



Abundance, Distribution, Utilisation and Conservation of *Sinarundinaria alpina* in Bwindi and Mgahinga Forest National Parks, South West Uganda.

Robert Bitariho and Mbokuyo Mosango

Abstract

Sinarundinaria alpina (Schumann) C.S. Chao & Renvoise, a tropical African montane bamboo, is heavily used by local communities for household items such as granaries, baskets, ropes and trays. This article presents the results of a study carried out on the abundance, distribution and utilisation of *S. alpina* in Bwindi and Mgahinga National Parks. Both in-forest and household surveys were used to collect the data. It was found that canopy tree cover plays a role in the distribution of the species. Bamboo abundance and thickness decreased with increasing forest canopy cover from the homogenous bamboo forest type to the mixed bamboo forest types. Bamboo rhizomes are harvested from the two parks for on-farm planting. We conclude with suggestions for conservation of the species.

Introduction

Sinarundinaria alpina (Schumann) C.S. Chao & Renvoise, growing in Bwindi Impenetrable and Mgahinga Gorilla National Parks, is a tropical high altitude woody member of the Poaceae (montane bamboo). It occurs gregariously within mountain forests in tropical Africa (Kigomo 1988, Wimbush 1945). In Uganda, it is found in the Rwenzori Mountains, Mt Elgon, Mgahinga Gorilla National Park, Echuya Forest Reserve and Bwindi Impenetrable National Park (Howard 1991). Because of its occurrence in protected areas, this useful plant resource is one of the causes of conflicts between forest managers and surrounding local communities.

Bamboo plays an important role in the protection of water catchment and prevention of soil erosion, especially in mountainous areas. Additionally its shoots provide food for animals such as mountain gorillas (*Gorilla gorilla*

beringei) and elephants (*Loxodonta africana*) in Bwindi and Mgahinga, which eat bamboo shoots. According to Weber (1981), bamboo culms may provide up to 90 % of the mountain gorilla diet during the rainy seasons in Mgahinga. In Bwindi National Park, elephants feed extensively on bamboo shoots during the rainy seasons (Babaasa 2000).

The bamboo forest in Bwindi (Butynski 1984) is also a habitat for some animals such as blue monkeys (*Cercopithecus mitis kandti*) and l'Hoeest monkeys (*Cercopithecus l'Hoeesti*). Golden monkeys (*Cercopithecus mitis* sp.) are mainly restricted in the bamboo zone in Mgahinga and feed mostly on bamboo shoots and bamboo fresh tops (Aveling 1984).

In Bwindi, the bamboo forest occupies an area of about 5.2 km² only in the southeast corner of the Park's southern sector. In Mgahinga, however, it occupies a larger area of 19.5 km² and occurs from the Mount Sabinyo-Gahinga saddle to the western slopes of Mount Muhavura.

Correspondence

Robert Bitariho, Institute of Tropical Forest Conservation, Ecological Monitoring Programme, P.O. Box 44, Kabale, UGANDA. bitarihorobert@itfc.org

Mbokuyo Mosango, Department of Botany, Makerere University, P.O. Box 7062, Kampala, UGANDA. dmosango@yahoo.com

Ethnobotany Research & Applications 3:191-200 (2005)

In this area, bamboo is the dominant vegetation occupying about 58% of the Park's total area.

Bamboo is a widely used forest product in homesteads adjacent to Bwindi and Mgahinga National Parks. It is the single-most important plant resource, with a multitude of uses including building poles, bean stakes, granaries, basketry and fuel in Gisozi and Rukongi parishes of Mgahinga. In Bwindi, it is used for granaries and basketry in the parishes of Kitojo, Mushanje and Nyamabale (Cunningham 1996). This article presents our findings on the abundance, distribution and utilisation of montane bamboo in Bwindi and Mgahinga two National Parks.

Study site

Bwindi and Mgahinga National Parks are Afromontane forests in the southwestern part of Uganda, located at the edge of the western rift valley. They are part of the remaining few "islands" of the Central African refugia of the Pleistocene times. Bwindi has an area of 331 km² and lies along latitude 0°53' to 1°8'S and longitude 29°35' to 29°50'E. Mgahinga has an area of 33.5 km² and is 25 km south of Bwindi (latitude 1°23'S and longitude 29°39' E).

Like most parts of Uganda, Bwindi and Mgahinga have two rainy and dry season peaks. Bwindi's average rainfall is about 1500 mm while Mgahinga has an average annual rainfall of about 1652 mm. Bwindi overall temperature ranges from 7 to 20 °C, while Mgahinga's temperatures range from 4 to 18 °C (Butynski 1984).

Using aerial photographs of the two parks and preliminary site surveys, three bamboo forest types were distinguished: the homogenous bamboo forest (HOM), the mixed bamboo dominant forest (MBD) and the mixed bamboo forest with other tree species dominant (MOD). The homogenous bamboo forest type has pure bamboo. The mixed bamboo dominant forest has some other tree species but bamboo is dominant. The mixed bamboo forest with other tree species dominant has bamboo but other tree species are dominant. In Mgahinga, all three forest types occur while in Bwindi only two types of mixed bamboo dominant forest occur.

