in the modern era.

Uses were broadly categorised into medicine, food, construction, fuel (firewood and charcoal), and others. Appointments were made with informants regarding when to conduct the interviews. The interviewing process took place in the informants’ homes or at a place of their choice such as farms, and each session lasted between one to one and half hours.

Secondary information was sourced from Chitipa District Forestry Office, Chitipa Agricultural Office, Regional Forestry Office (Mzuzu) and the National Herbarium and Botanic Gardens of Malawi.

Forest survey

Based on observations from the reconnaissance survey that *O. dactylophylla* was depicting patchiness, the adaptive cluster sampling (Thompson and Seber 1996) was used to investigate abundance and distribution of *O.dactylophylla* in the Mubanga Forest Reserve. Adaptive cluster sampling (ACS) is becoming an attractive and appealing technique of sampling seemingly clustered and rare species (Philippi 2005). Though very little of this method has been applied in the field, let alone to plants, the approach is proving to be relatively more efficient than the conventional simple random sampling in capturing spatial distribution patterns and providing close approximations of study populations that are patchy and have low abundance (Smith *et al* 1995; Krebs 1999; Acharya *et al* 2000; Ishwar *et al* 2001; Vasudevan *et al* 2001; Hanselman *et al* 2003; Smith *et al* 2003), as the approach takes advantage of the spatial aggregation of populations (Philippi 2005).

The basic tenets of ACS are that initial sampling quadrats (primary quadrats) are selected and when target individuals are found in primary quadrats, then neighbouring quadrats are repeatedly searched for the target individual (s) and added to the sample until a network of quadrats is established (see Thompson and Seber 1996). Questions on how to select primary sample units; criterion for neighbourhood; threshold for rarity and patchiness to warrant ACS; and when to stop sampling have been dealt with elsewhere and debate still continues (e.g. Hanselman *et al* 2003; Smith *et al* 2003; Vasudevan *et al* 2003; Philippi 2005).

In this investigation, primary quadrats were chosen by simple randomization to sample *O. dactylophylla* (e.g. Ishwar *et al* 2001). The study map was divided into a 100 m-interval grid system. Quadrats were then assigned numbers starting from one. Using random digits, a total of 23 quadrats (covering nearly 2% of the total target area) measuring 100 x 100 m from a possible 1034 quadrats in the indigenous forest were selected (quadrats that were less than half the chosen quadrat size were excluded, a total equivalent of 24 quadrats). Advantages of larger plot sizes include providing better estimates of mean densities where species depict natural patches or "clumps" (Peters 1996; Sutherland 1996). In addition, it is relatively easier to locate large randomly selected plots in the field (reducing time spent on locating plots as is the case with smaller sample plots).

Quadrats were located in the field using the GPS. Temporary quadrats were laid out one at a time, and each quadrat was searched for *O. dactylophylla*. A total of six persons were involved in the search for the tree in each quadrat. During the search, two people with GPS handsets were assigned to walk on either side of each quadrat to confirm whether tree was inside or not. Whenever *O. dactylophylla* was found in the primary quadrat, neighbouring quadrats (referred to as secondary quadrats) of the same size were also searched on four sides of the primary quadrat. The condition for neighbourhood was based on occurrence of *O. dactylophylla* (diameter at breast height, DBH $\geq$2.5 cm).

Tree data on the following were collected: (1) number of *O. dactylophylla* in each quadrat; (2) DBH; (3) canopy height; (4) root and bark harvest to quantify human pressure following scale according to Cunningham (2001, Ch.4, pp. 96-

143); (5) GPS position for each *O. dactylophylla* tree sampled; and (6) shading i.e. whether tree was on open space or under shade. An arbitrary value of either 0 or 1 was assigned to quantify shading (where 0 = not shaded; 1= partly or completely shaded).

Diameter measurements were taken at 1.3 m from the ground, but if tree was branched at this height DBH was taken below or above it. Whenever a tree forked from the ground, DBH was calculated from sums of the squares of their DBH. A Suunto clinometer and DBH tape were used for taking tree canopy height and DBH measurements, respectively. Considering that *O. dactylophylla* is a slow growing species (Radcliffe-Smith 1996), and therefore in order to increase depth of information obtained from the sample, a minimum diameter limit of 2.5 cm was chosen in this study (Peters 1996). All individuals DBH <2.5cm, or height <2 m were considered juveniles and thus no measurement was taken on them apart from their numbers and GPS positions being recorded in each quadrat. In addition, counts of coppices were also recorded.

Voucher specimens of both *O. dactylophylla* and important plants that became evident during the interviews were collected and deposited at the Herbarium and Botanic Gardens regional offices in Mzuzu (Appendix 1).

Data Analysis

Microsoft Excel was used to summarise and analyse ethnobotanical information obtained from the interviews. Responses were coded to quantify information used in the analyses. *O. dactylophylla* was unknown to two informants out of the 66; the two were thus excluded in all the analyses.

Following Gomez-Beloz (2002) the following were calculated: reported use value (RU) of *O. dactylophylla* with the number of events being one (an event being the process of asking one informant on one day about the uses of *O. dactylophylla* they knew); plant part value (PPV), in this study expressed as a percentage; and specific use value (SU). Furthermore, in order to establish use importance within a particular plant part of *O. dactylophylla*, intra-specific use value (IUV) was also calculated, also expressed as a percentage in this study. RU values were broken down by number of uses reported for each part ($\Sigma RU_{plant\ part}$) (Table 1).

Table 1. Contractions used in the calculation of use values for O. dactylophylla

Contraction	Definition	Relationship/formula
RU	Ratio of the number of uses reported in each event by an informant	
ΣRU	Total number of reported uses for a plant	
$RU_{plant\ part}$	Number of uses reported for each plant part	
PPV	A value given for a specific plant part; it is equivalent to ratio between number of reported uses for each plant part and total number of reported uses for that plant	PPV = ($RU_{plant\ part}$/ΣRU)
SU	Number of times a specific reported use is reported by an informant	
$SU_{plant\ part}$	Number of specific uses for each plant part	
IUV	Ratio of specific use and reported use for a plant part	IUV = ($SU_{plant\ part}$/$RU_{plant\ part}$)

Data from the forest survey were summarised and analysed in Excel and Minitab 14. Data from the ACS was treated in a way that the number of primary quadrats with *O.dactylophylla*, cluster size (number of quadrats in a cluster or network), and density in a cluster were used as indicators of abundance of clusters, area occupied by a cluster and abundance of *O. dactylophylla* in a cluster, respectively (Vasudevan *et al* 2001). Density in a cluster was expressed as the number of *O. dactylophylla* per quadrat. Mean density ($\tilde{\mu}$) per quadrat and its corresponding variance was estimated based on the Hansen-Hurwitz estimator `eq. 1, 2´ (Thompson and Seber 1996) to provide an estimate of population density in the area. Edge quadrats[4] not considered part of the network (Philippi 2005), and thus not used in the calculations.

The Hansen-Hurwitz (*HH*) estimator:

$$\tilde{\mu}_{HH} = \frac{1}{n}\sum_{i=1}^{n} w_i$$

$$\widehat{\mathrm{var}}(\tilde{\mu}_{HH}) = \frac{N-n}{Nn(n-1)}\sum_{i=1}^{n}(w_i - \tilde{\mu}_{HH})^2$$

where w_i is the mean quadrat abundance (y_i/x_i) for quadrats in network i, (y_i is the number of individuals in the entire network, x_i the number of quadrats in the network i.e. network size), n the number of networks (initial quadrats) and N the number of possible quadrats from which n was chosen.

[4] Empty quadrats other than primary quadrats associated to a network.

Results

Knowledge and uses of *O. dactylophylla*

In spite of the knowledge gap on the existence of *O. dactylophylla* in the larger part of Malawi, and to science in particular, the interviews demonstrated that the species is a household name around the reserve. Only two out of the selected 66 informants did not know *O. dactylophylla* and its uses at the time of the interview. The two, a female and a male, had lived in the area for one year and 40 years, respectively. Probably the latter was evading further enquiries considering the time period he had lived in the area.

