POTENTIAL FOR JOINT MANAGEMENT AND MULTIPLE USE OF NYUNGWE FOREST, RWANDA

BY

Jean Damascène NDAYAMBAJE

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Supervisor: **Dr. Isla M. GRUNDY**

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DECLARATION

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and has not previously in its entirety or in part been submitted at any university for a degree.

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ABSTRACT

Nyungwe Forest in the South West of Rwanda is surrounded by a dense human population (350 people/km^2) which depends on subsistence agriculture and livestock. Previous reports on the Forest have shown that its survival is threatened by illegal use of its resources. Participatory rural appraisal was conducted in five Communes next to the Forest to study the community's perceptions, uses and interests with respect to access and management of the Forest. Respondents perceived the Forest as a source of 18 categories of products of which only 14 were said to be of value for the respondents' livelihoods. Land, timber and minerals (gold) were the priority resources preferred by more than 55% of the respondents. Other important resources included fodder/pastures, wooden goods, fuelwood and poles. Fourteen different species were most preferred for timber, 16 for poles, 45 for medicinal materials and six for wooden goods. However, the majority of these species were preferred for multiple uses as timber, poles and medicines.

A forest resource assessment was carried out to identify the stock of the preferred tree species. Not all woody resources mentioned as being preferred were available, with some tree species not found at all in the Forest. In order to identify tree species that can be used sustainably, different criteria including abundance (density), dominance, diameter size-class distribution and regeneration, were used in combination. Of the 12 tree species recorded in the Forest and most preferred for timber, only three species were present in sufficient abundance and sizes to allow sustainable utilisation. Of the 12 pole species identified, six were not vulnerable to exploitation, and of the preferred medicinal tree species only five were considered to fit into this category.

Low resource availability and the need to address the interests of adjacent communities necessitated management options which enable access to some resources and benefits the communities as well as conservation measures to protect the biodiversity. A range of joint forest management options is discussed in order to assess the feasibility of a collaborative approach in the management of Nyungwe Forest. Some recommendations are made with respect to access to resources, the use of substitutes and areas for future research.

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OPSOMMING

Nyungwe Bos in die suidweste van Rwanda word omring deur 'n digte bevolking van 350 mense/km² wat van bestaanslandbou en lewende hawe afhanklik is. Vorige verslae het aangedui dat die voortbestaan van die Bos bedreig word deur die onwettige gebruik van sy hulpbronne. 'n Evaluering is in vyf gemeenskappe (*Communes*) langs die Bos gedoen om die gemeenskap se persepsies oor, gebruike van en belangstelling in die toegang tot die Bos, sowel as die bestuur daarvan te bestudeer. Die mense van hierdie plattelandse gebied is by die evaluering betrek. Respondente sien die Bos as 'n bron van produkte wat in 18 kategorieë ingedeel kan word, maar waarvan slegs 14 kategorieë van waarde is vir die respondente om 'n bestaan te kan maak. Meer as 55% van die respondente het grond, hout en minerale (goud) as die belangrikste hulpbronne aangedui. Ander belangrike hulpbronne sluit in veevoer of weivelde, houtartikels, brandhout en pale. Die respondente het 14 verskillende houtspesies verkies as timmerhout, 16 vir pale, 45 vir medisinale gebruike, en ses vir houtartikels. Die meerderheid van hierdie spesies is egter verkies vir veelvuldige gebruike soos timmerhout, pale en medisyne.

'n Evaluering van die hulpbronne in die bos is uitgevoer om te bepaal hoeveel bome van die gunstelingspesies daar in die bos is. Nie al die houthulpbronne wat deur die respondente verkies is, was beskikbaar nie, en sommige boomspesies is glad nie in die Bos gevind nie. Ten einde boomspesies te identifiseer wat vir lewensmiddele gebuik kan word, is 'n kombinasie van verskillende kriteria gebruik, insluitende die hoeveelheid bome (digtheid), dominansie, die verspreiding van die verskillende klasse deursneegroottes, en regenerasie. Van die 12 boomspesies in die Bos wat na aanleiding van hierdie evaluering opgeteken is en wat voorheen as gunstelingspesies vir timmerhout aangedui is, is daar slegs drie wat volop en groot genoeg is om vir lewensmiddele gebruik te word. Van die 12 spesies wat vir pale geïdentifiseer is, is ses teen oorontginning bestand, en van die gunsteling medisinale boomspesies val slegs vyf in laasgenoemde kategorie.

Lae hulpbronbeskikbaarheid en die behoefte om die aangrensende gemeenskappe se belange aan te spreek, het bestuuropsies genoodsaak wat toegang tot sommige hulpbronne moontlik maak en wat die gemeenskappe bevoordeel, sowel as bewaringsmaatreëls ten einde die biodiversiteit te beskerm. 'n Verskeidenheid gesamentlike bosbestuuropsies is bespreek ten einde die uitvoerbaarheid van 'n benadering van samewerking in die bestuur van die Nyungwe Bos te ondersoek. Enkele aanbevelings is gemaak wat betref toegang tot hulpbronne, die gebruik van plaasvervangers, en studiegebiede vir verdere navorsing.

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DEDICATION

This thesis is dedicated to my dear wife, Mrs Assumpta, to my sons Jean Yves, Jean Hubert, Ghislain and Joel Clint, and to my sister, Donatilla.

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1 INTRODUCTION

1.1 RWANDA: OVERVIEW

Rwanda is a small (26 338 km^2) land-locked country in Central Africa between latitude 1°05' and 2°50' South and longitude 28°50' and 30°25' East. It borders Burundi in the South, Uganda in the North, Tanzania in the East and the Democratic Republic of Congo in the West (Figure 1.1). It is hilly with altitudes less than 1 500 m in the eastern plateau but rising to between 1 500 and 2 000 m in the central plateau area and higher in the West and North. The following geographic regions are distinguished, moving from West to East (MINETERRE, 2000):

- The north-south ridge of the watershed between the Congo and the Nile, with peaks rising to between 2 400 m and 3 000 m. The remnants of Rwanda's natural forests are found on this ridge;

- The highlands that are an extension of those in Uganda and form the centre of the country between the Congo-Nile Crete in the West and the eastern zone, and decrease in altitude from West to East. Within the altitudinal range of 1500 m and 2000 m, the centre of the country is characterised by a mosaic of hills with rounded tops, separated by large swamps which cover almost half of the country's area. A ridge of five volcanoes in the far North-West dominates the Congo Nile Crete. From the West and moving eastwards are found the peaks of Kalisimbi (4507 m), Bushokoro (3 711 m), Sabyinyo (3 634 m), Gahinga (3 474 m) and Muhabura (4 127 m).

- A large eastern zone of hills and swampy lakes, located from Kigali to the border with the Republic of Tanzania, occurs at altitudes between 1 000 and 1 500 m. A large section of this zone lies within Akagera National Park.

Rwanda has a sub-tropical climate with an average annual temperature of 18°C. The average rainfall is 1250 mm, falling in two seasons separated by two dry seasons.

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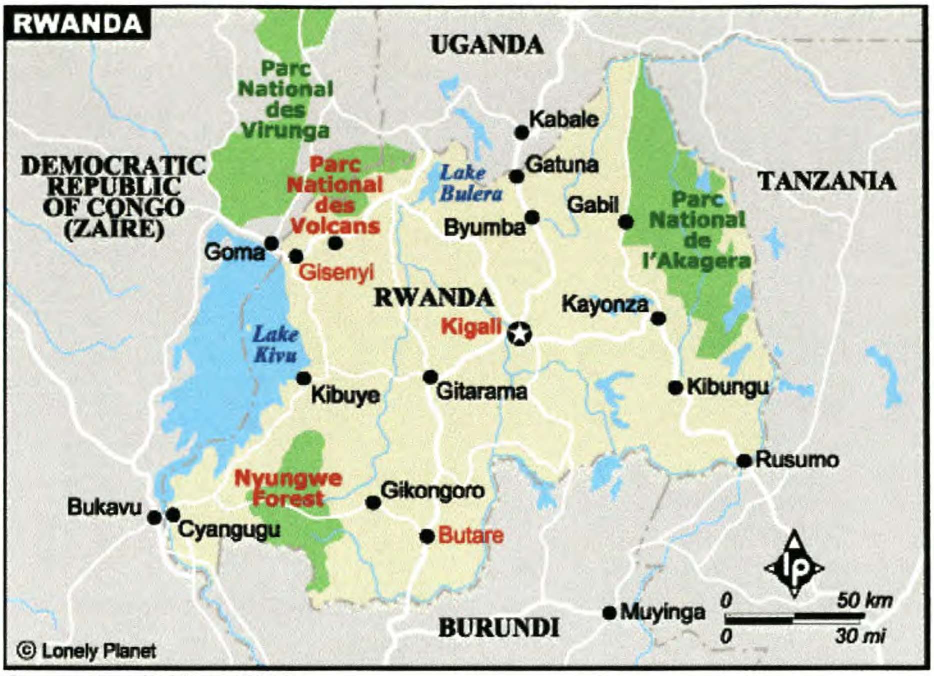

Source: Lonely Planet (2001).

Figure 1.1. Geographical location of Rwanda

1.2 POPULATION

The population of Rwanda was estimated to be 7.733 million in 2000 with a natural increase rate of 2.1 % and a density of 320 inhabitants per km^2 (ADB, 2001). The rural population density of Rwanda is one of the highest in Africa (MINAGRI, 1998). In 1991, 94% of the population lived in rural areas and the remaining 6% in urban areas. A socio-demographic survey by MINECOFIN (1998) found that 91.1% of the active population is in the agricultural sector, 1.7% in industry and 7.2% in the services sector. At national level, the average size of the household is 5 persons and the farm size less than one hectare. The current demographic features lead to mixed farming where diversified cropping and livestock farming are practised. The farming techniques are exclusively manual (MINAGRI, 1998).

About 70% of 1.3 million ha of land is cultivated, the majority of it on family farms. The latter are found on all types of land, including land of marginal quality for agricultural production (MINAGRI, 1998). A large number of these farms are not profitable and households live on the threshold of rural poverty. In 1997, the GDP per capita was US$ 240 (MINECOFIN, 1998), which was less than half of the most

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recent estimate for low income Sub Saharan Africa of US$ 490 (World Bank, 1998). The main constraints to production include a strong pressure on natural resources, the natural land infertility and the lack of use of agricultural inputs (MINAGRI, 1998). Land shortage is particularly prevalent in high altitude zones (MINAGRI, 1997).

1.3 STATUS OF FORESTRY IN RWANDA

1.3.1 Forest plantations

Forest plantations have been established in Rwanda since 1920 with the introduction of fast growing exotic tree species, mainly *Eucalyptus spp.* (*Eucalyptus tereticornis* and *E. saligna*), for the purpose of protecting high mountainous areas from erosion and for the supply of fuelwood. By 1967, about 20 000 ha of forest plantations had been established. Wide scale plantation forestry started in 1967 with the commencement of the first donor-funded Forest Project, Projet Pilote Forestier (PPF). From 1967 to 1975, PPF established 5500 ha in Kibuye Prefecture. The year 1975 was a turning point for plantations with the start of a tree planting campaign and large scale development projects, supported financially and technically by several organisations abroad. The total area planted during that year was 25 500 ha (Habiyambere, 1997). In 1990, 247 500 ha of forest plantations were created (Habiyambere, 1997). Between 1993 and 1995, all silvicultural activities stopped due to war and genocide in Rwanda. In 1995, these activities started again, including establishment and rehabilitation of damaged plantations. The total forest plantations were estimated at 247 500 ha in 1991 (Habiyambere, 1997) and at 256 300 ha in 1997 (MINITERRE, 2000).

Apart from *Eucalyptus spp.*, other new exotic tree species in plantations include *Grevillea robusta, Pinus patula, Cupressus lusitanica, Callitris spp., Acacia melanoxylon* and *Casuarina spp.* These are established largely on government lands, as only a small proportion of plantation land is privately owned (FAO, 1999; Mihigo, 1999). A few local tree species were planted, particularly in buffer zones around indigenous forest reserves (Habiyambere, 1997). Beside plantation forestry, trees on farmer's fields are an integral part of the production systems. Both local and exotic tree species with agroforestry potentialities are mixed or inter-planted with food

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crops. They are normally established around the homesteads, along erosion control ditches, scattered on farms or used to demarcate farms. In 1989, trees on farms covered an estimated area of 87 200 ha (FAO, 1999). Effective inventory data for forest plantations are reported to be unavailable (FAO, 1999).

Based on ownership, forest plantations in Rwanda are divided into governmental, communal and private categories. The area of forest plantations belonging to the second category was the largest in 1990 (Table 1.1).

Table 1.1. Distribution of forest plantations in Rwanda by tree species and ownership in 1990.

	Government		Communal		Private		Total	
Species	Area (ha)	%	Area (ha)	%	Area (ha)	%	Area (ha)	%
Eucalyptus spp.	30 600	50	69 370	70	61 040	70	161 010	65
Pinus patula	18 360	30	9 910	10	4 360	5	32 630	13
Cupressus lusitanica	4 900	8	7 930	8	8 720	10	21 550	9
Acacia menaloxylon	4 280	7	6 940	7	-	-	11 220	5
Callitris spp.	1 830	3	2 970	3	-	-	4 800	2
Grevillea robusta	-	-	-	-	4 360	5	4 360	2
Casuarina spp.	1 230	2	1 980	2	-	-	3 210	1
Others	-	-	-	-	8 720	10	8 720	3
Total	61 200	100	99 100	100	87 200	100	247 500	100

Source: Mihigo (1999), MINAGRI (1997) and Murererehe (1999)

The plantation forest cover declined following the 1994 crisis in Rwanda. Habiyambere (1997) reported that the large displacement of people and cutting of forest plantations for fuelwood and shelter needs resulted in a loss of 15 000 ha and extensive damage to 25 000 ha.

1.3.2 Montane forests and savanna woodlands

Rwanda's protected forests consist of closed forests that are generally submontane or montane, concentrated in the west of the country, and in the mountains bordering Kivu Lake (FAO, 1999). The submontane forests are mainly broad-leaved, moist deciduous forests and are characterised by species such as *Syderoxylon adolfi-friederici* and *Entandrophragma excelsum*. These are largely secondary growth, with

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most of the original forest having been cleared and only small patches of primary forest remaining in inaccessible areas. Above 2 000 m, the predominant forest type is broadleaved moist evergreen forest, with characteristic species including *Syzygium parvifolium, Xymalos monospora* and *Psychotria spp.* Stands of *Arundinaria alpina* are found in the mountains of the Zaire-Nile ridge above 2 300 m to 2 400 m in almost pure condition or mixed with *Podocarpus latifolius* and *Polyscias fulva* (Bosshard, 1971). *Arundinaria* stands are also found in the Birunga National Park bordering Uganda and the Democratic Republic of Congo.

Major montane forests in Rwanda include three natural forests, namely Nyungwe, Mukura and Gishwati. These forests belong to the afromontane forests of the Albertine Rift and are characterised by high biodiversity (MINITERRE, 2000). The Volcano National Park, in the northern mountainous border of Rwanda and the Democratic Republic of Congo and Uganda, is a remnant montane forest set aside as a forest reserve since 1933 (Spinage, 1972). The east of the country has extensive areas of savanna woodland, with *Acacia seyal* and *Combretum binderanum* found on deep soils and *Pappea ugandensis* on lateritic soils (Hecq and Froment, 1961). Open sclerophyllous forests of *Croton dichogamus* and *Euphorbia dawei* cover part of Akagera National Park (FAO, 1999). Savanna woodland and gallery forests make up about 163 ha and are home to a variety of plant species used as traditional medicines, foods and for other human needs (MINITERRE, 2000).

Pressure for agricultural land, settlement and forest products has led to a reduction in size and to an irreversible loss of biodiversity of protected forests (MINAGRI, 1998). Table 1.2 shows the reduction in size of these areas between 1960 and 1999. Nyungwe Forest has undergone a significant rate of deforestation. Its current area is 89 150 ha (Gapusi, 1999), much bigger than that of the second largest existing natural forest, Mukura (1600 ha). The Gorilla sanctuary, Birunga National Park, has a remaining area of 12 760 ha from an initial cover of 30 000 ha in 1924 (Twarabamenye, 1999). There is no precise estimate of the cover of Gishwati Forest and savanna woodlands. Parts of Gishwati Forest and Akagera National Park have been declassified for human settlement (Mihigo, 1999; Williams and Ntayombya, 1999).

Table 1.2. Protected forests' cover change in Rwanda between 1960 and 1999 (MINAGRI, 1999).

	Forest cover (ha)						Cover
Protected forest	1960	1970	1980	1990	1996	1999	change, %
Nyungwe	114 025	108 800	97 000	97 000	94 500	89 150	21.8
Gishwati	28 000	28 000	23 000	8 800	3 800	-	-
Mukura	3 000	3 000	2 000	2 000	1 600	1 600	46.7
Birunga	34 000	16 000	15 000	14 000	12 760	12 760	62.5
Akagera	267 000	267 000	267 000	241 000	220 000	90 000	66.3
Other*	150 000	150 000	90 000	50 000	20 000	-	86.7
Total	596 025	572 800	494 000	412 800	352 660	193 510	

* Gallery and savanna woodlands.

1.4 FOREST PRODUCTS

1.4.1 Wood products

The major products from exotic and indigenous tree species include timber, poles, crafts and fuelwood. Quantitative data are disparate and only imprecise estimates exist for these products. *Eucalyptus* poles are used chiefly for construction purposes. The annual consumption of construction wood in the country's capital, Kigali, is about 15 000 to 20 000 m^3 per year, while it averages 40 000 m^3 in rural areas (Habiyambere, 1999). Timber is entirely produced by pitsawyers. Preferred species are *Eucalyptus spp.* (45%), *Cupressus spp.*, and *Grevillea robusta*. The annual consumption of timber is estimated at 36 000 m^3 (MINECOFIN, 1998), processed from a standing volume of about 72 000 m^3 (Habiyambere, 1999). *Eucalyptus* represents 45% of the market for timber; *Cypress* and *Grevillea* both 23% and *Pinus* 4.5%. The remaining 4.5% of this market is made up by imported wood from neighbouring countries and consists of high value tree species such as *Entandrophragma excelsum*.

MINECOFIN (1998) reported that forestry supplies 96.2% of the energy consumed in the country, of which 90.8% is firewood and 5.4% charcoal. In 1997, fuelwood consumption averaged 7.1 million m^3, 5% of which was used by small industries. For charcoal, which is traditionally produced and mainly consumed in urban areas, the

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annual production amounted to 46 000 tonnes, most of which (80%) was sold in the country's capital, Kigali (Habiyambere, 1999).

In 1996, the charcoal deficit was approximately 4.5 million m^3 per year (FAO, 1996). The result is the use of crop residues and other dead materials by rural people in place of fuelwood and charcoal (Niang and Styger, 1990). In the absence of alternative sources of energy, the forestry sector will continue to be the major source of energy supply. However, the sustainability criteria of woodlands and protected forests will not be met due to encroachment through fuelwood gathering and charcoal for sale in towns (Habiyambere, 1999).

1.4.2 Non-wood products

Non-wood forests products (NWFP) are still considered as secondary forest products in Rwanda (Murekezi, 1999). For many years, forests were considered as source of wood products, namely fuelwood, timber, building poles and woodcraft. Today, the interest in NWFP is gaining popularity as responses to national and international concern over the conservation of biodiversity and the multiple roles of NWFP in local livelihoods (FAO, 1992). In Rwanda, NWFP are found in managed forest plantations, in indigenous forests and woodlands. Commonly used NWFP include medicinal plants for traditional human and veterinary medicine, wild ornamental plants, honey, wild fruit, tree seeds, essential oil plants, mushrooms, game meat, and ecotourism (Murekezi, 1999).

1.4.2.1 Medicinal plants

Medicinal plants used in traditional human and veterinary medicine are increasingly in demand for research interests and traditional medicinal purposes. For instance, Mbarubukeye (1992) found that 80 000 patients have visited the Centre for Traditional Medicine of Bare in south-eastern Rwanda, since its creation in 1978 (Kayinamura, 1986). Additionally, the Pharmaceutical Centre (CURPHAMETRA) within the Rwanda Institute of Scientific and Technological Research (IRST), based in Butare Province in the South of the country, trains traditional healers' groups in collaboration with medical doctors in order to enhance the value of medicinal herbs.

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In veterinary medicine, 536 healers were identified in seven provinces of Rwanda (Mbarubukeye, 1992).

Woody plants whose parts are used in traditional human and veterinary medicine are found in natural forests, in savanna woodlands or in forest plantations. Mbarubukeye and Niang (1996) outlined a list of 59 tree species used in traditional human medicine and 39 tree species for veterinary medicine. Despite their value, these species are disappearing due to population pressure through deforestation and burning (Habiyambere, 1999).

1.4.2.2 Honey

Forests and woodlands play an important role in beekeeping. Habiyambere (1999) reported a list of 27 plant species associated with honey production in Nyungwe Natural Forest and 14 plant species outside this Forest. The potential for honey production in natural forests and forest plantations is not fully exploited (Nyilimana, 1997). Because harvesting methods are still traditional and include the use of fire, forests are at high risk of burning.

At National level, honey production declined between 1990 and 1994 due to the death of beekeepers during the genocide and following massive destruction of hives and other bee-keeping materials and equipment (Murekezi, 1999). In 1989, honey production reached as high as 441 365 kg (Murekezi, 1999). Since 1994, the production has been well below average. Available data on honey production in 1998 at the Rwanda Association for the Promotion of Integrated Development (ARDI) indicated a production level of 23 000 kg (ARDI, 1998).

1.4.2.3 Wild fruit and forestry seeds

According to Murekezi (1999), wild fruits are present in the forests but they receive little interest from the people, who prefer to consume fruits from agroforestry orchards. Wild fruits are generally eaten by children and by adults only during the periods of food deficit. Quantitative information on wild fruit production is not available. In Nyungwe Forest, woody plants producing edible wild fruits were

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identified as *Clerodendron fuscum, Parinari excelsa*, and *Myrianthus holstii* (Murekezi, 1999). In savanna woodlands, edible fruits are produced by *Rumex maderensis, R. usambarensis, Cajanus cajan, Carica edulis, Rhus vulgaris, Solanum taitente* and other *Solanum spp.* (Dessouter, 1991).

Local collection of tree seeds in natural stands and plantations is carried out by the Tree Seed Centre (TSC) within the Rwanda Agricultural Research Institute (ISAR). The seeds are supplied for tree planting and afforestation activities all over the country. Before 1994, the annual delivery of tree seeds by TSC was nine tonnes, purchased by both tree planting projects and private growers (CGF, 1993).

1.4.2.4 Fodder plants and grasses

Natural forests and savannas are valuable sources of animal feeds. However grazing is not allowed within state's forests. In the case of Nyungwe Forest, silvopastoral practices were permitted in new forest plantations in the buffer zone. About 20 grass species were grazed by livestock on the ground layer of these plantations (Gasana, 1988). The pressure of pastoralists on Gishwati Natural Forest resulted in the degazettement of 1200 ha for grazing between 1983 and 1993 (Murekezi, 1999). The Akagera National Park in the eastern region of the country contains palatable grass species, the most important of which are *Themeda triandra* and *Panicum maximum* (Mvukiyumwami, 1987).

1.4.2.5 Wild flowers

Many wild plant species are invaluable sources of horticultural material. Fischer and Hinkel (1992) produced a list of some species producing spectacular individual blooms or mass displays of colour and interesting forms. Unfortunately, the export market of cut flowers is not developed. Potential markets have been identified in the Netherlands and Belgium. A local co-operative, Highland Flower Association, exports about 1500 kg of flowers per week; but exports are limited by the number of flights to Kanombe International Airport (Kigali) where only one airline makes two trips per week (Murekezi, 1999).

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1.4.2.6 Essential oil plants

Many local plant species are used to produce medicines and perfumes in Rwanda. The Rwanda Institute for Scientific Research and Technology (IRST) extracts various oils which are used for pharmaceutical purposes. Some of the plant species producing valuable oils are *Plantago lanceolata, Calendula officinalis, Datura stramonium, Eucalyptus globulus, E. smithii, Capsicum frutescens, Neorautanenia mitis, Thymus vulgaris, Pentas longiflora, Pelarganium graveolens, P. raduta, Cymbopogon afronardus, C. winterianus, C. citratus* and *C. flexanomus* (MICOMART, 1998).

1.4.2.7 Mushrooms

Wild mushrooms occur in most of Rwanda's forests and are associated with *Termitomyces* (Hayes, 1991). Artificial production of these mushrooms is not yet possible due to difficulties in collecting the micro-organisms (Murekezi, 1999). Thus the potential productivity of wild mushrooms is not sufficiently enhanced. Only women and children collect and eat the mushrooms. However, the demand for mushrooms increases in towns as well as in rural areas. At the national level, artificial production of mushrooms in 1991 was about six tonnes (Hayes, 1991). The potential for mushroom production is high and the export market is available either in Europe or in Africa (Murekezi, 1999).

1.4.2.8 Game meat

In the past in Rwanda, game meat was obtained from buffalo, antelopes, zebra, guinea fowl, and duikers among others, through hunting. Today, illegal hunting for bushmeat is still underway in protected forests. As a result, a few mammals and birds are present in both Akagera National Park (Ndayambaje, 1999) and in Nyungwe Forests (Gapusi, 1999) as a result of human disturbances.

1.4.2.9 Ecotourism

Rwanda's forests and savannas are diverse. The country has a number of endemic plant and animal species with high ecotourism potential. Akagera National Park, Nyungwe Natural Forests and Birunga National Park are important wild lands that, when their maximum exploitation for ecotourism is attained, will contribute a large share towards the availability of foreign exchange in the national economy (Habiyambere, 1999). For instance in 1989, the turnover from ecotourism was about US$ 1 078 000 of which US$ 475 500 accrued from Birunga National Park (ORTPN, 1989). This income takes account of direct revenues from entry fees and is considered to be low in relation to the ecotourism potential of the country (Murekezi, 1999). Forest reserves are the major focus of the ecotourism industry (MINAGRI. 1998). The challenge, however, is to satisfy the interests of the visitors and at the same time avoid social conflict and pressure on the environment. The best way is to ensure that both the country and the communities share the benefits from conservation of ecotourism resources.

