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Harvesting of non-timber forest products and implications for conservation in two montane forests of East Africa

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ABSTRACT

Plant species-level research that comprises inventories, impact studies and monitoring is necessary if plant resources are to be harvested sustainably by human populations living adjacent to protected areas in sub-Saharan Africa. This research assessed the extraction of plant products from two montane forest ecosystems, Uzungwa Scarp Forest Reserve (USFR) and Bwindi Impenetrable National Park (BINP), East Africa. In USFR, data from vegetation sampling and interviews with local people were used to understand the ecological and socio-economic aspects of non-timber forest product (NTFP) harvesting. The densities of eight commonly harvested tree species, most of which were used as building poles, were approximately 2.4–4.5 times lower in disturbed versus undisturbed habitats across all four sites in USFR. Interviews with 91 women and 54 men suggested that most species were harvested for medicinal uses (57 species) and building purposes (50 species). In BINP, the liana *Loeseneriella apocynoides* (Apocynaceae), is harvested for basketry weaving. Evidence suggested that the liana was harvested in both protected and unprotected areas of BINP. Data collected suggested a negative impact on this species in an unprotected versus a protected area, with stem diameters larger than 1 cm significantly more abundant in the protected area. This study reveals that harvesting of NTFPs occurs even in these two protected forest areas, and that over-exploitation not only threatens species of high-demand, but could also alter forest structure and composition. Management practices that encourage the monitoring of sustainable harvesting levels of species and promote alternative plants for the same uses should be considered as part of conservation strategies.

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1. Introduction

The harvesting and consumption of plant products from natural forests is known to account for a large proportion of the livelihood of people living close to such habitats (Padoch, 1992; Godoy and Bawa, 1993; Carpentier et al., 2000; Dovie et al., 2002; Ticktin, 2005). The majority of these plant products are non-timber forest products (NTFPs), a term that encompasses biological materials used for purposes other than for commercial timber. NTFPs produced in tropical forests can be grouped into four categories (Conelly, 1985; Peters, 1990; Grundy and Campbell, 1993; Cunningham, 1996; Ayuk

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et al., 1999; Dovie et al., 2002): (i) fruits and seeds, with plant parts harvested mainly for fleshy fruit bodies, nuts and oil seed; (ii) plant exudates such as latex, resin and floral nectar; (iii) vegetative structures such as apical buds, bulbs, leaves, stems, barks and roots, and (iv) small stems, poles and sticks harvested for housing, fencing, fuelwood, and craft and furniture materials (e.g. carvings, stools).

Wild plants are an important source of edible fruits, leafy vegetables, and herbs, and are particularly important in ensuring food security and maintaining the nutritional balance in peoples' diets (Falconer, 1994; FAO, 1995). During famine, wild plants become essential to human survival, and at other times they both prevent the need for cash expenditure and provide a source of income to cash-poor households (Scoones et al., 1992; Guijt et al., 1995; Emerton, 1996; Cunningham et al., 2002; Guedje et al., 2003). Between 4000 and 6000 NTFPs have been cited to be of commercial value (Iqbal, 1993; SCBD, 2001), and as of 1997, at least 150 NTFPs had been documented as important in terms of international trade (FAO, 1997). It is estimated by the FAO that the total value of internationally traded NTFPs is about 1.1 billion US Dollars annually. However, the link between the economic benefits of NTFPs and their resource base (including local availability and sustainability) and sources is poorly understood (Hall and Bawa, 1993; Mendelsohn, 1994; Macía and Balslev, 2000; Ticktin et al., 2002; Stewart, 2003; Nakazono et al., 2004).

Inadequate information on the ecological productivity, growth forms, life history and conservation of the various species involved complicates management scenarios (Wickens, 1991; Zuidema, 2000), the setting of conservation priorities and defining sustainable harvest levels. The lack of adequate information has led some scientists to propose that intense harvesting of NTFPs is feasible because of the supposedly low associated ecological impacts (e.g. Boot, 1997). However, excessive extraction of forest products is likely to impact negatively on the population dynamics of the plants being exploited, leading to changes in community structure and organization (Moegenburg and Levey, 2002). Generally, it has been established that the overall ecological effects, impacts and responses of forest utilization are underpinned by floristic composition, the magnitude or intensity, and the modes and seasons of harvesting (Peters, 1994; Arnold and Ruiz Pérez, 2001).

