Plant harvest impacts and sustainability in Bwindi Impenetrable National Park, S.W. Uganda

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Abstract

Sustainable utilization of forest resources has been widely adopted as a conservation strategy, but that sustainability has rarely been empirically tested. Plant resource extraction from Bwindi Impenetrable National Park (BINP) by local communities has been legalized and controlled in areas called multiple use zones (MUZs). Through a series of systematic transects and plots, we determined harvest impacts of two mostly harvested medicinal plants of *Rytigynia kigeziensis* VERDC.l and *Ocotea usambarensis* Engl in BINP. The plots were placed in MUZs and non-MUZs. Data on biomass production and population dynamics were collected from the plots. We also analysed forest society records for the past 3 years to determine annual plant resource offtakes from BINP. Bark production of the two plants in MUZs and non-MUZs are not significantly different, suggesting an insignificant change in bark production because of bark harvest. Annual bark harvests of the two plants are between 0.26–1.64% of available bark stock. These are too low to cause any noticeable negative impacts and are sustainable. Annual bark harvest of *R. kigeziensis* and *O. usambarensis* should be increased from the original 1% to about 3% of available bark stock to allow more involvement of the marginalized poor people like Batwa in BINP.

Key words: bark harvest, biomass, medicinal plants, utilization

Résumé

L'usage viable des ressources forestières a été largement adopté comme stratégie de conservation, mais cette viabilité n'a que rarement été enquêté empiriquement. L'extraction de ressources végétales du Parc National Impénétrable de Bwindi (BINP) par les communautés locales a été légalisée et contrôlée dans des zones appelées 'les zones d'usage multiple' (les MUZ).A travers une série de transectes et placettes systématiques, nous avons déterminé l'impact de la récolte de deux plantes médicinale *Rytigynia kigeziensis VERDC.l* et *Ocotea usambarensis* Engl dans le BINP. Les placettes furent situées dans des MUZ ainsi que dans les nons-MUZ. Les données sur la production de biomasse et les dynamiques de la population furent ramassées des placettes. Nous avons analyséaussi les archives de la Société Forestière sur les trois dernières années afin de déterminer le niveau d'enlèvement des ressources végétales dans le BINP.La production d'écorce des deux plantes ne variait pas significativement dans des zones MUZ par rapport aux non-MUZ, ce qui suggère que la rècolte de l'écorce n'agit pratiquement pas sur la production de l'écorce. La rècolte annuelle des plantes représente de 0.26 à 1.64% des réserves d'écorce disponibles. Ces chiffres sont trop petits pour provoquer des dègâts perceptibles et sont viables.La récolte annuelle de *R. kigeziensis* et *O. usambarensis* devrait être augmentée à 3% des réserves d'écorce (de 1% actuellement) afin de permettre aux gens marginalisès et pauvres dans le BINP, tel Batwa, d'avoir une plus grande participation.

Introduction

Tropical forests have high species diversity, which include many valuable plant resources for harvesting. However, most of these plant resources are scattered throughout the forest at very low densities (Peters, 1994). The consequence of this is that these plant resources are vulnerable to over-harvesting. Controlled harvesting of nontimber forest products holds great potential as a method for integrating the use and conservation of tropical forests (Peters, 1994). In the past, plant resource collection by traditional forest societies was part of their culture and life style and contributed greatly to traditional forest management.

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When Bwindi was gazetted a national park in 1991, the traditional forest users of Bakiga, Bafumbira and Batwa were denied access to the forest resources that provided a means to their livelihood. As a result, conflicts commonly arose between protected area managers and the local communities adjacent the forest and loss of biodiversity because of widespread fires and intense poaching. Protected area managers sought ways of accommodating the needs of traditional forest users while at the same time maintaining biodiversity and ecosystem functions that the forest provides. A collaborative forest management approach was introduced in Bwindi Impenetrable National Park (BINP) in 1994, in which local communities were allowed access to plant resources for medicines and basketry weaving and placement of beehives. The first pilot parishes were Mpungu, Nteko and Rutugunda in 1994, by 1999 other nine parishes adjacent BINP were also allowed access to the forest. The local communities were given the responsibility of helping park managers in the protection and maintenance of biodiversity and ecosystem functions by reporting any illegal activities encountered.