The villages surveyed for this study were those adjacent to Bwindi and Mgahinga National Park's bamboo forests. These villages are found in the parishes of Kitojo, Mushanje and Nyamabale of Bwindi and Gisozi and Rukongi of Mgahinga.

Methods

Abundance, distribution and local utilisation of *S. alpina* were assessed in Bwindi Impenetrable and Mgahinga Gorilla National Parks between 1996 and 1997. The bamboo was sampled by stratified sampling of the three bamboo

forest types. Aerial photographs and preliminary surveys were used to identify the bamboo forest types. Transects were then laid out in each bamboo forest type and made along a predetermined east-west compass bearing following the method of Van Wyk *et al.* (1996). The first transect in each bamboo forest type was located randomly. Plots of 100 m² area were laid out systematically alternating on either side of the transect and separated by a distance of 100 m. In Bwindi, a total area of 0.4 ha was sampled while a total area of 0.6 ha was sampled in Mgahinga. The abundance and distribution of bamboo was assessed by counting the number of bamboo culms rooted within the plots. Diameter at breast height (DBH) was recorded using a millimeter vernier caliper. The age class types of bamboo were identified and classified as shoots, young, mature and old culms following identification by a local specialists classification (see Table 2). Shoots eaten by animals were recorded in each plot.

A structured questionnaire was administered to the 270 homesteads in Bwindi and 180 in Mgahinga. In addition individual interviews were conducted with homestead members in order to assess the community utilisation of *S. alpina*. The questions focused mainly on bamboo utilisation and bamboo product making techniques (items made, the number of culms used and the time spent). Lastly, bamboo gardens in each homestead were visited and farmers interviewed on the number of culms harvested each year.

Analysis of variance (ANOVA) single factor was used to test variations in the number of bamboo culms in the different forest types following Chandrasheraka (1996).

Results

Bamboo shoot and culm density measured in the transects of different forest types in each park are reported in Table 1. Three bamboo culm age classes (Table 2) were identified by local users as: young, mature and old culms. The young ones are usually green and soft; the mature ones are light green and tough while the old ones are yellowish and tough. The percentages of bamboo shoots consumed by animals are given in Table 3.

Table 1. Bamboo shoot and culm density in Bwindi and Mgahinga National Parks. (MOD, mixed bamboo other tree species dominant forest; MBD, mixed bamboo dominant forest; HOM, homogenous bamboo forest; measured as number of culms and shoots per hectare.

Bamboo Forest Type	Bwindi		Mgahinga	
	Shoots	Culms	Shoots	Culms
MOD	60	5965	451	5505
MBD	240	27045	1140	34475
HOM	-	-	2250	41020

Bitariho & Mosango - Conservation of *Sinarundinaria alpina* in Bwindi and 193 Mgahinga Forest National Parks, South West Uganda

Table 2. Bamboo age classes and their uses in Bwindi and Mgahinga National Parks.

Age class type (years)	Bamboo types	Use
<1	Shoots	Food for mountain gorillas, monkeys and elephants
1-4	Young culms	Weaving material for baskets, trays and ropes
5-7	Mature culms	Weaving material for granaries and beehives and uprights for basket weaving
>8	Old culms	Uprights for granary and beehive weaving, building poles for houses and fencing
Dead material	Dead culms	Firewood

Table 3. Percentages of bamboo shoots consumed by animals in Bwindi and Mgahinga National Parks. (MOD, mixed bamboo other tree species dominant forest; MBD, mixed bamboo dominant forest; HOM, homogenous bamboo forest; N = total number of shoots recorded.)

Bamboo shoot category	Bwindi		Mgahinga		
	MOD N=1000	MDB N=3000	MOD N=820	MBD N=4560	HOM N=15000
Eaten	94%	92%	45%	75%	85%
Not Eaten	6%	8%	55%	25%	15%

The uses of bamboo by the local communities living around Bwindi and Mgahinga National Parks are summarized in Table 4. The average number of stems needed and time taken to make a bamboo product and its longevity reported through the surveys and interviews are listed

in Table 5. The percentage of homes with bamboo gardens and the number of stems harvested from these gardens is reported in Table 6. Homesteads in Bwindi harvest a range of 120-360 bamboo culms each year while homesteads in Mgahinga harvests a range 360-900 bamboo culms each year (Table 6).

Table 4. Average number of bamboo products per homestead in Bwindi (N= 270) and Mgahinga (N= 180) National Parks.

Products	Bwindi	Mgahinga
	Average number	
Baskets	3 ±3	7±6
Outdoor granaries	2±2	3±3
Houses	1±2	4±5
Trays	0.2±1	1±1
Beehives	1±6	1±2
Indoor granaries	1±2	2±3
Ropes (bundles)	0	6±22
Stretchers	0.1±0.4	0
Straws	0	1.5±5
Others	0	0.5±1

Table 6. Percentages of homesteads with bamboo gardens and the amount of bamboo culms harvested per year. (N = number of sampled homesteads.)