The major method of acquiring TK in Mubanga area is a combination of oral tradition and observation. The informants indicated different sources of their knowledge: the main one being their parents (66%), followed by herbalists (18%) and friends (11%). Some TK is also acquired from spouses and through dreams (i.e. spirit-given, according to the informants). Usually a daughter observes and understudies her mother and a son his father; and oral tradition is passed on in a step-wise manner as the child grows. Not very surprisingly therefore that most informants cited their parents as their sources of knowledge.

According to the informants, the method of sustenance of this knowledge is by memory and is mostly maintained within family set ups (91%). Only 6 of the 64 informants indicated documentation of their knowledge, and amongst them were some traditional birth attendants.

It transpired that the tree is mostly known and used for traditional medicine (cited by all informants) and least used as fuelwood (cited by only 4 of the 64 informants). Use categories for *O. dactylophylla* as reported by informants are summarised (Fig. 2).

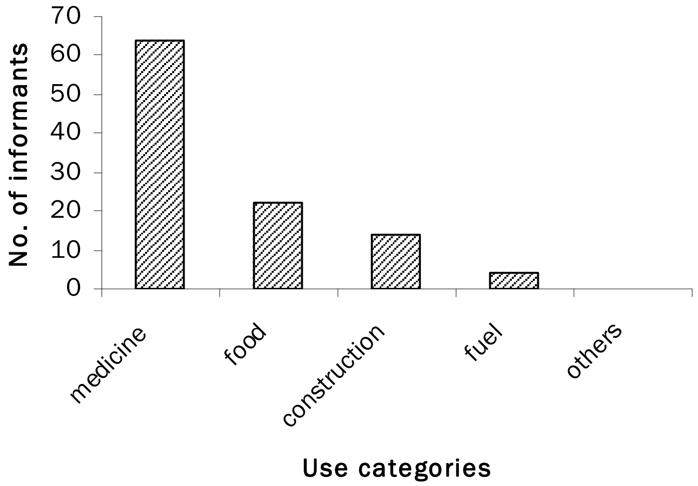

Fig. 2. Use categories for O. dactylophylla by number of informants around Mubanga Forest Reserve

Reported use values (RUs), plant part values (PPVs), specific use values (SUs), and intra-specific use values (IUVs) were determined (Table 2).

Table 2. Use table calculated for O. dactylophylla in Mubanga area

$RU_{plant\ part}$	PPV (%)	Specific reported use	SU	IUV (%)
136 (rt)	55	abdominal pain	34	25
		general body pain	25	18
		sexually transmitted diseases (STDs) e.g. syphilis, gonorrhoea	15	11
		body weakness (tiredness)	14	10
		malaria	13	9
		pneumonia	12	8
		purging	10	7
		coughing	3	2
		fever	2	2
		headache	2	2
		constipation	1	1
		abortion	1	1
		wounds	1	1
		swollen leg	1	1
		eye infection	1	1
		snake bites	1	1
70 (bk)	28	abdominal pain	15	22
		body weakness (tiredness)	11	16
		malaria	10	14

		STDs (syphilis, gonorrhoea)	8	12
		purging	7	10
		pneumonia	6	9
		general body pain	4	6
		headache	3	4
		coughing	2	3
		constipation	1	1
		eye infection	1	1
		sore throat	1	1
		snake bites	1	1
22 (fr)	9	fruit eaten	22	100
18 (st)	7	poles for construction	14	78
		firewood	4	22
2 (lf)	1	abdominal disorders	1	50
		abortion	1	50
ΣRU=248				

rt = root; lf = leaf; bk = bark; fr = fruit; st = stem; oth = others e.g. above ground parts

RU = reported plant value; PPV = plant part value; SU = specific use value; IUV = intra-specific use value

The root of *O. dactylophylla* is the most used part (PPV = 55%) and the leaf the least (PPV = 1%). The root has a number of uses, but abdominal pain, general body pain, sexually transmitted diseases (STDs), and body weakness or tiredness are its most important uses with IUVs of 25%, 18%, 11%, and 10%, respectively. From the IUVs of the bark it would appear, abdominal pain, body weakness, malaria, STDs and purging are its important uses with values of 22%, 16%, 14%, 12%, and 10%, respectively.

The fruit of *O. dactylophylla* was reported as being edible though this study did not establish whether it is eaten for its nutritional or medicinal values, and often it is difficult to separate the two.

There was a dissonance in responses regarding side effects resulting from the use of *O. dactylophylla* as a remedy against different ailments. No side effect was reported by 83% of the informants while 17% indicated to have had negative experiences and/or have heard of side effects particularly when pregnant women use the medication orally. Effects cited included abortion, sweating and vomiting.

Harvesting and human pressure

The interviews demonstrated that both the forest reserve and customary land serve as sources for *O. dactylophylla* for various purposes. Informants also indicated having a deep knowledge of the growing conditions for *O. dactylophylla* which include sandy soils especially in *dambo* land near forest margins.

No major harvesting occurs for fruits. According to the informants, fruits are usually consumed on the spot whilst in the forest. Poles are occasionally cut for construction and only few stumps (10) were observed coppicing in the sampling quadrats during the forest survey.

Human pressure was investigated in two ways: root and bark harvest. Dug-out sites were a common scene in the forest. However, only locations where remains of *O. dactylophylla* could be seen such as branches, stumps, roots, or juveniles sprouting from root remains were recorded. In the absence of such evidence, it was difficult to tell whether what was dug was *O. dactylophylla* or not. Consequently, only 20 dug-out sites were recorded in the sample plots.

Rating of diggings around trees also proved difficult as most areas were old or covered by soil resulting from run-offs. For practical purposes of quantifying magnitude of human pressure, each dug-out site was considered to have contained a single tree. Sixty nine percent of the trees had no diggings while nearly 20% had a few roots or only the tap root remaining, and 11% completely dug-out (n = 174). Root diggings representing human pressure are summarised (Fig. 3).

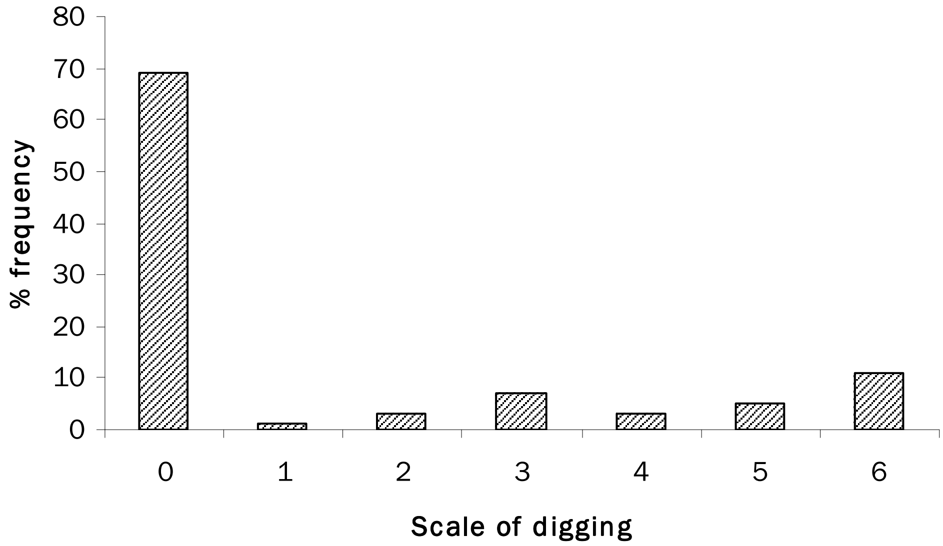

Fig. 3. Root harvest of O. dactylophylla in the Mubanga Forest Reserve
[Scale: 0 = no root removal; 1 = <15% of lateral root removed; 2 = up to 25% of lateral roots removed; 3 = up to 50% of lateral roots removed; 4 = up to 75% of lateral roots removed; 5 = >75% of lateral roots removed; and 6 = total lateral root & taproot removed i.e. whole tree removed. Adapted and modified from Cunningham (2001), p. 141].