Almost any type of resource harvesting conducted in a tropical forest has an impact on the ecological functions of the forest. The exact magnitude of this impact depends on the nature and intensity of harvesting and the particular species or type of resource under exploitation (Peters, 1994). In BINP, over 46 plant species are harvested in areas designated as multiple use zones (MUZs) (Fig. 1). The harvested plant species are of differing life history and range from herbs to trees. Some of these plants may experience minimal impacts after harvest like harvesting leaves of *Mimulopsis solmsii* Schweinf (a vigorous sprouting herb common in BINP forest gaps) while others may experience extreme harvest impacts. Over-harvesting of plant resources will not only affect the forest ecosystem but also the livelihood of the people concerned by loss of the plant resource in the forest. Tropical forests experience different microclimates that affect plant resource distribution and density and in most cases influence the scarcity of the harvested plant resource if it is over-harvested.

Probably the most difficult question asked by many conservationists is whether harvesting of a particular natural plant resource is sustainable or not. There is little or no information available on the biomass production of most tropical plant species or about the ways in which plant species interact (Cunningham, 2000). Many conservationists have often made assumptions that since local people have harvested resources from the forest for a long time, harvesting must be sustainable. Godoy & Bawa (1993) do not agree, they state that directly measuring the rate of plant extraction and comparing it to the rate of natural replacement is the

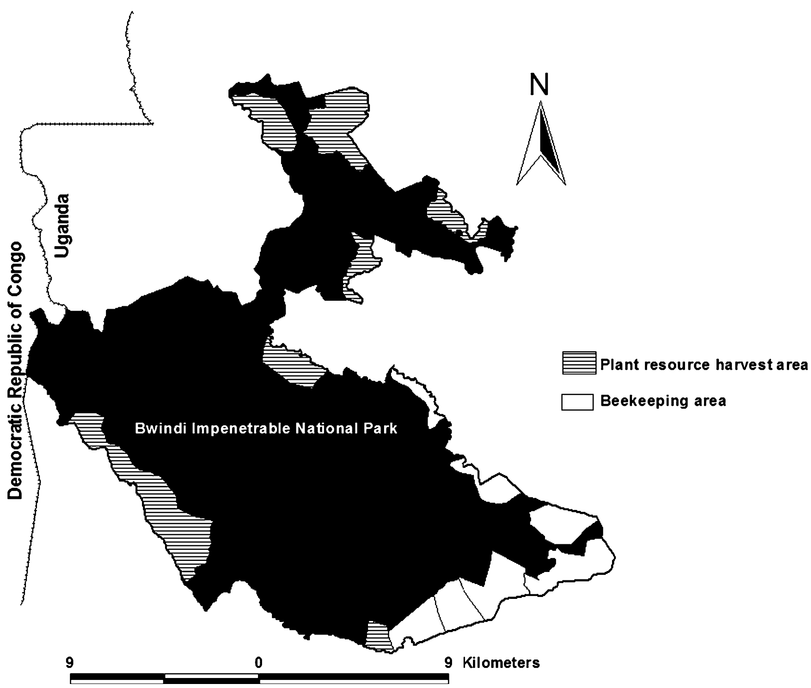

Fig 1 Map of the multiple use zones of Bwindi Impenetrable National Park, S.W. Uganda

best way of determining sustainability of plant resource harvest.

There are few, if any, examples, of the demonstrably sustainable extraction of nontimber forest products from tropical forests, because of lack of a sufficient knowledge base to design a sustainable extraction system (Boot & Gullison, 1995). The ecological consequence of harvesting plant resources in BINP remains poorly studied and there is little or no biological information known on most of the plants being harvested.

Although hundreds of plant species are used from forests, it is clearly impractical, with limited funding and personnel, to monitor all plant species harvested (Cunningham, 1995). It is important to prioritize which plant species to monitor for harvesting impacts. Priority needs to be given to plant species that are on high demand, slow growing and habitat specific (Cunningham, 2000).

Plant species with all or most of the vulnerable characteristics were considered for monitoring in the MUZs of BINP. The selected plant species were *Rytigynia kigeziensis* VERDC.l and *Ocotea usambarensis* Engl. The two plant species were selected from an array of several other plant species that are harvested in BINP.