Different parts of plants are harvested for NTFPs (Peters, 1994; Peters, 1996). Although the uses of these products are very different, their harvest may produce impacts that can be either beneficial or detrimental to the species. The actual impact of harvesting depends on the specific growth form or type of resource that is removed. Intensive and uncontrolled harvesting can reduce the abundance of solitary plants (Conelly, 1985; Peters, 1990; Grenand and Grenand, 1996; Stewart, 2003; Bitariho et al., 2006). Rising demands have caused the over-exploitation of many multi-stemmed species with collectors cutting plants too young or too close to the ground, which might inhibit re-sprouting. Kahn (1988) noted that harvesting of leaves may have a negligible effect on the plant population being exploited if: (i) individual plants are not killed in the process; (ii) a sufficient number of healthy leaves are left on each plant to photosynthesis; (iii) the reproductive structures and apical buds are not damaged, and (iv) sufficient time is allowed between successive harvests for the plant to produce new leaves. The harvesting of roots, bulbs and bark usually kills or fatally weakens the exploited plant species (Davenport and Ndangalasi, 2002).

In this paper, we examine NTFP harvesting in two protected areas of East Africa, the Uzungwa Scarp Forest Reserve in Tanzania and Bwindi Impenetrable National Park in Uganda. The objectives were to (i) document the plant used by local communities around protected Uzungwa Scarp Forest Reserve; (ii) assess the density of the plants in harvested and non-harvested sites in both study areas; and (iii) evaluate the harvesting of plant resources in these two protected East African highland forests.

2. Methods

2.1. Study areas

Our study sites are located in the highlands of Eastern Africa, which are heavily populated due to their good agricultural potential (Burgess et al., 2007a).

The Uzungwa Scarp Forest Reserve (USFR) (Fig. 1, total area 207 km^2) is located in the southern part of the Udzungwa

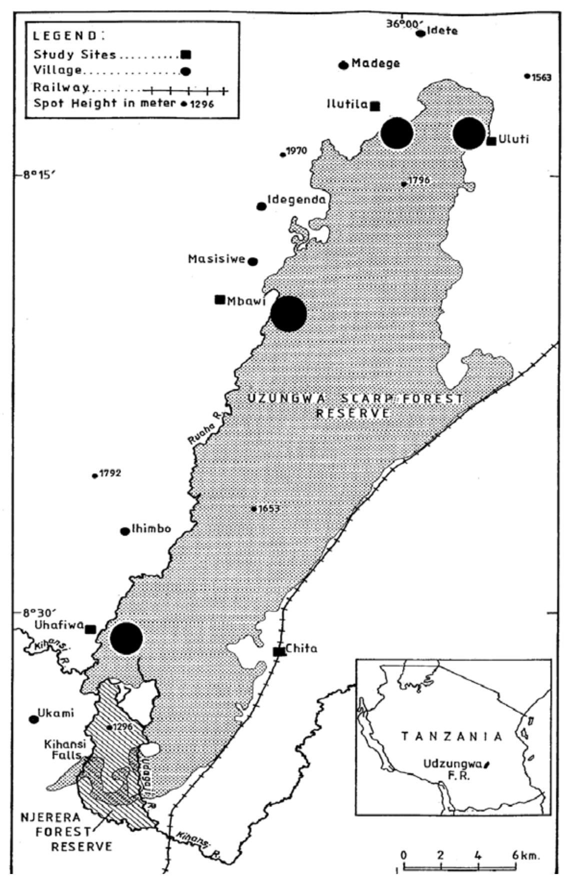

Fig. 1 – Map of the Uzungwa Scarp Forest Reserve, Tanzania, to show the location of four primary study sites (largest black circles). Disturbed sites were located within the forest reserve but tended to be closer to the primary villages (marked by smaller black squares) whereas undisturbed sites were farther away from these villages.

Mountain range which itself is within the Eastern Arc Mountains of Tanzania. This mountain range is recognized as one of the world's 25 biodiversity hotspots (Myers et al., 2000). USFR is one of the richest sites for biodiversity in this hotspot (Lovett, 1998; Dinesen et al., 2001; Burgess et al., 2007b). The USFR is classified as montane forest and has an altitudinal range of 300–2060 m above sea level. It is categorized as a protective forest where all types of extractive activities are prohibited. However, there are 19 villages around the forest and villagers obtain most of their NTFPs from USFR (Ndangalasi, 2004).