Site	Homesteads with bamboo gardens	Number of bamboo stems harvested/homestead/year
Bwindi (N =270)	4%	120 - 360
Mgahinga (N = 180)	58%	360 - 900

Table 5. Average number of stems needed and time taken to make a bamboo product and its longevity in Bwindi and Mgahinga National Parks.

Products	Number of Stems		Time taken (hours)		Longevity (years)	
	Bwindi	Mgahinga	Bwindi	Mgahinga	Bwindi	Mgahinga
	Average					
Baskets	5±0	4±2	18±9	15±9	1±0	2±4
Outdoor granaries	36±18	71±41	52±34	50±29	11±9	9±4
Houses	150±107	321±141	420±300	447±388	23±17	25±17
Trays	4±1.2	3±2	20±7	16±11	2±0	2±0
Beehives	8±4	7±3	18±10	12±6	8±6	4±2
Indoor granaries	15±8	16±15	25±7	20±11	11±11	19±4

Discussion

Bamboo culm density, age class and, size class distribution

Bamboo shoot and culm density decreases with increasing tree canopy (Table 1). probably because of the shade created by the increasing canopy tree density from the mixed bamboo forest other tree species dominant to the mixed bamboo dominant forest types. Forest tree canopy probably impedes on the light intensity and duration for the bamboo culms underneath and may therefore inhibit the growth of the montane bamboo. Bamboo culm density is therefore higher in the homogenous bamboo forest type than in the mixed bamboo dominant forest and the mixed bamboo forest other tree species dominant types. Although there is no quantitative evidence, there seems to be interspecific competition for light and soil nutrients in the mixed bamboo forest other tree species dominant and the mixed bamboo dominant forest types that may affect bamboo culm abundance and distribution thus leading to the homogenous bamboo forest type having the highest bamboo culm density.

The majority of bamboo in Bwindi and Mgahinga National parks are of the old age class while the least are the bamboo shoots and young culms age class with larger height stems (Figure 1). Each bamboo age class has particular uses (Table 2). Bamboo shoots are eaten by gorillas, monkeys and elephants; young culms are used as weaving materials for baskets, trays and ropes; mature culms are used as weaving material for granaries and beehives; old culms are used as building poles for houses and fencing; and finally, dead culms are used as firewood. The study shows that the bamboo forests in Bwindi and Mgahinga contains little weaving material for baskets although building poles are abundant.

The diameter size distributions varied significantly between the bamboo forest types ($F=216$, $P=0.05$, and $F=227$, $P=0.05$ respectively, ANOVA single factor analysis) (Figure 2). Thick bamboo culms dominated in all forest types and their diameters range between 24.5 and 48.5 mm in Bwindi, and between 16.5 and 48.5 mm in Mgahinga. However, there was relatively a higher occurrence of thick bamboo culms (> 40.5 mm) in Bwindi than in Mgahinga. Furthermore, culm thickness decreases with increasing tree canopy. In Bwindi, for example, the bamboo culm diameters decrease from the mixed bamboo dominant forest to the mixed bamboo forest other tree species dominant bamboo forest type; and in Mgahinga the thickest bamboo culms are found in homogenous bamboo forest type and the thinnest in the mixed bamboo forest other tree species dominant.

There are other possible factors affecting the bamboo culm thickness like soil nutrients, drainage type and inter-

specific and intraspecific competitions but are beyond the scope of this study, further investigations could be done.

Like the diameter height and diameter distributions, the age class size distributions of bamboo vary with bamboo forest types ($F=35$, $P=0.05$, and $F=520$, $P=0.05$ respectively, ANOVA single factor analysis) (Figure 3). More older bamboo (> 7 m) were found in Bwindi than in Mgahinga, especially in the mixed bamboo dominant forest type (Figure 3A&B). Like the bamboo culm diameters, the height of bamboo culms seems to be affected by forest tree canopy. Bamboo culm height decreased with increasing tree canopy except for the mixed bamboo dominant forest type of Mgahinga.

Other complex factors like soil nutrients, drainage and interspecific competitions may affect the bamboo culm height and these could be investigated in further studies but seem to have contributed to the anomaly in the mixed bamboo dominant forest type of Mgahinga National Park.

Bamboo consumption and utilisation

The number of shoots eaten by animals (Table 3) is high (74-93%) except in Mgahinga the mixed bamboo forest other tree species dominant type (43%). Bamboo shoots normally sprout during the rainy seasons and this is when animals come to feed on them. The most important consumers of bamboo observed were mountain gorillas, monkeys and elephants. Animals feed quite extensively on bamboo shoots in all the bamboo forest types of Bwindi and in Mgahinga (Table 3). The high rate of consumption of bamboo shoots by animals is probably counterbalanced by a high bamboo shoot production during the rainy seasons. This study was carried out during the rainy seasons when animals were feeding extensively on the bamboo shoots.

Based upon the surveys of local communities, it appears that a variety of products are made from bamboo (Table 4). However, the number of bamboo products made per homestead varies considerably. There are more baskets in each homestead than other bamboo products. Bamboo products, especially baskets, granaries and house construction materials were used more in Mgahinga than in Bwindi. As Tables 3 and 4 show there is a demand for bamboo shoots (by animals) and young bamboo culms (for basket weaving) and yet these are less abundant in the bamboo forest types of both parks (Figure 1).

