The structure and status of forest fragments outside protected areas in central Uganda

Deborah Baranga[1]*, Colin A. Chapman[1,2] and John M. Kasenene[3]

[1]Department of Zoology, Makerere University, P.O. Box 7062, Kampala, Uganda, [2]Department of Anthropology and McGill School of Environment, McGill University, 855 Sherbrooke St. West, Montreal, Quebec, H3A 2T7, Canada and Wildlife Conservation Society, 2300 Southern Boulevard, Bronx, NY 10460, U.S.A. and [3]Department of Botany, Makerere University, P.O. Box 7062, Kampala, Uganda

Abstract

Given the extent of tropical forest deforestation and as a number of conservation programmes and local communities rely on forest fragments, it has become important to understand how fragment exploitation by local communities affects forest structure and function. The effects of forest exploitation on forest structure and status of forest fragments were investigated in 20 nonreserved forest fragments in central Uganda. Enumeration of plots showed that tree species composition of the forest fragments was 60.0%, 23.7% and 6.3% for under-storey, middle and top canopy trees respectively. The major activity was fuel wood extraction (65%), followed by brick making (10%), cultivation and livestock paddocks (10%), charcoal burning (5%), local brew distillation and others (5%). These extractive processes caused drastic structural changes, habitat degradation and destruction. Tree stumps enumeration indicated that under storey trees formed the highest proportion for wood extraction. There was no significant difference in the level of forest exploitation (basal area loss) among forest patches of varying sizes.

Key words: forest exploitation, forest fragments, forest structure, outside protected areas, status, structure

Résumé

Etant donné l'étendue de la déforestation tropicale et vu qu'un certain nombre de programmes de conservation et de communautés locales dépendent de fragments forestiers, il devient vraiment important de comprendre comment l'exploitation de ces parcelles par les communautés locales affecte la structure et les fonctions forestières. Les effets de l'exploitation forestière sur la structure et le statut des fragments forestiers ont été étudiés dans 20 fragments forestiers non préservés du centre de l'Ouganda. Le dénombrement des parcelles a montré que trois compositions d'espèces des fragments forestiers composaient respectivement 60,0%, 23,7% et 6,3% du sous-bois, de l'étage moyen et de la canopée. L'activité principale était l'extraction de bois de feu (65%), suivie par la fabrication de briques (10%), les enclos pour la culture ou le bétail (10%), la fabrication de charbon de bois (5%), la distillation de boissons locales et autres (5%). Ces diverses extractions causaient des changements structurels importants, une dégradation de l'habitat, voire sa destruction. Le dénombrement des souches d'arbres a montré que les arbres des sous-bois constituaient la plus grande proportion des arbres prélevés. Il n'y avait pas de différence significative du niveau d'exploitation forestière (perte de surface réelle) entre les îlots forestiers de tailles différentes.

Introduction

The projected human population increase (United Nations, 2005), 90% of which will occur in developing countries (Potts, 2007) that sustain the greatest proportion of the world's biodiversity, poses many challenges to ecological systems because of the high global deforestation rate (FAO, 2005) and increasing demands for environmental products and services (Houghton, 1994). In Uganda, closed-canopy tropical forest has reduced from 20% of the country's land area to just 3%, while 18% of its remaining forest was lost between 1990 and 2000 (Howard *et al.*, 2000). Recent estimates suggest an annual loss rate of 7% for tropical high forest, 5% for woodland and 4% for bushland (Pomeroy & Tushabe, 2004).

It is critical to understand the conservation value of forest fragments, as they may represent opportunities for

**Correspondence:* E-mail: dbaranga@zoology.mak.ac.ug

important conservation gains. Only 5% of tropical forests are legally protected and many of them are subjected to illegal exploitation (Redford, 1992; Oates, 1996). Furthermore, many tropical species are locally endemic or are rare and with patchy distribution (Struhsaker, 1975; Richards, 1996), which predisposes many of these species to increased extinction risk when habitats are modified (Terborgh, 1992). Consequently, conservation of many such species will depend on the capacity of fragmented forests to support their populations.

Most forest fragments are not formally protected areas, hence the necessity to assess the impact of anthropogenic activities so as to promote their ecological functions and ensure continued provision of benefits for social and economic development. An estimated 94% of the human enterprises in Uganda is powered by wood (Becker, Banana & Bombya-Ssembajjwe, 1995). In 1986, the World Bank estimated Uganda's fuel-wood demand at 18.3 million m^3 $year^{-1}$, while in 1991 its annual fuel-wood production was estimated at 15.6 million m^3 $year^{-1}$, leaving a deficit of 2.7 million m^3 $year^{-1}$ (Howard, 1991). The impact of this on different types of forest fragments is largely unknown (Chapman *et al.*, 2007).