1.4.2.10 Other goods

Various other goods are manufactured from plants obtained mainly from natural stands. These are used to make various crafts and curios. Mbarubukeye and Niang (1996) illustrated a number of plant species whose parts are used to manufacture various objects, including baskets, mats, beehives and calabashes.

1.5 FOREST POLICY AND LEGISLATION

Rwanda lacks a formal forest policy and legislation. The first piece of legislation providing for protected areas dates back to 1925 when the country, together with Burundi and the Democratic Republic of Congo, were under Belgian colonial rule (Spinage, 1972). Official reserves were created by the Belgian authorities in 1933 (Vedder and Weber, 1984). Since Rwanda achieved its independence in 1962, Law Ordinances have provided for establishment of managed areas. The Law Ordinance of 18 June 1973 established rules applicable to national parks, hunting reserves, and strict nature reserves. This law has been slightly modified by the Decree Law of December 18, 1973, establishing by presidential decree special reserves, national parks and hunting reserves.

In 1988, Rwanda reshaped its forestry legislation, with the adoption of Law No. 47/1988 (JORR, 1989). This law was based on an old decree of 18 December 1930 that provided, among other things, for the creation of forest reserves and the protection of forest species. Dating from the colonial mandate, it applied to felling carried out by, or for, European settlers, leaving the Rwandan population to use the forest in conformity with their customary rights. The rapid population growth resulted in severe deforestation that the old legislation was unable to control (FAO, 1989).

In response, the revised forest legislation defined a legislative framework for action and intervention in forestry. It highlighted aspects of forest ownership (public, community and private forest land), forest conservation and protection, forest establishment and tending, silviculture and management, harvesting, funding of forest programmes, national and communal forest planning, as well as forest law enforcement. Generally, the State reserves the right of ownership and control of all forest management operations (MINAGRI, 1984; JORR, 1989). In 1984, because of the conservation importance of natural forests, the Rwandan Government adopted an Action Plan aimed at maintaining essential ecological processes and at preserving genetic diversity of flora and fauna as well as satisfying national demand for direct and indirect benefits from forests (MINAGRI, 1984). Major programmes within the plan focussed on:

- The establishment of integral natural reserves of 59 340 ha, of which 15 000 ha are in Birunga National Park, 5 000 ha in Gishwati and 39 840 ha in Nyungwe forests;
- The demarcation of 7 500 ha of forests for restricted use;
- The establishment of buffer zones between the different forests and the adjacent communities.

In 1987, Rwanda adopted a ten-year National Forest Plan (1987 - 1997). This plan defined objectives, perspectives and a plan of activities in the forest sector. It has been a very useful document but its implementation has sometimes been constrained by disparate objectives and means, very wide interpretation of its content and lack of monitoring and evaluation for a regular review (AGRIFOR CONSULT, 1997).

1.6 PROBLEM STATEMENT

Protected areas in Rwanda have undergone a tremendous rate of regression since 1960. Gapusi (1999) reported a regression rate of 21.8% of Nyungwe Forest between 1960 and 1998. The study by Muderevu (1974) estimated the annual rate of regression of Nyungwe Forest at about 750 ha. He concluded that the Forest would disappear completely within a period of 84 to 134 years if adequate strategies are not adopted and implemented. Many authors have indicated that the loss of biodiversity in Nyungwe Forest results from illegal use (Gapusi 1999; MINAGRI, 1998; MINITERRE, 2000).

Protected forests in Rwanda are under acute threat by adjacent communities (MINITERRE, 2000). The underlying causes are reported to be high population densities, overwhelming poverty and dependence on land and other natural resources (MINAGRI, 1998). Therefore, these factors result in great land and resource degradation, and consequent pressure on forest reserves. Both at national and local levels, the capacity to manage forest reserves with respect to human and financial resources is inadequate (WCS and ORTPN, 1995). As a result of these factors, the legal status, mandate and management of these forests have suffered substantially. Various strategies have been proposed by many authors and consultants (IUCN, 1987; IUCN and WWF, 1985; Mackinon and Mackinon, 1986; Perlez, 1988; Wilson, 1991) on how to improve the conservation, protection and management of forest reserves in Rwanda. However, resource degradation through encroachment by local people has been increasing over the years and culminated during the 1994 crisis in Rwanda.

Various studies from Rwanda have emphasised the importance of improving the relationship between local communities and the management of the forest reserves (Bahigiki and Vedder, 1987; Gapusi, 1999; IUCN, 1979; MINITERRE, 2000; Renner, 1991; Renner, 1992; Vedder and Weber, 1984; Weber, 1992). Constant pressures on protected forests, however, have resulted in incremental loss of resources from the reserves.

The survival of Rwanda's forest reserves depends on mechanisms that recognise the need for access and use by local people, while simultaneously co-ordinating local

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development and conservation of forest reserves. Following gazettement of all natural forests as forest reserves in 1984, these local communities received limited access to some resources (Renner, 1991). At present, there is a tendency by relevant state departments to seek ways of accommodating the needs and interests of local communities, with increased focus on maintaining a balance between conservation and utilisation of forest resources in protected areas (MINETERRE, 2000). Therefore sustainable utilisation of forest resources in protected areas, including Nyungwe forest, is a mechanism for involving communities in conservation and management of these areas.

1.7 JUSTIFICATION OF THE STUDY

Prior to the establishment of Nyungwe Forest as a Forest Reserve, the local people around the Forest had access to wood and NWFP. From 1933, they were barred from removing the forest products from the Forest (Mbonyintwari, 1989). Consequently, conflict between the Forest Department and the local people began. For example, during the establishment of the buffer zone between the local communities and the Reserve, the land that was previously exploited by local people was taken back by the authorities, instilling disenchantment in the people (Renner, 1992). On gazettement of Nyungwe Forest as a Forest Reserve, local households utilising the buffer zone for settlement, agriculture and livestock farming were settled outside this zone or compensated for having to leave the Forest. After the people left, conservation measures were instituted involving the planting of exotic tree species. This, it was believed, would serve to mark the boundaries of the Nyungwe Forest as stated in the 1984 Action Plan for the conservation and management of natural forests on the Congo Nile Crete, where Nyungwe Forest is located (MINAGRI, 1984).

With respect to conservation of Nyungwe Forest, the Rwandan Government, in collaboration with funding agencies, adopted strategic actions aimed at reducing the dependence of local communities on the Forest. Access to some forest resources was also granted only in the buffer zone, including fuelwood gathering, taungya agroforestry and beekeeping (Barbier, 1992). Some of these rights to local people were established following socio-economic studies and recommendations by various consultants including Bahigiki and Vedder (1987), Barbier (1992), MINAGRI (1992), Renner (1991), Stebler *et al.* (1984), and Weber (1992).

Socio-economic studies show the importance of the Forest to local communities in terms of wood and NWFP (Bahigiki and Vedder, 1987; Renner, 1992). On the other hand, Nyungwe Forest is also an important water catchment's area and plays an invaluable role in soil protection (Budowski, 1976; Sorg, 1978). Despite all these advantages and perceptions, Nyungwe Forest is threatened by illegal activities that impact negatively on its size and biodiversity (MINAGRI, 1998). Human disturbances and unlawful activities are the major causes of regression and losses of plant and animal species (Gapusi, 1999; Muderevu, 1974).

At present, Nyungwe Forest is managed by the Nyungwe Conservation Project (PCFN) in partnership with the Rwanda Office of Tourism and National Parks (ORTPN) with limited financial and human resources (Barakabuye, 2001). Activities in Nyungwe Forest and in the buffer zone are limited to forest protection and public awareness programmes, ecological studies and monitoring of animal populations (WCS and ORTPN, 1995). Tourism activities are not fully enhanced. Against this background, opportunities for income-generating activities to local people are too few or lacking. Few local people are employed as forests guards for the protection of the Forest. The revenue from tourism in Nyungwe Forest is too little and has no impact on the livelihoods of the local communities (Weber, 1992). The major focus of the management of the Forest is to contain all illegal activities coming from the neighbouring communities.

The Government of Rwanda, represented by the Ministry of Land and Environment, has vested interests in the conservation of Nyungwe Forest, with its rare and endangered flora and fauna and potential for sustainable ecotourism, for which only a small area of the original size is available (MINAGRI, 1997). Faced with rural poverty, local peoples' strategies include access to land through deforestation, agricultural intensification, migration, and off-farm income activities in rural areas (Habimana, 1982; Weber, 1989).

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It may be futile to aim at conserving the biological diversity in Nyungwe Forest without understanding the problems underlying its conservation. Addressing the needs of the neighbouring communities can partly alleviate threats to conservation. In addition to tangible benefits, intangible benefits that local people derive from the Forest near to them should be considered. Nyungwe Natural Forest and its buffer zone are rich in resources. It is important to identify activities of interest to local people that could be allowed so as to utilise the resource sustainably and for conservation purposes. Due to dependence on the Forest, communities could be organised at the local level to use the resources. This approach could result in the local people to utilise the resources in a sustainable way, leading to their conservation. The adoption of such an approach would tend to answer questions related to community involvement in forest management and to the benefits this community may obtain in return. In Nyungwe Forest, resource exploitation is not practised, but there is a need to determine whether the local communities could use the resource sustainably if legal rights for resource exploitation are given to them.

With all its boundaries surrounded by poor households, the long-term future of the Nyungwe Forest depends on a strong partnership among various stakeholders, including local communities. Addressing the conflict over the Nyungwe Forest, enhancing biodiversity and improving availability of resources units require a management option which protects the Forest from the damaging use and supervises the use of the Forest.

Joint Forest Management (JFM) or Collaborative Management is generally accepted as a viable arrangement that benefits the forest and the major partners, namely the government and the local communities (UFRIC, 2000). JFM emerged from India and encompasses management schemes based on the sharing of responsibilities, benefits and obligation from the forest between local people and usually the state (Wollenberg, 1999). The communities receive benefits from such involvement, which are clearly spelt out at the start of the programme (Nhira and Matose, 1996).

JFM is most applicable to public/state land, or to collective property where resources are managed under local management rules. For its effectiveness, there must exist a decision-making authority, recognised and respected at the local level. In the case of conflict, the presence of a mediator capable of leading negotiations, is important (Dubois, 1998). Monitoring of the community level forest management enables the provision of checks and balances as well as the identification of successful community-level management. It also contributes to the building of trust and confidence, as has been the case for the community-managed forests in Asia and the Pacific (Fisher, 1999). Thus, this study takes the first step in assessing ways of managing Nyungwe Forest in a sustainable manner with the participation of local communities who lost access to forest resources. Approaches to achieving this stem from the understanding of the priority needs and interests of local communities in the Nyungwe Forest.

Resources of interest to local people are scattered throughout the forest at different intensities. Hall and Bawa (1993) and Peters (1996) have proposed methods for collecting information on the abundance and distribution of NWFP from tropical forests. In some countries like Uganda, some work has been done on the density and distribution of different plant species being harvested in Multiple Use Zones of montane forest areas (Bitariho, 1999; ITFC-EMP, 1999; Kamatenesi, 1997; Muhwezi, 1997; Ogwal, 1998). In Nyungwe Forest, many plant species have been harvested illegally and are still in high demand for different uses (Gapusi, 1999).

In the case of Nyungwe Forest, no work has been done on resource exploitation and impact. This study aims at providing baseline data on forest resources of importance to local communities. Further, it evaluates the Forest in terms of the numbers and sizes of trees and of what species may be harvested. The assessment of regeneration potential of valuable plant species is also emphasised, since it provides valuable data for resource managers (ITFC-EMP, 2001). The general approach of the study involves focussing on the preferred forest resources through the use of participatory rural appraisal techniques. The potential of the Nyungwe Forest to provide these resources has been assessed by focused research on the density, size-class distribution and regeneration potential of preferred tree species for timber, poles and medicinal materials.

In line with the formulation of policies that involve the management and conservation of natural resources, it is worthwhile to assess the possibilities of recognising local people rights and responsibilities as well as partnerships in decision-making. The government may pass certain user rights and responsibility to the local communities as a strategy to overcome the conflict between the community needs and the conservation of the Nyungwe Forest. Therefore, it is important to provide guidelines that may lead the government and non-governmental partners to develop and implement decisions over the management of Nyungwe Forest with the dual focus of improving the local community livelihoods and enhancing proper management of Nyungwe Forest. Legislative and policy framework would take account of community gain in sustainable utilisation and conservation of biodiversity in Nyungwe Forest.

1.8 AIM AND OBJECTIVES OF THE STUDY

1.8.1 Overall aim of the study

The overall aim of this study was to contribute to improved livelihoods of rural communities by involving them in sustainable utilisation of forest reserves. Focus was placed on assessing the potential supply of wood and non-wood products for adjacent community needs in Rwanda's forests. Thus, the backbone of this study was to assess the current status of resource use and management of Nyungwe Forest and to determine the potential for community involvement in management and sustainable utilisation of wood and NWFP from the Forest.

1.8.2 Objectives of the study

In view of the above aim, the study of the potential for joint management and multiple use of Nyungwe Forest has the following objectives:

i. To identify local people's problems, needs, preferences and interests in access to and use of resources in Nyungwe Forest.

ii. To identify the potential of Nyungwe Forest to provide the most preferred timber, pole and medicinal species by local communities.

iii. To inventory the forest resources in order to ascertain the abundance, the size-class distribution and the regeneration potential of the preferred tree species in the periphery of Nyungwe Forest. .

iv. To determine the tree species that can be used sustainably.

v. To recommend a management option that enables access to resources and community involvement in management and utilisation of Nyungwe Forest resources.

1.9 Potential benefits

The potential benefits of this study relate to the participation of local communities in management and conservation of Nyungwe Forest, particularly deriving increased benefits from the sustainable utilisation and conservation of the Forest. Within this framework, local communities are expected to work for the protection of Nyungwe Forest, thereby avoiding illegal use of the Forest. The study helps to assess the potential for sustainable utilisation of the Forest and provides recommendations which decision-makers may use in devolving some power and responsibility for collaborative management of state forests.

1.10 THESIS STRUCTURE

The thesis is structured in the following manner:

- Chapter Two describes how the research was conducted. It covers the methods used both for the Rapid Rural Appraisal exercise and the Nyungwe Forest resource assessment. It is also designed to give an account of the methods used in the analysis of the households survey and forest inventory data.

- Chapter Three covers the findings of the study. The results of the participatory assessment cover household surveys, group and key informant interviews. Also, within this chapter, forest inventory results are provided, with emphasis on preferred tree resources identified during the surveys.

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- In Chapter Four, the discussion of the various results is presented, based on the findings of the study and supported by relevant literature where appropriate.

- Chapter Five summarises this study's findings and provides suggestions and recommendations for the way forward. Areas of future research related to community utilisation and sustainability of Nyungwe Forest are proposed.

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2 STUDY AREA AND METHODS

2.1 STUDY AREA

2.1.1 Description of Nyungwe Forest

This section provides information about Nyungwe Forest by reporting its biophysical characteristics and biological diversity. An overview of the Forest is given, relating to conservation interests and the characteristics of the adjacent population.

2.1.1.1 Size and location of Nyungwe Forest

Nyungwe Forest is located in the South West of Rwanda, near the southern shore of Kivu Lake (Figure 2.1). Nyungwe Forest covers approximately 90 000 ha (Gapusi, 1999). It is one of the largest blocks of lower montane forest in Africa (Weber, 1989). The majority of its area stretches within Gikongoro and Cyangugu Provinces, while a very small proportion of the Forest is found in Kibuye Province (Sorg, 1978). It also extends to Kibira National Park in Burundi (Budowski, 1978). Nyungwe Forest is found at latitude $2^0$17'S – $2^0$49'S and longitude $29^0$05' – $29^0$29' E (Sorg, 1978). It occurs within the western part of the tectonic Rift along the Zaire-Nile Divide (Weber, 1989). The altitudes within the Forest range from 1 600 m to more than 2 700 m (Budowski, 1976). The mean annual rainfall is 1744 mm, typical of an African rainforest (Sun *et al.*, 1996). The temperatures in Nyungwe Forest are generally cool, with an average minimum temperature of 10.9^{0}C and an average maximum temperature of 19.6^{0}C (Sun *et al.*, 1996). Temperatures rarely fall below 0^0C in high altitude zones of the Forest (Budowski, 1976).

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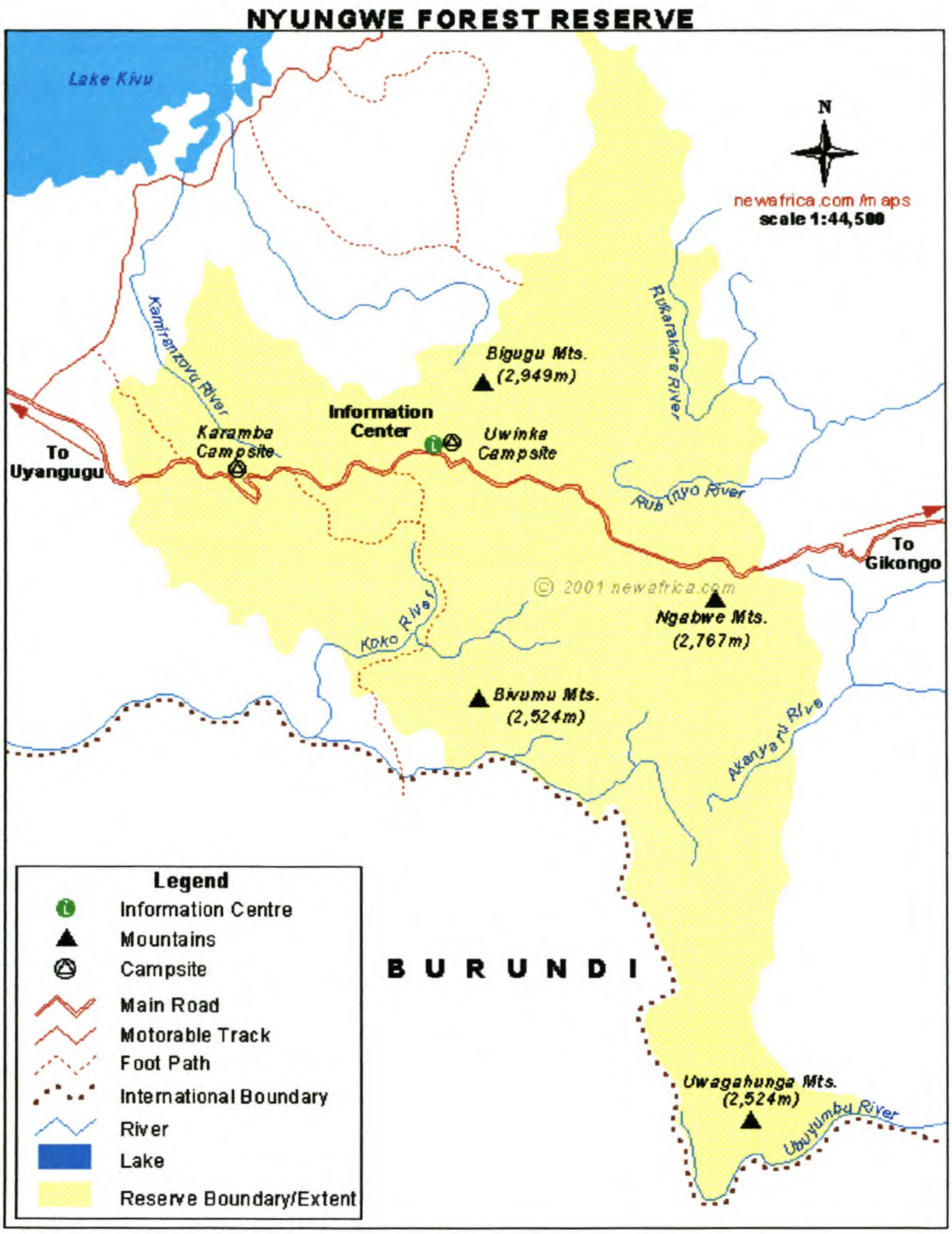

Source: Newafrica (2000).

Figure 2.1. Nyungwe Forest, showing altitudes inside the Forest.

2.1.1.2 Geology and drainage

The area of Nyungwe Forest is mainly composed of very old Precambrian rocks (Storz, 1983). Storz (1983) differentiates three geological parts of the Nyungwe Forest. In the eastern part of the Forest, the substratum is derived from granites and granitic rock. The homogenous character of these rocks creates narrow steep-sided valleys dominated by round hillcrests. Sorg (1978) reported that soils derived from such rocks are usually poor. In the western part of the Forest schist, quartzite and dolerite are the main parent rocks: the soils derived from these rocks are fertile (Sorg, 1978). These rocks result in a topography characterised by very steep slopes and very narrow valleys. Soils in the area of the Forest near Gisakura are basic, with contents of Silica, Iron and Magnesium.

The whole area of Nyungwe Forest is a vital water catchment containing sources of several perennial rivers that drain the Congo Basin and the Nile Basin (Barabwiliza, 1992). For the Congo Basin, five rivers found in Nyungwe Forest flow to Kivu Lake: Koko, Ruhwa, Rubyiro, Kamiranzovu and Kilimbi. The Nile Basin, on the other hand, receives water from the Nyabarongo, Nshili, Akanyaru, Rubyiro, Rukarara, Mbirurume and Mwogo Rivers.

2.1.1.3 Flora

Nyungwe Forest contains about 1 400 plant species, of which 400 are identified tree species, hundreds of *Orchidaceae* and over 200 mosses and lichens (MINAGRI, 1997). Its flora contains 42 endemic tree species, various medicinal plants and valuable hardwoods (Habiyambere, 1999). On the basis of altitude ranges, four vegetation strata are identified and recognised by dominant tree species, as described by Sorg (1978). Between 1 600 m and 2 000 m, dominant tree species reach 35 to 40 m in height. These include *Parinari excelsa, Newtonia buchananii, Symphonia globulifera, Entandrophragma excelsum* and *Albizzia gummifera*. *Orchidaceae* and ferns are abundant. This vegetation type covers 17% of the total area. At the altitude range of 2 000 – 2 300 m, dominant canopy tree species are *Entandrophragma excelsum, Parinari excelsa, Prunus africana, Ocotea usambarensis, Ficalhoa laurifolia* and *Chrysophyllum gorungosanum*. The shrub stratum is less dense and consists mainly of ferns. This vegetation represents 21% of the Forest. *Podocarpus latifolius* dominates at altitudes between 2 300 m and 2 500 m. This valuable tree species reaches 15 to 20 m in height. At this altitude mosses and lichens also occur, but the grass layer is poor and discontinuous. This type of vegetation occupies the largest area, estimated at 43%. At very high altitudes between 2500 m and 2700 m, the structure of the vegetation is dominated by shrub and herb growth forms. Tree species found at these altitudes include *Phillipia benguellensis, Agauria salicifolia, Faurea saligna* and *Hagenia abyssinica*. Due to high humidity, mosses, lichens and epiphytes are present. This vegetation is distributed over 19% of the total Forest area. Kamiranzovu wetland within Nyungwe Forest contains typical wetland vegetation types over an area of more than 3 500 ha in the northwest part of the Forest at an altitude of 1 860 m (Bouxin, 1974). The other large swamp of the Forest is Uwasenkoko.

Nyungwe Forest has relatively high species diversity. Studies of species dynamics found 62 plant species in an area of 12 500 m^2, which is higher than the 45 plant species per 10 000 m^2 found in South American montane forests (Gapusi, 1999). At an international scale, 13 species of endemic *Orchidaceae* are recognised (MINAGRI, 1998). These include *Disa eminii, D. robusta, Catyrium crassicaule, Cynorkis kassneriana, Disperis anthoceros, Calanthe sylvatica, Stolzia cupuligha, Eulophia horsfalii, Polystachya virginia, P. vulcanica, Chamaeangis sarchopylla, Draphananthe burtii* and *Cyrtochis arcuata*. Gapusi and Mugunga (1997) have listed a number of tree species in Nyungwe Forest that are rare or in danger of extinction. The major species are *Habenaria macrantha, Disa robusta, Dispais anthoceros, Cynorkis kassneriana, Calanthes sylvatica, Polystachia virginia, Chamiseangis sarcophylla, Cyrthorchis arcuata, Aningeria altissima* and *Conyza volkensii*.

2.1.1.4 Fauna

A broad array of fauna is present in Nyungwe Forest, made up of approximately 265 bird species, 25 to 30 large mammals, many other small mammals, reptiles and insects (MINAGRI, 1998), including 126 species of *Lepidoptera* (Habiyambere, 1999). Mammals are dominated by primates that are unique to the area; a description of the most common species is given by Storz (1983). Table 2.1. provides a list of Latin and English names of some primate species found in the Forest.

Table 2.1. Latin and scientific names of some primates found in Nyungwe Forest (Storz, 1983).

Latin names	English names
Pan troglodytes schweinfurthi	Eastern chimpanzee
Papio anubis	Olive baboon
Colobus angolensis adolfi-friederici	Angolan black-and-white colobus
Cercopithecus lhoesti	L'Hoest monkey, mountain monkey
Cercopithecus mittis doggetti	Sliver monkey
Cercopithecus mona denti	Mona monkey
Cercocebus albigena johnstoni	Grey-checked mangabey
Perodicticus potto	Potto gibbon
Galago spp.	Bush baby
Cercopithecus ascanius schmidti	Red-tail monkey
Cercopithecus aethiops	Grivet monkey

A number of animal species is reported to be rare or endangered. The most rare ones include the forest hog *Hylochoerus meinertzhageni,* the blue duiker *Cephalophus monticola,* the bushbuck *Tragelophus scriptus,* the small-scaled tree pangolin *Manis tricuspis,* the giant pangolin *M. gigontea,* the spotted hyena *Crouta crocuta,* and the leopard *Panthera pardus*. MINAGRI (1998) reported 36 animal species characterising afromontane forests that are protected by CITES. Examples of these animals include the Ituri Forest chameleon *Chamaeleo adolfi frederici,* the flap-necked chameleon *C. dilepis idjwensis,* the Ruwenzori three-horned chameleon *C. johnstonii, Rhampholeon boulengeri* and the mountain monkey *Cercopithecus lhoesti*.