For medicinal purposes, generally older trees and not juveniles are preferred for harvesting. According to the informants, trees with DBH >2.5 cm are preferred (Fig. 4).

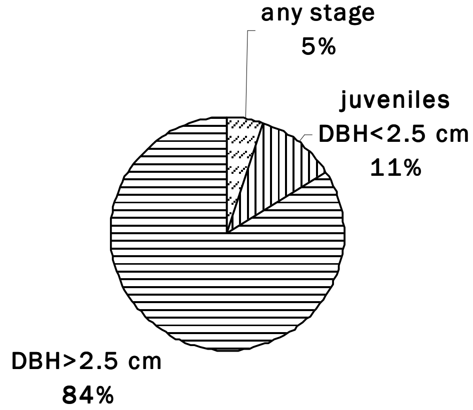

Fig. 4. Growth size stages of O. dactylophylla harvested in and around the Mubanga Forest Reserve, based on informants

While younger trees are easier to dig, the informants reported that older trees are preferred for efficacy of the remedy and the need to have more material. Remedy extracted from older trees is believed to be more efficient due to the relative higher concentration of active ingredients. The need to obtain more material from a single harvest could be a manifestation that the tree is of value and yet scarce.

Observations from the forest survey confirmed this preference of harvesting higher DBH size classes. Regression analysis (Fig. 5) shows a tendency towards the digging of older trees though it is somewhat weak ($r^2 = 0.194$, $P < 0.001$, n = 153).

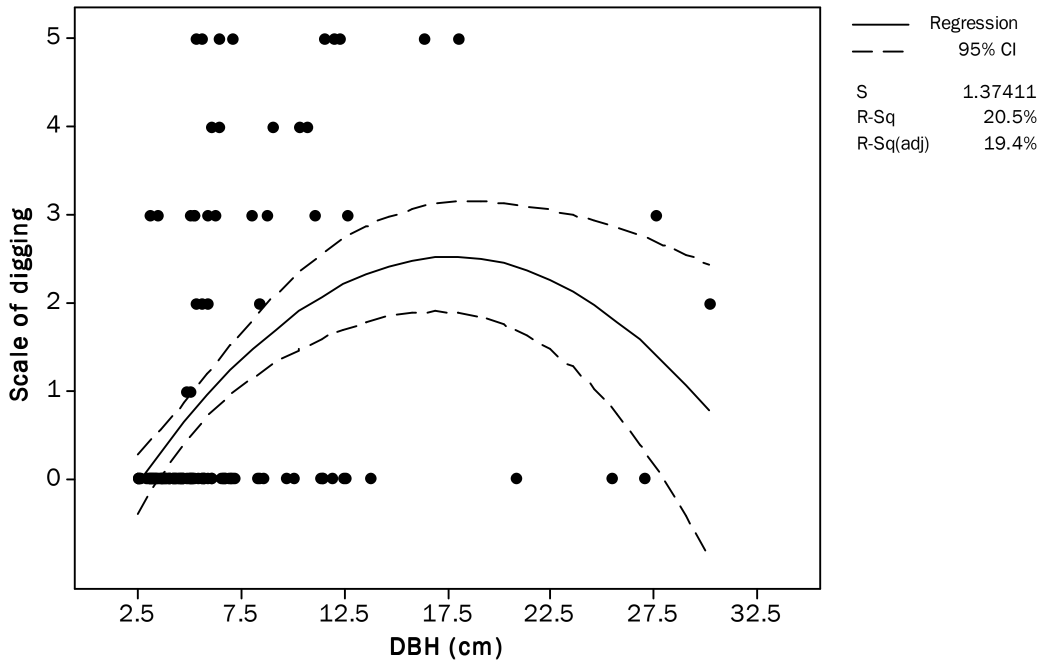

Fig. 5. Quadratic regression analysis of diggings with DBH changes of O. dactylophylla in the Mubanga Forest Reserve
[Scale: 0 = no root removal; 1 = <15% of lateral root removed; 2 = up to 25% of lateral roots removed; 3 = up to 50% of lateral roots removed; 4 = up to 75% of lateral roots removed; 5 = >75% of lateral roots removed. Scale 6 (whole tree dug-out) not presented. Adapted and modified from Cunningham (2001) p. 141].

Figure 5 shows a preferable DBH size range of approximately 3.00 to 15.00 cm. When trees with diggings were pooled together, the Mann-Whitney U test gave a mean DBH of 9.00 cm and median of 6.40 cm (n = 34, P <0.001). The minimum and maximum DBH size found dug in the forest was 3.00 cm and 30.20 cm, respectively.

While it was expected that the preference would increase with the increase in DBH size class, the regression is uncertain and does not predict this tendency as depicted by the confidence interval which tends to widen with increasing DBH size. From the forest survey, it was observed that very few trees (nearly 5% of the total sampled) had a DBH >15 cm; and only two of these had diggings.

Some of the dug-out scenes in the reserve were as shown below (Fig. 6).

Fig. 6. O. dactylophylla dug out for roots in Mubanga Forest Reserve. Juveniles on the right corner of bottom picture. [Photos: Leonard Manda]

It was observed that when a tree was completely dug-out, root remains would sprout.

Bark removal was not frequent during the forest survey. Of the trees sampled, only 5 trees were observed to have the bark removed from their stems. This suggests that probably there was a misunderstanding on the source of bark. It is most likely that a number of informants were referring to the bark scrapped from the harvested root and not from the trunk. Two of trees were as seen below (Fig. 7) and bark removal was rated (rating = 1). Rating of the bark removal was also a challenge as some marks were extremely old.

DBH = 12.7 cm DBH = 5.6 cm

Fig. 7. Bark removal for medicinal purposes from O. dactylophylla tree in Mubanga Forest Reserve

[Scale 1 = small patches removed, <10% of trunk bark usually for local use; Scale adapted and modified from Cunningham (2001), p. 136]. Photos: Joel Luhanga and Leonard Manda.

Various tools are used for harvesting the tree in the area but a hoe and axe make an ideal combination. According to the informants, rituals are uncommon when collecting or digging *O. dactylophylla* and there appears to be no particular season or time that influences harvesting. The tree parts are collected when need arises.

It is claimed that the tree roots are sold across the borders to neighbouring Tanzania and Zambia, but surprisingly interviews with the local informants did not support this claim. No key informant reported the existence of such a practice. It is worth mentioning though that prior to the time this study was being carried out, there was a rough historical evacuation campaign the previous year (September 2005) that saw encroachers evacuated from the reserve and memories of this event were still fresh in the minds of the local communities. Certainly, informants might have been harbouring some fears and this might have affected their responses particularly on issues pertaining to trade of the plant roots. Probably they might have considered the issue sensitive. Only two of the 64 informants reported the selling of some roots to people coming from other places within the district and other districts too such as Karonga where the plant is apparently not known to occur; perhaps these act as middlemen if claims of cross border trade are indeed valid.

Preparation, method of administration and storage

According to the informants, *O. dactylophylla* is usually used solo except for a few selected cases where a mixture is used with other plant species such as *Cassia abbreviata* Oliv. Preparation procedures, method of administration and period the remedy ought to be taken varies according to kind and severity of ailment. It was observed that procedures for similar ailments would vary from different informants. Often the root or bark is soaked in cold water and the decanted liquid is either taken orally or used in preparing porridge. Where storage of plant parts occurs, roots are dried and kept whole or grounded into powder. On the other hand, where leaves are used, fresh ones are preferred.

At the request of the informants, and due to ethical and rights considerations, detailed preparation methods and prescription are with held from publication.

How important is *O. dactylophylla* in Mubanga area?

Since the interviews demonstrated that *O. dactylophylla* is known for its medicinal values, a simple rating based on informants' consensus was used to determine whether or not *O. dactylophylla* was regarded as one of the more important medicinal tree species in the Mubanga area. The informants were requested to freelist alternative plant species to *O. dactylophylla* for the uses they knew. Seven species were mentioned with *Cassia abbreviata* Oliv. (34%) and *Vernonia amygdalina* Del. (20%) being the most cited species (Table 3).