This study aimed at assessing impact of plant harvesting on size class structure and biomass production of the two mostly harvested medicinal plants. The study also aimed at comparing annual bark production in MUZs and non-MUZs for the two medicinal plants and also determining their bark harvest sustainability. A direct comparison between natural and harvested populations was made to assess sustainability of the resource plants (Hall & Bawa, 1993).

Methods

Sampling design

A stratified sampling design was used in the setting up of transects and plots to assess the two plants and was based on the following:

• MUZs adjacent Mpungu and Masya parishes where harvesting of plant resources is legalized
• Non-MUZs adjacent Kitojo and Nteko parishes where plant resource harvesting is not legalized

Plot layout and size

Belt transects of 20×265 m running from an available human trail into the forest were used to assess stem density and size class distribution of *O. usambarensis*. Belt transects have the advantage of being able to sample efficiently a variety of habitats and microsites (Tuxill & Nabhan, 1998). The first transect was randomly selected and there after, other transects systematically set up. Transects were separated from each other by 100 m. A total of 34, 0.53 ha plots was set up; 22 in the MUZs and the others in the non-MUZs.

Rytigynia kigeziensis was assessed in plots of 20×20 m placed on line transects running from an available human trail into the forest and separated from each other by 15 m (Kamatenesi, 1997). Each plot alternated systematically on line transects from either left or right of transects. Systematic sampling plots have the advantage of estimating population abundance and density well and can be carried out without necessarily knowing the total area to be sampled (Tuxill & Nabhan, 1998). Like for *O. usambarensis*, the first transect was randomly selected and each transect separated from each other by 100 m. Two hundred and thirty-six 0.04 ha plots were used for *R. kigeziensis*. One hundred and seventy-two plots were placed in the MUZs and the others in the non-MUZs for *R. kigeziensis*.

Density and diameter class distribution assessment

All individual stems of *R. kigeziensis* and *O. usambarensis* rooted in plots (including sprouts >1.3 m long) were counted and their d.b.h. recorded using a millimetre vernier caliper and diameter tape. Individual stems that were <10 cm d.b.h. were recorded as sprouts and seedlings for *R. kigeziensis* and *O. usambarensis*, respectively (*R. kigeziensis* did not have seedlings) (Peters, 1994). The transects were permanently marked using concrete blocks, GPS readings and compass directions for future monitoring.

Yield assessment of two medicinal plants

Representative samples of *R. kigeziensis* and *O. usambarensis* were randomly selected from the plots of density and diameter assessment (three for each size class, Peters, 1994). These were then measured for bark thickness using a millimetre bark gauge. The bark thickness was measured at breast height of 1.3 m with four separate measurements taken around the tree trunk to get a mean bark thickness per tree (Cunningham, 2001). Each of the selected sample plants was permanently marked with an embossed metal tag for relocation. The yield assessment measurements were recorded annually for 3 years.

Resource users normally harvest bark up to a height of 2 m up resource tree trunk (Kamatenesi, 1997). Therefore, bark mass production of the two medicinal plants was calculated up to 2 m of trunk length. Calculation of total bark mass within 2 m of plant height was carried out based on the formula provided by Cunningham (2001) and Kamatenesi (1997):

$$\log \mathrm{BM}\ (\mathrm{kg}) = 0.72118(\log h) + 0.152919(\mathrm{BT}) - 0.11767(\mathrm{BT} \times \log D) + 0.037728(\mathrm{BT} \times \log h) - 2.04586$$

where BM is bark mass, D is diameter at breast height (cm), h is height = 200 cm and BT is bark thickness (cm).

Forest society reports

Forest society reports were introduced in BINP as away of involving local communities in monitoring plant resource offtakes from the forest. The forest society reports contain records of amount of plants resource harvested in a particular year. Forest society groups recorded these in data sheets provided by Uganda Wildlife Authority. We compiled the records into annual bark harvest offtakes for the two medicinal plants. Forest society reports describe methods of quick assessment of abundance and distribution of the resource plant by the local resource users.