Bwindi Impenetrable National Park (BINP), in Uganda (Fig. 2, total area 331 km^2) was declared a world heritage site in 1994 and has been ranked as one of the most important sites for biodiversity conservation in the Albertine Rift (Plumptre et al., 2007). It is home to half of the world's endangered mountain gorillas (*Gorilla beringei beringei*). The human population density around Bwindi Impenetrable National Park in Uganda is about 600–700 persons per square kilometre (Uganda 2002 population census), one of the highest human population densities in Africa (Plumptre et al., 2003). Due to an expanding human population, there is a growing pressure on the already decreasing resource base and local households are finding it more and more difficult to generate adequate income to provide for their daily needs. Dependence on the forest is rising (Emerton, 1997).

Prior to it being gazetted as a park in 1991, BINP provided basketry and medicinal plant resources to the local community who had free access to forest resources, but local communities were denied access thereafter. In 1994, Uganda National Parks (now Uganda Wildlife Authority-UWA), supported by conservation and development organisations, started a multiple-use programme for communities of the 21 parishes adjacent to the Park (Mutebi, 1994). Under this programme, extraction of NTFPs by three pilot communities in so-called multiple-use zones was permitted in the park in exchange for community assistance with UWA's conservation efforts (ITFC, 1999). Since then, new multiple-use zones have been set up to cover parishes that did not benefit from the initial 1994 pilot phase (ITFC, 1999). Our study area focused on one such multiple-use zone (Mpungu, elevation 1200–2000 m a.s.l), where extraction of NTFPs is allowed, and a non-multiple-use zone (Kitojo, 2000–2400 m a.s.l), where resource extraction is not permitted by park management (ITFC, 1999; Bitariho et al., 2006).

2.2. Study design

2.2.1. Uzungwa Scarp Forest Reserve

Four sites with similar vegetation (Ilutila, Uluti, Mbawi, and Uhafiwa) were identified to represent the entire forest (Fig. 1) and sampled from January 1999 to December 2001. Participatory Rural Appraisal (PRA) methods were used to identify and document the availability and use of local NTFPs, with interviews conducted in local community households (Chambers, 1990; Martin, 1995; Mascarenhas et al., 1991; Cunningham, 2001). A stratified random sampling of households in each sample area was employed, covering 145 people (91 women, 54 men) representing about 15% of the households. Men and women were interviewed separately to give women more freedom to express themselves, given the inherent division of labour between men and women in the society under study. In addition, a female interviewer was used to interview women wherever possible. Semi-structured questionnaires were used to allow for open-ended responses by the interviewee. Questions

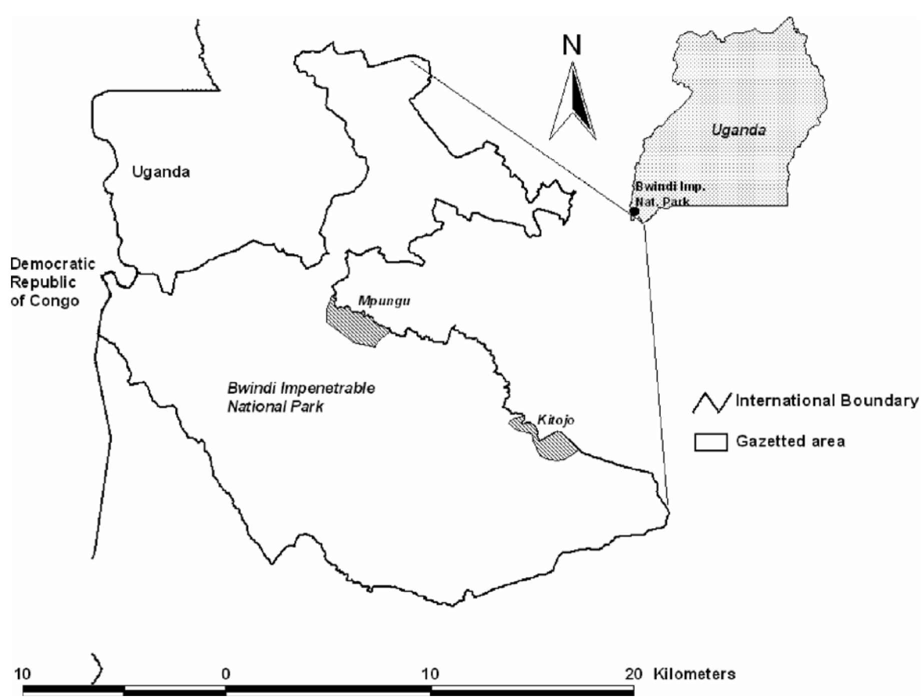

Fig. 2 – Study areas of Kitojo and Mpungu in Bwindi Impenetrable National Park, S.W Uganda.

most pertinent to this paper included the different plant species used by the household. The interviewees were required to list the species according to preference in descending order, for example species most preferred for building poles, fuelwood, medicines, weaving and basketry, tool handles etc.