Table 3. Alternative medicinal plant species to O. dactylophylla in the Mubanga Forest Reserve

Scientific name	Family	% Frequency
Cassia abbreviata Oliv.	Fabaceae	33
Vernonia amygdalina Del.	Asteraceae	20
Zanthoxylum caribaeum Lam.	Rutaceae	14
Diplorhynchus condylocarpon Pich.	Apocynaceae	2
Albizia adianthifolia W. Wight.	Fabaceae	2
Julbernardia paniculata Troupin.	Fabaceae	2
Maprounea africana Muell.Arg.	Euphorbiaceae	2

According to the informants, the reported species are not a complete replacement for *O. dactylophylla* but are used in particular selected cases, and often used in concoctions with *O. dactylophylla* particularly as remedies against abdominal pain or STDs. Nearly 25% of the informants did not provide any alternative plant species to *O. dactylophylla* for the reported medicinal uses.

At the mention of a plant species or more, each informant was requested to compare them with *O. dactylophylla*. A checkerboard was used with a list of species on both sides (vertical and horizontal sides) so as to compare every other species with another. Forty nine percent ranked *O. dactylophylla* as an important medicinal plant against its alternatives while 23% indicated that they would replace it with *C. abbreviata* for a few selected health conditions including malaria (Table 4).

Table 4. Rank order of importance of medicinal plants according to the informants (n = 48)

Name of species	% Frequency
Oldfieldia dactylophylla	49
Cassia abbreviata	23
Vernonia amygdalina	14
Zanthoxylum caribaeum	6
Diplorhynchus condylocarpon	2
Albizia adianthifolia	2
Julbernardia paniculata	2
Maprounea africana	2

Perceptions on population changes of *O. dactylophylla* and its conservation in Mubanga area

Local communities in Mubanga area proved to have adequate knowledge about their resource bases including knowledge about the growing conditions of *O. dactylophylla*; detailed knowledge about its distribution and demographic changes that have occurred in the population of the species with time including probable causative factors for such changes.

Eighty four percent of the informants stated that there has been a drastic decrease in the abundance of *O. dactylophylla* in the area, lamenting that the "tree is now scarce and one has to walk long distance to fetch it". Only 5 of the informants (representing 8%) reported the increase in abundance of *O. dactylophylla*, citing that the species is colonizing new places/patches as evidence for such claims. Another 5 of the informants indicated that there has been no obvious change in the abundance of *O. dactylophylla* around the area (Fig. 8).

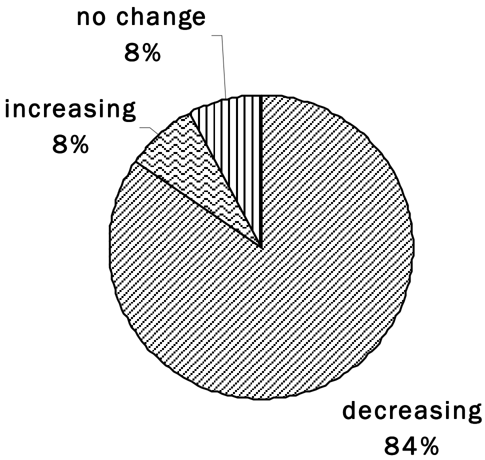

Fig. 8. Perceptions of the informants on the abundance of O. dactylophylla over time

Apart from abundance, local communities have also observed other changes in the population of *O. dactylophylla* for the past decade or so such as younger trees becoming dominant in the population (72%) and yet conversely, the tendency of the species to produce few fruits (9%). Another 13% of the informants indicated that older trees are becoming more dominant while 6% did not report any observed change.

They attributed the observed changes to factors such as over-collection (81%), [Table 5].

Table 5. Suggested factors causing perceived changes in the population of O. dactylophylla

Factors	% Response
over-collection	81
habitat loss/fragmentation	8
poor seed germination of the species	8
improper harvesting methods	3

According to the informants, more people are now using this plant than it was the case a decade or so ago with the increase in human population hence the over-collection. Only two of the 64 informants mentioned improper harvesting methods as a contributing cause to the perceived changes.

The interviews demonstrated that people in Mubanga area value *O. dactylophylla* and are concerned about its future. This is evidenced from their response when they were asked if they felt the need for conserving *O. dactylophylla*: "Yes! Because it is important to us; so the future generations can also benefit from it."

As an intervention, several ways were suggested including the need to practice proper ways of harvesting and/or prevent over-harvesting; finding ways of propagating the tree; and instituting village-by-laws to regulate harvesting of *O. dactylophylla* in the backdrop of the realization that traditional methods of harvesting have increasingly been abandoned.

Transfer of traditional knowledge (TK) to the youth and perceptions on attitudes of the youth towards plant use and conservation

Most of the informants (89%) indicated at the time of the interviews that they do share their knowledge with their siblings. Each informant reported to have imparted TK about plant use and conservation to three individuals on average by the time this study was being conducted. However, they pointed out that they are particular of whom to share their knowledge with, particularly traditional medicine, for they believe that doing it anyhow would affect efficacy of the remedy. The remaining 11% of the informants indicated at the time of the interviews that they had not yet shared their knowledge citing different reasons including not being requested, and fear of compromising efficacy of the medicine.

Knowledge transfer is done in several ways: the common one being a combination of word of mouth and observation (84%). Youth also acquire some knowledge by doing i.e. learning by doing (16%). However, the practice of documenting TK seems to be poor amongst the youth in the area. Of the informants that cited sharing of knowledge, nearly 78% demonstrated the lack of documentation amongst the youth.

The transfer of TK to the youth has however met obstacles in the modern era. Of the 64 informants, 86% lamented that youth are no longer interested in TK and traditional medicine in particular. Several factors contributing to the perceived negative attitude were given. The most prevalent ones mentioned included the rapid dilution of culture (acculturation) resulting from infiltration of other cultures/traditions and effects of modernization such as the availability of western medicine on the counter. These make the youth disregard TK and consider it outdated.

However, the informants still feel something could be done to promote TK amongst the youth and thus contribute to sustainable use and conservation of biodiversity. Civic education on values of TK (64%), and continuous "training" (19%) beginning within family institutions, were the suggested solutions perceived would improve the current status. Seventeen percent of the informants were noncommittal on possible way out.

Abundance and distribution patterns of *O. dactylophylla* in the Mubanga Forest Reserve

From a total of 23 randomly selected quadrats, *O. dactylophylla* was only found in six quadrats giving a frequency of 26 %. A total of 29 trees were recorded from the primary quadrats (a single tree in each of the four quadrats while the remaining two had nine and 16 trees respectively). The Poisson distribution showed that *O. dactylophylla* has a patchy distribution pattern with an index of dispersion, $I > 1$ (mean = 1.3; $s^2 = 11$; $\chi^2 = 241$). Following the ACS, the 23 primary quadrats translated into 23 distinct networks or clusters (Table 6).

Table 6. Data from the adaptive cluster sampling

Network/cluster	tree count	network size
1	0	1
2	1	1
3	0	1
4	0	1
5	141	25
6	0	1
7	0	1
8	9	1
9	0	1
10	0	1
11	1	1
12	0	1
13	0	1
14	0	1
15	0	1
16	1	1
17	0	1
18	0	1
19	1	1
20	0	1
21	0	1
22	0	1
23	0	1

With recursive sampling, nearly 9% of the total indigenous forest was sampled (i.e. 95 quadrats including edge quadrats). *O. dactylophylla* was registered in only six of the 23 networks sampled and network size varied from one to 25 quadrats (mean = 2.04 and median = 1.00). Therefore, where *O. dactylophylla* occurs it might be found in patches with a mean and median area of about 2.00 and 1.00 hectares, respectively. The largest network had the number of trees varying from one to 22 per quadrat.