Results and discussions

Density and size class distribution of harvested plants

Rytigynia kigeziensis had the highest stem density in the non-MUZs than in the MUZs while *O. usambarensis* had the highest stem density in the MUZs than in the non-MUZs (Table 1). Density or the number of individuals per unit area is probably the ecological parameter of greatest interest to ethnobotanists. Low-density plants resources that are difficult for harvesters to locate, produce a low yield per unit area, and are extremely susceptible to over-harvesting (Peters, 1994). It may seem that bark harvest of *R. Kigeziensis* from the MUZs have caused a decrease in its stem density but this is more likely caused by other factors such as microclimates. The MUZs and the non-MUZs occur at slightly different elevations (between 1500 and 1800 m a.s.l. and, 2000 and 2400 m a.s.l., respectively) and may be the reason why the two plants show different stem densities in the MUZs and non-MUZs.

Table 1 Stem density of key harvested plants in BINP

	Stem density per hectare of the harvested plant species			
	Rytigynia kigeziensis		*Ocotea usambarensis*	
Zone	Mature	Sprouts	Mature	Seedlings
Non-MUZs	0.14	0.04	0.004	0
MUZs	0.03	0.02	0.02	0.02

The diameter class distributions of *R. kigeziensis* and *O. usambarensis* are significantly different in the MUZs and the non-MUZs (Kruskal–Wallis $K = 7.631$, $P = 0.022$ and Kruskal–Wallis $K = 65.447$, $P = 0.00$, respectively). The diameter class distribution of *R. kigeziensis* in both MUZs and non-MUZs show an exponential decline and are a characteristic inverted 'J' type of distribution (Fig. 2). The distribution shows a population of the plant with many more juveniles than adults and is what is commonly observed in natural populations that are stable in density and self-replacing (Hall & Bawa, 1993).

The diameter class distribution of *O. usambarensis* in the MUZs is similar to those of *R. kigeziensis* mentioned above (Fig. 3). The distribution shows a population with many juveniles than adults and is what is commonly observed in natural populations (Hall & Bawa, 1993). The diameter class distribution of *O. usambarensis* in the non-MUZs shows a population with very few seedlings and adults. The *O. usambarensis* is a tree that was also originally cut for timber 14 years ago before Bwindi was made a national park, and could have contributed to the 'unnatural' size class distribution of the tree in the non-MUZs where timber harvesting was highest.

Size class histograms provide an immediate identification of the poorly represented stages of the life history, therefore indicating the heavily harvested individuals that require immediate attention (Hall & Bawa, 1993). The first signal that a plant population is being subjected to an overly intensive level of harvest is usually manifested in the size-class distribution of that population (Hall & Bawa, 1993; Peters, 1994). Bark harvest for medicinal use of the two plants has been ongoing since 1994. It therefore seems likely that bark harvest has not caused any noticeable impacts on the size class structure of the two harvested plants.

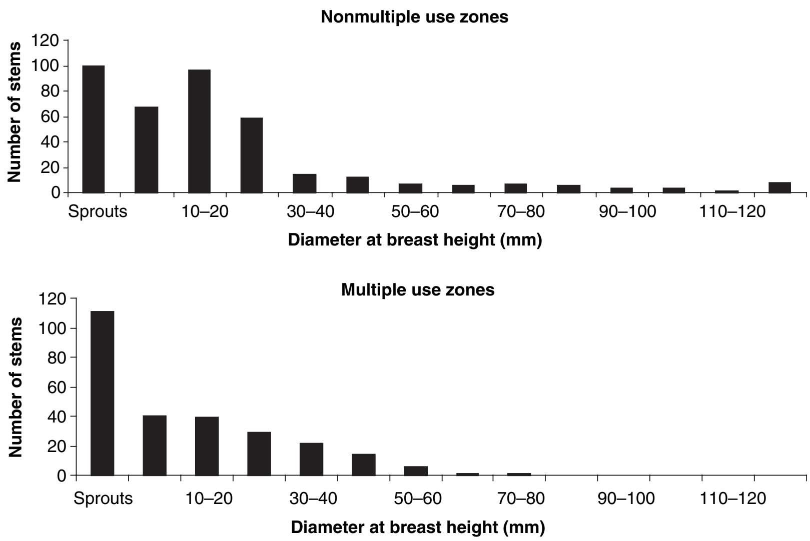

Fig 2 Diameter class distribution of *Rytigynia kigeziensis* in nonmultiple use zones and multiple use zones of BINP