The objective of the study was to investigate the extent of human activities in and around the forest patches and assess their effect on forest structure and status in the Lake Victoria shore area in central Uganda. Since, as in many tropical regions, land ownership patterns vary from being owned and managed by the local community to nongovernmental ownership (e.g. the church) and government reserves, we consider ownership patterns on the extent and nature of human activities and forest degradation. We also consider the views of local people whose livelihoods often depend on these fragments.

Materials and methods

The study was conducted in a 600 km^2 area (a forest-savanna-agricultural mosaic dominated by human habitation and other human infrastructural development) in central Uganda. Within this area, two study sites were located (Baranga, 2004a). Site 1 had 20 nonreserved forest patches ($0^0 05^0$N, $0^0 16^1$N and $32^0 30^1$E, $32^0 38^1$E) of which Zika Forest (Buxton, 1952) with evergreen moist vegetation was the largest and least disturbed. Kisubi Forests (owned by the Roman Catholic Church) constituted the majority of the other patches. On the whole, 75% of the patches was offshore, 15% riparian and 10% dry-mainland forest patches. At Site 2 was Mpanga Forest Reserve ($0^0 15^1$ N, $32^0 15^1$ E), a medium altitude moist evergreen forest (of about 4.5 km^2) of Type C, *Piptadenia-strum-Albizia-Celtis* forest (Langdale-Brown, Osmaston & Wilson, 1964; Howard, 1991), with four zones at different stages of colonization and maturity (Dawkins & Philip, 1962). As a legally protected area, this forest was sampled for comparative purposes with the forest patches.

Current human activities and patch size were determined directly. Stand structure was quantified by tree census and enumeration along transects (5 m width) divided into plots (5 m × 10 m) at 10 m intervals, to achieve the 'minimal area' based on the Brain–Blanquet concept (Moore, 1962; Kershaw, 1973). Trees species classes (Raunkiaer, 1934; Swaine & Hall, 1986; Richards, 1996) were evaluated using the diameter at breast height (dbh), at a height of 1.3 m from the ground of all trees with a diameter of 3.8 cm (10 cm girth) and above. Tree stumps were enumerated and their diameters were used to calculate tree basal area loss as an index of forest exploitation. The status of the forest patches was assessed by allocating them scores: from 1 to 4 (1-fairly intact; 2-disturbed; 3-degraded, 4-highly degraded) based on factors such as presence or absence of distinct upper, middle, lower and ground layers, thick undergrowth, presence of gaps and human activities such as tree cutting and forest clearing.

Results

All the forest patches were small: varying from approximately 2 to 20 ha. During the study, the size of some patches was further reduced by forest clearing for cultivation. Zika Forest (protected for research purposes) was the least disturbed. Tree size classes indicated the status of forest patches at different stages of succession and reflected different levels of disturbance as shown by three representative stand structures of the 20 forest patches and one for Mpanga Forest Reserve (Fig. 1). The range included Namulanda representing small and individually owned forest fragments; Nabinonya belonging to a private institution; Zika a reserved forest and Mpanga Forest Reserve, a gazetted central forest reserve.

Most of the small fragments had secondary forest vegetation that comprised of under-storey species and limited middle-storey species. Kisubi forests (mainly mixed forests) had a small representation of primary forest species at intermediate stages of succession. Mpanga Forest Reserve and Zika Forest (to a lesser extent) had a good