The number of trees in a network varied from 0 – 141 trees, with a mean and median of 6.70 and 0.00, respectively. This was highly correlated with the network size influenced by the single large network (r = 0.998, P <0.001, n = 23). Density in network ranged from 0 – 9 trees/per quadrat; all primary quadrats without trees (17, network size of each = 1) had a density of zero. The mean density estimated from the *HH* estimator (eq. 1) was 0.81 trees/quadrat (var =0.19, n = 23). Thus, *O. dactylophylla* could be found as 1 tree/ha. The total population of *O. dactylophylla* in the reserve is thus estimated at 838 trees (the 95 confidence interval calculated at the critical $t_{0.05}$ value gives a range of -0.15 to 1.77 trees/ha).

A total of 110 juveniles were noted in the networks, 98% of which were in the largest cluster. All the 20 dug-out sites were also recorded in this cluster. Sprouts of root remains in the dug-out sites contributed to the majority of juveniles in this cluster.

Abundance distribution for growth size classes are as presented below (Fig. 9).

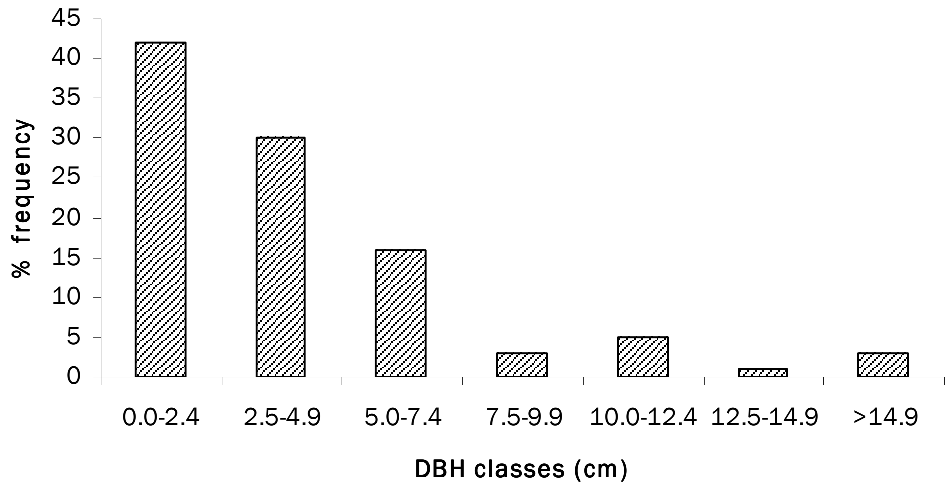

Fig. 9. Abundance of O. dactylophylla by DBH class in the Mubanga Forest Reserve

Most trees had small boles with a mean DBH of 6.30 cm and median DBH of 4.70 cm (n = 154, *P* <0.05). Very few trees were above 15.00 cm, the maximum DBH size recorded being 38.9 cm.

Juveniles were also an abundant growth stage of the population indicating that the few older trees present are probably regenerating well. Though not all distances between parent trees and juveniles were measured, but it was noted that they were usually found within a radius of approximately two meters from the parent trees. It was further observed that the tree flowers early in its growth stage. Some trees with DBH as small as 2.5 cm could be found in flower.

Furthermore, most trees were short with a mean height of 3.50 m and median of 2.00 m (n = 154; *P* <0.05), [Fig. 10]. The highest tree recorded was 9.00 m.

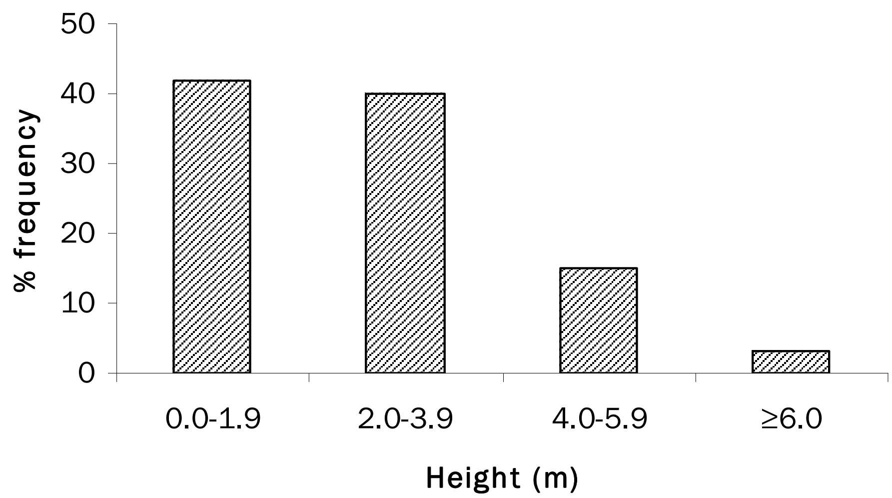

Fig. 10. Abundance of O. dactylophylla by height class in the Mubanga Forest Reserve

The terrain in the Mubanga Forest Reserve is in such a way that the land slightly slopes on the western side of the reserve, and where it slopes the soils become increasingly sandy loam as you approach the *dambos*. It was towards the *dambos* in the forest margins that *O. dactylophylla* mostly appeared to occur (Fig. 11).