2.1.1.5 Management history and conservation interests

Nyungwe Forest was gazetted as a Forest Reserve under Legal Notice No. 83 bis Agris of December 12th, 1933 (PCFN, 1989). The Colonial authority aimed to prevent the total disappearance of the Forest. In 1934, the status was modified slightly by the Legal Notice No. 33/Agri of May 24th, 1934 to include a special exploitation regime of the Forest (Mbonyintwari, 1989).

Within the framework of management and conservation of natural forests on the Congo Nile Crest, the 1984 Action Plan aimed at conserving Nyungwe Natural Forest qualitatively and quantitatively (Renner, 1991). The Forest Department was responsible for its management and conservation. To facilitate this, four management zones of Nyungwe Forest were delineated as stated in the 1984 Action Plan. In

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partnership with the Swiss Government, the World Bank, and the Central Fund for Economic Co-operation, the Rwandan Government promoted conservation and management of the Forest. Various developmental activities integrated rural development with conservation.

'The Projet Pilote Forestier (PPF)' was the first project that operated in Nyungwe Forest and the buffer zone since 1970 (MINAGRI, 1984). This project established exotic plantations with the objective of marking the boundaries of Nyungwe Forest and keeping it from encroachment by neighbouring communities (Grison and Braesco, 1984). The project initiated a series of other activities consisting of rural afforestation so as to secure fuelwood and pole supplies to local communities in adjacent Communes. At Rangiro (Cyangugu) and Gisovu (Kibuye), a large number of pitsawyers who encroached on the Forest were used as project workers.

In 1982, the 'Projet Crête Zaire Nil' (CZN) was opened in the North-East of Nyungwe. This project integrated forestry, agriculture and social activities. It also created a buffer zone and managed pastures (MINAGRI, 1984; PCFN, 1989). Both CZN and PPF did not cover the whole buffer strip between Nyungwe Forest and the local people. The southeast and southwest borders of Nyungwe Forest lacked adequate protection. Thus forest degradation continued, particularly due to illegal logging and gold mining (PCFN, 1989).

Since 1982, based on geographical zones, Nyungwe Forest has been managed by four projects named "Unité de Gestion de la Zone" and referred to as UGZ 1 to UGZ 4 respectively (UGZ1, 1987; Weber, 1989), under the financial assistance of many bilateral and multilateral organisations. In the North-West, Nyungwe was managed by UGZ1 under financial support of the Swiss Co-operation since 1986. Two projects operated in the northeast: UGZ2, funded by European Development Fund (EDF) since 1982, and Mudasomwa Project, assisted by Belgium. The latter project concentrated its action in Mudasomwa Commune and conducted afforestation activities in rural areas. The southeast of Nyungwe Forest has been managed by UGZ3 since 1989, using funds provided by the Rwandan Government and the World Bank. Since 1987, the southwest of the Forest was under the responsibility of UGZ4, which was funded by the French Government (MINAGRI, 1991). The various UGZ realised different activities, including the establishment of 8 300 ha of forest plantations. In 1991, the various projects established about 10 000 ha of forest plantations of predominantly exotic tree species (MINAGRI, 1991). Other important roles played by the UGZ include (MINAGRI, 1991):

- The construction and maintenance of infrastructures: offices, staff accommodation houses, roads and trucks, forest roads, schools, water adduction, dispensaries, etc.
- Timber harvesting from thinning and marketing of timber and timber products;
- Inventory and research in Nyungwe Forest in collaboration with research institutions;
- Protection of the Forest from encroachment through regular patrols inside and outside the Forest;
- Establishment of forest management plans to guide interventions in the buffer zones;
- Public awareness and education programmes on the protection and conservation of Nyungwe Forest.

Due to its high biological diversity, PCFN in conjunction with ORTPN aimed at preserving Nyungwe Forest with increased focus on ecotourism, research and public awareness of conservation (ORTPN, 1991). PCFN was funded by USAID, African Wildlife Fund, Digit Fund and Wildlife Conservation International (WCI). Funds were used to improve technical and management capabilities, to increase the level of on-going biological, physical and socio-economic studies, to raise public awareness on the importance of biodiversity conservation and to provide various forms of administrative support to the project (PCFN, 1989). Activities of the various projects operating in Nyungwe Forest were planned to be co-ordinated by a Conservation Centre that had not become operational before 1994. Offices and staff houses were established at Kitabi (Mudasomwa Commune) but they were damaged during the genocide in 1994 (Gapusi, 1999).

2.1.1.6 Adjacent communities

On an administrative basis, the population of the Republic of Rwanda is organised into Prefectures and the latter into Communes. Depending on its size, each Prefecture comprises a number of Communes, which in turn are subdivided into administrative Sectors. A Sector is further broken up into administrative Cells, each being made up of at least 50 households. At each level, the leaders are elected locally.

The population living within the boundaries of Nyungwe Forest was organised and unevenly distributed over 11 Communes (today, two or more Communes have been fused together to form a District). This population was estimated at 500 000 people in 1997 (MINAGRI, 1997). MINAGRI (1984) distinguished two types of communities living around the Nyungwe Forest. The eastern ridge comprised less populated Communes within the agricultural region of Congo Nile Crest, characterised by poor soils on steep topography, relatively higher farm size than at national level, low population growth, relatively low quality of life and food insecurity. The other characteristic of this region was the high decrease in farm size that made agricultural intensification by use of agricultural inputs difficult. Land in the border strip of Nyungwe Forest was of particular interest due to its high organic matter content.

MINAGRI (1997) defined the western ridge of Nyungwe Forest as falling within the Communes of the "Impala and Kivu Lake Borders" agricultural region, where farming conditions were favourable. The average farm size was very small (about 0.39 ha per household) but sufficiently productive. A large area of Nyungwe forest was cleared through expansion of arable land in this locality.

Besides agriculture, the population as a whole derives a livelihood from activities in the Forest and in the buffer zone. In the buffer zone, livestock farming is not well developed and is dominated by sheep, goat, and pig rather than cattle (MINAGRI, 1984). Within the forest of Nyungwe, activities are illegal and consist of gold mining, logging, hunting, bee-keeping, agriculture and collection of medicinal herbs (MINAGRI, 1984; PCFN, 1989, Gapusi, 1999).

2.2 RESEARCH METHODS

This chapter describes the methods employed in the collection and analysis of quantitative and qualitative data in order to achieve the study objectives outlined in section 1.8.2. The methods used for the study have two components:

- Participatory rural appraisal (PRA) techniques were used to determine the problems, needs, priorities and interests of local communities in Nyungwe Forest. Interviews were conducted in the surrounding areas of the Forest. Interviews within individual households were in the form of open-ended questions. Further, data were obtained through in-depth discussion on general issues with small groups and key informants.

- Forest resource assessment was carried out as the focal point of the study in order to find out how well stocked Nyungwe Forest is to guarantee a sustainable supply of resources that are mostly preferred by local communities. In addition, it aimed at collecting information on which to base recommendations for resource uses. Because of time and financial constraints, it was not possible to cover more than a small part of forest area adjacent to communities, and so the survey focussed only on the highly preferred plant species identified during the PRA exercise. The survey was carried out to achieve the following specific objectives: -

  i. To estimate the abundance (presence or absence) of the forest resources that are believed to be important to the livelihoods of local communities;

  ii. To determine the abundance of each species present and the size-class distribution of individuals at different diameter classes;

  iii. To assess the regeneration potential of useful plant species to local communities;

  iv. To recommend the resources for which the communities could have access.

For the purpose of this study, basic information on species types, density, frequencies, diameter-class distribution, species dominance and regeneration were collected. Some of these parameters determine sustainable levels of resource use as described by Peters (1994).

2.2.1 Selection of the study sites

The study area was stratified into two sections, based on agro-ecological zones defined by Niang and Styger (1990) using biophysical characteristics and crop types. The Bufundu and Bushiru highlands in the eastern and northern part of the forest comprise eight ex-Communes of similar population densities in the range of 200 to 250 persons per km^2. The second area, the Impala Ferralsols Region, stretches over three ex-Communes (Karengera, Kagano, Busozo) in the western ridge of the Forest with a population density of 250 to 350 inhabitants per km^2.

A further subdivision of the region was based on past project management zones. Within each zone, one Commune was selected to represent the project area. Other bases for selection of sample sites included the interface of the Communes with the Reserve, the degree of deforestation at the forest edge and altitude ranges within the Forest. The latter criteria were used because of their potential impact on the availability and diversity of resources. Based on geographical contiguity with the Forest, a total of five Communes were selected for this study. The five Communes were Kagano and Busozo at the western ridge of the Forest, Nshili in the south-east, Mudasomwa and Musebeya in the eastern side of the Forest (Figure 2.2).

2.2.2 Participatory Rural appraisal

2.2.2.1 Selection of households

The households of each Commune are not equally close to the Forest. Administrative Sectors extending into Nyungwe Forest were identified and further stratification aimed at selecting a variety of households at "Cell" level, using the criteria of the closest location to the Forest. At most, two Sectors next to the Forest were considered for each Commune and the respondents randomly selected in two Cells.

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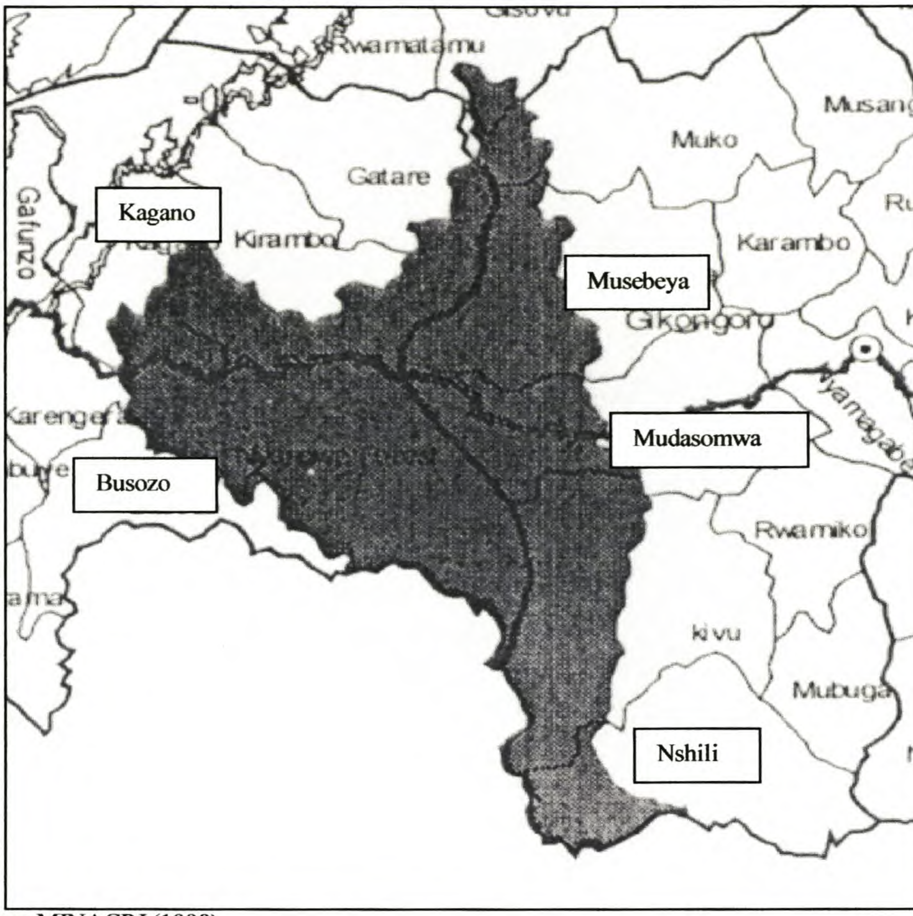

Source: MINAGRI (1998).

Figure 2.2. Communes neighbouring Nyungwe Forest, showing the survey sample distribution.

Within each Cell, the number of households interviewed was 10, representing a fifth of 50 households per Cell. Therefore, a total number of 200 households spread over five Communes in different Sectors and Cells in the vicinity of the Forest were interviewed. A sample of this size is much larger than the sample size of 70 households used by Wambugu (1999) in Embu district of Kenya and recommended by Palm *et al.* (1993) as appropriate for making inferences about the larger population. Due to heterogeneity and the large adjacent population, the sample size of 200 households was thought to represent the conditions around Nyungwe Forest.

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2.2.2.2 Selection of groups and key informants

In the communities neighbouring Nyungwe Forest, there are no identified homogenous groups using the forest resources. Groups of five to 10 people living near the Nyungwe Forest were randomly identified with the aid of the head of each Cell or members of the local administrative committee at Cell levels, since they are living with and leading the people living close to the Forest. Individuals known to be the heaviest users of the Forest and forest products were selected for group discussion. Various key informants were approached to identify the current challenges and opportunities facing managers of the Forest. These respondents were important stakeholders in the future conservation and management of Nyungwe Forest. They included the administrative authority of each Commune being surveyed and staff of a number of relevant bodies, including PCFN, ORTPN, the Department of Environment in the Ministry of Land and Environment, various NGOs and Co-operatives, the Regional Agricultural Services, tea factories and private enterprises.

2.2.2.3 Data collection

Household and group interviews provided information on resource availability within Nyungwe Forest as well as species preferences and their uses, land tenure and land-use, socio-economics and general information on agriculture and livestock keeping, and perceptions of institutions that might shoulder the responsibility for sustainable utilisation and conservation of Nyungwe Forest resources (Appendix 1). Interviews with groups and key informants focussed on resource preferences and ranking. The discussions also focused on utilisation and conservation strategies of the Forest with active participation and increased benefits to local communities.

Information that relates to resource abundance and distribution were explored through subjective assessment based on the interviewee's knowledge of a particular resource. The abundance of a given resource was measured on a scale of 1 to 5, corresponding to the DAFOR (Dominant = 5, Abundant = 4, Frequent = 3, Occasional = 2 and Rare = 1) scale (Smith *et al.* (1985). From a list of available resources in the Forest, three important resources to communities were prioritised and appraisals were made to determine the uses of the resources. In order to identify habitats of the Forest that might receive intensive use by the local communities, information on resource abundance and distribution were sought in relation to landscape, i.e. whether the resource occurs on hilltops, on slopes, in the bottomlands or in the swamps. Nyungwe Forest resources were categorised based on household use of the resources. Subjective quantity estimates of marketed products were investigated, focussing on the season of resource harvest and market location. Harvesting of some parts of plant resources such as roots and bark has an impact on the availability of the forest resources and their response to disturbance (Peters, 1996; Wild and Mutebi, 1996). Consequently, respondents were asked to identify parts of plants used for different purposes. For wildlife resources, emphasis was put on the game used to provide various game products to local communities. Methods and time of hunting were also emphasised as they were thought to influence the wildlife population dynamics.

Land tenure, land-use, and socio-economic status of local communities were obtained through semi-structured interviews with groups and individuals and were collected by means of an open-ended questionnaire and discussions. Data on socio-economic status concerned the personal economic and financial situations in terms of the level of education, the enterprises undertaken by the household and the sources of income. Information on land tenure and land use aimed to understand the process of land acquisition and the management of soil fertility. These were thought to influence the dependence of people on forest resources.

The questionnaire also included questions on institutional arrangements that are believed by households to enable the conservation of the resources for the benefit of rural communities. Questions focused on mechanisms at local level that enabled access to resources by local communities. Finding strategies to coordinate local needs and the conservation of Nyungwe Forest and linking the management of the Forest to community involvement, sustainable utilisation, and governance was emphasised.

2.2.2.4 Data processing and analysis

Prior to analysis, the interview data were coded and organised into categories following the procedure described by Babbie and Halley (1998), and Neuman (2000). Numerical codes were assigned to semi-structured responses on the background information of the respondents. Responses were all recorded on paper and, depending on the frequency of the answers, broad categories were created.

The survey data were entered and organised into Statistical Package for Social Sciences (SPSS) (Babbie and Halley, 1998) data format. The recode procedure was used to transform all pre-existing variables into different variables either by discarding the "don't know" and "no answer" responses or by dividing a pre-existing variable into different categories and coding each category differently. The latter procedure has been applied to questions that related to family size, level of education, farm size, quantities of crops at harvest, and others. In some instances, categorical data were transformed into continuous values without contorting the respondents' responses. As the interview was flexible and allowed detailed and anticipated information, some responses from some local people could not be coded and therefore the information was used to support the discussion of the results. For the survey data, limited quantitative analysis was performed, focusing mainly on frequencies and associated histograms so as to provide visual illustrations and to support descriptive results.

2.2.3 Forest resource assessment

2.2.3.1 Sampling design and plot sizes

The size of plots depends on the characteristics of the community being sampled. Peters (1996) recommended plot sizes of 16 to 100 m^2 for shrubs and understorey vegetation. For the study of small trees and shrubs, Stanley and de Olieveira Castro (1959) recommended the use of small plots of 4 x 4m or 2 x 2m, always located in the same corners of the larger plots. However, small plots produce density estimates with a large error term. In contrast, Kruger *et al.* (1997) recommended using plot sizes that are scaled to the canopy height of a particular forest. In their study in South African forests, they used 20 m by 20 m plots, randomly located in a forest with a canopy height of 20 m.

For this study, plots were established with the aid of a prismatic compass, tape measure, machete, and ranging poles. They were placed 1 km inside Nyungwe Forest

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from each side of the forest edge community being surveyed. In each part of the forest area, two plots each measuring 2500 m^2 (i.e. 50 m x 50 m) in size (Sample unit A) with the corresponding nested areas (Sample units B and C) were established (Figure 2.3). The survey procedure was based on the method used by Fedlmeier (1998) for the study of the development of secondary forest in Costa Rica. Over sample unit A, trees greater or equal to 10 cm diameter at breast height (DBH) were recorded.

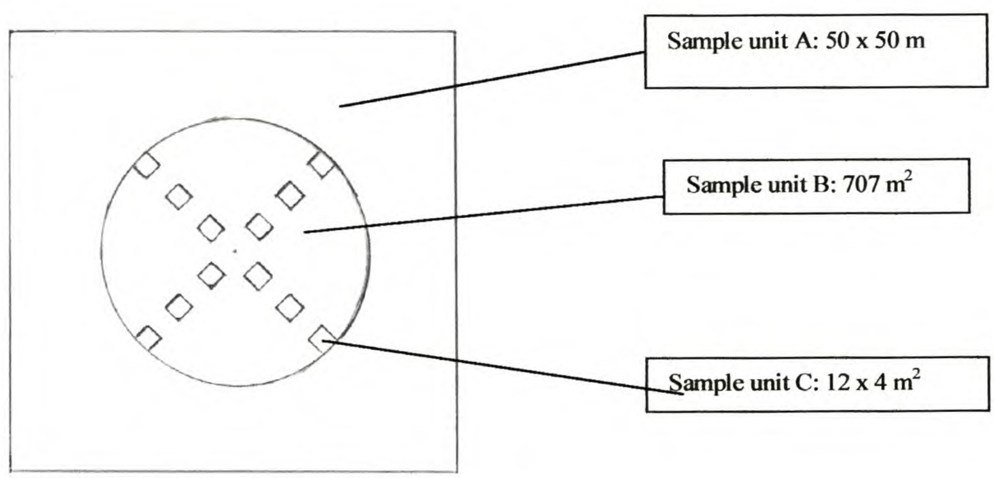

Figure 2.3. Subdivision and size of the sample units used for forest resource assessment, Nyungwe Forest.

Sample unit B was measured off from sample unit A for appropriate assessment of abundance of small trees greater than 1.30 m height and DBH of 2.5-9.9 cm. A circular shape of 15 m radius (i.e. 707 m^2) was selected. Seedlings and saplings were recorded in twelve 2 m x 2 m nested sub-units (Sample unit C) within sample unit B. The sub-units were delineated following the diagonals of Sample unit A and placed at 3 m intervals. Individuals of 0.10 m to 0.30 m height and DBH of less or equal to 2.5 cm were recorded. Peters (1996) scaled small trees of this size to tree seedlings or saplings. Therefore, regeneration assessments were done on an area of 48 m^2, lying in the range of plot sizes recommended by Peters (1996). For the study, a total number of 10 sample units with 10 corresponding nested subunits and 60 sub-subunits were used.

2.2.3.2 Data Collection

Quantitative and qualitative information was recorded on tree species found in the sample plots. The aim was to gather information on the availability and abundance of the preferred tree species in relation to other tree species present. Preferred tree species were defined as those that were identified during the participatory rural appraisal as mostly being sought after by local communities for use as timber, poles and medicinal materials. They were also referred to those species that were frequently used in the past by the local people before the Forest was gazetted a forest reserve. The following parameters were recorded during the forest assessment: tree species composition (local names), stem densities, diameter at breast height (DBH), and stem quality of the most preferred timber and pole species.

Plant identification and species composition

Within each sample unit, tree species were identified in the field by a team of five local persons including two forest rangers who provided vernacular names. Local people were included in the survey team because they were knowledgeable of the local names of the tree species. Scientific names were identified by making reference to the work on Rwanda Flora by Troupin (1985, 1983, 1978), Troupin and Bridson (1982) and Troupin and Donneaux (1982). Individual plants of every species were also recorded.

Density, frequency and diameter size-class distribution

Density, or the count of individuals of species within the plot (Davis and Johnson, 1987; Kent and Coker, 1992), is the ecological parameter of interest to ethnobotanists (Peters, 1996). Hall and Bawa (1993) and Peters (1994) reported that density and size-class distribution are indicators of the impact of exploiting a given population. Density describes not only the degree to which the site is being utilised, but also the intensity of competition between trees.

In this study, density measures that combined tree sizes and the number of individuals were used. Individual trees were counted in each of the sample plots and recorded in the appropriate diameter class. Frequency as a measure of species abundance (Kent and Coker, 1992) was used to provide the proportion of individuals of the most preferred tree species in relation the number of individuals of all other tree species present in the sample plots. Tree species abundance was quantified by tallying the number of stems of each species in different DBH size classes. Large canopy tree species or tree species greater than 10cm DBH were grouped into 10 cm diameter class.

Species dominance

Species dominance was used as a measure of the contribution of each individual species to the forest standing biomass (Owiunji, 1997). The assessment of standing biomass was measured by the basal area, measured at breast height, of individuals of a particular species. Species dominance was used as an index to ecological dominance and an indirect measure of biomass (Cunningham, 2000; Peters, 1994).

Assessment of the regeneration of the most preferred tree species

Regeneration assessment was used for quantifying the density of seedlings and saplings in the forest area adjacent to communities surveyed around Nyungwe Forest. The aim was to assess whether or not the canopy tree species that were most preferred were capable of producing seedlings and saplings in the Forest. Seedlings and saplings were recorded for their numbers.

Quality of the most preferred timber and pole species

A quick visual assessment of the straightness of the tree bole in each plot was made. Stem quality was evaluated on a six-point scale in terms of their suitability for utilisation as timber or poles. The quality of the stem was matched with the quality of the stem provided on Figure 2.4 below. Therefore, points 1 to 6 were used to mean stems of excellent, very good, good, fair, poor, and very poor quality stems.

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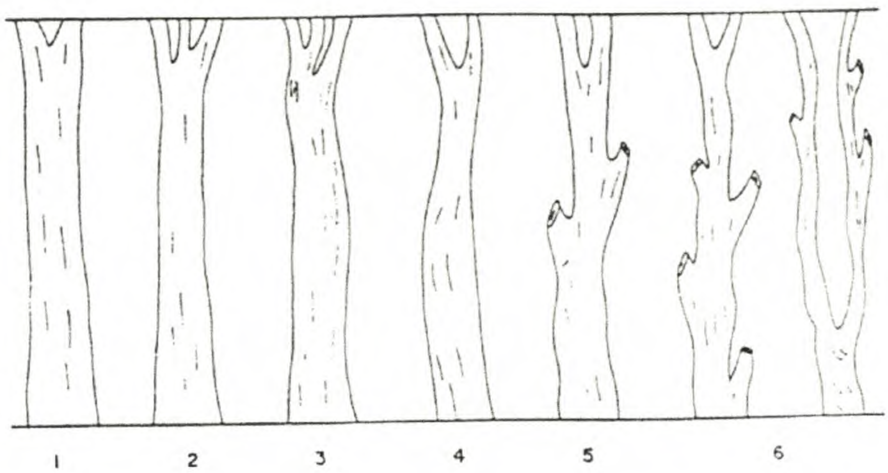

1 = excellent; 2 = very good; 3 = good; 4 = fair; 5 = poor; 6 = very poor.

Figure 2.4. Different levels of stem quality used in the resource assessment, Nyungwe Forest.

2.2.3.3 Data analysis

Tree species identification and composition

A list showing the scientific and vernacular names of the tree species was made by compiling all tree species found in all forest areas next to the Communes being surveyed. Tree species composition was assessed for large trees (trees greater than 10 cm DBH), for medium trees (trees of 2.5 - 9.9 cm DBH) and for the seedlings and saplings (individuals of 0.10 - 1.30 m height and < 2.5 cm DBH) at the different study sites.

Density and diameter size-class distribution

Analysis of size-class distribution was limited only to the tree species most preferred by local communities. The selection of these species was based on the results of the household survey and on the relative frequency in the species composition data obtained from forest inventory. Diameters of the most preferred tree species were compiled into size-class histograms showing the distribution of the stem densities into different DBH size classes. Species distribution curves were generated to reflect the tree species demographic pattern by plotting DBH size classes versus the stem densities per hectare (ITFC-EMP, 1999). The resulting histograms reflected the current status of the Forest in relation to the most dominant canopy tree species.

A sample provides an estimate of the population parameter of interest, as it is impossible to measure the entire population (Mead *et al.*, 1993). Confidence limits define a range of values around the sample mean, which is expected to include the true population mean with a certain degree of confidence (Snedecor and Cochran, 1967).