Disturbed habitats (i.e. where the local community extract more NTFPs) and undisturbed habitats (areas with minimal or no signs of human extraction of NTFPs), were identified and located in each sampled area. We use the term “undisturbed” to make a clear distinction from “disturbed” habitat, but we recognize that these habitats did have some level of human activity. Following the methodology of Kent and Coker (1995), Martin (1995) and Murali et al. (1996), ten 0.1 ha plots were established in the form of a continuous 1000×10 m transect in both the disturbed and undisturbed habitat types in each of the four sites. In each plot, all trees with diameter at breast height (dbh) $\geqslant 10$ cm were enumerated and recorded by species. Where applicable, the local names were recorded and local uses of parts of trees and shrubs documented following consultation with local guides and village elders. Signs of use, such as debarking of trees, were also noted (Peters, 1994; Cunningham, 1996; Fashing, 2004).

2.2.2. *Bwindi Impenetrable National Park*

We studied NTFP use in Mpungu where plant resource extraction has been ongoing since 1994, and Kitojo where there were minimal or no signs of human extraction of plant resources (Bitariho et al., 2006). Plot sizes of 20×20 m were used for the assessment of the woody liana, *Loeseneriella apocynoides* (Apocynaceae) (Alder and Synott, 1992; Muhwezi, 1997). Sampling was carried out from February to April and July to August 2004. All individual stems and basal diameters were recorded in a total of 100 plots. After random establishment of the first transect, subsequent transects were located systematically with plots also placed systematically on either side of transects. Sampling covered the upper elevations of Mpungu and lower elevations of Kitojo so as to minimise potential climatic effects on this species’ distribution patterns. Signs showing evidence of harvesting of the focal species were also recorded.

2.3. *Data analysis*

To infer the overall effects of NTFP harvesting, we selected eight of the most commonly exploited tree species (see Table 2) present in both habitat types (disturbed vs. undisturbed) at each of the four sites. The density of each tree species was calculated based on the individual number of stems recorded within the 1 ha transect. We used a paired t-test to compare the densities of the eight species in disturbed versus undisturbed habitats at each of the four sites. Household data on the number of plant species used per category of use was analysed using a χ^2-test.

In BINP, we used a χ^2-test to test for an association between dbh size class and site (or type of resource use) of *L. apocynoides*. The size class was broken down into <1 and >1 cm dbh to reflect recruiting and mature individuals, respectively.

3. Results

3.1. *Uzungwa Scarp Forest Reserve*

3.1.1. *Extraction of NTFPs*

Seven categories of NTFPs were identified from the interviews in USFR (Table 1). The number of species among all NTFP uses was not equally distributed ($\chi^2 = 97.5$, df = 6, $p < 0.0001$). Fifty-seven species (20.2% of total) are exploited for medicinal use. Only two (0.7%) of 21 fruit and vegetable species collected from the reserve were used as vegetables, namely *Basella alba* (Basellaceae) and *Solanum nigrum* (Solanaceae); the rest were used as fruits. A list of the commonly exploited species in USFR is provided (Table 2).

3.1.2. *Density and distribution of plant species*

The densities of the most commonly extracted plant species differed significantly between the disturbed and undisturbed habitats at each of the sites. In general, the eight tree species had lower densities in disturbed compared to undisturbed habitats. Average densities were 2.4, 2.6, 3.6 and 4.5 times greater in disturbed as compared to undisturbed habitats for Uhafiwa (mean stem density ±SE = 53.9 ± 24.7, 22.5 ± 13.7), Uluti (38.5 ± 12.7, 15.1 ± 6.6), Ilutila (62.3 ± 16.3, 17.5 ± 3.9) and Mbawi (90.3 ± 38, 19.9 ± 9.6), respectively (Fig. 3). A list of the tree species observed in the study sites and their primary uses are included in Table 2.