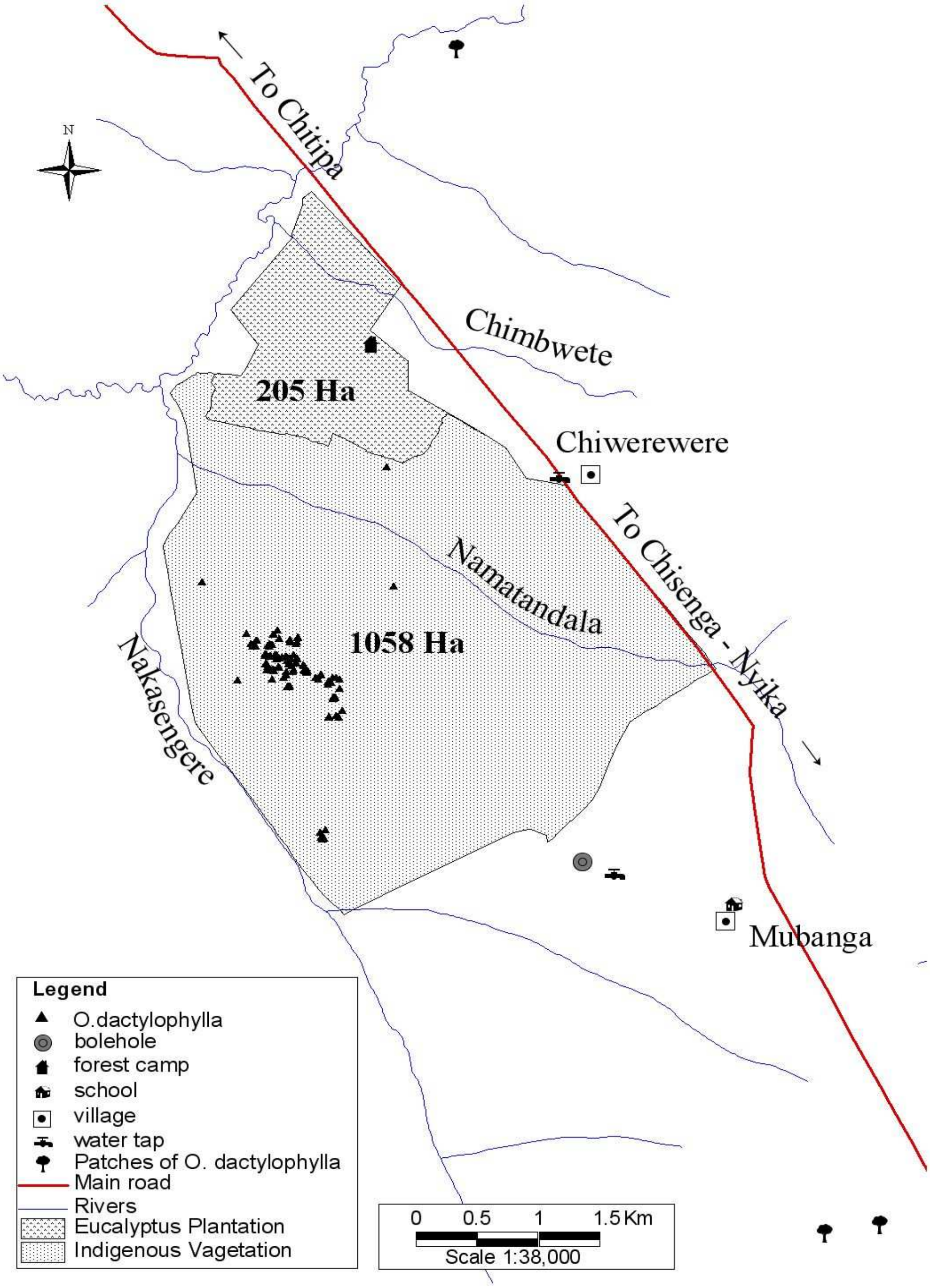

Fig. 11. Distribution of O. dactylophylla in the Mubanga Forest Reserve

Trees occurred at an altitude of 1268±13 m above sea level (n = 154; $P<0.05$). It was observed that only 14% of the sampled trees were found to be partly or completely under shade, suggesting that the plant prefers open areas. Even when it occurred amongst woodland forest, it was rarely under shade.

It was further observed that shrub species such as *Protea* spp. were also relatively common where *O. dactylophylla* was found growing. Other associated tree or shrub species were also noted in the sample plots (Appendix 2).

Discussion

Uses of *O. dactylophylla*, parts used and human pressure

The interviews demonstrated that *O. dactylophylla* is mainly used as a medicinal plant (Fig. 2). Despite the fact that fuelwood is the major source of energy in Malawi, satisfying about 90% of the country's energy requirements (Malawi Government 2002), yet *O. dactylophylla* appears not to be preferred for fuelwood (Fig. 2; Table 2). Probably this is a new use that the tree is being put into with diminishing priority species such as *Brachystegia* spp. It is likely that with a national deforestation rate estimated at 2.8% per year (Malawi Government 2002) and thus loss of priority species for fuelwood, certain species that appear to be non-priorities such as *O. dactylophylla* would become the only available options sooner or later.

The part of a plant species used determines the mode of harvesting and consequently, its likelihood survival (Byg and Balslev 2001; Stagegaard *et al* 2002; Okello and Ssegawa 2007). The observation that harvesting of *O. dactylophylla* for its root involves uprooting the whole tree poses a threat to the survival of this trees species in the Mubanga Forest Reserve. According to Okello and Ssegawa (2007), local extinction may occur when roots and reproductive parts of a plant are intensively and improperly harvested especially if there is insufficient time for regeneration. Based on the current findings though, it cannot be explicitly concluded that the tree is over-harvested. The results however do provide an indication that the species is prone to over-harvesting and unsustainable use with increasing number of users and possibility of trade. While a greater proportion of the sampled trees (69%) were found to have no diggings (Fig.3), it is expected that more trees would be dug out with the increase in number of users.

Since traditional knowledge (TK) is dynamic, and is knowledge and experiences tested over time (Kolawole 2001; Springuel 2005), it is most likely that some uses that did not have high informant consensus (or reported uses) and thus smaller IUVs are novel uses for *O. dactylophylla*. Some of the reported uses such as pneumonia and abdominal disorders have also been reported elsewhere (Bossard 1996), and this could suggest the efficacy of the medication against such health conditions.

The uncertainty towards the digging of bigger DBH size classes as demonstrated by the regression analysis (Fig. 5) could be explained by either one or a combination of the following reasons. Firstly, *O. dactylophylla* trees with DBH > 15 cm occur in very low frequencies in the reserve (Fig. 9) as a result of previous diggings that saw older trees being dug, or due slow growing nature of the species. It should be noted that the reserve is a secondary forest and was under customary land before it was negotiated a forest reserve and some areas were subjected to some kind of agricultural activities. The 20-year period or so since it was proposed a forest reserve might not have been adequate enough to allow this slow growing species to develop fully. Secondly, perhaps the deep root system that develops as the tree grows bigger makes digging strenuous and time consuming - certainly one would not want to be found digging the whole tree, lest he be nabbed by forest guards. Lastly, *O. dactylophylla* has generally a small bole, and Radcliffe-Smith (1996) describes the species as having a DBH of up to 25 cm. Both the first and the third reasoning appear to be somewhat linked to the intrinsic behaviour of the species.

How important is *O. dactylophylla* in the Mubanga area?

Although *O. dactylophylla* was chosen *priori* by the researcher, it was evident from the simple rating that it is considered one of the important species in the area (Table 4). Though some informants could have given responses to merely please the researcher, (and therefore these results should be taken with caution), the findings generally do give an indication that the tree is of value to the area. Its importance is arising from its use as a medication against a number of health conditions (Table 2).

Byg and Balslev (2001) noted in their study on a palm (*Dypsis fibrosa*) that often it is not the many uses that make a species important in the eyes of local communities; at times a single specific use value does. Byg and Balslev contend that importance of a species is area specific. If a species meets particular needs in a society then it is likely to be considered important in that area. For *O. dactylophylla,* it appears its painkilling and restorative effects make it a household name in Mubanga area though it is poorly known in other parts of Malawi.

The area is likely to have a number of important medicinal plants but this study dwelt on alternative plant species to *O. dactylophylla* and/or those plants used together with *O. dactylophylla*). Consequently, only a couple of plant species were cited as important species in the area by informants. Plant species such as *C. abbreviata* and *V. amygdalina* are arguably other important species in the Mubanga area. *V. amygdalina*, for instance, has been studied and is reported to be screened for antimicrobial activities (Kamatenesi-Mugisha *et al* 2007). A further investigation to profile useful medicinal plants in the area ought to be conducted.

Perceptions on population changes of *O. dactylophylla* and its conservation in the Mubanga area

Resource users are better placed to notice changes that occur in their resource bases (Shackleton *et al* 2001). According to Byg and Balslev (2001), local communities are also able to identify changes in population abundance, species composition and structure, including human induced changes.

The interview demonstrated that local communities around the Mubanga Forest Reserve do observe the decreasing trends in the abundance of *O. dactylophylla* in the wild (Fig. 8). In addition, they are also aware that these changes are mainly human induced resulting from over-collection. Obviously a question that would come to ones' mind is: "Why then do local communities continue over-collecting when they are quite aware that such practices deplete their resource bases?"

One possible explanation could be the rapid growth of human population against limited resources. This has exacerbated pressure on scarce, slow growing and limited distributed species that have potential medicinal values such as *O. dactylophylla*.

Rural communities in developing countries are also pressed with poverty. Poverty has been identified both as a cause and consequence of over-harvesting of natural resources, and the resultant has been degradation of the environment (e.g. Shingu 2005). Pressed by poverty, local communities often pay a blind eye to the damage they cause to favoured species and the surrounding environment. Developing basic appropriate information that is handy to local communities on sustainable means of harvesting of target species, and addressing poverty by means of providing appropriate ways of earning a living is not only important for sustainability of *O. dactylophylla* and other plant species but would also go a long way in maintaining healthy ecosystems for human development.

Another school of thought could be the effects of modernization. According to Tongkul (2002), modernization has brought along individualistic life styles and commercialization such that individuals are driven by greed and profit or material gain. These tend to make individuals in local communities disregard traditional community values about appropriate resource use and management.

Yet, another extremist view could lie in "if I don't get it somebody would get it type-of-thinking" a direct consequence of the tragedy of the commons, considering that harvesting of wild resources is often subjected to open access. This becomes more serious with rare and limited distributed plant species.

The fate of *O. dactylophylla* in Mubanga Forest Reserve and other surrounding areas lies in the hands of the local communities as they are custodians and resource users themselves. According to Gadgil (1995), local communities often see the need for sustainably using or conserving a species when (a) they are aware of its scarcity; (b) the exhausted species is irreplaceable; and (c) they have control over the resource base. Cunningham (1993) suggests that for a species to be conserved by local communities it must be of value to the local communities.