In this study, stem densities were calculated as a measure of abundance of the most preferred tree species for timber, poles and medicinal materials. The calculated confidence interval of 95% for the mean stem densities and the lower limit confidence interval were used as conservative estimates of the density of the resource. In contrast, stem densities at the upper limit of the confidence interval were considered abundant enough for utilisation. These confidence intervals were then used to determine the level at which the preferred tree species were abundant enough for utilisation.

In their research on stand density management in the United States, Drew and Flewelling (1979) quoted by Davis and Johnson (1987) found that the stem density of 0.55 stems per hectare is the level at which total growth per hectare level out and competition-induced mortality of trees begins. As the density of 1.0 is an empirically fitted maximum in nature (Davis and Johnson, 1987), preferred tree species with a stem density of 1.0 stems per hectare and above were considered to have a high enough stem density to recommend them for utilisation. The guiding concept for the harvesting of timber, pole and medicinal materials was to reduce the density to a level such that the density of the preferred tree species will grow back to or slightly above the 0.55 stems per hectare at the next scheduled harvesting of these products.

Species dominance

Species dominance was measured by the basal area (G), i.e. cross-sectional area of an individual of a particular species measured at breast height (Philip, 1983). The following formula was used for the calculation of the basal area:

$G = \pi \times ((DBH)^2/4)$, where:

G= basal area (m^2/ha);

$\pi = 3.14$;

DBH = diameter at breast height (cm).

The contribution of each individual species to the forest biomass was measured by the relative dominance (D), which is defined as the cross-sectional area for each species divided by the basal area for all species.

$D = G_s/G_{tot}$, where;

D = relative dominance or relative basal area (m^2/ha);

G_s = basal area for a given species (m^2/ha);

G_{tot} = basal area for all species (m^2/ha);

The calculated proportion was used to compare the contribution of each species to the total standing biomass. With a total index of 1.0 for all the species in the sample forest area, a tree species with a relative basal area of 0.01 and more was subjectively said to have a 'high contribution' to the forest standing biomass and that with less than 0.01 to have a 'low contribution'. Species of the latter category were immediately not classified with harvestable tree species.

Regeneration characteristics

The most abundant and dominant preferred tree species were compared in terms of corresponding available seedlings and saplings. Seedling and sapling densities of these species were compared by means of histograms showing the relative abundance of trees across the study sites. The relationship between tree species and relative abundance of seedlings/saplings was considered to be a measure of species

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regeneration and thus was used to predict the ability of the preferred tree species to produce significant resources.

Quality of the boles of the most preferred timber and pole species

Data on the quality of the stems were presented as percentages. The six levels of the quality of the stems were aggregated into three categories namely good, fair and acceptable. For the most abundant and dominant preferred tree species, histograms were constructed to provide a visual display of the percentage of individuals with good, fair and acceptable stem quality.

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3 RESULTS

3.1 PARTICIPATORY RURAL APPRAISAL

This section presents the information collected during interviews with individual households, small groups and key informants. The results of the participatory rural appraisal (PRA) include the socio-economic status of the respondents, the assessments of the availability of resources in Nyungwe Forest, their relative abundance estimates and the prioritisation of important resources to community livelihoods. The section also presents a list of key institutions that were acknowledged by the interviewees to be appropriate for better management of the utilisation of Nyungwe Forest. Also presented here are the experiences of individual key informants relating to Nyungwe Forest management problems and the strategies adopted to reduce the conflicts between local people and forest managers. In many cases, the total percentages of responses exceeds 100% because the respondents mentioned more than one item for examples the types of crops farmed, the resources available in Nyungwe Forest, the uses of resources, the types of conflicts and the strategies to avoid them, among others.

3.1.1 Socio-demographic characteristics

In the study area, interviews were conducted in 200 individual households of which 161 (80.5%) were represented by men and 39 (19.5%) by women. Thus, most of the information was collected from men who were the heads of the households. Information on marital status indicated that 85.5% were married, 7.5% widows, 6.0% single, and 1.0% divorced. Figure 3.1 illustrates the age distribution of the respondents.

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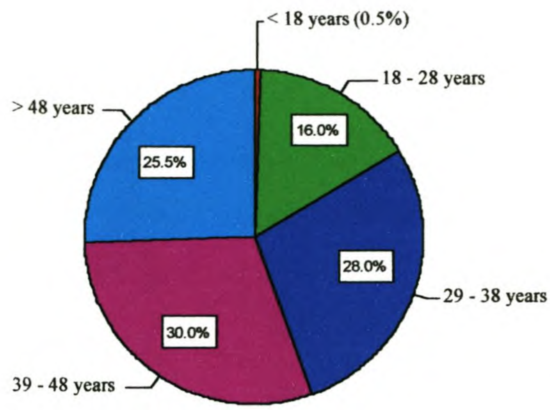

Figure 3.1. Age classes of the respondents in the study area, n = 200

The majority (43.5%) of the households contained 5 – 7 members (Figure 3.2). This coincides with the national statistics, which indicate an average family size of five persons (MINECOFIN, 1998). Large households (10 or more members) were reported by 36% of the respondents. One of the reasons for large family size appears to be the hosting of the children orphaned as a consequence of the 1994 genocide.

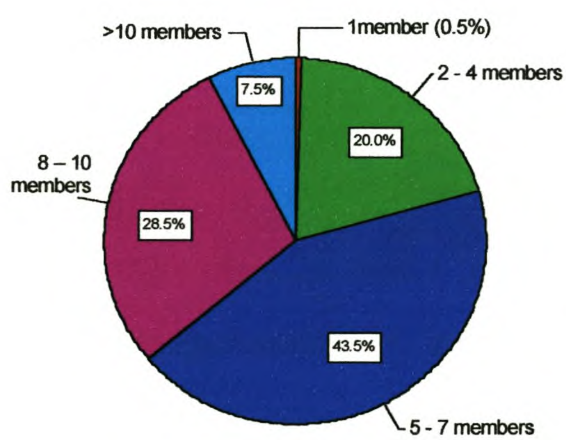

Figure 3.2. Family size of the respondents in the study area, n = 200

Table 3.1 shows the level of education of the respondents and indicates that the majority of the respondents had little or no primary school education. This was particularly the case in the Kagano and Mudasomwa Communes, where people had

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abandoned school education in order to engage in tea harvesting for income generation.

Table 3.1. Education level of the respondents in the study area, n = 200

Education level	%
No school	34.5
Some primary school	39.5
Primary school completed	19.0
Some secondary school	6.0
Secondary school completed	1.0
Total	100.0

Other reasons for school abandonment, such as the lack of school fees, were expressed by 6% of the respondents. A very low percentage (1%) of the respondents had completed their secondary education, and none of the respondents had reached university level. This implies that people educated to secondary and university levels were living outside their native area, probably due to better employment and income generating opportunities in other parts of the country. As a result, less educated people were encountered in all the households interviewed.

3.1.2 Farm size and land ownership

Land is a major form of capital for the production of crops, livestock and tree resources. Figure 3.3 shows the farm sizes of sample households in the study area.

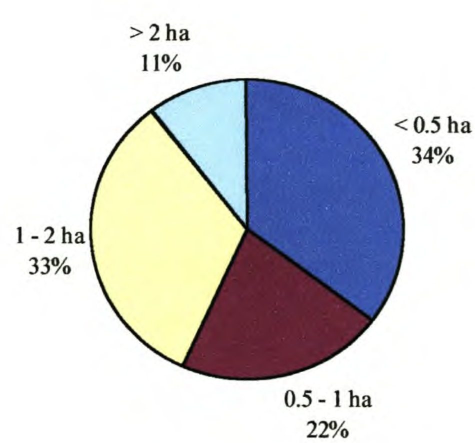

Figure 3.3. Farm sizes of the respondents in the study area, n = 200

Many respondents (35%) owned less than 0.5 ha of farmland. The majority (41%) obtained their land through state allocation (Figure 3.4).

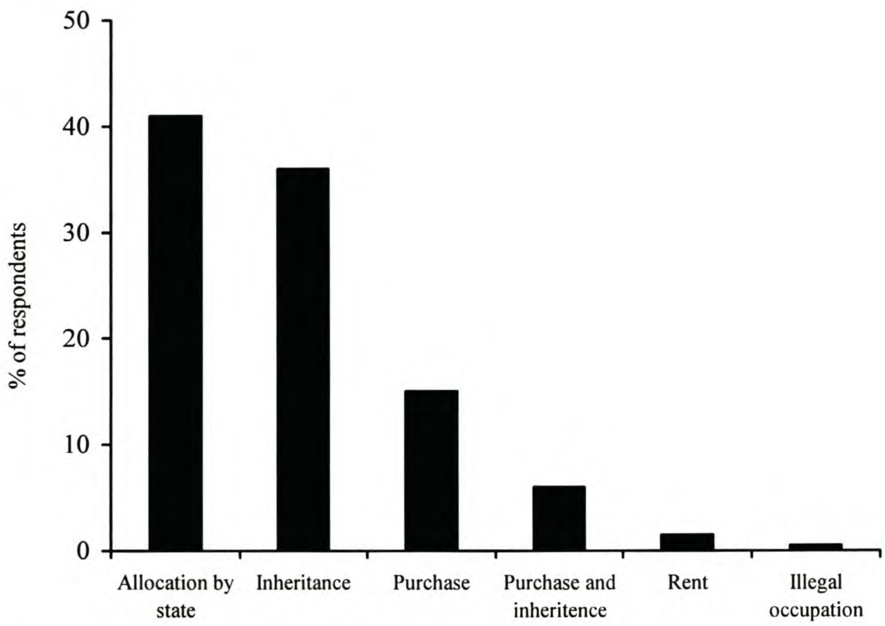

Figure 3.4. Processes of land acquisition by the respondents in the study area, n = 200.

Another 36% obtained their land through inheritance. Some respondents (15%) had purchased farms from neighbours, while a few respondents (6.0%) indicated that their land was both purchased and inherited. Where land was acquired through donation by the state, as in Musebeya Commune, the average farm size was 2 ha. Areas where land was largely inherited, for instance in Nshili Commune, the farm size was less than 1.0 ha. Previous research by MINAGRI (2000) found that the average farm size in Gikongoro Province, which includes three of the five Communes surveyed (Mudasomwa, Musebeya, Nshili), was 1.26 ha, comparatively higher than the 1.0 ha owned by 79% of all households in Rwanda.

3.1.3 Livelihood activities and sources of income

Not a single respondent indicated only one livelihood activity. Most people combined food production and livestock farming with other activities such as beekeeping, charcoal making, pitsawying, handcraft, employment, commerce and mining. As a result, agriculture was a source of livelihoods to 99.5% of the respondents, and livestock keeping to 74.0%. Tree-related livelihood activities included pitsawying (9%) and charcoal making (4.5%) (Figure 3.5). Only a few respondents ranked the practices of beekeeping (one respondent) and mining (three respondents) in Nyungwe Forest as important activities for people's livelihoods.

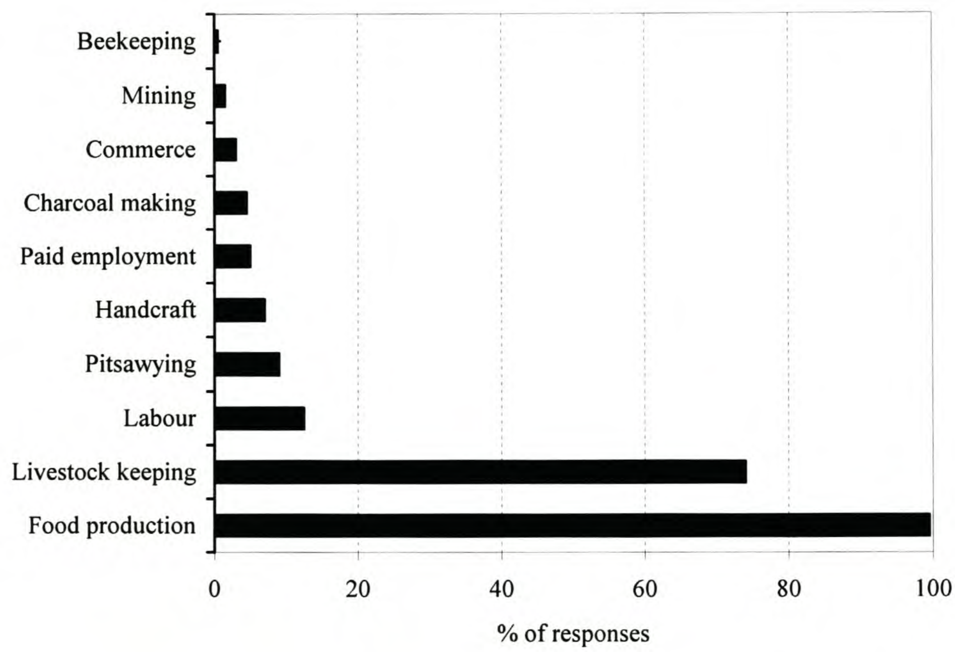

Figure 3.5. Priority enterprises of the respondents in the study area, n = 200.

Agriculture was a source of income to 75% of the respondents, while 40% of the respondents obtained cash from livestock keeping. Income earnings from tree products were reported by 10% of the households. About 30% of the respondents had off-farm income, and only 6% had paid employment. A small percentage of respondents (2.5%) were engaged as casual labourers on neighbouring farms, particularly in tea harvesting where tea factories were operational.

Other sources of cash income included the sale of craft works, the sale of fruit and gold mining. Respondents also indicated that credit systems in the study area were not developed and, as a result, financial resources for many households (78%) were self-generated, with little or no access to bank credits. A few respondents (8%) had established a mechanism of a 'rotating fund' among group members. This system enabled each group member to be awarded a lump sum of money from the monthly contributions of all other members. The respondents highlighted the importance of this system in enabling members to cover high costs, including the expenditure for house building, the purchase of livestock and the payment of school fees. Despite the advantages of such schemes however, most (69%) of the respondents were not registered with any group or association. Other respondents (20%) were members of farmers' associations.

3.1.3.1 Crop farming

All the respondents managed their farms predominantly for the production of food crops. They grew traditional food crops, including sweet potatoes, Irish potatoes, bananas, maize, wheat, peas, and cassava, with sweet potatoes and maize being the most prominent in the study area (Table 3.2). The principal objective of crop farming was to generate enough food for domestic consumption and to meet other basic needs through income accrued from the sales of excess production on local markets. Crops grown for food and cash income were predominantly Irish potatoes, bananas and wheat. A few respondents grew other cash crops such as tea (7.5%, n = 15) and trees (4.5%, n = 9).

Table 3.2. Important food and cash crops grown by the respondents in the study area.

Crops	Percentage of respondents	
	Food crops	Food and cash crops
Irish potatoes	17.0	51.0
Maize	34.7	19.5
Wheat	20.5	22.0
Peas	23.5	14.0
Beans	37.0	7.0
Cassava	19.0	13.5
Sweet potatoes	45.5	16.0
Banana	6.0	22.5
Vegetables	11.5	6.0

Generally, crop harvests were small, with the majority of the households harvesting less than five bags (one bag is approx. 100 kg) even in areas where the crops were most suited to soils and climate (Table 3.3). Irish potatoes, maize and wheat were common in Musebeya, Mudasomwa and Nshili. Roots and tubers (cassava and sweet potatoes) were preferred crops in Busozo, and banana production was specific to the agro-climatic conditions of Kagano Commune in the North-West of the study area. Factors that were said to influence the quantity at harvest included the non-use of improved inputs and the destruction of crops by wild animals.

Table 3.3. Estimates of crop harvests by the respondents in the study area.
Results are presented for important crops mentioned by more than 20% of the households.

No. bags	Percentage of respondents							
(1 bag = 100 kg)	Irish potato	Maize	Wheat	Bean	Peas	Cassava	Sweet potato	Banana
< 1	3.8	26.2	33.3	62.5	65.8	11.6	3.9	10.7
1 – 2	25.0	43.0	37.0	29.5	25.0	40.6	16.4	-
3 – 5	31.1	14.0	23.5	6.8	7.9	24.6	18.8	-
6 – 8	4.5	2.8	1.2	-	-	5.8	11.7	-
9 – 10	18.9	11.2	2.5	-	-	5.8	3.1	-
> 10	16.7	1.9	-	1.1	1.3	1.4	4.7	-
No estimate		0.9	2.5			10.1	41.4	89.3
Total	100	100	100	100	100	100	100	100

3.1.3.2 Other plant species grown

Apart from crops, trees, shrubs and grasses were also farmed by many of the respondents. The presence of fruit, medicinal and fodder plant species is widespread in the survey area. Exotic fruit plants on farms included avocado (*Persea americana*), Japanese plum (*Cyphomandra betacea)*, passion fruit (*Pasiflora edulis*), citrus (*Citrus lemon*), guayava (*Psidium guayava*), mangoes (*Mangifera indica*), custard apple (*Anona reticulata*) and pawpaw (*Carica papaya*). Of the households interviewed, 48.5% had planted avocado. Only 21.5% and 19.5% of the respondents had plum trees and passion fruit on their farms, respectively. The remaining fruit plant species were planted by fewer than five households.

The respondents mentioned the presence of 20 medicinal plants traditionally used to treat humans and livestock on their farms (Appendix 2). These plant species were indigenous, and they were planted or conserved on farms. The most common were *Iboza riparia* (33.0%), *Plecthranthus barbatus* (20.5%) and *Vernonia amygdalina* (13%).

Different fodder species were included as components of the farming system with the objective of controlling erosion. At the same time, they were used to feed domestic livestock during periods of fodder shortage. Many respondents (59%) established *Setaria spp.* on erosion control ridges or on terraces. Other fodder species mentioned were *Panicum hochstetteri, Cynodon aethipicus, Tripsacum laxum, Digitaria hackelii* and *Triumfetta cordifolia*. The elephant grass *Pennisetum purpureum* was present on 18.5% of farms and its leafy biomass and young plants were cut to feed livestock during the dry season of July to August.

Horticultural crops grown in the study area were largely cabbages and amaranths. Of the 200 households interviewed, 39.5% produced cabbages, particularly in the swamps. Amaranths were present in the home-gardens of 24.5% of the respondents. The prevalence of these vegetables was attributed to an existing local market as well as to the need for food supplements within the households. Other vegetables and fruits of limited interest included carrots, pineapples, onions and courgettes.

3.1.3.3 Livestock farming

Within the study area, livestock farming was complementary to food production. Different livestock types were present, but they were unevenly distributed among the respondents (Table 3.4).

Table 3.4. Numbers and distribution of livestock types in the study area.

	% of respondents					
No. of livestock	Cattle	Goats	Sheep	Pigs	Chicken	Rabbits
None	63.5	44.5	59.5	78.0	89.0	93.5
1	9.5	5.0	6.5	12.5	1.0	-
2 – 4	21.0	24.0	18.0	7.5	4.0	2.0
5 – 7	4.0	18.5	11.0	2.0	3.5	1.5
8 – 10	2.0	4.0	5.0	-	1.5	1.5
> 10	-	4.0	-	-	-	1.5
Total	100.0	100.0	100.0	100.0	100.0	100.0

Goats (56.5%) and sheep (40.5%) were the most commonly kept livestock among the respondents, while only 36.5% kept cattle. Pigs were important in the study area and were kept by 22% of the people interviewed. Chickens and rabbits were also kept. Some households kept all the types of livestock, while others had none. The purpose of livestock farming was predominantly for manure production, except in the case of rabbits and chickens, which provided about 30% of the respondents with protein. Income was also an important aspect of livestock keeping, especially in the case of sheep and goats. Many households obtained an income from sales of goats (70.8%), sheep (56.3%) and pigs (44.4%). About 22% of the households obtained cash from cattle through the sale of unproductive cows, calves or milk.

Of the households interviewed, 60 to 80% used manure from cattle, goats, sheep and pigs on their farms owing to the low soil fertility caused by erosion and continued cultivation. For better productivity, when affordable, manure or compost combined with inorganic fertilisers including NPK and lime, were used.

Grazing practices by the respondents are shown on Figure 3.6. Grazing practices consisted predominantly of free range grazing (67.7%) and zero grazing (32.3%). During the dry season, fodder plants were collected everywhere, from wetlands and swamps, as well as from farms (terraces and erosion control ridges).

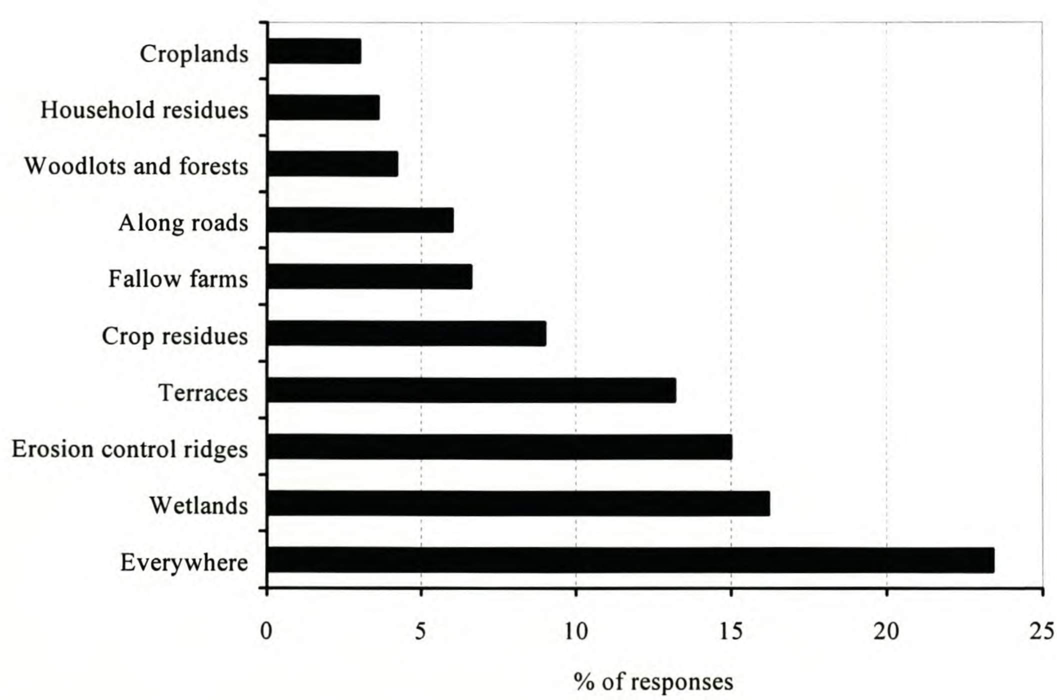

Figure 3.6. Sources of fodder during the dry season in the study area.

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3.1.3.4 Tree crops

Apart from fruits and medicinal plants present on farms, 66.3% of the households owned plantations of different sizes (Figure 3.7), usually as small woodlots of less than 0.5 ha. The farm sizes of the respondents showed a strong positive relationship with tree crop area (Pearson's correlation $r = 0.35$, $p<0.001$, $n = 200$). The planting of *Eucalyptus spp.* was common, alone or in combination with other tree species, namely *Pinus patula* and *Grevillea robusta* (Figure 3.8).

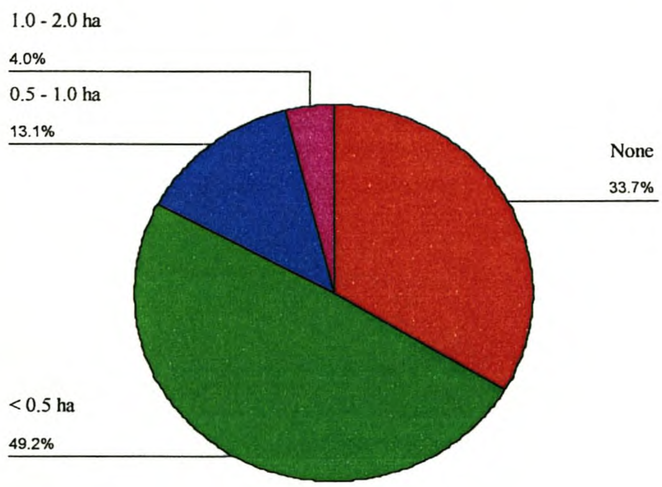
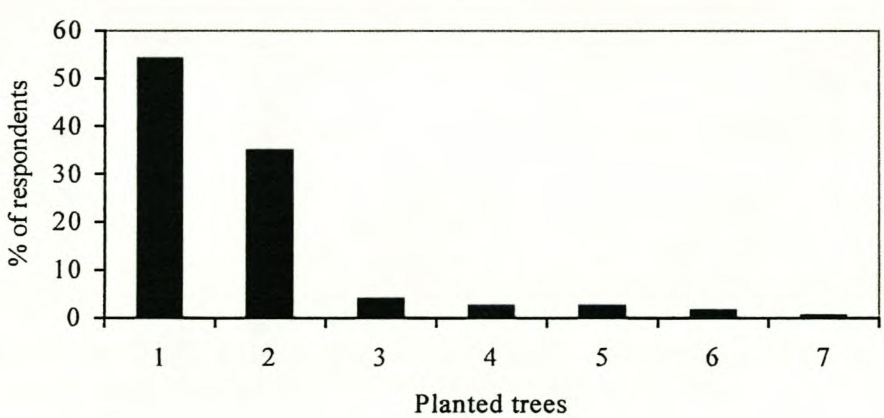


Figure 3.7. Plantation areas owned by the respondents in the study area.



1 = *Eucalyptus spp.*; 2 = None; 3 = *Eucalyptus spp.* and *Pinus patula*; 4 = *Cupressus lusitanica*;

5 = *P. patula* and *C. lusitanica*, 6 = *Arundinaria alpina*, Cypress and *Hagenia abyssinicà* 7 = *Eucalyptus spp.* and *Grevillea robusta.*

Figure 3.8. Tree species planted by the respondents in the study area.

The majority of people (54.4%) indicated that they planted trees as their main source of building poles. Those who planted *Pinus patula*, *Cupressus lusitanica* and *Grevillea robusta* (10.3%) aimed to produce timber by pitsawying, as they recognised an increasing market demand for this product.