3.2. *Bwindi Impenetrable National Park*

The diameter size class distribution of *L. apocynoides* in the two sites was significantly different with a greater proportion of small stems in the disturbed site (Yates corrected $\chi^2_{(df = 1)} = 10.21$, $p < 0.001$, Fig. 4).

4. Discussion

4.1. *USFR*

Most NTFP species fell into the categories of medicinal and building uses at USFR. Among the heavily exploited species for medicinal purposes are *Mkongwa* (in an unknown taxon currently under taxonomic study), *Strychnos mitis*, *Craterispermum longipendunculatum*, *Ocotea usambarensis* and *Allanblackia ulugurensis* because they are used either as an aphrodisiac and/or for curing ailments related to stomach-ache and

Table 1 – Summary of NTFPs categories identified in the field and corresponding number of plant species used

NTFP use category	Number of species used
Medicinal plants	57
Building poles	50
Wood fuel	35
Edible fruits and vegetables	21
Tool handles	9
Weaving and basketry	8
Thatch material	7

Table 2 – List of species preferred by the local communities around the Uzungwa Scarp Forest Reserve based on 145 interviewees

Species	Site	Use	Part(s) used
Acacia mearnsii (Leguminosae) *	Uh	Fuelwood, building	Stem, branches
Agauria salicifolia (Ericaceae)	Mb,Uh	Fuelwood, building	Stem, branches
Albizia gummifera (Leguminosae)	Ul, Il, Mb,Uh	Tool handles, building	Stem
Allanblackia ulugurensis (Clusiaceae)	Il	Medicinal	Bark
Anthocleista grandiflora (Loganiaceae)	Ul, Il, Mb, Uh	Medicinal	Stem bark
Aphloia theiformis (Flacourtiaceae)	Mb, Uh	Fuelwood, building	Stem, branches
Basella alba (Basellaceae)	Ul, Il, Mb, Uh	Vegetable	Leaves
Bersama abyssinica (Meliaceae)	Mb, Uh	Medicinal, fuelwood	Bark, stem, branches
Bridelia micrantha (Euphorbiaceae)	Mb, Uh	Fuelwood, building	Branches, stem
Canthium oligocarpum (Rubiaceae)	Ul, Il, Mb, Uh	Building	Stem
Cassipourea gummiflua (Rhizophoraceae)	Ul, Il, Mb,	Building, fuelwood	Stem, branches
Cassipourea malosana (Rhizophoraceae)	Ul, Il	Building, fuelwood	Stem, branches
Cleistanthus polystachyus (Euphorbiaceae)	Ul, Il	Building, fuelwood	Stem, branches
Commelina benghalensis (Commelinaceae)	Uh	Vegetable	Leaves
Craterispermum longipendunculatum (Rubiaceae)	Ul, Il	Medicinal	Stem bark