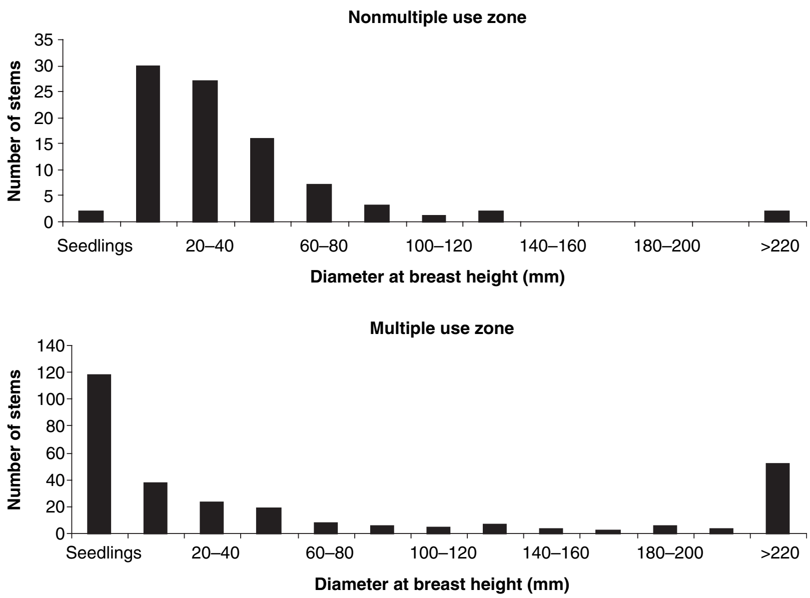

Fig 3 Diameter class distribution of *Ocotea usambarensis* in nonmultiple use zones and multiple use zones of BINP

Biomass production

Biomass production of *R. kigeziensis* and *O. usambarensis* in the MUZs and the non-MUZs are not significantly different (t-test = 0.798 and $P = 0.43$ and one-way ANOVA = 2.06 and $P = 0.11$, respectively) (Figs 4 and 5), suggesting an insignificant change in bark production because of bark harvest. Bark harvest for medicinal use of the two plants has most likely not caused any noticeable impact on the biomass production of the two plants.

There is a very strong positive correlation between diameter and bark mass production of the two plants in both MUZs and non-MUZs (Pearson correlation = 0.89 (non-MUZs) and 0.74 (MUZs) for *R. kigeziensis* and Pearson correlation = 0.86 (non-MUZs), 0.83 (MUZs) for *O. usambarensis*). Kamatenesi (1997) also observed that diameter was very strongly correlated to bark mass of *R. kigeziensis*. Average bark mass per stem of *R. kigeziensis* and *O. usambarensis* is 0.45 and 0.45 kg, respectively.