Trees were converted to fuelwood by 28.7% of the respondents and to charcoal by 9%. Charcoal was a common product for sale. Others said that money was obtained from the sales of poles. On average, income from tree products for many households did not exceed 10 000 Rwandan Francs[1] (RWF) per year (Figures 3.9 through 3.11).

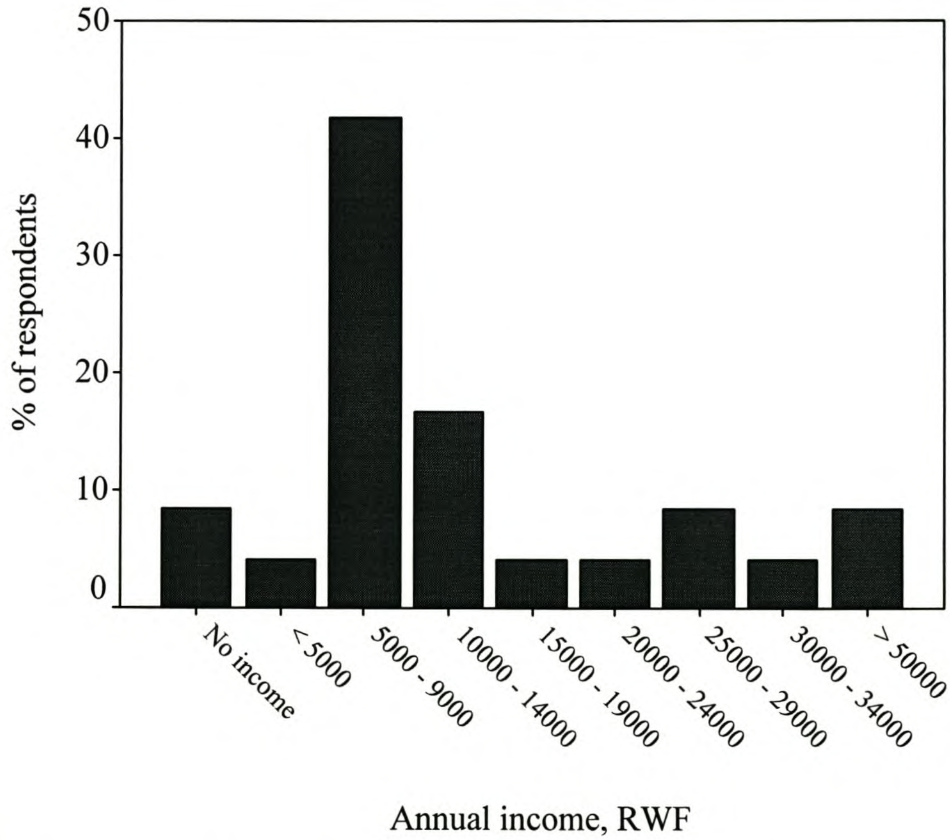


Figure 3.9. Annual income from the sale of charcoal by the respondents in the study area

[1] At the time of writing, 1US$ was equivalent to 473 RWF

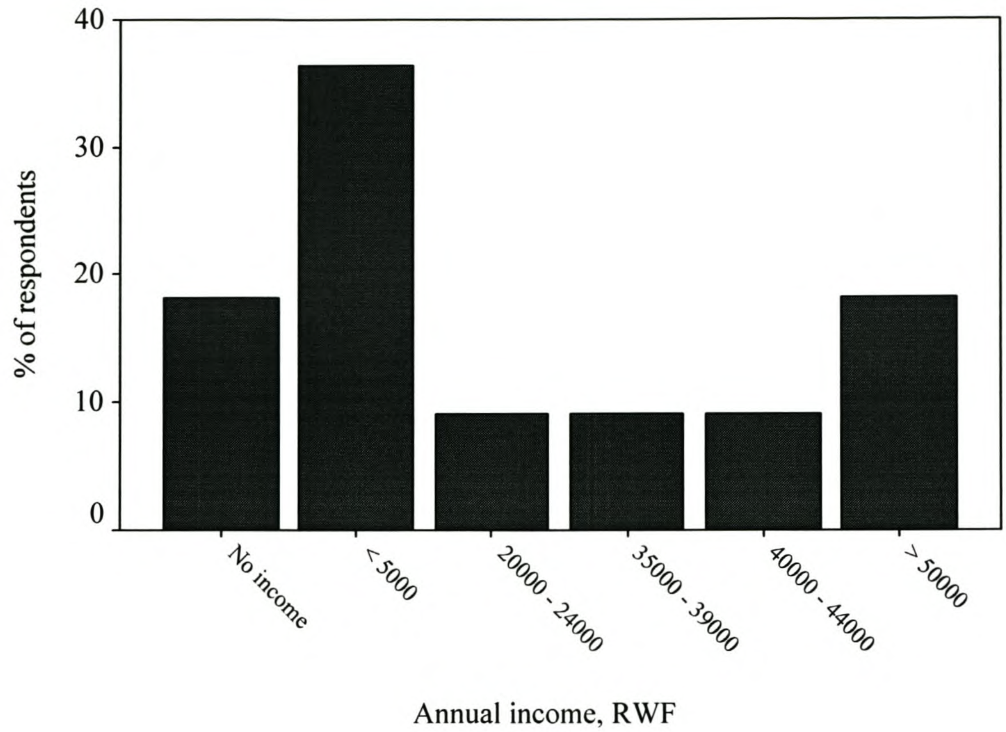


Figure 3.10. Annual income from the sale of lumber by the respondents in the study area.

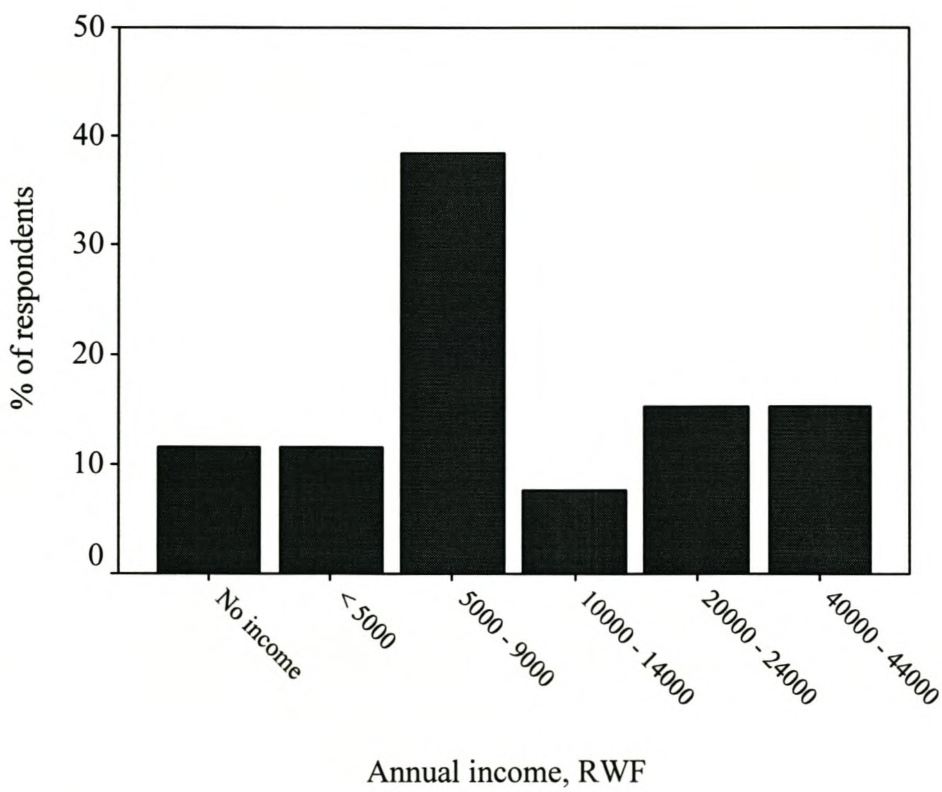


Figure 3.11. Annual income from the sale of building poles by the respondents in the study area.

3.1.4 Soil fertility status and management

Soil fertility in the study area was a key concern to many households. When asked to rate the fertility status of their farms, 55.5% of the respondents said it was moderate, while others considered the fertility of their farms as very poor (18%) and poor (16.5%). Many people (85%) reported that soil fertility decline in the study area was a major impediment to the productivity of crops. Many causes of soil fertility decline were cited, but inadequate use of manure, fertiliser and compost was a crosscutting problem among all the Communes surveyed (Table 3.5).

Table 3.5. Causes of soil fertility decline listed by the respondents in the study area.

Causes of soil fertility decline	No. responses	Percent of responses (%)
Lack of use of manure, fertiliser and compost	131	65.5
'Senility' of land	64	32.0
Continued cultivation, no fallow	33	16.5
Erosion	20	10.0
Soil acidity	9	4.5
Lack of use of terraces	7	3.5
Lack of use of improved crop varieties	6	3.0
Small farm size	4	2.0
Inadequate agricultural practices	3	1.5
Overgrazing	1	0.5

Farmers' strategies to improve the fertility status of their farms were varied, but the majority (53.5%) were using manure, fertiliser, compost or a combination of these. The respondents with land shortage problems said that they were renting land from the neighbours (22%) or that they served as casual labourers on neighbours' fields (15%). The remaining respondents had adopted various solutions to cope with low fertility, including the practice of natural fallow, the use of terraces to prevent soil erosion, the registration as farmer's association members and the use of improved seeds.

3.1.5 Respondents' perception of Nyungwe Forest resources

The 200 respondents listed 18 categories of resources present in Nyungwe Forest. Of the 18 resource categories, only 14 were said to be important for the respondents' livelihoods. Table 3.6 shows these resources, their abundance estimates and their uses by the respondents. The most important products from the Forest, according to more than 50% of the interviewees, were land, timber and minable gold. Nyungwe Forest was seen as a source of fodder and pastures but by few respondents (16%). Appendix 3 shows a list of palatable tree and grass species mentioned by 5 or more respondents. The most mentioned were *Panicum hochstetteri, Triumfetta cordifolia, Mariscus thomaiophyllus* and *Digitaria hackelii*.

Table 3.6. List of important resources for community's livelihoods in the study area, n = 200.

Resources	% respondents	Abundance estimate	Uses
Land	68.5	D (49)	S/C (75.4)
Timber	58.5	D (45)	C (62.9)
Gold mine	56.5	F (72)	C (89.7)
Fodder and pastures	16.0	F (8)	S/C (59.4)
Wooden and woven item	13.5	D (21)	S/C (48.3)
Fuelwood	11.0	D (18)	S (78.3)
Poles	10.5	D (20)	S (74.1)
Employment	9.0	A (5)	S (90)
Honey (beekeeping)	7.5	A (6)	C (71.4)
Charcoal	3.5	NM	C (87.5)
Medicinal plants	3.5	A (5)	C (62.5)
Rain and humidity	3.5	NM	NM
Ecotourism	2.5	NM	C (100)
Game-meat	1.0	F (5)	S (77.8)

A = Abundant; D = Dominant; F = frequent; NM = not mentioned
S = subsistence; C = commercial; S/C = subsistence and commercial
( ) indicates the percentage of responses for each resource.

The perception of resources in the Forest by individual interviews compared favourably with that of the group participants in all the study sites. On the whole, 21 resources were listed and their abundances estimated (Table 3.7). Timber, poles, fuelwood and beekeeping were the major abundant resources common to all study survey sites. However, land availability was a controversial resource on which the participants had a long discussion before a consensus was reached. Land availability was perceived differently in terms of its size and soil fertility. For some participants, the land area was large but not productive enough as the soil fertility declined after one to two years of continued use. Others classified land as abundant because there existed fertile wetlands in the Forest. A similar debate occurred again for the participants' perceptions of indigenous timber trees. Some claimed that they did not know what was in the Forest, as they were not allowed to go there. Others said that timber trees were abundant because the Forest was protected, was regenerating and no pitsawying was carried out, as it was in the past.

Table 3.7. Assessment of the availability of resources in Nyungwe Forest by groups in the study area.

Resources	Musebeya	Nshili	Kagano	Mudasomwa	Busozo
Gold	F	F	A	F	F
Timber	D	D	D	D	F
Land	D	F	D	O	A
Medicinal plants	O	O	A	F	O
Charcoal	D	NM	F	D	NM
Ecotourism	F	NM	NM	NM	NM
Fuelwood	D	F	D	D	D
Wildlife	D	D	A	A	A
Rain and humidity	D	D	D	D	D
Goods	D	D	F	F	NM
Poles	D	D	D	D	A
Employment	D	F	D	A	A
Beekeeping	D	D	D	A	D
Pastures	O	O	NM	A	F
Bean stakes	D	NM	NM	NM	NM
Water	D	D	D	D	D
Vegetables	R	R	R	R	O
Mushrooms	R	R	R	R	O
Wild honey	R	NM	NM	R	O
Fruit	R	NM	R	R	R
Bushmeat	F	NM	F	O	F

D = Dominant; A = Abundant; F = Frequent; O = Occasional; R = Rare; NM = Not mentioned

From household interviews, only a few respondents indicated the availability of building poles (10.5%, n = 21), fuelwood (11%, n = 22), medicinal plants (3.5%, n=7) and charcoal (11%, n = 22) in the Forest. Ecotourism potential was a resource mentioned by a very few people, only 2.5% of the respondents, and only 9% identified the potential of the Forest to provide local employment. The Forest's ecological functions, such as its influence on local climate, were cited as resources by 3.5% of the respondents.

3.1.6 Resource preferences and ranking

This exercise enabled the participants to list the resources that they thought would be of value to their livelihoods if they were given access to use them. In general, however, as some resources were mentioned and listed, the participants from some groups reacted by commenting that their preferences could not be met, as the Forest was not theirs but for the State, the Rwanda Office of Tourism and National Parks (ORTPN) and the foreign tourists.

Preferred resources were ranked using both discussion and the pairwise ranking of importance of resources to communities. Table 3.8 shows the ranked order of the resources in order of their importance in relation to each other. The most important resources listed by the participants were land, timber and gold, but the ranking appeared to be dependent on the agro-ecological zone and the socio-economic characteristics of the population. Land preference ranked high in areas where farm sizes were small, as in Nshili and Kagano, but not in Musebeya where people had an average farm size of 2.0 ha. Whereas timber was the first priority in Mudasomwa, gold mining was important for the community in Busozo.

These preferences partly explain the problems encountered by the local authorities and the conservation services with regard to the illegal use of the Forest. Deforestation for arable land was a severe problem in Busozo, particularly in the Bweyeye Sector.

Table 3.8. Ranking of resource categories in the study area

Rank order	Musebeya	Nshili	Kagano	Mudasomwa	Busozo
1	Land	Land	Land	Timber	Gold
2	Timber	Timber	Gold	Gold	Land
3	Fuelwood	Gold	Timber	Land	Timber
4	Pastures	Bamboos	Poles	Charcoal	Pastures
5	Employment	Pastures	Employment	Fuelwood	Employment
6	Poles	Poles	Fuelwood	Beekeeping	Rain
7	Ecotourism	Fuelwood	Goods	Medicinal plants	Poles
8	Charcoal	Employment	Beekeeping	Bushmeat	Bushmeat
9	Beekeeping	Beekeeping	Pastures	Goods	
10	Rain	Charcoal	Medicinal plants		
11	Gold	Bushmeat	Bushmeat		
12	Medicinal plants				
13	Goods				
14	Bushmeat				

In Nshili and Kagano, available information suggested that both the buffer zone and Nyungwe Forest were used to produce food crops. Food production and hunting in the Forest were mostly practised by about 1 000 indigenous people, Batwa, who lived inside the Forest. Unlawful users of the Forest were given fines or were jailed. At Kagano, the illegal use of the Forest and the buffer zone was condemned by a fine ranging from 10 000 RWF to 20 000 RWF. Strategies to reduce the rate of deforestation were many and included the management of the largest wetlands in the environs of the Forest, namely Kamiranzovu and Uwasenkoko. Other suggested ways of reducing the conflict from land problems were the delimitation and management of

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pasture lands, the intensification of agriculture involving the use of erosion control methods and fertilisers, and the establishment of projects that could provide local employment.

Timber was the first priority needed in Mudasomwa, second in Musebeya and Nshili and third in Kagano. Although the participants denied the harvesting of timber from the Forest, The Nyungwe Forest Conservation Project (PCFN) and the local authorities recognised illegal logging of commercially important timber tree species in all the Communes being surveyed. They indicated that illegal logging was taking place throughout the year, with intense activity during the dry season. Timber was sold locally, outside the area or in neighbouring countries such as in the Republic of Burundi that borders with Nshili and Busozo Communes in the South of the Forest. The local authorities and the conservation services were much concerned about charcoal making and fuelwood gathering in Nyungwe Forest and in the buffer zone. Proposed solutions for reducing the conflict over illegal timber exploitation, charcoal making and fuelwood gathering included among others:

- Licensed harvesting and pitsawying of mature or dead trees in specified areas of the Forest;
- Harvesting timber trees in the buffer zone;
- Privatisation of the management of Nyungwe Forest;
- Distribution of seedlings of fast growing preferred tree species to local communities in order to enable them to establish their own sources of tree products;
- Revival of forestry projects.

Gold mining was the highest priority in Busozo, followed by Kagano and Mudasomwa. At Busozo, mining was an alternative form of livelihood, and the group participants indicated that it was the only source of income for the majority of households, whereas people in Kagano and Mudasomwa were getting income from tea factories. For instance, the Tea Factory at Gisakura in Kagano Commune employed annually approximately 5 000 casual labourers for which the salaries averaged 40 million RWF.

The Rwanda Office of Tourism and National Parks suspended gold mining because the activity led to the deviation and pollution of rivers and loss of biodiversity of the Forest. Mining in the valleys in the vicinity of the Forest resulted in the cutting of trees, erosion, hunting, agriculture and the sale of beer in the Forest. According to the conservation services, mining rights in bottomlands and valleys could only be granted to organised groups and the activity guided by a memorandum of agreement.

Except for the high rankings given to land, timber and gold resources, preferences for other resources ranked variably, with exception of bushmeat which appeared to be of less interest to all five communities. Bamboo, *Arundinaria alpina*, bamboo ranked among the most important resources at Nshili compared to other study sites. This indicated the extensive use of bamboo collected without permit from the Forest for house construction and for basketry material.

Groups in Musebeya, Kagano and Mudasomwa Communes identified medicinal plants as important resources. Current use of the resource was permitted by the Nyungwe Conservation Project (PCFN) and had shown little impact to the Forest. The practice of beekeeping was also considered important, particularly where beekeepers' associations were formed. PCFN restricted the activity to the buffer zone and in open areas inside Nyungwe Forest. Beekeeping, however, was reported to result in runaway fires in all the study sites. Conservationists estimated that the possibility of runaway fires could be addressed through the formation of beekeeper's associations. Beekeeping was practised during the period of April to August when tree species favoured by bees were in flowers. On the local market, honey was sold at 500 RWF to 800 RWF per kilogram. Honey was consumed as food, as an ingredient of beer, and wax was used for the local production of candles.

3.1.7 Tree species preferences and uses by the respondents in the study area

3.1.7.1 Timber tree species

Hardwood tree species from Nyungwe Forest were preferred for their sizes, durability and wood colour for different uses. Table 3.9 shows the most commonly used tree species. Other preferred timber species are presented in Appendix 4.

Table 3.9. Tree species most preferred for timber by the survey respondents around Nyungwe Forest, n = 200

Only tree species mentioned by 10 or more respondents are presented.

Tree species	Percentage of responses
Podocarpus latifolius	64.0
Entandrophragma excelsum	56.0
Podocarpus falcatus	38.0
Symphonia globulifera	15.5
Parinari excelsa	13.5
Faurea saligna	12.0
Carapa grandiflora	11.5
Dasylepis racemosa	10.0
Syzygium parvifolium	10.0
Hagenia abyssinica	8.0
Ocotea usambarensis	7.5
Newtonia buchananii	6.0
Polyscias fulva	5.0
Strombosia scheffleri	5.0

A range of timber species was mentioned by the respondents as being used for the production of wooden items. Generally, goods were obtained from the following key tree species: *Polyscias fulva* (a musical instrument, locally known as '*inanga*'), *Ocotea usambarensis* (household utensils, beer boat), *Markhamia lutea* (household utensils), *Carapa grandiflora* (household utensils), *Dasylepsis racemosa* (beer boats) and *Asparagus falcatus* (beer boats). Other wooden and woven goods were obtained from non-timber forest species and included bamboo *Arundinaria alpina*, different climbers (*Smilax anceps, Urera cameroonensis, U. hypselodendron*) and shrubs (*Triumfetta cordifolia*).

3.1.7.2 Building poles

The preference of tree species for poles in the study area was based on the quality of the stems. Major characteristics of suitable trees for poles included stem straightness, durability and a suitable diameter of at least 10 cm. Tree species preferred for quality building poles are given in Table 3.10. Poles were used for house building, for fencing of livestock and the home compound. Bamboo was also used for building particularly in Nshili Commune next to the forest area where it occurs.

Table 3.10. Tree species whose stems are preferred for building poles in the study area, n = 200.

Only tree species mentioned by 10 or more respondents are presented.

Tree species	% of responses
Macaranga neomildbraediana	36.0
Cassipourea ruwenzoriensis	28.5
Strombosia scheffleri	26.0
Syzygium parvifolium	13.5
Carapa grandiflora	12.5
Casearia runssorica	12.5
Olea hochstetteri	6.5
Arundinaria alpina	6.5
Parinari excelsa	6.0
Alchornea hirtella	5.5
Podocarpus latifolius	5.5
Oxyanthus speciosus	5.5
Faurea saligna	5.0
Cassipourea gummiflua	5.0
Milletia spp.	5.0
Symphonia globulifera	5.0
All tree species	5.0

Only 9.5% of the respondents indicated that Nyungwe Forest was a source of building poles in the past, where quality-building poles were abundant. Even now, of the 25 respondents who mentioned building poles as one of the most important resources for their livelihoods, 80% (n = 20) categorised the availability of building poles in the Forest as very abundant. The majority of the respondents (52.1%) said that poles occurred dominantly everywhere in the Forest. Most people (74.1%) estimated that access to Nyungwe Forest would satisfy their subsistence needs for building poles.

3.1.7.3 Medicinal plants

Respondents listed 45 medicinal tree species found in Nyungwe Forest (Appendix 5; Table 3.11). Products from these plants particularly the bark, were traditionally used by medical practitioners to treat people or livestock. Bark material was used from 56.5% (26 out of 45 species) of the medicinal plants mentioned by the respondents.

For some species, both bark and leaves could be used as sources of medicine (Table 3.11). Trees are the major life form category of the medicinal plants, with the exception of *Asclepiadaceae spp.*, *Begonia meyeri-johannis* and *Sericostachys scandens* which are climbers.

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Most people reported that medicinal plants were used locally to treat intestinal parasites in people and livestock. There is no commercial trade in medicines. Men were mentioned as the major harvesters of medicinal plants by 67.4% of the respondents, while 30.2% said that both men and women harvested medicinal plants.

Table 3.11. Plant species used for medicinal purposes in the survey area, n = 200.

Only plant species mentioned by 3 or more respondents are presented.

Plant species	Local name	Part used	No. respondents
Carapa grandiflora	*Umushwati*	Bark	51
Prunus africana	*Umwumba*	Bark, roots	27
Syzygium parvifolium	*Umugote*	Bark, leaves	22
Zanthoxyllum gilletii	*Umuturirwa*	Bark	16
Croton megalocarpus	*Umunege*	Bark	16
Dichrostachys cinerea	*Umunkamba*	Leaves	10
Fagaropsis angolensis	*Umugomera*	Bark	9
Ocotea usambarensis	*Umutake*	Bark	8
Rapanea melanophloeios	*Uruneke*	Bark, leaves	8
Ocotea michelsonii	*Umuganza*	Bark	8
Mitragyna rubrostipulosa	*Umuzibaziba*	Leaves, bark	7
Vernonia amygdalina	*Umuravumba*	Leaves	7
Asclepiadaceae div. spp.	*Indarama*	Tubers	6
Canthium oligocarpum	*Umushabarara*	Bark, leaves	6
Cyathula polycephala	*Igifashi*	Leaves	6
Maesa lanceolata	*Umuhanga*	Leaves, roots	5
Begonia meyeri-johannis	*Irebe*	Leaves	5
Xanthoxyllum usambarensis	*Intareyirungu*	Bark	5
Symphonia globulifera	*Umushishi*	Bark, leaves	3
Pentas decora	*Isagara*	Leaves, bark	3
Brillantaisia cicatricosa	*Icyunga*	Bark	3
Faurea saligna	*Umutiti*	Bark	3
Myrica kandtiana	*Isubyo*	Wood	3
Tabernamontana johnstonii	*Umuronzi*	Leaves, bark	3
Canthium glabriflorum	*Imvuvu*	Bark	3

The respondents varied widely in their estimates of the amount of medicinal plants that could be collected from the Forest. From a total of 129 respondents who knew about medicinal plants, 44.2% (n = 57) estimated the amount collected to be small while 36.4% (n = 47) said moderate quantities were harvested. Forty-four percent of the respondents said that medicinal plants were found everywhere in the Forest, while 26% (n = 35) located many medicinal plants in the bottomlands. The remaining respondents found medicinal plants in several different locations, including valleys, disturbed areas, and hilltops. Medicinal plants such as *Vernonia amygdalina, Iboza riparia, Mitragyna rubrostipulosa*, and *Lantana trifolia* were also found outside Nyungwe Forest in disturbed areas and on fallow farms.

3.1.8 Uses of wild foods

Wild foods collected from the Forest (Table 3.12) are used either for subsistence or as a source of modest income from their sales on the local market. They are seasonally obtained from the Forest, most frequently during the wet seasons.

Table 3.12. Wild food resources found in Nyungwe Forest, as mentioned by the respondents in the study area, n = 200.