In the Mubanga area, it is the value local communities place on *O. dactylophylla* tree and the realization among local communities that the tree is becoming increasingly scarce that various conservation ways were suggested. It would appear that the local communities deliberately did not mention protected areas as one of the ways of conserving *O. dactylophylla* in the area. They might have had a feeling that this would mean restricting themselves from harvesting in the forest reserve. This study made them realize the responsibility they have in taking care of this scarce species as it was made clear to them that *O. dactylophylla* is apparently known to only occur in this area in the country.

Transfer of traditional knowledge (TK) to the youth and perceptions on attitudes of the youth towards plant use and conservation

Global trends in the loss of TK (e.g. Gadgil *et al* 2000; García-Serrano and Del Monte 2004; Alves and Rosa 2005; Tardío *et al* 2005) have not spared the Mubanga area. According to the informants, youths in the Mubanga area are becoming increasingly uninterested in TK and traditional medicine in particular. Acculturation and modernization have made the youth undervalue TK and consider it outdated. Modernization has also to some extent made middle aged elders, the would-be custodians of TK, disappear from villages in search for "better life" in towns and cities. The result has been subsequent loss of this long time acquired knowledge and experiences because life in town requires mastery of different skills altogether.

Gadgil *et al* (2000) and Tongkul (2002) report that modern medicine and spending of more time in towns (where schools are usually located) on the part of the youth are some of the issues making a package of modernization that is contributing to the loss of TK. Introducing and/or scaling up courses in school curricula such as anthropology, cultural heritage, ethnobiology, ethnoecology among others would promote TK values and conservation of biodiversity amongst the youth.

When all things are said and done about the factors that contribute to loss of TK, the factor of resource dwindling as reported by Maikhuri *et al* (2000) still remains valid, even though this did not come out clearly as one in this study. The loss of forests and thus loss of valuable species in the wild has rendered the transfer of TK especially on medicinal plants worthless. Traditional knowledge holders no longer have practical examples for young ones to observe and use since useful species that go along with such knowledge are no longer there largely due to anthropogenic factors such as over-collection and habitat loss.

Although the youth seem to be the major culprits in the loss of TK due to their losing interest, it could also be argued that some elders share the blame for remaining secretive and not ready to share their knowledge. The tendency amongst some knowledge holders to keep their knowledge secretive, particularly on plant medicinal uses and conservation practices, has been reported elsewhere (Maikhuri *et al* 2000; Fassil 2005). The belief that the efficacy of remedies would be compromised comes out as the major reason for being secretive although Fassil suggests that some traditional knowledge holders, especially traditional healers, feel they would lose their status in society if such knowledge became common knowledge.

Nevertheless, it appears not all is lost in the Mubanga area if the fraction of the informants (89%) that shares its TK with the youth is anything to go by. How much TK would be preserved in the process is a different question altogether considering various socio-economic factors that go along with modernization and the fact that most of this knowledge is not documented. Merits and demerits of documenting TK have been dealt with elsewhere (e.g. Agrawal 1995; Gadgil *et al* 2000; Maikhuri *et al* 2000; Alves and Rosa 2005; Fassil 2005; Tardío *et al* 2005), but the bottom line is that globalization with its material pursuits is taking its toll on TK. Appropriate documentation and use would make basic uses and values of plant species available to future generations for exploitation and conservation even when the present custodians of knowledge are long gone.

Abundance and distribution of *O. dactylophylla* in the Mubanga Forest Reserve

The findings show that *O. dactylophylla* is a rare tree in the Mubanga Forest Reserve. The large dispersion in the mean number of trees per quadrat is indicative of the large differences existing between quadrats in the networks sampled and between networks. The ACS has been shown to show similar trends when large differences exist between network sizes and density both between and within networks (e.g. Acharya *et al* 2000). The tendency of *O. dactylophylla* to occur in low frequencies in the wild was also reported in neighbouring Tanzania (Mgumia and Oba 2003).

Although the Poisson distribution depicted clustering behaviour and results from the primary quadrats indicated that the tree is rare in the reserve, the ACS did not demonstrate a high clustering pattern except for one network. It is possible that this is the only largest cluster existing in the reserve. The quadrat size used might also have been too large such that more than one network would be captured. With a possibility of more clusters existing, density per quadrat might be higher and its corresponding variance might be lower than the current findings.

In order to delineate different patches when studying this tree species, a relatively smaller quadrat size and a different method such as the systematic adaptive cluster sampling (SACS) could be used to come up with a closer population estimate, as this would capture different habitat heterogeneities (Acharya *et al* 2000). The ACS procedure did however show the spatial distribution than would have been demonstrated by the simple random sampling.

This study did not investigate factors causing spatial distribution and abundance of *O. dactylophylla*. However, low seed production, limitations in seed dispersal and failure of seeds to become seedlings are some of the intrinsic factors suggested to affect species spatial distribution patterns (Gaston and Kunin 1997; Donovan and Puri 2004); although some authors have related abundance and distribution to a species ability to utilize resources, persist, and evade competition exclusion (Eriksson and Jacobsson 1998). According to Linares-Palomino (2005), plant distribution significantly changes with changes in abiotic factors such as light, topography, nutrients, moisture and depth. Additionally, biotic factors including facilitative and competitive interactions or associations have been suggested to affect plant distribution patterns (Anderson *et al* 2001).

On the other hand, anthropogenic activities such as over-collection and improper methods of harvesting have also been reported to cause scarcity and subsequent loss of species elsewhere (Berkes *et al* 2000; Shackleton *et al* 2002; Gemedo-Dalle *et al* 2005; Springuel 2005). The exact cause (s) for scarcity and patchiness behaviour in *O. dactylophylla* are unknown and ought to be investigated.

Based on observations that juveniles tend to sprout either from lateral roots or remains of the dug-out roots, one could therefore argue that digging out whole trees is one of the disturbance regimes that ought to be promoted in the area as it appears to facilitate regeneration of this trees species. But a number of questions remain unanswered. How much should be dug-out? Under what conditions do root remains sprout? Whether this sprouting from root remains or lateral roots is an adaptive response to digging is also nebulous. Some species, for instance *Parinari* sp., were also noticed to show a similar kind of behaviour of coppicing from lateral roots although they did not have diggings. More work is thus needed particularly on seed biology, dispersal mechanisms and regeneration of *O. dactylophylla*. The ability for roots to sprout would provide potential material for propagation trials for this species.

The relative abundance of juveniles and small DBH sizes in the population of *O. dactylophylla* (Fig. 9) could be indicative that the species is regenerating well but has a poor survival rate. Most tropical or subtropical tree species have been shown to depict a similar kind of reverse J-shaped population growth curve (Hall and Bawa 1993). While emergence of more juveniles could be indicative of reproductive potential of a species, survival of such juveniles to higher DBH sizes or reproductive stages is important if a particular species is to persist.

Two broad factors might explain the relative high frequency for mid-size DBH classes. Firstly, it could be selective harvesting, methods and intensity of harvesting. The tendency towards harvesting larger trees might have left trees of lower DBH class over time, and these are now the only available options for digging. Alternatively, could it be the fact that the species is intrinsically slow growing and small-sized tree (Radcliffe-Smith 1996) such that those trees with a DBH >25 cm are outliers?

Conclusions

The potential use of *O. dactylophylla* as a medicinal tree coupled with its limited distribution range has put this tree species under pressure making it prone to over-collection and/or unsustainable harvesting. While results from this study do not explicitly show that the tree is over-harvested since over-harvesting is often linked to the existence of commercial trade, and on the other hand finding a common understanding on what is sustainable harvesting often proves difficult, but certainly the removal of whole plants for their roots cannot be considered sustainable if such practices are not regulated especially with the increasing number of users.

This study has shown that *O. dactylophylla* is rare and somewhat clustered in the Mubanga Forest Reserve. With each harvest and particularly the removal of trees, the tree would become increasingly scarce with the increase in the number of users since such harvest is unlikely to match its recruitment process. A similar status is expected in patches outside the reserve boundary, in the customary or private land where the species exists; although this may not be the case as certain resource users have often tended to consider public resources as government's sole responsibility and hence subject to abuse.