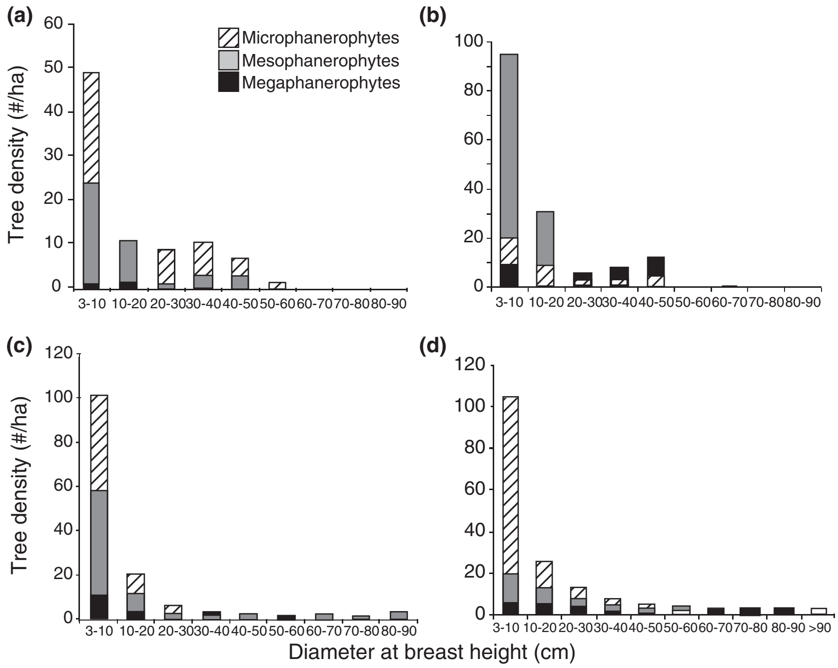

Fig 1 The Diameter at Breast Height (DBH) distribution for a series of representative forest patches in the Kampala area of Uganda (a) Namulanda, (b) Nabinonya, (c) Zika Forest and (d) Mpanga Forest Reserve

representation of all tree classes. The overall composition of under-storey (micro-), middle (meso-) and top canopy tree species (mega-phanerophytes) was 60.0%, 23.7% and 6.7% respectively (Fig. 1). Under-storey trees included species like *Coffea canephora*, *Barteria fistulosa* and *Teclea nobilis*, while *Markhamia lutea*, *Ekerbergia senegalensis*, *Ficus exasperata*, *Bosqueia pheboros* and *Measopsis eminii* were among the common middle-storey species. Canopy trees (mainly in Mpanga Forest and a few in Zika Forest) included species such as *Canarium schweinfurthii*, *Guarea cedrata*, *Lovoa tracheoloides*, *Entandrophragma angolensis* and *Piptadeniastrum africana*.

The major activity among the forest patches was fuel-wood extraction which accounted for 65% of the tree basal area loss (Table 1). It was the highest at Kanywa which had sand quarry nearby with brick burning as a daily activity. Other demands for fuel-wood included brewing local beer and domestic use in homes and institutions (e.g. schools). Poles were cut for construction and paddock fencing and at Sinzi, large trees (e.g. *Musanga cecropoides*) were used to build fishing canoes. Areas overgrown with grasses (e.g. *Setaria kagerensis* and *Olaira latifolia*) were characteristic of sites previously used for burning wood for charcoal and those extensively degraded. The effect of these activities on the status of the forest fragments was such that only Zika (5%) was assessed as intact, while 55% were disturbed, 25% degraded and 15% were highly degraded (Table 1). A regression analysis showed no relationship between tree basal area loss (tree stumps density) and patch size ($B = -1.0142$, $R^2 = 0.1295$, $P > 0.05$).

Discussion

Our data illustrate that most of the forests in Central Uganda have been degraded by human activities, as partly reflected by the forest structure curves. For example, because of the previous felling of large canopy tree species and middle storey trees, Namulanda forest patch was dominated by under-storey trees. Kisubi forests had a small representative of primary forest species in intermediate stages of succession, while Mpanga Forest Reserve and to a lesser extent, Zika Forest represented stable age/size distributions (Swaine and Hall, 1986; Kasenene, 1987). In general, the stand structure suggests that these extractive processes are not sustainable.

The rate and extent of forest encroachment, disturbance and depletion are determined by many factors including the legal status and land ownership of each forest area. At times, the private forest ownership can be detrimental as a change in land use practices may not take into account conservation issues. However, it was apparent that institutional ownerships played a positive role in conserving

Table 1 Tree basal area loss and forest status due to extractive activities in twenty forest patches in the 'Kampala Area', (June 1990–August 1991)