The number of bamboo culms needed and time taken to make a homestead product is variable, depending on the product made (Table 5). More bamboo culms are used for building houses than for making any other homestead product. Variation in the number of culms used per homestead is probably due to the size of the products being made. The longevity of bamboo products is also vari-

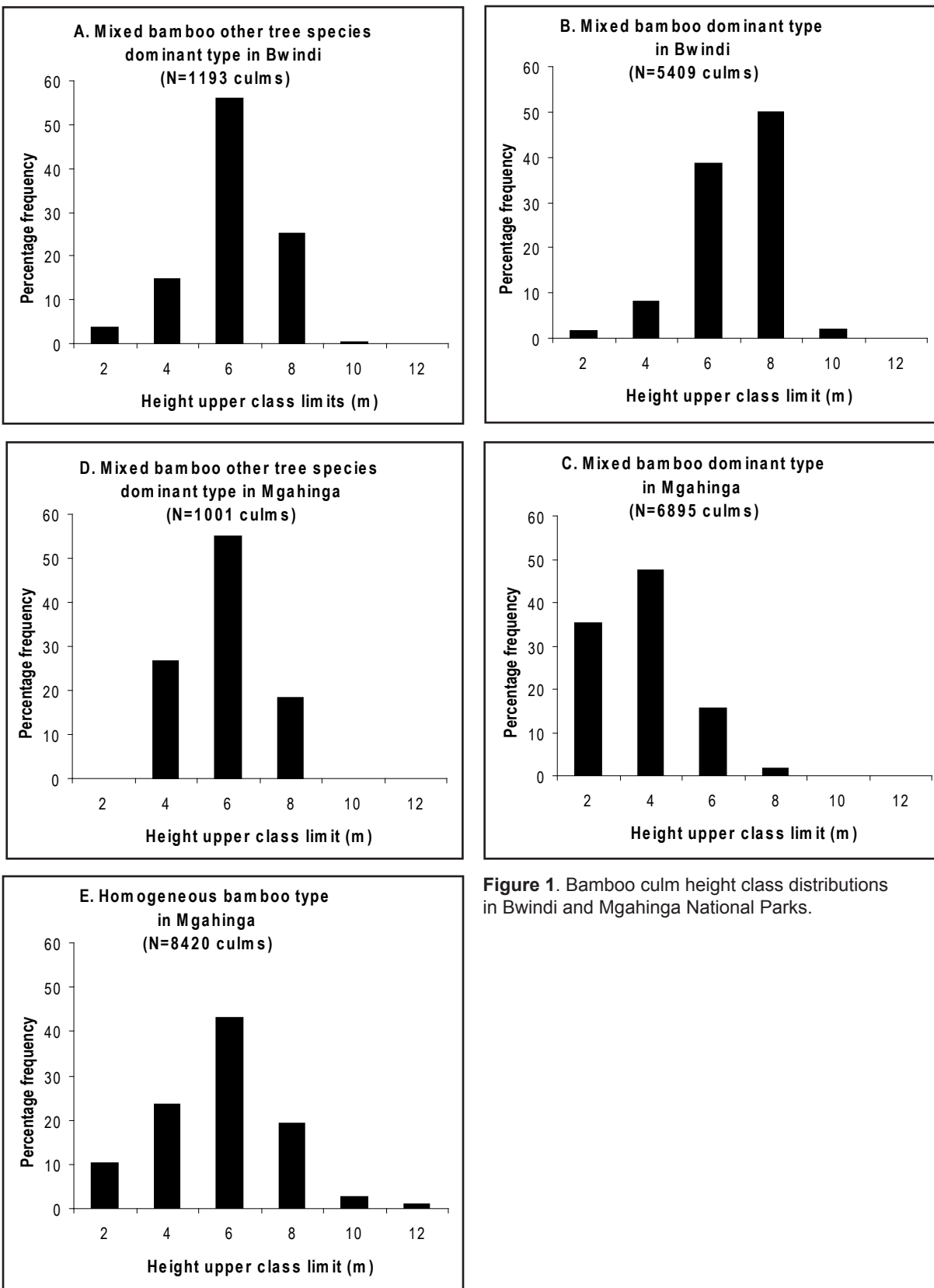


Figure 1. Bamboo culm height class distributions in Bwindi and Mgahinga National Parks.