This investigation has also demonstrated that local communities recognize the values of maintaining the existence of a species and showed that they have the potential to conserve resources around them. However, pressing needs arising from socio-economic and demographic factors including poverty and population growth tend to force them pay a blind eye to the dwindling resource bases. Finding appropriate ways that would strike a balance between local needs and conservation is vital in the management of biodiversity.

Often conservation efforts are likely to succeed if such efforts address the local needs. The local communities around Mubanga Forest Reserve would want to see *O. dactylophylla* not only sustainably utilized but conserved for this generation and generations to come. The need for conserving *O. dactylophylla* is arising from the values they have found in this species and the realization that the species is increasingly becoming scarce. This calls for the involvement of local communities around protected areas, numerous ungazetted forest reserves and other key habitats in the country in the identification of local needs that would be included in developing appropriate management tools for such areas.

Local communities in the Mubanga area have also demonstrated to host a wealth of knowledge about their surroundings and changes that occur in populations of species around them including those arising from anthropogenic activities. This could also be true with other communities elsewhere in the country. This realm of knowledge could be harnessed and integrated with scientific knowledge and used in the mammoth task of identifying, describing and conserving Malawi's biodiversity.

However, rapid loss of TK on plants is of great concern for the conversation and management of biodiversity since loss of TK has been shown to have a consequent loss of associated biodiversity. How to address this loss in Malawi and beyond is not only a biodiversity, conservation, ecological, environmental or ethnobiological issue; it is an ethical, legal, socio-economical and political issue as well.

Recommendations

The following recommendations are proposed:

Research into the distribution of *O. dactylophylla* in the country ought to be conducted to determine its status at national level. The status of the species in its geographical distribution range should also be determined.

Propagation trials for *O. dactylophylla* ought to be conducted. These would provide seedlings that could be used for restoring the species in the wild. Some seedlings could be supplied to local communities around the reserve to raise in their home gardens for medicinal and other reported traditional uses.

Considerations to gazette the Mubanga Forest Reserve ought to be made and/or co-management practices initiated in the area and around many other forest reserves across the country that are likely to be in a similar state. While gazetting would ensure the reserve is recognized as public land and therefore legally protected, co-management practices would foster a sense of ownership of resources amongst local communities and thus promote sustainable use of such resources.

The cutting of trees for charcoal and firewood for sale at local markets to generate income is turning the reserve into a bare land. Appropriate alternative sources of income generating activities ought to be identified and promoted in the Mubanga area to reduce rural poverty and thus abate pressure on forest tree resources so as to maintain the indigenous forest biodiversity.

Chitipa District is one of the districts where the Government of Malawi intends to develop a Rural Growth Centre[5]. Against this background, it is envisaged that demand for fuelwood as a source of energy will grow tremendously with the increase in population that will eventually move to the district. It is important therefore that relatively fast growing tree species, suitable for the district and surrounding areas, be identified to provide fuelwood while possibilities of other alternative sources of energy are being sought.

There is need to scale-up investigations into TK and practices in Malawi to prevent complete loss of this knowledge and thus help conserve biodiversity associated with such knowledge.

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[5] Basically small rural towns with similar amenities like in cities.

Investigations ought to be done on cross border trade in medicinal plants, focusing on areas such as amount of the trade, estimated revenue generated, species involved and how loss of species through informal trade could be mitigated.

Rigorous investigations into useful medicinal plants for both humans and veterinary purposes ought to be done in the country. Information obtained from such investigations would be useful in the formation of the country's data base and/or monographs that could be used in promoting benefit sharing that might result from use of such resources or their parts. In addition, upon establishment of standard procedures and clinical evidence for efficacy, quality and safety, remedies from such species could be incorporated into the country's health system. Investigations of this nature would also reveal species that are more vulnerable to harvesting so as to find possible ways of sustainably utilizing them and/or protecting them from being completely lost.

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Appendix 1 Voucher specimens collected in Mubanga Forest Reserves

Scientific name	Botanical family	Specimen number*	Local name**
Cassia abbreviata Oliv.	Fabaceae	MLS/0106	Namayoka
Vernonia amygdalina Del.	Asteraceae	MLS/0206	Chisowoyo
Zanthoxylum caribaeum Lam.	Apocynaceae	MLS/0306	Pupwe
Julbernardia paniculata Troupin.	Fabaceae	MLS/0406	Nachilenje***
Maprounea africana Muell. Arg.	Eurphorbiaceae	MLS/0506	Kasamphanya***
Albizia adianthifolia W.Wight.	Fabaceae	MLS/0606	Munthenganthenga***
Diplorhynchus condylocarpon Pich.	Rutaceae	MLS/0706	Muntalembe***
Oldfieldia dactylophylla (welw.ex Oliv.) J.Leon.	Eurphorbiaceae	MLS/0806	Nabonga

* Specimen collected by Manda, Luhanga and Sibale

**Name as known in Mubanga area

***Species mentioned by a single informant

Appendix 2 Associated tree/shrub species of *O. dactylophylla* in Mubanga Forest Reserve

Scientific name	Family	Habit
Parinari curatellifolia Planch. ex Benth.	Chrysobalanaceae	tree
Hymenocardia acida Tul.var. mollis.	Euphorbiaceae	tree
Pseudolachnostylis maprouneifolia Pax.	Euphorbiaceae	tree
Catunaregam spinosa (Thunb.) Tirveng.	Rubiaceae	shrub/tree
Julbernardia paniculata (Benth.) Troupin.	Fabaceae	tree
Flacourtia indica (Burm.f.) Merr.	Flacourtiaceae	tree
Maytenus heterophylla (Eckl.f.Zeyh.) N.Robson.	Celastraceae	shrub/tree
Diplorhynchus condylocarpon (Muell.Arg.) Pich.	Apocynaceae	tree
Bauhinia thonningii Schum.	Fabaceae	tree
Pavetta schumanniana F.Hoffm ex K.Schum.	Rubiaceae	tree
Magnistipula butayei De Wild. subsp bangweolensis	Chrysobalanaceae	tree
Psorospermum febrifugum Spach.	Guttiferae	shrub
Multidentia crassa (Hiern.) Bridson & Verdc.	Rubiaceae	shrub
Rothmannia englerama (K.Schum.) Keay.	Rubiaceae	tree
Eriosema ellipticum Baker	Fabaceae	shrub
Combretum zeyheri Sond.	Combretaceae	tree
Ochna holstii Engl.	Ochnaceae	shrub/tree
Commiphora africana (A.Rich.) Engl.	Burseraceae	tree
Syzygium owariense (Beauv.) Benth.	Myrtaceae	tree
Combretum molle R.Br.ex Don	Combretaceae	tree
Isoberlinia angolensis (Benth.) Hoyle & Brenan	Fabaceae	tree
Bobgunnia madagascariensis (Desv.)J.H.Kirkbr. & Wiersema	Fabaceae	tree
Senna petersiana (Bolle) Lock.	Fabaceae	tree
Euphorbia matabalensis Pax.	Euphorbiaceae	tree
Ozoroa pwetoensis (Van der Veken.) R.&A.Fern. var. angustifolia	Anacardiaceae	Shrub
Catunaregum spinosa (Thunb.) Tirveng.	Rubiaceae	shrub/tree
Bridelia cathartica Bertol.f.	Euphorbiaceae	tree
Brachystegia utilis Burtt Davy & Hutch.	Fabaceae	tree
Terminalia sericea Burch. ex DC.	Combretaceae	tree
Syzygium guineense (Willd.) DC.	Myrtaceae	tree
Combretum collinum Fresen.	Combretaceae	tree
Vitex madiensis Oliv.var. Milanjiensis (Britten.) Pierper.	Verbenaceae	tree
Protea spp.	Proteaceae	shrub
Brachystegia boehmii Taubert	Fabaceae	tree

Trees identified with the help of Ibrahim Patel, a plant parataxonomist working at the National Herbarium and Botanic Gardens