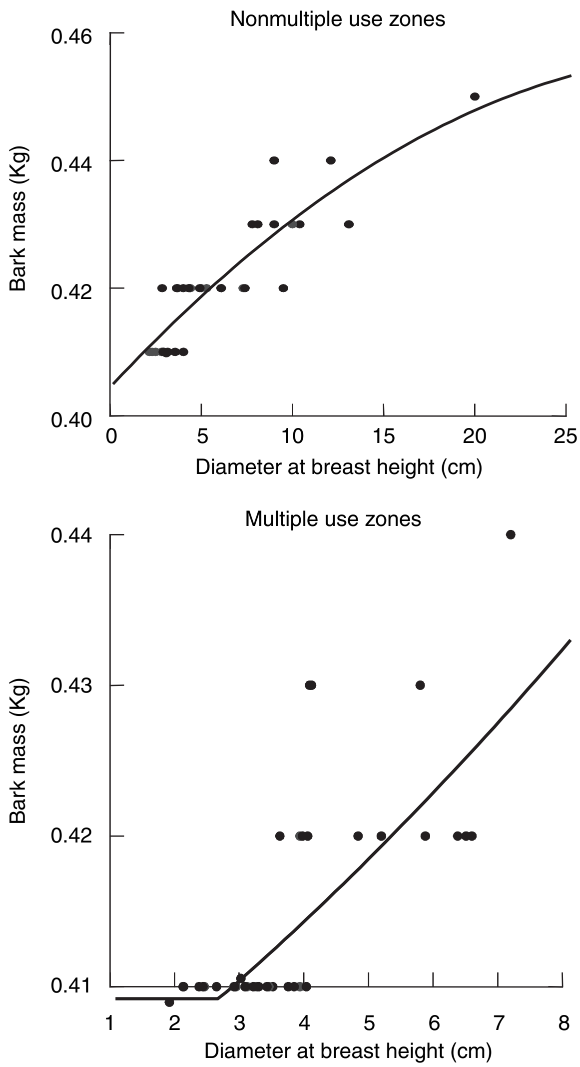

Fig 4 Biomass production curves of *Rytigynia kigeziensis* in nonmultiple use zones and multiple use zones of BINP

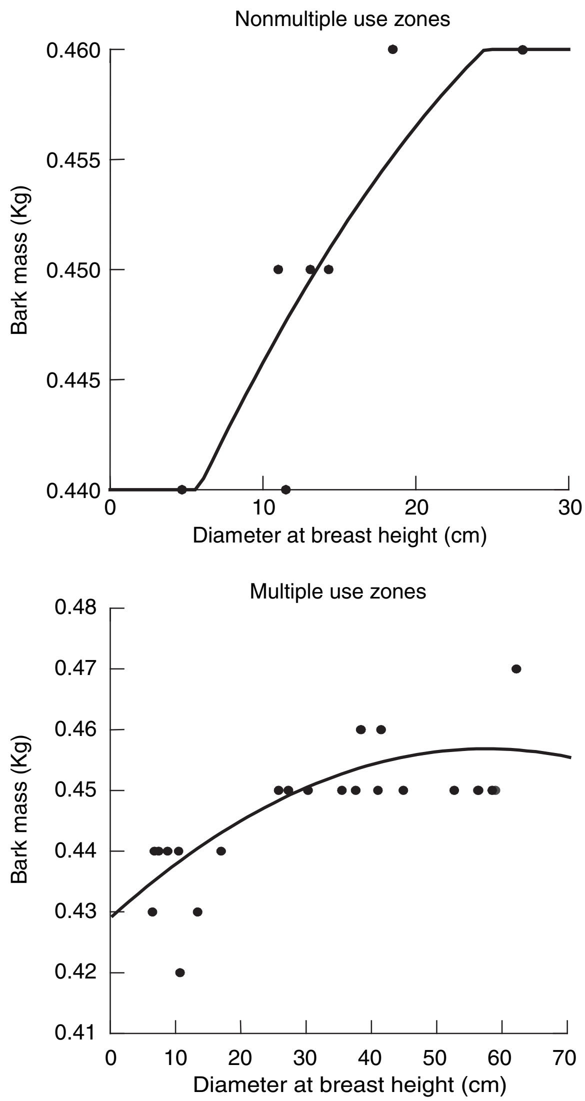

Fig 5 Biomass production curves of *Ocotea usambarensis* in nonmultiple use zones and multiple use zones of BINP

Forest society records assessment

There has been a steady decline in the amount of bark harvest and the number of resource users visiting the MUZs; this was more pronounced after 1998 (Fig. 6). The forest societies are no longer active like in the past and some resource users interviewed have mentioned that they no longer hold regular meetings to review the resource-harvesting program.

According to Godoy & Bawa (1993), foraging from the forest may be an inferior occupation, a job carried out until people find ways to switch to occupations that are more profitable and this may be the case in BINP. There seems to be a declining interest in the multiple use programmes as the local people get involved in income generating activities such as those funded by local Non Governmental Organisations (NGOs) working around BINP. New government programmes on health, education and poverty eradication such as provision of health services at every sub-county, provision of free education through the Universal Primary Education (UPE) and Poverty Eradication Action Plan (PEAP) interlinked with Plan for Modernization of Agriculture (PMA) have greatly reduced local people from foraging from BINP forest for plant resources.