Cremaspora triflora (Rubiaceae)	Mb, Uh	Spear handles	Stem
Cryptocarya liebertiana (Lauraceae)	Ul, Il, Mb, Uh	Building, fuelwood	Stem, branches
Cyathea manniana (Cyatheaceae)	Ul, Il, Mb, Uh	Building, thatch	Stem, leaves
Cyperus exaltatus (Cyperaceae)	Ul, Il	Thatch	Whole plant
Dodonea viscosa (Sapindaceae)	Uh	Fuelwood, building	Stem, branches
Drypetes gerrardii (Euphorbiaceae)	Ul, Il	Building, fuelwood	Stem, branches
Embelia schimperi (Myrsinaceae)	Uh, Mb	medicinal	Leaves
Eucalyptus spp. (Myrtaceae) *	Uh	Fuelwood, building	Stem, branches
Galinisoga parviflora (Compositae)	Ul, Mb, Uh	Vegetable	Leaves
Gynandropsis gynandra (Capparaceae)	Mb, Uh	Vegetable	Leaves
Halleria lucida (Scrophulariaceae)	Ul, Il Uh,	Fruits, fuelwood	Fruits, whole plant
Harungana madagascariensis (Clusiaceae)	Uh	Building	Stem
Heinsenia diervilleoides (Rubiaceae)	Ul, Il	Building, fuelwood	Stem, branches
Hibiscus diversifolia (Malvaceae)	Ul, Il	Fibres for weaving	Stem bark
Hyperrhanea spp. (Graminae)	Uh	Thatch	Whole plant
Imperata cylindrica (Graminae)	Il, Mb	Thatch	Whole plant
Ipomoea involucrata (Convolvulaceae)	Ul, Il, Mb, Uh	Building as fibres	Whole plant
Kotschya spp. (Leguminosae)	Uh	Fuelwood, building	Stem, branches
Nuxia floribunda (Loganiaceae)	Mb, Uh	Fuelwood, building	Stem, branches
Pinus patula (Pinaceae) *	Mb	Building	Stem
Psychotria sp. (Rubiaceae)	Ul, Il, Mb, Uh	Building	Stem
Schoenoplectus corymbosus (Cyperaceae)	Ul,Il,Mb,Uh	Weaving baskets and mats	Whole plant
Solanum nigrum (Solanaceae)	Ul,Il,Mb,Uh	Vegetable	Leaves
Strombosia scheffleri (Olacaceae)	Ul, Il	Building, fuelwood	Stem, branches
Strychnos mitis (Loganiaceae)	Ul, Il	Medicinal	Stem and root bark
Syzygium guineense (Myrtaceae)	Ul, Il, Mb, Uh	Building, fuelwood	Stem, branches
Tabernamontana stapfiana (Apocynaceae)	Ul, Il	Medicinal	Stem bark
Teclea simplicifolia (Rutaceae)	Ul, Il	Building, fuelwood	Stem, branches
Tecomaria nyassae (Bignoniaceae)	Uh,Mb	Fuelwood, medicinal	Stem, branches, roots
Trilepisium madagascariense (Moraceae)	Ul, Uh	Building	Stem
Triumfetta rhomboidea (Tiliaceae)	Uh	Fibres for weaving	Bark
Triumfetta sp. (Tiliaceae)	Ul, Mb, Uh	Vegetable	Leaves
Zanthoxylum sp. (Rutaceae)	Ul, Il, Mb, Uh	Medicinal	Leaves, bark