Food	Percentage of responses
Fruit	88.5
Game	14.5
Mushrooms	32.0
Vegetables	66.5
Wild honey	11.5

The most important edible fruits to the respondents are *Myrianthus holstii* (88.5%, n=172) and *Rubus rigidus* (17%, n = 34). Other wild fruits mentioned by the respondents are *Cyphomandra betacea* (5.5%, n = 11), *Physalis peruviana* (5.0%, n = 10), *Passiflora edulis* (7.5%, n = 15) and *Citrus lemon* (0.5%, n = 1). These were all reported to be available in Nyungwe Forest from seeds dispersed from plants originally established on farms.

Edible wild mushrooms identified by their local names included *ibizinu, ibihumyo, imegeri, utwoba, intyabire* and *ubushikiri*. According to the respondents, these mushrooms are commonly growing in association with termite mounds or with dead trees. Mushrooms provided seasonal income from sale in local markets. Prices for one mushroom ranged from 10 RWF to 50 RWF, depending on the location of the market. Mushroom gathering was practised mostly by women and children.

Wild vegetables from Nyungwe Forest are another seasonally available resource that was used as a dietary supplement or as a source of small income. Annual herbs whose leaves are used as food include different *Amaranthus spp*. and *Solanum nigrum*. Local names of some *Amaranthus spp.* were *bwizabwishyamba, inderama, umuhuruza* and *umushokorankoko*. The vegetables were found in various locations in the Forest. Most respondents mentioned their occurrence in swamps (39.8%, n = 53), and in disturbed areas, including forest areas that had been cleared for agriculture and burned areas (28.6%, n = 38). The wild vegetables were mostly gathered for subsistence use, but a local market for *Solanum nigrum* did exist. For this vegetable, out of 75 respondents, 41.5% suggested a market price of 5 to 10 RWF per handful. As for other NWFP from Nyungwe Forest, the major collectors of wild vegetables were children and women who collected small amounts at a time.

Honey is a wild food that can be found in the Forest. A few respondents (11.5%, n = 23) mentioned its availability from ground or tree-nesting bees known locally as *inkura*. Wild honey is collected from hollow tree trunks or branches as well as underground. Wild honey is used solely for household consumption. Honey production was listed as an important activity in the Forest, and associated with the availability of plant species favoured by bees and hills inside the Forest that provided the best sites for placing hives. Forest plants that were important sources of nectar and pollen to bees were listed as *Sericostachys scandens*, *Brillantaisia cicatricosa*, *B. nitens*, *Mimulopsis excellens*, *Syzygium parvifolium* and *Virectaria major*. The areas preferred for hive placement were those with high densities of flowering trees, climbers and herbs.

Bushmeat was of value to adjacent communities. Animal species were hunted for subsistence. Other wild foods, consisting of two tuberous species, were mentioned by only a few respondents. These were *Afromomum angustifolium* (2%, n = 4) and *Discorea spp*. (2%, n = 4), reportedly gathered by poor people and the indigenous people Batwa, who were living inside the Forest. The low numbers of users suggests that the two wild foods were not commonly of value in all the survey sites.

3.1.9 Respondents' knowledge of wildlife species

The respondents mentioned 32 wildlife species and estimated their abundance in the Forest. Their presence was determined by the noise of wildlife from the Forest or observations inside or outside the Forest. Commonly cited wildlife included crop raiding animals such as bushpigs (82%, n = 164), chimpanzees (48%, n = 97), grivet monkeys (25.5%, n = 51), black and white colobus monkeys (44.5%, n = 86) and olive baboons (73%, n = 146).

Wild animals caught for domestic meat were listed by many respondents. Respondents perceived most of the crop raiding animals to be abundant because they were easily seen in groups on farms or heard from the Forest. According to many respondents (25% to 50%), dominant wild animals consisted of monkeys, baboons and colobus. A few wild animals were estimated to be rare in the Forest: elephant (*Loxodonta africana*) (92%, n = 23), buffalo (*Syncerus caffer*) (80%, n = 4), civet (*Viverra civetta*) (54.5%, n = 6) and bushbuck (*Tragelaphus scriptus*) (55.6%, n = 15). Generally, edible animals were said to be few.

Animals hunted for subsistence included the black-fronted duiker *Cephalophus nigrifrons* (98.2%, n = 167), the yellow-backed duiker *C. sylvicultor* (99%, n = 102), the bushpig *Potamochoerus porcus* (100%, n = 127), the African elephant *Loxodonta africana* (36.5%, n = 35), the African buffalo *Syncerus caffer* (98.7%, n = 75), and the bushbuck *Tragelaphus scriptus* (98.9%, n = 86). Many other small animals, including the Gambian rats, rabbits, a bird species identified by its local name *igikoyi*, and a small mammal known locally as *inkezi,* were valuable sources of animal proteins. Of the 200 respondents, only 17 said that monkeys were hunted from the Forest either for food (76.5%) or for reducing the population of crop raiding animals (23.5%).

Hunting was practised in all seasons. Of 183 people who answered, 71% estimated that hunting was done throughout the year, although a few argued that hunting is frequent during the rainy season because animal footprints are visible on the ground. Commonly cited hunting methods included dogs (22.3%, n = 42), dogs and spears (29.3%, n = 55), and snares (23.4%, n = 44).

According to the people interviewed, two factors, namely the reproduction rate and the 'no hunting rule', contributed to the change in animal population size of wild animals in the Forest. Compared to the past, an increase in the population of monkeys was observed by 40 % of the people interviewed, baboons by 24.5%, bushpigs by 8%, colobuses by 6.5% and chimpanzees by 4.5%. Chimpanzee's populations in particular were thought to be increasing because they are not eaten. Where the number of wild animals was perceived to have decreased, this decrease was attributed to hunting. Respondents perceived a reduction in numbers of black-fronted duiker (*C. nigrifrons*), yellow-backed duiker (*C. sylvicultor*), and porcupine *Atherurus africanus*.

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The hunting for meat, skins, teeth, horns and medicines caused the local extinction of some wild animals as recognised by the respondents (Table 3.13).

Table 3.13. Respondents' knowledge of locally extinct wild animals in Nyungwe Forest, n = 200.

English names	Latin names	% of respondents
Elephant	*Loxodonta africana*	60.5
Buffalo	*Syncerus caffer*	30.5
Leopard	*Panthera pardus*	8.5
African lion	*Panthera leon*	6.0

3.1.10 Current resource access and use

The majority of the respondents (97.5%) said they had no access to resources in Nyungwe Forest. A few individuals (3%) admitted access to cut bamboo (*Arundinaria alpina*) from the Forest. In Nshili Commune in the south-eastern zone of the Forest, more than five persons said they were aware of the regulations but that, due to poverty and lack of alternatives, they kept on harvesting bamboo from the Forest. Others perceived that they benefited from the ecological function of the Nyungwe Forest in their areas, even though they were not permitted to access land and other resources in the Forest. In the buffer zone, however, the respondents collected dead branches for use as fuelwood (31.5%) and grasses (23%) for fodder. Agriculture in the bottomlands in the environs of the Forest was practised by 11.5 % of the interviewees. Others used the buffer zone as a settlement site because they argued that they had not been compensated for leaving the forest plantations.

3.1.11 Respondents' perception of conflicts and conflict resolution

In the study area, the respondents listed four types of conflicts arising from their cohabitation with the Forest (Table 3.14), the major conflicts being between local people and either the conservation services or the government. These conflicts occurred when the Nyungwe Forest Conservation Project (PCFN) and the extension services evicted the local people who were encroaching on the Forest. Some respondents also accused the Rwanda Office of Tourism and National Parks (ORTPN) of employing outsiders as forest guides and rangers. Conflicts between the local people and the government were attributed to lack of government decisions permitting the use of resources in the Forest by neighbouring communities. The respondents adjacent to the Forest were mostly concerned about their crops that were raided by wild animals. While illegal users of the Forest were severely sanctioned, respondents claimed that in contrast they were not compensated for crops damaged by wild animals.

Table 3.14. Nature of conflicts listed by the respondents in the study area, n = 200.

Conflict	% of respondents
Local people vs. government	45.5
Local people vs. wildlife	24.5
Local people vs. conservation	48.0
Local people vs. militia	20.5
Local people vs. extension service	2.5
Within local people	0.5

Twenty percent of the survey respondents reported that, during the last two weeks, armed bandits coming from the Forest had threatened their lives and stolen their livestock. This was an uncommon problem, and respondents proposed the use of force for its resolution. Apparently, tensions or competition among local villagers over Nyungwe resources did not exist within the community surveyed (Table 3.15).

Table 3.15. Importance of conflicts over resource use and access, as rated by the respondents in the study area.

Conflict	n	Importance of conflict			
		Not important	Important	Very important	Most important
Local people vs. government	107	6.5	9.7	12.7	71.0
Local people vs. wildlife	50	-	6.0	8.0	86.0
Local people vs. ORTPN*	97	21.6	23.7	23.7	30.9
Local people vs. militia	41	2.4	12.2	7.3	78.0
Local people vs. agricultural extension services	5	60.0	-	40.0	-
Within local people	1	100	-	-	-

* Rwanda Office of Tourism and National Parks.

Only 89 respondents suggested strategies for the resolution of local - government conflict. Of these, approximately 24% suggested consultation between the local people, the government authorities and the conservation services in order to establish resources that could be used. Other commonly mentioned strategies included creation of job opportunities in the area, the demarcation of a use-zone where resource use

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would be permitted, the use of fines, fencing of the Forest to avoid crop destruction by wild animals and compensation for damaged crops by wildlife.

3.1.12 Respondents' perception of past and present forest management

Of the households interviewed during the survey, 85.7% said that the management of Nyungwe Forest was under the responsibility of the state. When asked what role the state played in forest management, 62.5% of the respondents said that the state was involved in forest protection activities. Twenty percent thought that the management of the Forest by the state had encompassed the allocation of land to local people in the Forest adjacent areas. Only 11.7% believed that the Forest belonged to everyone, as access was open to all. Harvesting rights were said to be exclusive to the state and the colonial authority, and the provision of harvesting licenses was recognised by 16% of the respondents. At the local level, agricultural extension services and the local administration were reported to enforce regulations and to sensitise local people on the importance of conserving Nyungwe Forest.

3.1.13 Respondents' views of appropriate institutions for forest management

Community organisations are important for collaborative management of forests (Wild and Mutebi, 1996). Survey respondents were asked to name institutions in which they had trust and confidence (Table 3.16) and to give reasons for their answers.

Table 3.16. Proposed institutions for management by the respondents, n = 200

Institutions	% of respondents
District	24.0
Cell	16.5
ORTPN	12.5
Local protection committee	10.5
Sector	10.0
MINAGRI*	7.5
Local administrative committee	6.5
Developmental Project	6.0
Government	3.5
Local farmers' associations and co-operatives	3.0
Total	100.0

* Ministry of Agriculture, Livestock and Forestry.

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Twenty-four percent were of the view that the District Administration was the most appropriate institution that could enable community use of resources and manage the Forest sustainably because of the power and authority that the District holds over all development issues in the region. Many argued that local concerns were best known at District level.

Other reasons for the choice of District as the appropriate organisation included: -

- The capability of the District to provide employment to local people;
- The ability to mobilise enough resources for management and protection;
- The part of the Forest near to the respondents lies within the District geographical zone;
- The leadership at District level was elected by local people;
- The District had a vested interest in the conservation of Nyungwe Forest, more than any other organisation.

Similar institutions were identified during interviews with groups in the five Communes surveyed. Generally, institutions in which local people had confidence were local and concerned with local administration and development (Box 3.1).

Box 3.1. Proposed institutions for management of Nyungwe Forest utilisation

District Administration. The District based administration has been introduced in Rwanda very recently within the framework of good governance and decentralisation of administrative authority. A District is geographically based and comprises one or more adjacent ex-administrative Communes. The leaders of the Districts were elected locally in order to manage the affairs of the Districts and to coordinate activities in the administrative Sectors.

Administrative Sector. This is a lower level of the District Administration. It is based on the administration of at least 250 households within the same geographical area. The leaders at this level consist of an executive committee of nine people elected on their merits by local people. Each member has specific responsibilities in the sector, including health, education, communication, and security, among others. The sector Coordinator is the head of the Sector and he is assisted by a secretary.

Administrative Cell. This is a further subdivision of the Sector and refers to an administrative area occupied by at least 50 households. The structure of the Cell is similar to that of the Sector, with the community leadership elected locally and its representation found in women, youth and men.

Nyungwe Forest Conservation Project (PCFN). A conservation project managed by ORTPN and funded by USAID and WCS. It was established in 1988. It deals with conservation, environmental education and research on fauna and flora in Nyungwe Forest.

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The interviewees perceived key roles that these institutions should play with regard to resource use and access in Nyungwe Forest. Below is a compilation of the roles that came out from household and group interviews:

- To participate in protection and conservation of Nyungwe Forest;
- To employ local people in pitsawying mature trees and in enrichment activities on degraded and burned areas in Nyungwe Forest;
- To negotiate access to resources from the highest authorities and to participate in the organisation of associations for resource utilisation (for example, associations of beekeepers, gold-miners, herbalists, and basketry makers);
- To identify and delimit use areas in the part of the Forest adjacent to communities, including land for agricultural development;
- To raise awareness on the importance of conserving Nyungwe Forest;
- To provide technical and financial assistance to organised resource users;
- To provide incentives for protection;
- To resolve conflicts over resource use and access.

Individual responsibility for forest management was assessed by asking the respondents what they could do to sustain Nyungwe Forest resources. Answers were many and diverse. The responses in Table 3.17 show that the respondents have an interest in having access to resources in the Forest.

Table 3.17. Individual responsibility of the respondents for sustainable forest management in the study area, n = 200.

Activity	% of respondents
Participation in protection and management	29.0
Respect of laws, regulations and guidelines	21.0
Reporting offenders	21.0
Non-destructive use of the Forest	19.5
Harvesting mature trees and enrichment planting	11.5
Participation in awareness raising	9.5
Use of demarcated use zone	8.5
Selective harvesting of mature trees	4.0
Rotational harvesting and enrichment planting	2.5
Enforcement of patrol	1.0

The most common suggestion for community involvement (29%, n = 200) in forest protection and management was through participation in related activities, followed by the respect of laws, regulations and guidelines (21%, n = 200) and the report of offenders to authorities (21%, n = 200). Only 19.5% of the respondents said that they would commit themselves to what they pretended to be non-destructive activities in the Forest, including agriculture and mining in the swamps, gathering of fuelwood and other non-wood products.

3.2 FOREST RESOURCE ASSESSMENT

Species composition and tree abundance were analysed for distribution among and within the forest areas adjacent to the communities surveyed in Musebeya, Nshili, Kagano, Mudasomwa and Busozo Communes. Abundances of tree species in different diameter sizes are presented for the three categories as indicated in Table 3.18.

Table 3.18. Categories of trees used during the analysis.

Categories	Height (m)	DBH (cm)
Small trees	0.30 - 1.30	< 2.5
Medium trees	> 1.30	2.5 - 9.9
Large trees		≥10.0

The subdivision into small, medium and large trees corresponds to the definition of seedlings and saplings, poles and trees by Mwima (2000) and Owiunji (1997), respectively. The small trees were recorded for the assessment of the regeneration of tree species represented by large and medium trees. Data on tree and species abundance are presented on the basis of diameter size-class distributions among and within the study sites. Further, the assessment of abundance, dominance, size-class distribution and regeneration is presented for the most preferred tree species identified during participatory rural appraisal (PRA).

3.2.1 Identification of tree species

The local and scientific names of all tree species are given in Appendix 6. Some local names were applied at "generic level," and a single local name could correspond to two or more species, as reported by Cunningham (1996). For example, the single local name "ingongo" corresponded to three *Cassipourea* species, *Cassipourea ruwenzoriensis, C. ndando, and C. congoensis*; "umunkamba" was a local collective name applied to various species including *Ormocarpum tricocarpum, Dichrostachyus cinerea*, and an on-farm medicinal plant, *Clematis simensis*. The matching of local names to scientific names also required attention because a local name given to a single plant species sometimes differed from one area to another. For instance, local people in Nshili and Busozo Communes used the local name "rwamba" to describe *Prunus africana* whereas others used "umwumba" to describe the same species. Despite this shortfall, local knowledge of tree species represented a practical, less time consuming and cost-effective method for identifying resource of interest to local communities in the absence of an operational Herbarium and qualified ethnobotanists in Rwanda.

3.2.2 Tree species abundance and density analysis for the study area

For the whole sample area, there was an average of 439 large trees per hectare (standard deviation = 52 stems/ha), represented by 54 species. The mean density of medium trees per hectare was 1 407 (standard deviation = 542 stems/ha), also represented by 54 tree species. Small trees averaged 5 146 individuals per hectare (standard deviation = 3776 stems/ha) but they were represented by only 34 tree species. The large standard deviations indicate that the stem densities differed greatly among the study sites. The results of the analysis of variance indicated significant differences in stem densities among the three tree categories (Table 3.19).

Table 3.19. Analysis of variance of the densities of trees among tree categories

Tree category	Stem density/ha
Small trees	5146A
Medium trees	1407AB
Large trees	439 B
F-value	6.97*
p-value	0.02

* indicates significance at $p < 0.05$.

The Tukey's test of the comparison of the means showed that the densities of small trees did not differ significantly from the densities of medium trees but differed significantly from the densities of large trees. The analysis of the whole sample indicated that there were no significant differences in the densities of individuals between the study sites (d.f = 4, F=0.59, p>0.5) with a minimum significant difference of 8380 stems per hectare.

A separate Chi-square analysis of the whole sample showed that the distribution of trees among the five study sites was not even (χ^2 = 1880.31, d.f. = 8, p<0.001). However, tree species were evenly distributed among these sites (χ^2 = 11.55, d.f. = 8, p = 0.17). The difference in the distributions may reflect the heterogeneity in the study area, as the plots were located in areas with different altitudes, soils and different degrees of disturbance.

Some species had many representative individuals, contributing significantly to the total density of trees recorded on each study site. The contribution of each tree species to the total density of individuals recorded in each study site and at different tree categories is presented in Appendices 7 through 9. Table 3.20 summarises the occurrence of the 10 most dominant species by site and tree categories.

Table 3.20. Occurrence of the 10 most dominant tree species, by site and tree category.

	Tree categories		
Tree species	Small trees	Medium trees	Large trees
Strombosia scheffleri	2, 3, 4, 5	1, 3, 4, 5	1, 2, 3, 4, 5
Carapa grandiflora	1, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
Cleistanthus polystachyus	2, 3	2, 3, 5	2, 3, 5
Myrianthus holstii	1, 2, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
*Casearia runssorica**	1, 2, 3, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
Symphonia globulifera	1, 2, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
*Cassipourea ruwenzoriensis**	3, 5	1, 2, 3, 4, 5	1, 2, 3, 4, 5
*Parinari excelsa**	3	1, 3, 4	1, 2, 3, 4, 5
*Macaranga neomildbraediana**	3, 5	1, 2, 3, 4, 5	1, 2, 3, 5
Chrysophyllum gorungosanum	1, 3, 4, 5	1, 2, 3, 4, 5	1, 2, 4, 5

1 = Musebeya; 2 = Nshili, 3 = Kagano, 4 = Mudasomwa; 5 = Busozo.
* Species that were not among the 10 most dominant species in the small tree category but were dominant as large and medium trees.

Seven tree species were represented in the large trees and the small trees in all the five sites. Only seedlings and saplings of *Symphonia globulifera* were recorded in all the five study sites. The marked differences in the presence of seedlings and saplings of tree species in all the study sites could be attributed to environmental conditions, to shade intolerance of some species, and to disturbances in the periphery of Nyungwe Forest. These differences are also reflected in the stem densities of the species (Table 3.20 above). Figure 3.12a to 3.12c provide a comparison of the stem densities of the 10 most dominant tree species recorded in the three tree categories. Figure 3.13 indicates that the densities of small and medium trees were generally higher than those of large trees in all the study sites.

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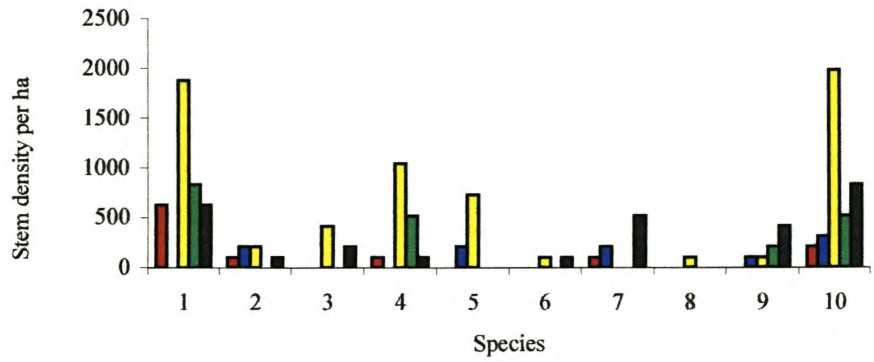


Figure 3.12a. Stem densities per hectare of the 10 most dominant tree species represented by small trees

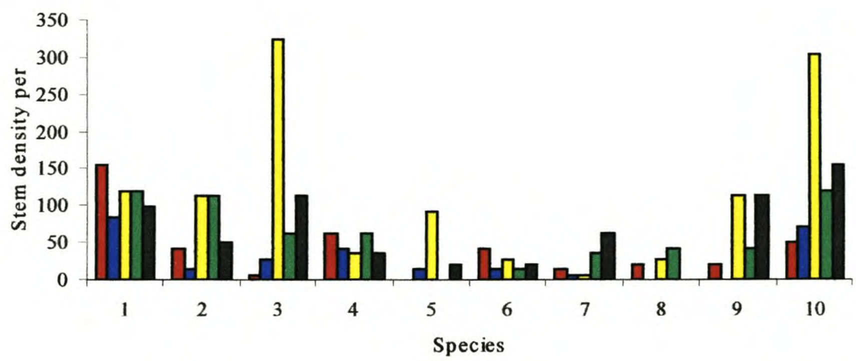
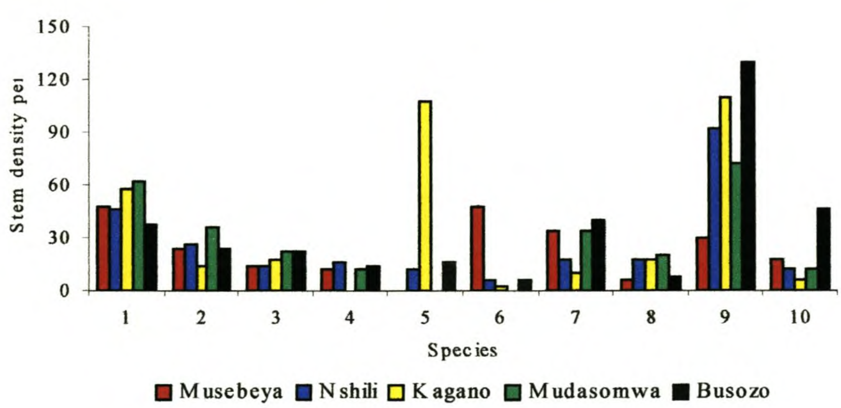


Figure 3.12b. Stem densities per hectare of the 10 most dominant tree species represented by medium trees.



1 = *Carapa grandiflora;* 2 = *Casearia runssorica;* 3 = *Cassipourea ruwenzoriensis;* 4 = *Chrysophyllum gorungosanum;* 5 = *Cleistanthus polystachyus,* 6 = *Macaranga neomildbraediana;* 7 = *Myrianthus holstii;* 8 = *Parinari excelsa;* 9 = *Strombosia scheffleri;* 10 = *Symphonia globulifera.*

Figure 3.12c. Stem densities per hectare of the 10 most dominant tree species represented by large trees.

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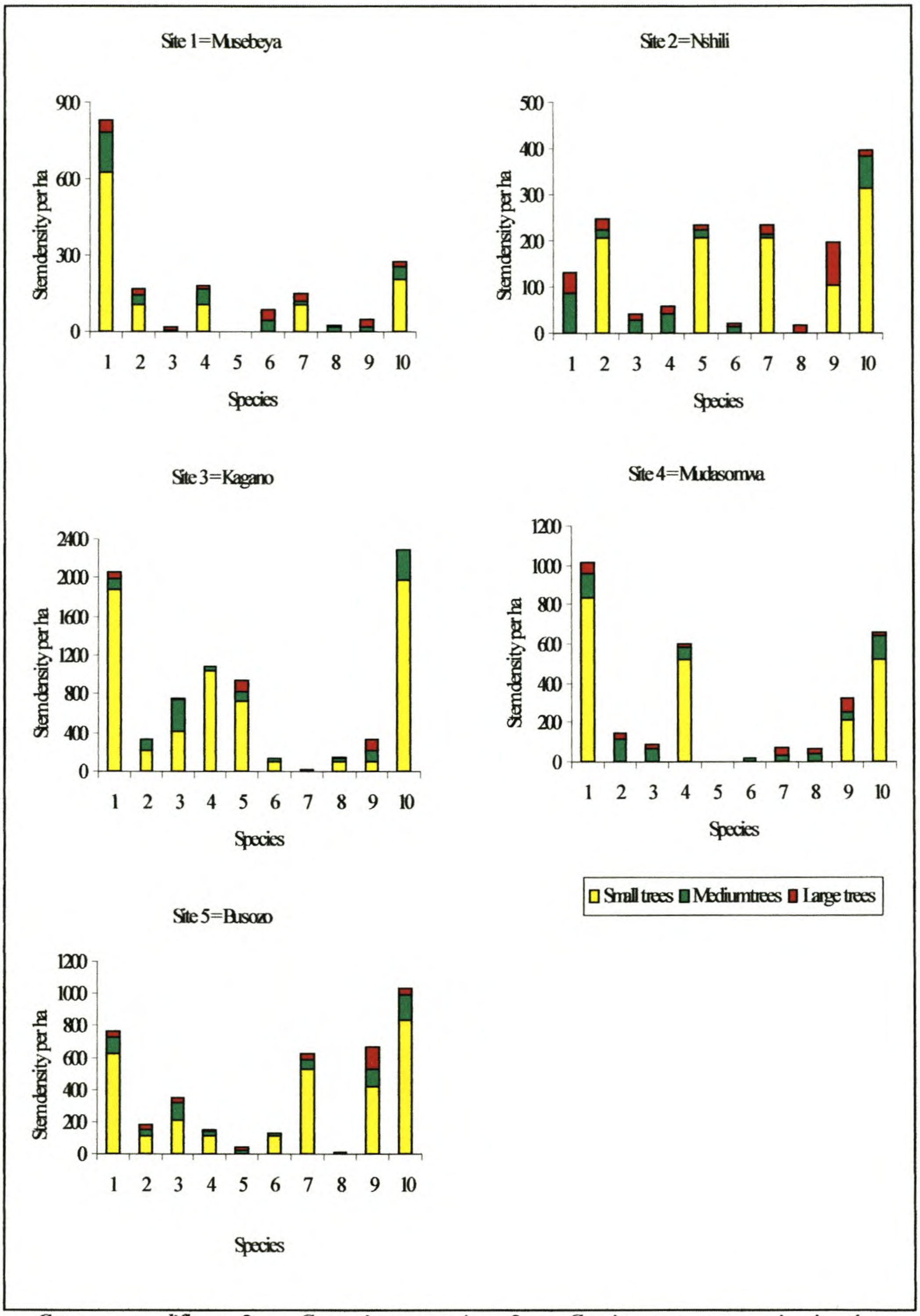

1 = *Carapa grandiflora;* 2 = *Casearia runssorica;* 3 = *Cassipourea ruwenzoriensis;* 4 = *Chrysophyllum gorungosanum;* 5 = *Cleistanthus polystachyus,* 6 = *Macaranga neomildbraediana;* 7 = *Myrianthus holstii;* 8 = *Parinari excelsa;* 9 = *Strombosia scheffleri;* 10 = *Symphonia globulifera.*

Figure 3.13. Comparison of stem densities per hectare of the 10 most dominant species between tree categories, by study site.