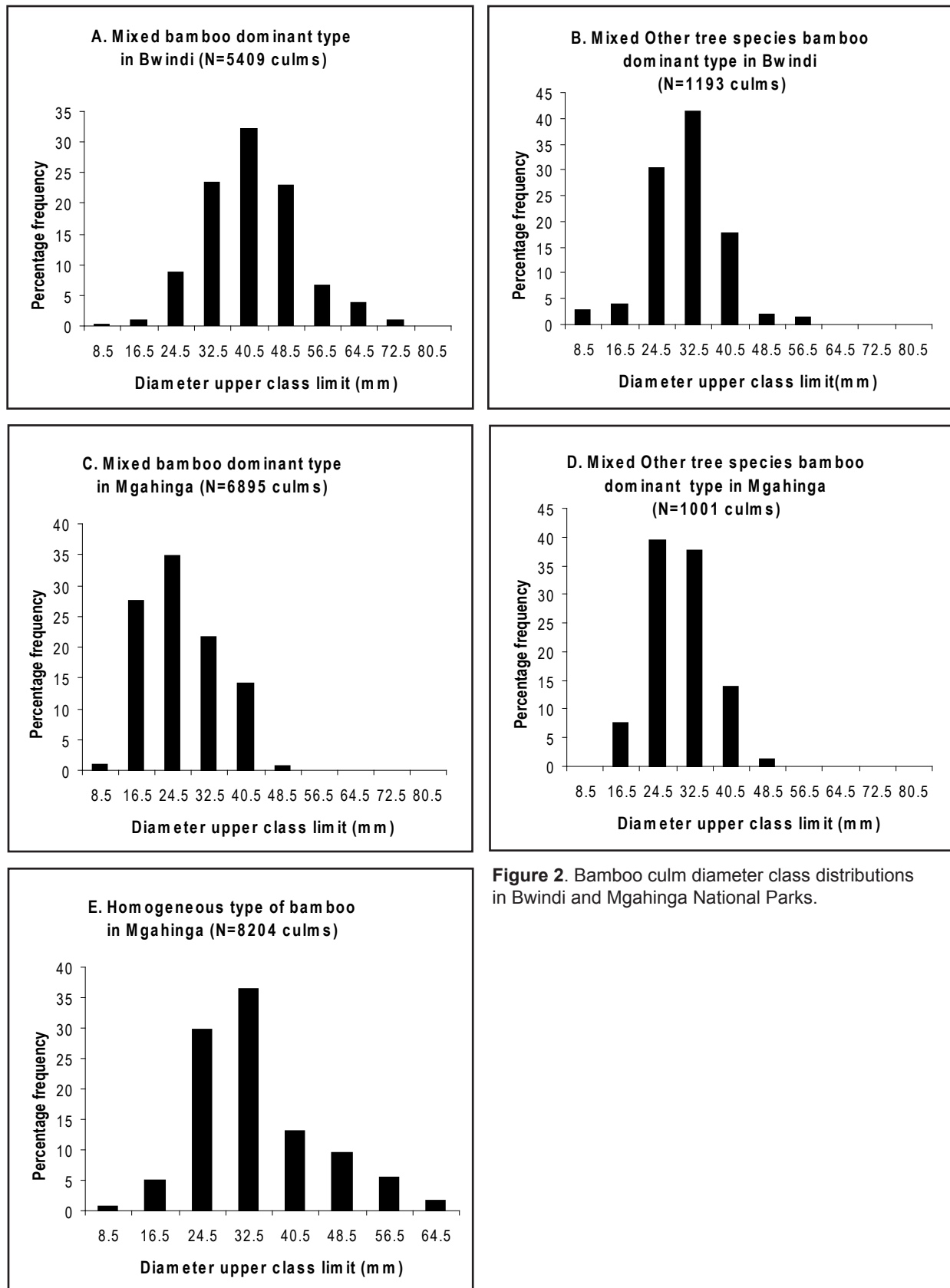


Figure 2. Bamboo culm diameter class distributions in Bwindi and Mgahinga National Parks.

Bitariho & Mosango - Conservation of *Sinarundinaria alpina* in Bwindi and Mgahinga Forest National Parks, South West Uganda 197