Site abbreviations are as follows: Il = Ilutila, Mb = Mbawi, Uh = Uhafiwa, Ul= Uluti. Exotics species that came from private woodlots near the villages are denoted with an asterisk (*).

coughing (Shangali et al., 1998; Zilihona et al., 1998), ailments common and prevalent among the local people in the study area (Mmari and Mabula, 1996). The relatively low stem density of these species, their confinement to the northern part of the reserve, coupled with poor harvesting methods including cutting and removal of all the bark or the entire tree lead us to conclude that they may be locally vulnerable in this area (Peters, 1994; Cunningham, 2001). Our observations are partially supported by Zilihona et al. (1998), who ran rapid-transect samples of a broader area of USFR, reporting that for at least two species, *Strychnos mitis* and *Ocotea usambarensis*, excess harvesting for building poles and timber, respectively, has reduced stem density, especially in the north of the reserve.

Harvesting of the bark, stems or whole trees appears to be an acute problem in disturbed habitats of USFR. While we acknowledge that differences in species composition between transects might exist even before harvesting (Chapman et al., 1997; Fashing and Gathua, 2004), the extraction of NTFP seems to negatively impact tree abundance, because we

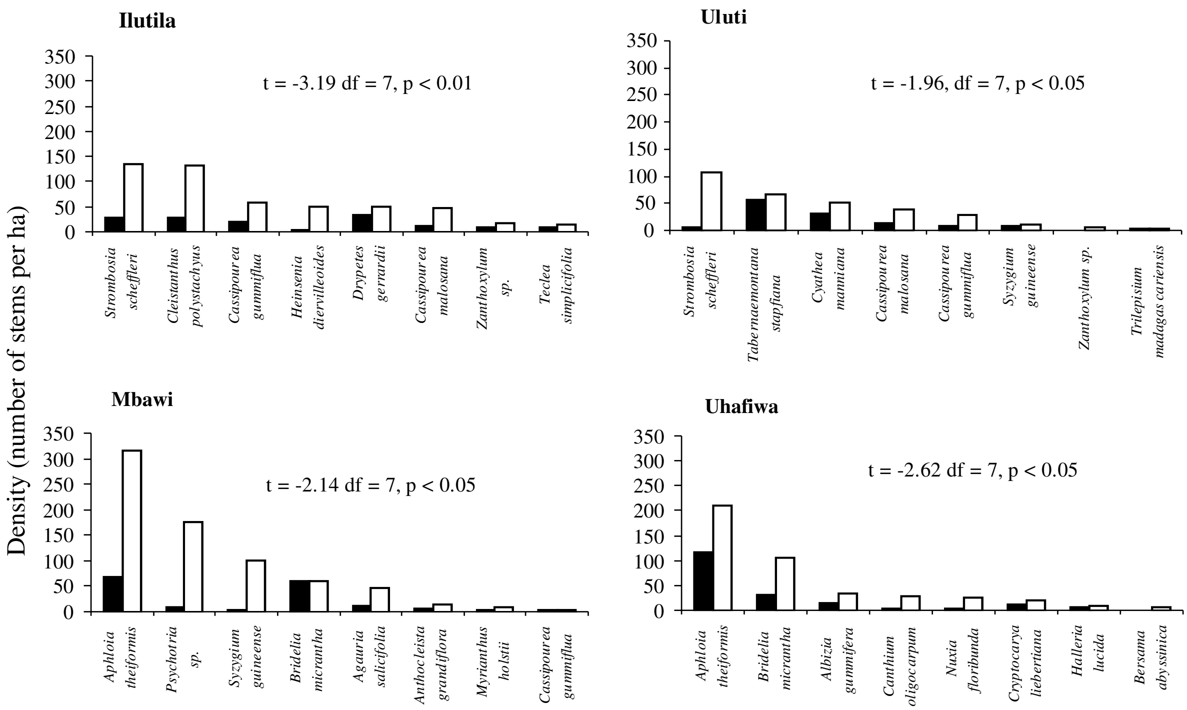

Fig. 3 – Comparison of stem density of eight exploited tree species common to both disturbed (black shading) and undisturbed (unshaded) habitats at each of the four Uzungwa Scarp Forest Reserve sites.

found that the most commonly harvested species at each of the four sites in USFR had consistently and significantly lower stem densities in disturbed versus undisturbed forest tracts. This result suggests that excessive harvesting in disturbed habitats is evident. For building purposes, the most commonly harvested species across all sites were *Cyathea manniana*, *Bridelia micrantha*, *Cassipourea gummiflua*, *Cassipourea malosana*, *Syzygium guineense*, *Aphloia theiformis*, *Zanthoxylum* sp. and *Strombosia scheffleri*. The first five species were also found to be in high demand as building materials by local communities spread across eight villages in the USFR (Zilihona et al., 1998). Extraction of trees, either by extreme debarking, uprooting or actual cutting of the entire trunk or stem probably explains the lower abundances of targeted trees in disturbed habitats (see Table 2). Harvesting of most of these tree species is probably not sustainable, and appears to influence species diversity and forest composition in USFR (Ndangalasi, unpublished data).

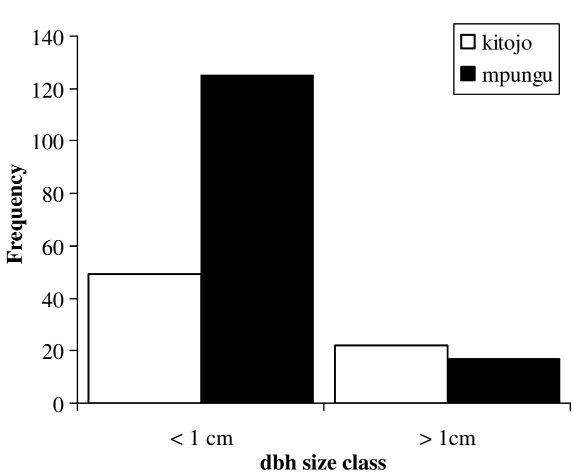

Fig. 4 – Distribution of different DBH size classes of *Loeseneriella apocynoides* between Kitojo and Mpungu areas in Bwindi Impenetrable National Park, Uganda.