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3.2.3 Diameter size-class distribution of trees among and within the study sites

Table 3.21 shows the densities of trees by size-class categories in all the five study sites.

Table 3.21. Diameter size-class distribution of large trees among the study sites.

The analysis included only species which registered a frequency greater or equal to five

		DBH size classes (cm)				
		10.0 – 19.9	20.0 – 29.9	30.0 – 39.9	40.0 – 49.9	≥ 50
Sites	s	Stem densities per ha				
Musebeya	19	184	88	84	46	38
Nshili	10	60	62	60	30	64
Kagano	10	142	90	62	32	56
Mudasomwa	13	154	88	58	20	32
Busozo	12	194	80	42	36	34

s = number of species with a frequency greater than five.

Kolmogorov – Smirnov tests were applied to the data to test the differences in the distributions of stem densities between pairs of sites as these tests are more appropriate than the chi-square test when the number of cases is small and when the expected frequencies at each category are also small (Bryman and Cramer, 1997; Zar, 1999). The results of the analysis are given in Table 3. 22 below.

Table 3.22. Kolmogorov – Smirnov tests comparing distributions of trees of different sizes in pairs of sites

Sites	Most extremes differences				
	Absolute	Positive	Negative	K-S Z	2-tailed p
Musebeya vs. Nshili	0.60	0.20	-0.60	0.95*	0.33
Musebeya vs. Kagano	0.20	0.20	-0.20	0.32	1.00
Musebeya vs. Mudasomwa	0.40	0.00	-0.40	0.63*	0.82
Musebeya vs. Busozo	0.40	0.20	-0.40	0.63*	0.82
Nshili vs. Kagano	0.40	0.40	-0.20	0.63*	0.82
Nshili vs. Mudasomwa	0.40	0.40	-0.40	0.63*	0.82
Nshili vs. Busozo	0.40	0.40	-0.40	0.63*	0.82
Kagano vs. Mudasomwa	0.20	0.20	-0.20	0.32	1.00
Kagano vs. Busozo	0.40	0.20	-0.40	0.63*	0.82
Mudasomwa vs. Busozo	0.40	0.40	-0.20	0.63*	0.82

K-S Z: Kolmogorov – Smirnov Z

* indicates significance at p-value = 0.05.

The tests indicated that there was no difference in the distribution of stem densities between Musebeya and Kagano, and between Kagano and Mudasomwa. The observed differences in the distributions of trees of many pairs of sites illustrated differences in the two distributions. This could result from some species being represented by more trees than expected at some diameter size classes, to some species that do not grow up to larger sizes or to the effect of selective logging of suitable species and sizes for timber or poles.

The analysis of distribution indicated that some tree species of different sizes were evenly distributed among two or more sites. Table 3.23 compares the distribution of the species among the study sites. *Carapa grandiflora*, *Casearia runssorica*, *Maesa lanceolata*, and *Cleistanthus polystachyus* were found in all the five study sites, but they were unevenly represented among the diameter size classes. Among the tree species that occurred in all the study sites, the size-class distribution was even for *Myrianthus holstii* and *Cassipourea ruwenzoriensis*.

Table 3.23. Chi-square analysis to investigate the distribution of species among the study sites and within diameter size classes.

The differences in degrees of freedom were due to species that were not common to all the study sites and to species with no representative individuals in some diameter size-classes.

Tree species	n	d.f.	χ^2	DBH size classes	Occurrence
Carapa grandiflora	126	16	32.53**	A, B, C, D, E	1, 2, 3, 4, 5
Casearia runssorica	62	16	29.43*	A, B, C, D, E	1, 2, 3, 4, 5
Cassipourea ruwenzoriensis	45	12	8.67	A, B, C, D, E	1, 2, 3, 4, 5
Chrysophyllum gorungosanum	28	12	9.99	A, B, C, D, E	1, 2, 4, 5
Cleistanthus polystachyus	68	8	20.78**	A, B, C, D, E	1, 3, 5
Cremaspora trifolia	21	2	1.40	A, B	1, 3, 4
Diospyros gabonensis	17	3	0.62	A, B, C, D	3, 4
Grewia mildbraedii	11	3	0.24	A, C, D, E	1, 4
Maesa lanceolata	20	3	20.00***	A, B, C, D	1, 5
Myrianthus holstii	68	12	11.32	A, B, C, D	1, 2, 3, 4, 5
Newtonia buchananii	18	1	0.07	A, E	3, 4
Oxyanthus troupinii	19	2	0.28	A, B, C	1, 4
Parinari excelsa	28	8	14.16	A, B, C, D, E	2, 3, 4
Strombosia scheffleri	217	16	52.12***	A, B, C, D, E	1, 2, 3, 4, 5
Symphonia globulifera	44	12	13.04	A, B, C, D, E	1, 2, 4, 5

* Significant at $p<0.05$, ** significant at $p<0.01$, *** significant at $p<0.001$

1 = Musebeya, 2 = Nshili; 3 = Kagano; 4 = Mudasomwa; 5 = Busozo.

A = 10.0 - 19.9 cm; B = 20.0 - 29.9 cm; C = 30 - 39.9 cm; D = 40.0 - 49.9 cm; E = ≥ 50 cm

3.2.4 Presence of preferred tree species in the study area

During the PRA, the respondents identified different tree species for different uses. A minimum frequency of 10 responses was used as a guiding criterion for narrowing down the list of preferred tree species. The forest resource assessment established that not all woody resources mentioned as being used by the respondents were found in the Forest. Only 12 (i.e. 85.7%) of the 14 most preferred timber species were found as large trees and 12 (i.e. 75%) of the 16 preferred for pole species were found as

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medium trees. Some of the most preferred timber tree species that were not found included *Faurea saligna* and *Ocotea usambarensis*. Among the tree species preferred as building poles, *Oxyanthus speciosus, Faurea saligna* and *Milletia sp.* were not encountered. Of the 45 most preferred medicinal trees, only 17 species were recorded. Some medicinal plants mentioned during PRA surveys were not found at all during the forest resource assessment, including *Prunus africana* and *Ocotea usambarensis*. Of the six tree species preferred for wooden goods, only three were found in the sample area. These were *Polyscias fulva*, *Dasylepsis racemosa* and *Carapa grandiflora*. Tables 3.24a and 3.24b show the most preferred tree species identified in the sample area.

For the whole sample area, 54 species including the most preferred tree species for timber, poles, wooden items and medicinal materials, were recorded as large and medium trees. Based on the total number of individuals recorded in the sample area (1097 large trees and 995 medium trees), tree species occurring 10 or fewer times were defined as 'rare species', those occurring 10 – 40 times as 'average species' and 41 times or more (nearly twice the average number of trees) as 'common species'. Tables 3.24a and 3.24b and Figure 3.14 show the occurrence categories of the tree species recorded in all the study sites. For timber tree species, five species were classified as rare. Tree species with average occurrence were four. Timber tree species of common occurrence were *Strombosia scheffleri, Carapa grandiflora* and *Symphonia globulifera.* Of the 16 medicinal tree species, rare tree species in the large tree category were six (37.5%) whereas rare ones recorded as medium trees were nine. Five medicinal tree species had 'average occurrence'.

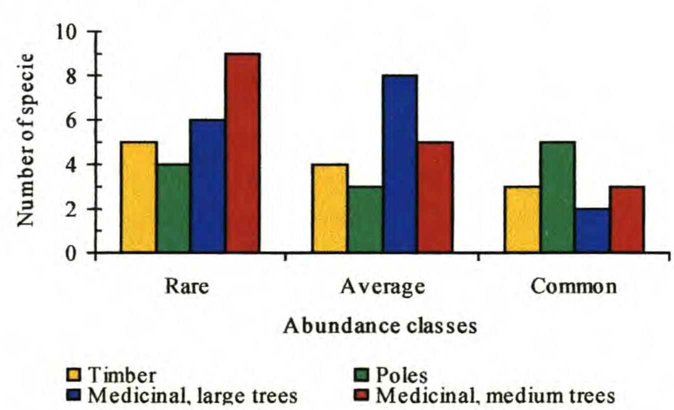

Figure 3.14. Occurrence categories of preferred tree species in the sample area

Table 3.24a. List of preferred timber and pole species and their occurrence categories in the study area

Tree species	Occurrence value	Occurrence category
Timber		
Carapa grandiflora	126	Common
Dasylepsis racemosa	4	Rare
Entandrophragma excelsum	18	Average
Hagenia abyssinica	1	Rare
Newtonia buchananii	12	Average
Podocarpus latifolius	2	Rare
Parinari excelsa	35	Average
Podocarpus falcatus	3	Rare
Polyscias fulva	8	Rare
Strombosia scheffleri	217	Common
Symphonia globulifera	47	Common
Syzygium parvifolium	21	Average
Poles		
Alchornea hirtella	1	Rare
Carapa grandiflora	82	Common
Casearia runssorica	47	Common
Cassipourea gummiflua	2	Rare
Cassipourea ruwenzoriensis	76	Common
Macaranga neomildbraediana	17	Average
Olea hochstetteri	5	Rare
Parinari excelsa	13	Average
Podocarpus latifolius	3	Rare
Strombosia scheffleri	41	Common
Symphonia globulifera	99	Common
Syzygium parvifolium	39	Average

Table 3.24b. List of preferred medicinal species and their occurrence categories in the study area.

Tree species	Occurrence value	Occurrence category
Medicinal species, large tree category		
Bridelia brideliifolia	1	Rare
Canthium oligocarpum	4	Rare
Carapa grandiflora	126	Common
Entandrophragma excelsum	18	Average
Maesa lanceolata	21	Average
Neoboutonia macrocalyx	12	Average
Newtonia buchananii	12	Average
Olea hochstetteri	1	Rare
Oxyanthus troupinii	20	Average
Parinari excelsa	35	Average
Pauridiantha paucinervis	13	Average
Rapanea melanophloes	9	Rare
Symphonia globulifera	47	Common
Syzygium parvifolium	21	Average
Tabernamontana johnstonii	19	Average
Zanthoxylum gilletii	2	Rare
Medicinal species, medium tree category		
Bridelia brideliifolia	1	Rare
Canthium oligocarpum	21	Average
Carapa grandiflora	82	Common
Entandrophragma excelsum	5	Rare
Maesa lanceolata	1	Rare
Neoboutonia macrocalyx	1	Rare
Newtonia buchananii	32	Average
Olea hochstetteri	5	Rare
Oxyanthus troupinii	79	Common
Parinari excelsa	13	Average
Pauridiantha paucinervis	11	Average
Rapanea melanophloes	3	Rare
Symphonia globulifera	99	Common
Syzygium parvifolium	39	Average
Tabernamontana johnstonii	5	Rare
Zanthoxylum usambarense	3	Rare
Zanthoxylum gilletii	3	Rare

Preferred tree species for building poles were identified among the species in the medium tree category and consisted of trees of 2.5 – 9.9 cm DBH. Their distribution into occurrence categories revealed that *Alchornea hirtella*, *Podocarpus latifolius* and *Olea hochstetteri* were rare. *Syzygium parvifolium, Macaranga neomildbraediana* and *Parinari excelsa* had average occurrence while at least five of the tree species preferred for building poles occurred frequently in the sample area and were defined as 'common species'. They included *Carapa grandiflora, Casearia runssorica, Symphonia globulifera* and *Cassipourea ruwenzoriensis*.

3.2.5 Abundance of the most preferred tree species in the sample area

The stem densities of the preferred tree species were calculated relative to the stem densities of all species per hectare. The stem densities ranged from 0.05 to 7.59 stems per hectare for timber tree species and 1.35 to 5.77 stems per hectare for poles. For medicinal trees, the stem densities ranged from 0.59 to 3.52 and 0.72 to 4.05 stems per hectare for the preferred tree species recorded as large and medium trees, respectively. Tables 3.25a to 3.25c show the relative densities of the preferred tree species by tree categories.

Table 3.25a. Relative densities of the preferred timber tree species.

Tree species	Stem density per ha	Relative stem density
Strombosia scheffleri	86.8	19.77
Carapa grandiflora	50.4	11.48
Symphonia globulifera	18.8	4.28
Parinari excelsa	14	3.19
Newtonia buchananii	8.4	1.91
Syzygium parvifolium	8.4	1.91
Entandrophragma excelsum	7.2	1.64
Polyscias fulva	3.2	0.73
Dasylepsis racemosa	1.6	0.36
Podocarpus falcatus	1.2	0.27
Podocarpus latifolius	0.8	0.18
Hagenia abyssinica	0.4	0.09
Mean stem density		3.82
Standard error		1.71
Confidence level (95%)		3.77

Table 3.25b. Relative densities of the preferred pole tree species.

Tree species	Stem density per ha	Relative stem density
Symphonia globulifera	140.03	9.95
Carapa grandiflora	115.98	8.24
Cassipourea ruwenzoriensis	107.50	7.64
Casearia runssorica	66.48	4.72
Strombosia scheffleri	57.99	4.12
Syzygium parvifolium	55.16	3.92
Macaranga neomildbraediana	24.05	1.71
Parinari excelsa	18.39	1.31
Olea hochstetteri	7.07	0.50
Podocarpus latifolius	4.24	0.30
Alchornea hirtella f. glabrata	1.41	0.10
Cassipourea gummiflua	2.83	0.20
Mean stem density		3.56
Standard error		1.00
Confidence level (95%)		2.21

Table 3.25c. Relative densities of the preferred medicinal tree species.

	Medium trees		Large trees	
Tree species	Stem density/ha	Relative stem density	Stem density/ha	Relative stem density
Symphonia globulifera	140.03	9.95	18.80	4.28
Carapa grandiflora	115.98	8.24	50.40	11.49
Oxyanthus troupinii	111.74	7.94	8.00	1.82
Syzygium parvifolium	55.16	3.92	8.40	1.91
Newtonia buchananii	45.26	3.22	8.40	1.91
Canthium oligocarpum	29.70	2.11	1.60	0.36
Parinari excelsa	18.39	1.31	14.00	3.19
Pauridiantha paucinervis	15.56	1.11	5.20	1.19
Entandrophragma excelsum	7.07	0.50	7.20	1.64
Olea hochstetteri	7.07	0.50	0.40	0.09
Tabernamontana johnstonii	7.07	0.50	7.60	1.73
Rapanea melanophloeios	4.24	0.30	3.60	0.82
Zanthoxyllum gilletii	4.24	0.30	0.80	0.18
Zanthoxyllum usambarense	4.24	0.30	-	-
Bridelia brideliifolia	1.41	0.10	0.40	0.09
Maesa lanceolata	1.41	0.10	8.40	1.91
Neoboutonia macrocalyx	1.41	0.10	4.80	1.09
Mean stem density		2.38		2.11
Standard error		0.78		0.69
Confidence level (95%)		1.66		1.46

Using a density of equal or greater than 1.0 stems per hectare (at the lower limit of the 95% confidence interval) as a cut off limit for harvestable timber tree species following Davis and Johnson (1987), there were seven tree species which could be considered abundant enough for utilisation. Of these species, commonly available tree species were *Strombosia scheffleri* and *Carapa grandiflora.*

Among medicinal tree species, there were 11 species that were considered abundant enough to allow collection of medicinal materials from large trees. *Carapa grandiflora, Symphonia globulifera* and *Parinari excelsa* were the most abundant medicinal tree species in the large tree category.

Within the medium tree category, only eight medicinal tree species were abundant enough to be listed as harvestable species. *Carapa grandiflora* and *Symphonia globulifera* were predominant in the Forest and were classified among the abundant medicinal tree species.

Finally, seven tree species of the medium tree category were abundant for potential supply of poles. The five most abundant were, in decreasing order of their abundance, *Symphonia globulifera*, *Carapa grandiflora, Cassipourea ruwenzoriensis, Casearia runssorica* and *Strombosia scheffleri*.

3.2.6 Dominance of the most preferred tree species

All abundant preferred timber species had a relative dominance greater or equal to 0.01 and contributed more to the forest standing biomass. Of the most abundant and preferred pole species, the only tree species which showed a relative dominance of less than 0.01 was *Macaranga neomildbraediana*. However, many of the medicinal tree species represented by large trees showed a low contribution to the total biomass of the Forest. Tree species with sufficient contribution owing to their relatively higher densities of their stems included *Carapa grandiflora, Syzygium parvifolium, Parinari excelsa, Symphonia globulifera* and *Newtonia buchananii*. The medicinal tree species of the medium tree category contributed sufficiently to the standing biomass, with the exception of *Canthium oligocarpum*. The relative dominance of the species in the large tree category is presented in Appendix 10.

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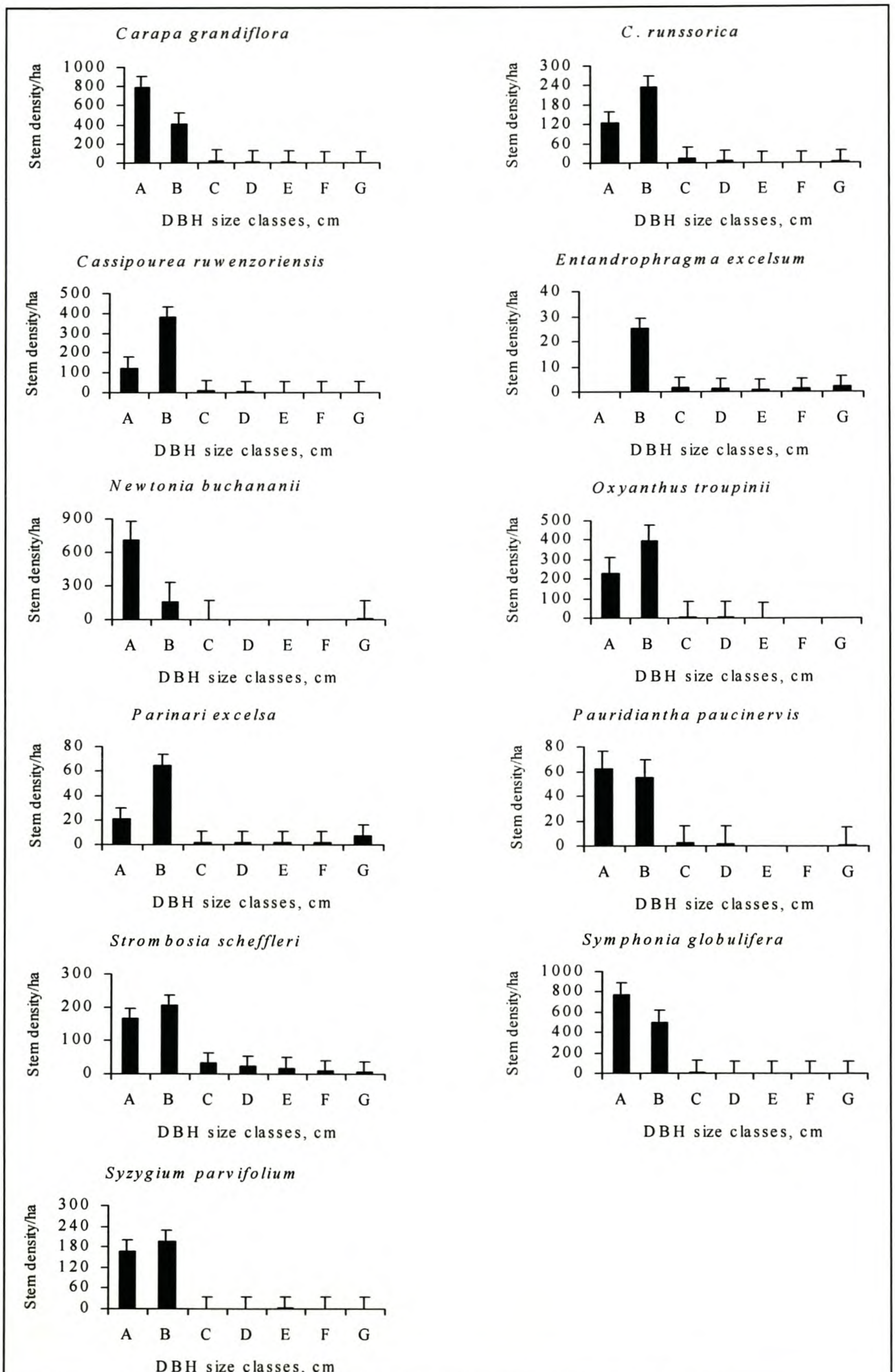
3.2.7 Size-class distribution and regeneration of most abundant preferred tree species.

The distribution of stem densities into different diameter size classes differed among the preferred tree species (Figure 3.15). Of the 11 species, only *Carapa grandiflora* and *Symphonia globulifera* approximated the 'inverse J' curve that is characteristic of a mature and stable system or a population that is self-perpetuating (Bazzaz, 1998; Luken, 1990). This suggests that there were shade-tolerant species with abundant regeneration. For some species including *Cassipourea ruwenzoriensis, Parinari excelsa, Casearia runssorica, Oxyanthus troupinii* and *Syzygium parvifolium*, the infrequency of seedling establishment caused a reduction in the smaller size class, followed directly with a greater number of saplings or individuals of 2.5 – 9.9 cm DBH. Similarly, *Newtonia buchananii* and *Pauridiantha paucinervis* showed no overall pattern, with intermediate classes that contain no individuals at all. This suggests that the existing level of saplings were insufficient to re-stock these classes.

The shape of the curve of *Entandrophragma excelsum* was also irregular, with the lack of regeneration among the smaller size class and the presence of saplings and few large trees in other diameter size classes. Generally, E. *excelsum* was found at lower density compared to other species. It can be seen from the curves of *E. excelsum* and *Parinari excelsa* that their size-class distributions exhibit relatively more large trees at the largest size class (i.e. ≥50 cm DBH) than those found at the intermediate sizes. This could indicate temporarily variable recruitment in the stages of their life history.

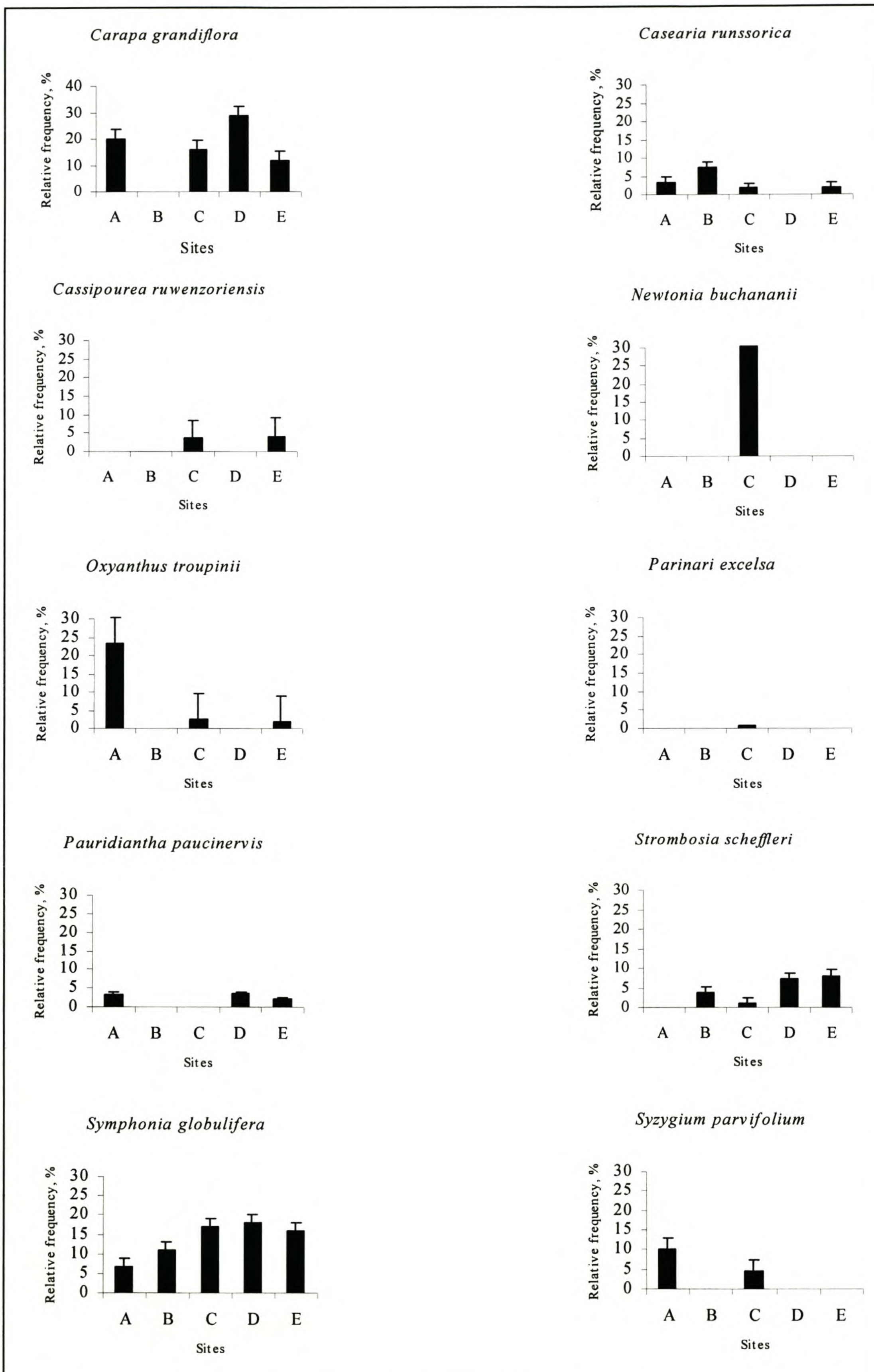
The observed pattern in the size-class distribution of *Oxyanthus troupinii* represents a population that has very few large trees and relatively abundant seedlings and saplings. This pattern illustrates a population of a long-lived tree species that experienced a period of very poor recruitment or past intense harvesting of large trees.