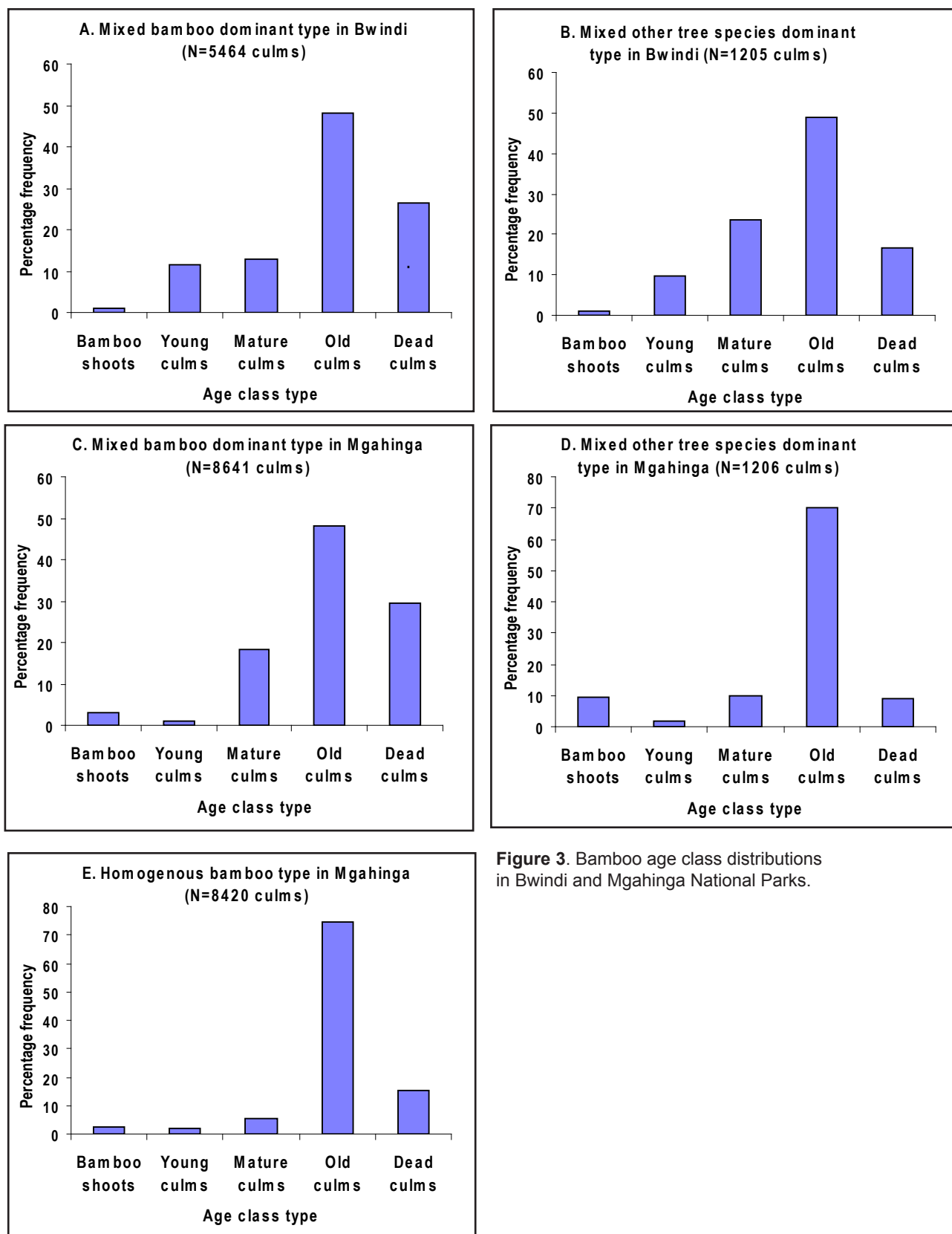


Figure 3. Bamboo age class distributions in Bwindi and Mgahinga National Parks.