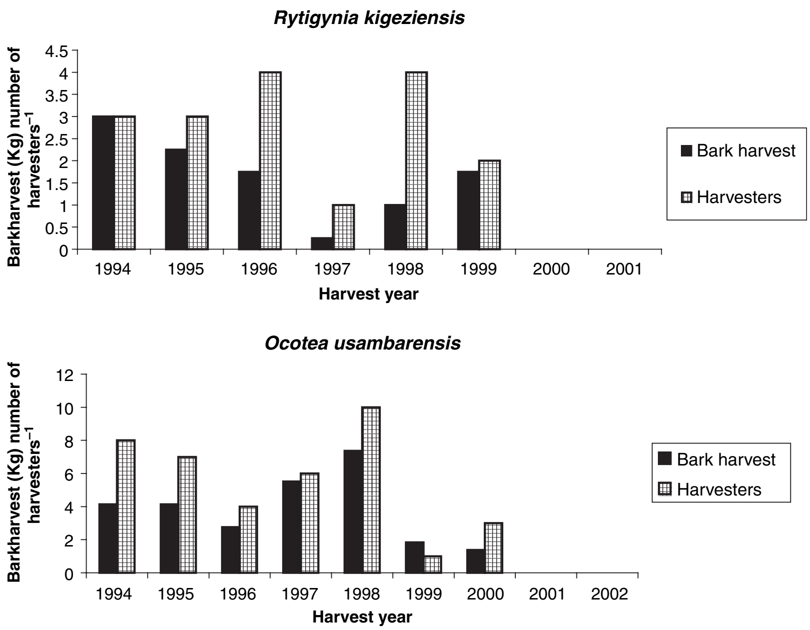

Fig 6 Annual bark harvests of *Rytigynia kigeziensis* and *Ocotea usambarensis* in BINP multiple use zones

The new government programmes have led to a reduction in poverty levels in rural communities adjacent BINP in particular and Uganda in general. Such programs have helped improve the livelihoods of the rural poor and reduced pressure on BINP forest for plant resources extraction. Government and NGOs working around BINP have also provided employment opportunities to the people adjacent BINP, and are therefore able to purchase forest product alternatives such as medicines from local clinics, nylon sacks and baskets from local markets.

Despite the declining interest in multiple use, forest dependency by a cross-section of other people below the poverty line like the Batwa and traditional resource users is still a force to reckon with. These people, few as they may be, still depend on the forest for medicinal and basketry weaving purposes and it would be wrong to completely ignore them. Some of the illegal activities such as wild honey collection, fishing and wild yam collection reported by the BINP rangers could be caused by such people as they continue to search for the resources that they were denied.

Plant resource harvest sustainability

Annual bark harvests of *R. kigeziensis* and *O. usambarensis* from MUZs are too low (range from 0.26% to 1.64%, Table 2). The percentage bark harvests of the available bark stock are too low to cause any noticeable impacts on the harvested plants and can be assumed to be below maximum sustainable yields.

Harvesting sections of bark samples from a stem of *R. kigeziensis* or *O. usambarensis* may have an affect of diverting plant resources from reproduction to healing the wounds created because of bark harvest. In the most serious cases of bark harvest, reproductive capability of the plant may be seriously affected (Hall & Bawa, 1993). From the results and field observations it is quite clear that bark harvest from *R. kigeziensis* and *O. usambarensis*

Table 2 Percentage bark harvests of two mostly utilized medicinal plant in BINP

Plant	Annual bark harvest (kg)	Allowed annual bark harvest (kg)	Available bark mass (kg)	Area sampled (ha)	Bark mass per unit hectare	Area of whole zone (ha)	Bark mass available in MUZ (kg)	% bark harvest of actual bark present
Rytigynia kigeziensis	0.9–5.3	3.5	63.8	71	0.9	360	324	0.28–1.64
Ocotea usambarensis	1.0–5.8	no data	73.5	71	1.04	360	374	0.26–1.55

stems in BINP has caused minimal impacts on the population dynamics and bark production of the two medicinal plants. Annual bark harvest of *R. kigeziensis* and *O. usambarensis* therefore should be increased from the original 1% to about 3% of available bark stock to allow more involvement of the marginalized poor people like Batwa in BINP.

Acknowledgement

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