4.2. BINP

The prevalence of small diameter sizes of *L. apocynoides* in both very disturbed (Mpungu, multiple-use zone) and less disturbed sites (Kitojo, not multiple-use zone) is typical of a population with many resprouts but very few mature stems as a result of intense harvesting in both sites (Hall and Bawa, 1993; Bitariho et al., 2006). The whole plant stem is harvested for making tea baskets and this has resulted in negative impacts on the stem size structure of the species not only in legalised harvest zones but even in areas where harvesting is forbidden. This is an indication of high demand levels for the species, a pattern quite similar to two other species in BINP, a shrub *Rytigynia kigeziensis* (Rubiaceae) and a large tree *Ocotea usambarensis* (Lauraceae), which are both harvested for medicinal purposes (Bitariho et al., 2006). For *L. apocynoides*, there are almost no 'useful' harvestable stems (>2.4 cm) in both zones. The plant is slow growing and takes over 20 years to reach a harvestable size (Muhwezi, 1997) and yet is in high demand for making tea-harvesting baskets. A tea factory in the vicinity of the study area has been promoting tea growing and this may have exacerbated the over-harvesting of *L. apocynoides* in all the forest areas of BINP.

The impacts of harvesting plant parts can be manifested in various ways depending on what is being harvested and in which environmental context. Important effects are changes in the forest structure and composition and the population dynamics of the plants being harvested due to limited regeneration and recruitment (Arnold and Ruiz Pérez, 2001; Ticktin, 2004). Delays in growth, fruit and seed production, and subsequent regeneration or resprouting are typical because plant resources (e.g. nutrients) are relocated from reproduction to healing the 'wounds' created from harvesting (Haig and Westoby, 1988; Hall and Bawa, 1993). *L. apocynoides* is expected to decline in numbers due to over-harvesting, even in nominally protected areas such as Kitojo.

4.3. *Management implications for NTFPs*

The inadequate information on the ecology and physiology of NTFP species is the major drawback to initiatives aimed at managing the resource base (Macía and Balslev, 2000; Ticktin, 2004). Though there have been some successes, these do not equally match the rate at which the NTFP sector is developing. A robust management scenario comes only after several years of experimentation (e.g. Nakazono et al., 2004). Red-Listing and other criteria have been adopted by conservationists to set limits to harvesting of supposedly rapidly decreasing taxa. However, the enactment of laws to control harvesting as at our study sites, have been adopted but hardly enforced.

A market approach has been argued as a valid means of assuring sustainability of NTFP harvesting. This approach maintains that improved producer prices, adding value locally to NTFPs, and organising people to manage the resources on their own may lead to sustainable utilisation, and can therefore lead to the goals of long-term economic rights of people to access NTFPs and commercialisation (Nepstad, 1992; Stiles, 1994). However, there are concerns that the lack of data on growth rates, population density and rates of regeneration of targeted species as well as the lack of regulations for NTFPs could lead to over-harvesting and degrade the resource base, leading to conflicts and tension among stakeholders (Homma, 1992; Chamberlain et al., 1998; Dovie, 2003).

In the context of this study however, given that harvesting of NTFPs occurred even in protected areas, there is little doubt that NTFPs can only be sustainably managed if economic alternatives and incentives other than those coming from the NTFP sector are developed to meet the actual needs of the local people. This will require appropriate incorporation of livelihood activities into collaborative forest management (CBF) practices with recognition and management of NTFPs.

4.4. *Conclusion*

The USFR is one of the most biologically important forests in the Udzungwa Mountains (Dinesen et al., 2001) and it is where most of the medicinal plants are also confined (Shangali et al., 1998). Exploitation of NTFPs appears to be moderate to high and occurs even in protected areas. Some species, especially those used as building poles, appear to be heavily harvested, particularly near villages (see Fig. 3). Results for BINP were not dissimilar, where a woody liana, *L. apocynoides*, had few harvestable populations with populations instead dominated by re-sprouts even in protected and controlled areas. The high demand for tea baskets from the nearby out-growers tea factory may have hastened the depletion of this species.

Harvesting of NTFPs negatively impacts plant species that are in high demand by local communities in the two East African forests, thus having the potential to alter forest structure and integrity in the forests (Hall et al., 2003). Similarly, exploitation of trees for charcoal production in forest patches surrounding Kibale NP, Uganda, could have devastating effects on the overall ecosystem and local human communities (Naughton-Treves et al., 2007). Efforts such as planting of the most utilised species on adjacent farms should be encouraged as alternatives to NTFP extraction from the forest. Concentrating on NTFPs that are sufficiently valuable to local communities would likely enhance such practices. Forest enrichment planting and the setting of harvesting levels and cycles have been introduced in recent years in various areas (e.g. see Venter, 2000; Dovie, 2003; Ticktin, 2004; Romero et al., in press), but care should be taken to approach these practices against the background of potential ecological and socio-economic impacts.

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