Forest patch	Location	Tree basal area loss %	*Forest status	Main activities
Zika	Off-shore	1.2	+	Fuel wood cutting
Kanywa	Off-shore	54.0	++	Brick making & burning
Kisubi Paddock	Off-shore	8.4	+++	Fuel wood cutting
Kibale	Off-shore	5.4	++	Fuel wood cutting
Nabinonya	Off-shore	6.6	+++	Clearing for paddocks
Kisubi Girls'	Off-shore	25.2	+++	Fuel wood cutting
Kisubi Hospital	Off-shore	6.0	++	Fuel wood cutting
Kisubi Technical	Off-shore	21.3	++	Fuel wood cutting
Gogonya	Off-shore	10.1	++	Fuel wood cutting
Nalugala	Off-shore	23.7	++	Fuel wood cutting
Namulanda	Off-shore	36.4	++++	Charcoal production
Sinzi	Off-shore	7.4	++	Fuel wood cutting
Nganjo A	Dry	18.6	++++	Clearing for cultivation
Nganjo B	Off-shore	12.8	+++	Fuel wood cutting
Nganjo C	Off-shore	28.9	++	Fuel wood cutting
Seguku	Riparian	33.3	++++	Paddock fencing
Bunamwaya	Riparian	6.1	+++	Brick burning
Wamala	Riparian	14.9	++	Local brew distillation
Mawanyi	Off-shore	6.4	++	Fuel wood cutting
Katwe	Dry	2.8	++	Fuel wood cutting

*Forest status: +, Fairly intact; ++, disturbed; +++, degraded; ++++, highly degraded.

some of the forest fragments around Lake Victoria. This was the case with some Kisubi forests (Church owned) where guards patrolled the forests which reduced illegal exploitation. With the fragments we evaluated, either absence of forestland ownership (untitled land) or state ownership of forestland (forest reserve) may lead to relatively ineffective forest conservation, while ownership by a not-for-profit trust foundation (university, indigenous organization) of the forestland seems to be effective in forest conservation. Land ownership status directly influences forest degradation which impacts on environmental services, (e.g. protecting catchment areas, preventing soil erosion and moderating local weather conditions) as well as wildlife that depends on these forest fragments (Baranga, 2004b). While local communities within Uganda perceive environmental benefits with indirect economic values, such as ecosystem services, they rarely alter their activities because of these beliefs (Hartter, 2007; Goldman *et al.*, 2008).

Among the local populace, the most important value of forests is the timber products as a commodity for sale or a source of energy due to lack of alternatives. The value of timber has been aggravated by policy-makers who have tended to attach exclusive importance to timber (ANON, 1989). Fuel-wood collection was the main activity responsible for high levels of basal area loss from the forest patches. Firewood is the form of energy mostly used among many Ugandan communities partly due to its free and easy access and ease in use (National Academy of Science, 1980; Naughton-Treves & Chapman, 2002; Tabuti, Dhillion & Lye, 2003; Naughton, Kammen & Chapman, 2006), while other forms are either expensive or inaccessible to the poor (Naughton *et al.*, 2006). Additionally, small-scale commercial enterprises (brick making, charcoal production, beer brewing and distillation) require a continuous supply of wood. People are often discriminatory about the species they use for some activities (e.g. building poles, charcoal production, etc.) but are not selective for other activities (e.g. distillation). This can result in clearing large areas, with some exceptional tree species that tend not to be harvested because of cultural taboos (Tabuti *et al.*, 2003). In addition, many sites for charcoal production open the forest and destroy seedlings and tree saplings, thus reducing forest regeneration and promoting grassland invasion.

In Uganda, the demand for fuel-wood and building poles has been largely met from natural forests, woodlands and plantations, but as our data suggest these are rapidly being degraded and have deteriorated due to over-exploitation (Pomeroy & Tushabe, 2004). Thus, the cumulative effect of biomass loss could easily undermine ecological processes (Kasenene, 1987; Struhsaker, 1987, 1990; Perrings, Folke & Miller, 1992) and influence wildlife population dynamics in a negative way (Onderdonk & Chapman, 2000; Chapman *et al.*, 2003, 2007; Baranga, 2004b). Loss of habitat and ecosystem services and loss of biodiversity are some of the most serious environmental problems which faced past and now present societies.

Our data in combination with data from elsewhere in East Africa suggest that forest fragments that are community owned have a bleak future for the long-term conservation of old growth flora and fauna (Wahungu *et al.*, 2005; Anderson, Cowlishaw & Rowcliffe, 2007; Chapman *et al.*, 2007). Reversal of the present trends would require a major conservation effort involving the cooperation of local people, to arrest further degradation. This would also necessitate identifying alternative sources of income (e.g. ecotourism), fuel-wood supplies (e.g. a large scale woodlot project) and greater input in education and outreach. In reality, it is unlikely that a project of this magnitude will be initiated. Thus, small and unprotected forest fragments face a bleak future (Chapman *et al.*, 2007).

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