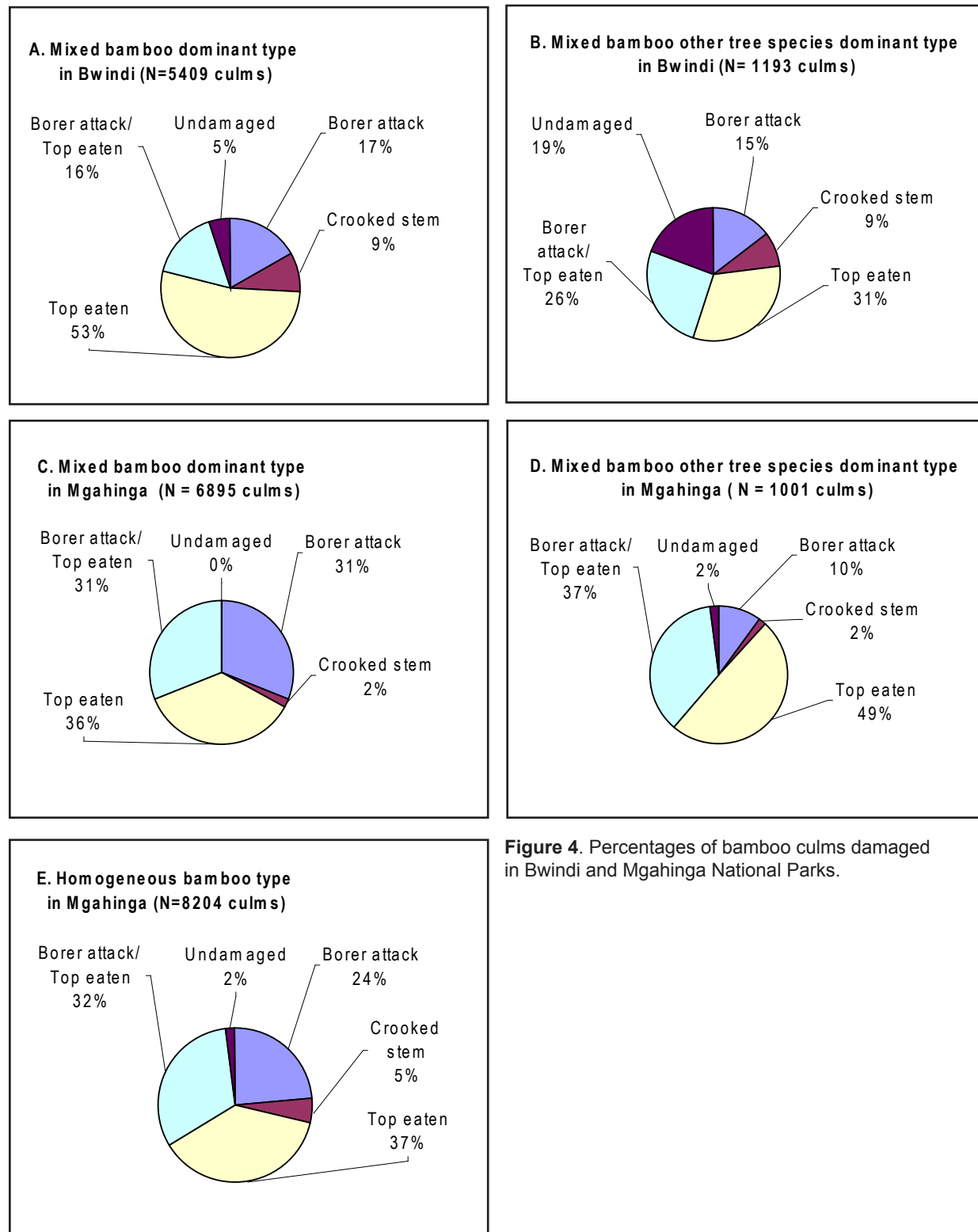


Figure 4. Percentages of bamboo culms damaged in Bwindi and Mgahinga National Parks.

Bitariho & Mosango - Conservation of *Sinarundinaria alpina* in Bwindi and Mgahinga Forest National Parks, South West Uganda 199

able. In general, houses last longer than any other bamboo product. The longevity of bamboo products depends on their care, the quality of bamboo used and the type of work the product will perform. However, this longevity can be affected by factors such as termite attack and exposure to rain.

According to several respondents, bamboo product makers normally select a certain type of bamboo depending on the required product. For example, thick and tall bamboo culms are used for weaving baskets and granaries while thin and short bamboo culms are mostly used for bean stakes. Most of the bamboo from the Bwindi and Mgahinga National parks is of poor quality for weaving and building purposes (Figure 4). The majority of the bamboo culms are either borer attacked, crooked or with eaten tops. Borer attacks on bamboo and broken tops of bamboo (as a result of monkey feeding) affect the quality of bamboo for homestead use (Bitariho 1999). The majority of the bamboo culms in both parks have eaten tops (monkeys usually eat the fresh top parts of the bamboo) (Figure 4). In Bwindi, the best bamboo culms are found in the mixed bamboo forest with other tree species dominant type (19%) while in Mgahinga the best bamboo culms are found in the mixed bamboo forest other tree species dominant and homogenous bamboo forest types (2%). The results imply that the bamboo forests in both parks are not a good source of bamboo culms for homestead use. Bamboo products made from such culms are easily attacked by termites and therefore have a short longevity.

Demand and Supply of bamboo

People living around Mgahinga National Park use bamboo culms more than those living around Bwindi (Table 6). This is the reason why there are more bamboo gardens around Mgahinga Park (58% of the 180 sampled homesteads). The demand of bamboo culms is therefore relatively high. In Bwindi, however, the cultivation of bamboo is very low, only 4% of the 270 sampled homesteads have bamboo gardens.

Conclusions

Before planning for effective management and exploitation of forest resources, forest managers need to know where the resources grow and in which quantity (Obua *et al.* 2000). This information on the occurrence and abundance of forest plants is important for sustainable management and utilisation of non-timber forest resources (Peters 1994). In this study, the major forest types where montane bamboo (*S. alpina*) occurs most in Bwindi Impenetrable and Mgahinga Gorilla National Parks have been highlighted.

Although bamboo culm density is relatively high in Bwindi and Mgahinga National Parks, their abundance varies

within bamboo forest types. Homogenous bamboo forest types have the most bamboo culms than other forest types. The highest presence of bamboo culms in the homogenous bamboo forest is probably due to the less impendence of light there than in the mixed forest types. In fact, this is the case with the Asian bamboo. Koichiro (1960), Reid *et al.* (1991) and Taylor & Zisheng (1993) stated that light intensity plays a major role in the abundance and distribution of bamboo stems. High bamboo density is found where light intensity is high, like in the homogenous bamboo forest type. Although these studies were based on the Asian bamboo, this may also be the case with the *S. alpina* since, the montane bamboo observed have healthier culms when in open places than in closed place during this study. Other complex factors also contribute to the abundance and distribution of the bamboo but cannot be demonstrated in this study. The thickest bamboo stems are found in the bamboo homogenous forest type, probably because of the absence of interspecific competition for light. However, in the other types of bamboo forests (mixed forest types), interspecific competition for light is higher. This is therefore a limiting factor to montane bamboo growth. Consequently, the number of bamboo stems and their thickness are reduced.

Five bamboo age classes were identified in the two National Parks: shoots, young culms, mature culms, old culms and dead culms. However, the old bamboo culms are more abundant in the two National Parks. When Bwindi and Mgahinga, were designated National Parks, harvesting of bamboo culms from the forest by the local communities was stopped (Bitariho 1999) presently only harvesting of bamboo rhizomes for on-farm planting is allowed. According to Kant *et al.* (1992), a long pause in cutting the bamboo culms results in many old individuals.

Bamboo culms are used for various purposes in the two National Parks but their number largely depends on the size of the product made. The main house, for example, requires more bamboo culms than the kitchen. Moreover, the life span of a bamboo product depends largely on how it is used. For instance, baskets last a very short time because they are used daily to carry crop products from gardens to markets. Houses last longer because they are usually protected with mud. Lack of alternatives like vines, lianas and woodlots, leads to the massive use of bamboo in Mgahinga Gorilla National Park unlike Bwindi National Park where there are alternatives (Bitariho 1999).

Areas with a high abundance of bamboo culms are the most preferred sites for bamboo harvesting since they have many culms that therefore reduce the time taken for harvest. Therefore the homogenous and the mixed bamboo dominant forest types would be the most preferred sites for bamboo harvesting, but these areas have bamboo of "poor" quality for homestead use. The mixed bamboo forest with other tree species dominant type is there-

fore the preferred site for bamboo used for bean stakes since most bamboo culms in this forest are thin and short.

The present harvest method of bamboo rhizome for on-farm planting in Bwindi and Mgahinga is haphazard and is not based on bamboo abundance and distribution. This could ultimately lead to the depletion of the bamboo species and, subsequently, bamboo forest ecosystems in these National Parks if conservation measures are not taken. It is therefore important to harvest bamboo rhizomes in selected areas of the homogenous and mixed bamboo forest types where the bamboo is abundant and also to encourage the local communities adjacent the two parks to set up homestead bamboo gardens in order to assure sustainable use of bamboo.

Acknowledgements

We are grateful to the World Wildlife Fund for Nature and the Institute of Tropical Forest Conservation for sponsoring this research. Many thanks to IUCN/Ford Foundation for providing us with a small grant publication award for this article. Our thanks also go to Drs A. McNeilage, R. Malenky, T. C. Cunningham and Ms Miriam van Heist for their positive comments.

Literature cited

- Aveling, C. 1984. Notes on the golden monkey, *Cercopithecus mitis kandti*, of the Virunga volcanoes, Rwanda. *African Journal of Ecology* 22:63-64.
- Babaasa, D. 2000. Habitat selection by elephants in Bwindi Impenetrable National Park, Southwestern Uganda. *African Journal of Ecology* 38:116-122.
- Bitariho, R. 1999. *The abundance, distribution and use of montane bamboo in Bwindi Impenetrable and Mgahinga Gorilla National Parks, southwestern Uganda*. M.Sc. thesis, Makerere University, Kampala, Uganda.
- Butynski, T. M. 1984. *Ecological survey of the Impenetrable (Bwindi) forest, Uganda and recommendation for its conservation and management*. Scientific Report, New York Zoological Society, New York.
- Chandrasheraka, U. M. 1996. Ecology of *Bambusa arundinacea* (Retz.) Wild. Growing in Teak Plantation of Kerala, India. *Forest Ecology and Management* 91: 83-91.
- Cunningham, A.B. 1996. *People, Park and Plant Use: Recommendations for multiple-use zones and development alternatives around Bwindi-Impenetrable National Park, Uganda*. People and Plants working paper 4, UNESCO, Paris.
- Howard, P. C. 1991. *Nature Conservation in Uganda's Tropical Forest Reserves*. IUCN, Gland, Switzerland.
- Kant, H., Kigomo, B.N. & J.K. Ndambiri. 1992. *Development of Bamboos in Kenya*. Report to the Kenya forestry master plan. Nairobi, Kenya.
- Kigomo, B.N. 1988. *Distribution, Cultivation and Research Status of Bamboo in Eastern Africa*. Kenya Forestry Research Institute, Nairobi, Kenya.
- Koichiro, U. 1960. *Studies on the Physiology of Bamboo with Reference to Practical Applications*. Experimental forest station, Faculty of Agriculture, Kyoto University. Resource bureau Science and Technics agency, Prime Minister's Office.
- Obua, J., S.F.M. Ogwal & D. Mosango. 2000. Ecology, utilization and conservation of *Smilax kraussiana* in Bwindi Impenetrable Forest National Park, Uganda. *Journal of Tropical Forest Science* 12:542-551.
- Peters, C.M. 1994. *Sustainable Harvest of Non-timber Plant Resources in Tropical Moist Forests: An ecological primer*. The Biodiversity Support Programme, Washington, D.C.
- Reid, D.G., A. Taylor, H. Jinchu & Q. Zischeng. 1991. Environmental influences on Bamboo *Bashania fangiana* Growth and Implications for giant panda conservation. *Journal of Applied Ecology* 28:855-868.
- Taylor, A.H. & Q. Zischeng. 1993. Structure and Dynamics of Bamboos in the Wolong Natural Reserve China. *American Journal of Botany* 80:375-384.
- Van Wyk, G.F., Everard, D.A., Midgley, J.J. & I.G. Gordon. 1996. Classification and Dynamics of a Southern African Subtropical Coastal lowland forest. *South African Journal of Botany* 62:133-142.
- Weber, A.W. 1981. *Conservation of the Virunga Gorillas: A socio-economic perspective on habitat and wildlife preservation in Rwanda*. M.Sc. thesis, University of Wisconsin, Madison.
- Wimbush, S.H. 1945. The African Alpine Bamboo. *Empire Forestry Journal* 24:33-39.