Figure 3.16 shows that the regeneration of the species is very variable across the study sites. The regeneration appears to be least at Nshili and Mudasomwa for some preferred tree species. Only *Symphonia globulifera* produced seedlings and saplings in all five study sites while seedlings of *Newtonia buchananii* were only recorded in the part of the Forest next to Kagano Commune.



A = <2.5 cm; B = 2.5-9.9cm; C = 10.0-19.9cm; D = 20.0 - 29.9cm; E = 30.0-39.9cm; F = 40.0 - 49.9cm; G = ≥50cm

Figure 3.15. Size-class distribution of the most abundant and dominant trees preferred for timber, poles and medicines.



A = Musebeya; B = Nshili; C = Kagano; D = Mudasomwa; E = Busozo

Figure 3.16. Relative abundance of seedlings and saplings of the abundant and dominant tree species across the five sites.

3.2.8 Quality of harvestable tree species for timber and poles

Figures 3.17 and 3.18 show the quality of harvestable trees for timber and poles. Figure 3.17 shows that the proportion of good quality stems suitable for timber was higher for *Symphonia globulifera, Entandrophragma excelsum, Parinari excelsa,* and *Strombosia scheffleri.* Boles of these tree species were cylindrical in form, from the ground to the first branch, and therefore were good enough for use as sawn timber. *Carapa grandiflora* and *Newtonia buchananii* had irregular taper and protuberances and could only be used with a considerable proportion of waste. *Syzygium parvifolium,* for which many stems ranged from fair to acceptable, would be better used for a product where stem straightness is not a major requirement. Of the most preferred tree species for building poles, *Symphonia globulifera* produced many quality stems, followed by *Cassipourea ruwenzoriensis* (Figure 3.18). However, less than 20% of the individuals of *Strombosia scheffleri* were of good quality stems.

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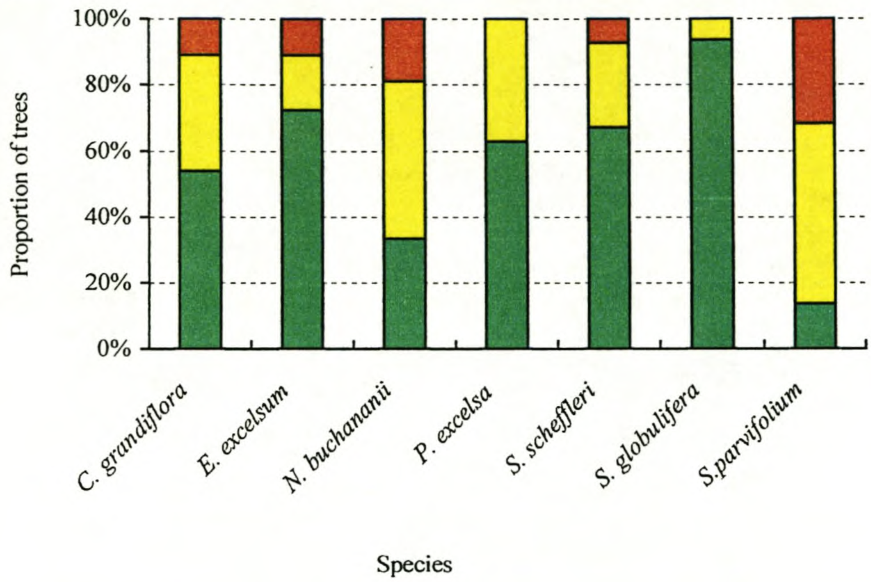

Figure 3.17. Proportion of trees with stem suitable for timber.

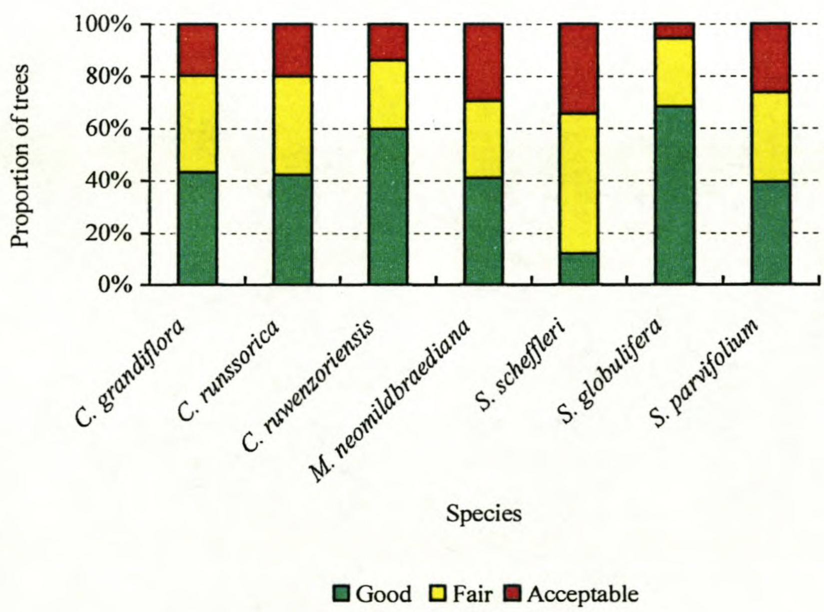

Figure 3.18. Proportion of trees with stem suitable for building poles.

4 DISCUSSION

In this chapter, both the results obtained from the household survey and from the forest resource assessment are discussed. The participatory assessment was carried out as a preliminary study aimed at collecting information on resource preferences and uses and the perceptions of local people regarding the appropriate institutions for the management of utilisation in Nyungwe Forest. Participatory techniques are commonly used to strengthen any management decisions. For example, Scott (1992) used PRA techniques to collect information on which to base recommendations for multiple use activities at Bwindi Impenetrable National Park in Uganda. In the resource assessment, the areas of the Forest next to the Communes surveyed were assessed for their potential to provide the preferred tree products to the communities. Cunningham (1996) carried out a similar forest survey prior to recommending use of resources at Mgahinga Gorilla National Park in Uganda.

Preferred tree products from Nyungwe Forest are discussed in relation to their availability, abundance, size-class distribution and regeneration. The discussion focuses on the tree species most preferred for timber, poles and medicinal materials as identified during the forest assessment. Other uses of the Forest are also discussed, including the production of wooden goods, fuelwood, charcoal, beekeeping, fodder, honey, bean stakes and land. A focus on these products is justified by their economic potential and the role they play in the livelihoods of forest-dependent communities (Neumann and Hirsch, 2000; Prasaad, 1999). Further, having discussed the resources available in Nyungwe Forest, the long-term potential of the Forest to provide these resources is presented together with recommendations on the management of the Forest for utilisation.

4.1 RESOURCE PREFERENCES, USES AND AVAILABILITY IN NYUNGWE FOREST

4.1.1 Wood products

4.1.1.1 Timber

The survey established that 29 tree species were preferred for use as timber, of which the most sought after were *Podocarpus latifolius, P. falcatus* and *Entandrophragma* *excelsum*. These timber trees were found in low densities in the Forest, suggesting that they were targeted for pitsawying. Logging of valuable trees has been very selective and unmanaged, and it has resulted in some tree species becoming endangered (Gapusi and Mugunga, 1997; Habiyambere, 1999; Sorg, 1978).

As an alternative to the loss of access to indigenous timber, the respondents were found to manage fast growing exotic timber species to cope with the short-term demand for furniture and construction materials or else to generate income needed by the households. The lack of indigenous timber tree species on the respondents' farms may reflect past social forestry programmes that emphasised the planting of exotic species, without a focus on the indigenous tree species preferred by the local people.

Illegal logging for indigenous timber by neighbouring communities has been reported to be a major threat to the conservation of the Forest (MINITERRE, 2000). Since the local communities favour certain species for timber, harvesting is likely to be selective. Selective logging affects mature forests and species composition, as a result of canopy gap formation (Howard, 1991). In addition, logging results in patchy distributions of both the species and size-class categories of trees and shrubs harvested (Cunningham, 1996). Timber species in the Forest showed this pattern, with a limited abundance of marketable sizes of timber tree species. These species were found at low frequencies, with fewer harvestable sizes and an increasing number of young trees. The small number of large sized hardwoods was probably a result of overexploitation.

Sustainable harvesting of timber is based on the methods of regeneration, silvicultural systems and yield regulation (Geldenhuys, 1998; ITTO, 1990). The ecological management of natural forest emphasises the extraction of resources that show a low impact of removal. Selective logging is thought to be a viable option if it is practised outside the conservation area of a forest (Struhsaker, 1997). Therefore, a management system could be developed for sustainable logging of timber over 10% of the total area of Nyungwe Forest as was established by a management plan developed in 1988 (Fimbel and Kristensen, 1994; MINAGRI, 1984) but not effectively implemented.

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4.1.1.2 Building poles

Nyungwe Forest is surrounded by human settlements. In the past, local people had collected building poles from the Forest. In the study area, managed woodlots are source of building materials. This is in common with other parts of the country where communities have managed trees for various uses, including small to medium sized poles which can be sold (den Biggelaar, 1996).

The loss of access to poles and other wood products from the Forest is compensated by tree planting on farms (Olson *et al.*, 1995). Ample quantities of poles appeared to be cultivated, but indigenous poles from Nyungwe Forest were apparently more preferred for their straightness and durability. From field observation, many houses were found to be built from cultivated *Eucalyptus* poles but in the south-eastern zone bamboo from the Forest was also used, with the use of the species decreasing with distance away from the edge of the Forest. The common use of cultivated poles in the study area was a result of the development of community nurseries and the supply of seedlings to local people by past donor-funded forest projects in order to reduce dependence on the Forest (MINAGRI, 1990).

There are no available data on the consumption of indigenous poles. Due to the high population density (350 people/km^2) and the number of households around the Forest, the demand for poles is expected to be very high, leading to increased illegal logging for poles. Programmes of tree planting on farms with suitable indigenous species could partly alleviate illegal cutting of poles from the Forest in the long-term.

4.1.1.3 Fuelwood and charcoal

In common with other rural areas in Rwanda, fuelwood provides the major source of household energy (MINECOFIN, 1998). Due to its high conservation status, fuelwood is the only commodity that a few people access from the buffer zone of Nyungwe Forest. Similar to poles, there have been attempts by foresters to provide fuelwood to adjacent communities to the Forest by encouraging tree planting on farms (Olson *et al.,* 1995). The production of fuelwood for household consumption was the second priority next to pole production in the survey area.

Charcoal production was considered as an income generating activity in the study area around the Forest. The respondents produced charcoal from their own *Eucalyptus* woodlots. Despite the availability of trees in farmers' fields, charcoal making has been reported as a threat to the conservation of the Forest (MINITERRE, 2000). This implies that there is a demand for charcoal from indigenous trees. Other reasons for exploitation of wood for charcoal from the Forest may be related to the shortage of land, which prevents some households from establishing woodlots. The demand for charcoal in cities also provides an economic incentive that encourages some individuals to encroach on the Forest.

The annual increase in the rate of fuelwood consumption in Rwanda is estimated at 2%, translating to an annual increase of three million m^3 per year, exceeding the limits of sustainable exploitation (Habiyambere, 1999). With an estimated forest cover of 7% of the country's area and the increasing demand for fuelwood and charcoal, the survival of the remnant indigenous forests is uncertain (Mitchell, 1997). It will likely depend on the development of suitable alternatives such as the use of biogas, the use of efficient cooking stoves and an active programme of community forestry in Rwanda (GEC, 2000; Percival and Dixon, 1995)

4.1.1.4 Wooden items

Households adjacent to Nyungwe Forest rely on locally produced materials. The local producers are highly selective of species since certain attributes are required of the wood for specific purposes. The most prominent characteristics are flexibility, durability, strength and resistance to splitting. The selective harvesting of these species can result in genetic erosion of the species as vigorous and quality individuals are removed from the population (Cunningham, 1996). The current rarity of these species could be partly explained by the effect of illegal harvesting.

Bamboo is used by local people in the south-eastern zone of Nyungwe Forest where it is predominant. Considerable quantities of materials made of bamboo are sold both locally and outside the area, or used for building purposes. The major incentive for the unlawful cutting of bamboo from the Forest is the economic advantages for individuals to benefit from the sale of goods. The use of bamboo for commercial and subsistence needs might result in overexploitation if not regulated or cultivated on farms for alternative sources of basketry and granary materials (Butynski, 1984). Bamboo can easily grow in people's gardens as shown by Cunningham (1996) as part of the management of Bwindi Impenetrable National Park in Uganda. Other tree species including *Markhamia lutea* and *Polyscias fulva* could receive attention in the development of agroforestry in Rwanda since they are indigenous species traditionally planted or conserved on farms (Niang and Styger, 1990) and valued for the making of various wooden items.

4.1.1.5 Bean stakes

Beans, both bush and climbing varieties, are among the staple foods produced in the zone surrounding the Forest. In the survey area, climbing beans were preferred for their high yield and resistance to heavy rains during the growing seasons. Bean stakes are essential for climbing bean production, and huge quantities of bean stakes are required. In the past, stakes were a common product obtained from Nyungwe Forest by neighbouring farmers. The most favoured tree species was *Alchornea hirtella*, which is presumably the reason for its low frequencies in the study area.

Many farmers in the area use branches of *Pinus patula*, *Eucalyptus spp.* and *Grevillea robusta* from their own farms or from the buffer zone for Nyungwe Forest as bean stakes. Far from the edge of the Forest, the shortage of adequate staking materials is reflected by the use of *Pennisetum purpureum* and stalks of sorghum and maize. As the population depends on agriculture for its subsistence, the demand for bean stakes is expected to increase. The demand cannot be met from the supplies available within the agricultural systems. It is recommended that in addition to assessing ways for the community to use bean stakes from Nyungwe Forest, development programmes should encourage the local people to cultivate their own supplies of bean stakes by establishing fast growing shrubs including *Mimosa scabrella* and *Chamaecytisus palmensis* identified by the Agroforestry Research in Rwanda to be suited on local soils and climate. Other species with high coppicing abilities could be introduced for the production of large quantities of stakes. For instance, communities surrounding Bwindi Forest in Uganda use bamboo for stakes (Wild and Mutebi, 1996).

4.1.2 Non-wood products

4.1.2.1 Land

Nyungwe Forest forms a physical barrier between two agro-ecological regions, with different farming systems found on either side (Renner, 1991). The sample area falls within the two agro-ecological zones, and so the farming conditions of the different groups of respondents vary. These differences were reflected in farm sizes, crop types and soil fertility.

The decreasing availability of new farmland means the population around the Forest is unable to support itself from agriculture. Problems of soil infertility result from acidic soils. These soils are severely degraded, which leads to low crop production and increased poverty (Olson, 1994). The communities adjacent to Nyungwe Forest lack access to production resources including livestock for manure production, fertilisers, and other means to manage soil fertility. This result supports the finding by Blaikie and Brookfield (1987) that access to production resources is felt differently between households within the same region depending on their ability to afford inputs.

In the past, adjacent communities used land outside and inside Nyungwe Forest in an extensive manner (Olson *et al.*, 1995) until they were relocated without compensation onto land outside the Forest (Renner, 1992). With the current process of land acquisition through inheritance, the farm size is unable to meet the subsistence needs of the local population. There is also a lack of alternatives to agriculture, including diversified sources of income. Newbury (1992) attributed the lack of off-farm opportunities in the southwest of Rwanda to the past government regimes that concentrated government funds on the development of their home region[2].

Local perception of Nyungwe Forest as a potential land resource could therefore be attributed to the historical background, including the influx of farmers looking for

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[2] *Newbury (1992) argued that the southwest of Rwanda had fewer opportunities than other areas as the former President Habyalimana Juvenal and the people he selected for important government posts concentrated funds in the North of the country where they originated.*

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fertile lands to the eastern edge of the Forest (Olson, 1990; Cambrezy, 1984). The preference for farmland from within the Forest stems from the past practice of clearing the Forest for food production (Barabwiliza, 1980). Overuse of forest products would result in loss of biodiversity in the long-term, but clearance for agriculture is the greatest threat (MINAGRI, 2000; Mitchell, 1997). This pressure is driven by poverty and a growing population in adjacent areas.

Subsistence agriculture was the major livelihood strategy amongst the survey population. Revenues from crops are relatively low, due to low prices given to agricultural produce (Ben Chabanne and Cyiza, 1992; World Bank, 1993). Income accrued by people around Nyungwe Forest can not meet their economic and financial requirements, resulting in an increased dependence on natural resources. Unless adequate strategies are adopted, increased land for agriculture and livestock farming will continue to be a major concern for local communities.

4.1.2.2 Gold mining

Local villagers have high expectations of earning cash income (Barakabuye, 2001) and therefore illegal mining is considered to be a major law enforcement and conservation problem (MINITERRE, 2000). Mining in defined zones was listed by MINAGRI (1993) with the priority activities that were considered for authorisation to organised groups. Recognising access of local groups to mineral reserves can help in improving incomes to local households. Habimana (1982) found that 28% and 10% of the sample population in Mudasomwa and Kivu Communes next to the Forest obtained cash income from gold mining, respectively. Although the sample population was too small to make inference about the large adjacent population as a whole, it is assumed that access to minerals in the Forest could be an alternative source of income to the neighbouring communities. Due to the negative impact of mining on the conservation of biodiversity, it is necessary to define and demarcate mining areas and to monitor activities by miners' groups.

4.1.2.3 Wildlife and ecotourism

In the past, neighbouring communities extracted bushmeat from Nyungwe Forest through hunting and the use of traps (Storz, 1983). The survey established that wildlife is not managed for utilisation as part of the livelihoods of the people adjacent to the Forest. Hunting for household consumption is regarded as a threat to the conservation of wildlife, including rare and protected animals such as chimpanzees and buffaloes (MINITERRE, 2000). The value of the resource in money terms cannot be estimated without an in-depth survey, as off-take from the Forest is illegal and bushmeat trade said to be non-existent.

In Equatorial Africa, hunting and bushmeat trade occupy a central place in the economy, and the volumes traded are substantial. For instance, the annual bushmeat trade in Gabon is valued at US $ 22 million on informal markets and at US $ 3 million on formal markets (Bailon 1996, quoted by Klein and van der Wall, 1998). In the Republic of Congo, 26 000 animals are said to be sold in Pointe Noire monthly, implying that half a million animals are killed for this market each year (Wilson and Wilson, quoted in Colchester, 1994). In Cameroon and in the Democratic Republic of Congo, the bushmeat consumption is estimated at 21 and 41 kg per person per year (Wilkie and Carpenter, 1999).

Wildlife can be managed as a source of subsistence or income. For example, the annual income from hunting and trapping in villages around the Korup National Park in Cameroon amounted to approximately US $ 1050 per hunter and accounted for 50% of the total village income (Infield, 1988). In Nyungwe Forest, the non-consumptive use of wildlife through ecotourism is favoured by the government managing institution, ORTPN (Barakabuye, 2001). The communities around Nyungwe Forest do not enjoy the benefits of ecotourism, apart from the employment of a few local guides, because all the economic benefits accrue to Government. In the year 2000, Nyungwe Forest registered 777 visitors from different foreign countries, from which US $ 6 722 were obtained by ORTPN (Barakabuye, 2001). This revenue is low compared with the revenues obtained before 1994. In the early 1990s, ecotourism in the Forest raised US $ 15 000 per year, but this amount was only enough to pay the staff and the upkeep of the Forest (Offutt, 1992). Since all of these

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revenues go to government funds, they have little impact on communities around the Forest. When carefully planned and managed, an ecotourism development in a tropical forest can provide a sustainable return, much of which can remain in the local economy (Horwich, 1988).

In many countries, attempts have been made to involve local people in the management of forest reserves and to create opportunities for local communities to benefit from the forests. This has been the case for Budongo Forest in Uganda (Langoya and Long, 1998), Serengeti National Park in Tanzania (Emerton and Mfunda, 1999), woodlands in Zimbabwe (Hasler, 1999) and wildlife management in South Asia (Kothari *et al.*, 2000). The potential for community involvement in wildlife management in Nyungwe Forest exists and it is justified for the following reasons: -

- Local people around the Forest have knowledge of the resources, including rare and endangered wildlife;
- They are aware of the value of wildlife as bushmeat and as an ecotourism attraction;
- They have knowledge of the reproductive cycles and the habitats of wildlife.

Nevertheless, with the present condition of poverty and absence of alternative livelihoods strategies, the sustainability of the wildlife resource is threatened. It is essential for the Government to consider approaches to natural resource management taken by many other governments which offer an immediate value to themselves and benefits to local communities.

4.1.2.4 Medicinal plants

Medicinal plants are an important element of traditional medicine on which 80% of the world population currently depends (WHO *et al.,* 1993). Of the 250 000 higher plants worldwide, one fifth are used as medicinal plants (WWF, 1994). The use of medicinal plants is one of the most important functions of non-timber forest products (Fedlmeir, 1998). Due to its illegal status, medicinal plants used by the local communities are supposed to be taken from farms.

Although traditional healers do exist in the region, it appears that most people in the region treat themselves or seek advice from friends, in particular from elder persons. No data are availed on the number of traditional healers in Rwanda. With an estimate of more than 500 medical practitioners who were registered to treat livestock in 1992 (Mbarubukeye, 1992), there is no doubt that traditional healers could number more than medical doctors. Medical clinics are found in the Communes next to the Forest. However, they are difficult for some people to reach, lack adequate physicians, and the drugs prescribed are often too expensive. This explains the dependence on locally collected medicinal plants for the treatment of various illnesses including headaches, diarrhoea, and dental cavities.

The leaf material is the major component of medicinal plants commonly collected on farms. Due to the low diversity of the species available on farms, additional material could be collected from the Forest. The majority of medicinal trees found in Nyungwe forest were preferred for their bark material. The debarking of trees for the gathering of medicinal material can result in death of the tree resource or its susceptibility to fungal attack and other diseases. In Madagascar, for instance, the collection of the bark of *Prunus africana* has resulted in its death (Kollert, 1998). Cunningham and Mbekum (1993) reported that stripping the bark off two opposing quarters of the trunk of *Prunus africana* in Cameroon enabled the tree to resist total injury. Thus the use of improved extraction methods of the bark of medicinal trees is a means of achieving sustainable utilisation of medicinal trees. Some tree species are unable to re-grow the bark removed and thus more vulnerable than those that can. Other factors that affect the sustainable harvesting of medicinal plants include the amount harvested, the level of commercial trade and the part used (Cunningham, 1996). Since medicinal trees in the Nyungwe Forest could be exploited largely by debarking, these trees are at high risk of death if the collection methods are not improved.

Medicinal plants have been shown to be economically important for sustaining local livelihoods. At present, in Nyungwe Forest, illegally collected medicinal plants are used for subsistence needs instead of commercial use. In some countries, however, medicinal plants are produced in large quantities, sold at local and international markets and contribute to the national economy. In Nepal, for instance, official records indicated an average of 50 tons per year of aromatic and medicinal plants commercially exported from the country (Aumeeruddy, 1998). In Ethiopia, seven medicinal plants are sold by vendors on local markets (Deffar, 1998). In South Africa in 1993, the annual trade of 20 000 tonnes of medicinal plants worth US $ 60 million were annually traded at the national level (Cunningham, 1993), and this figure is higher today. In the year 2000, the economic value of medicinal plants in South Africa approximated a value of US $ 41 million (approx. R 270 million) per annum (Mander, 1998, quoted by Lawes *et al.,* 2000).

The survey of medicinal plant use showed that local communities have considerable knowledge about many aspects of medicinal plants, including their abundance, uses and methods of harvesting. There is no doubt that medicinal plants cannot be managed effectively without the co-operation of the local communities, who are in the best position to protect and manage them. Although PCFN is seeking ways of managing the local collection of medicinal plants, agreements are needed between traditional healers' associations and the Nyungwe Forest authorities to confer certain rights and responsibilities. The agreements would define which medicinal plants should be used, the amounts to be collected, and by whom. This could result in an increased interest among local collectors in the protection and conservation of the resources for their continuing benefits.

4.1.2.5 Fodder plants and pastures

The forest legislation in Rwanda states that livestock must not be grazed in state owned forests (JORR, 1989). An exception has been made for the *Acacia melanoxylon* and *Pinus patula* plantations in the buffer zone for Nyungwe Forest, where cattle, goat and sheep were grazed on the herb layer (Barbier, 1992). In the survey, evidence was found that livestock is still being grazed in the buffer zone with the permission of the agricultural extension agents in the area. Available fodder grass and shrub species mentioned by the respondents are similar to those reported by Gasana (1988), the most common belonging to the families of *Poaceae, Asteraceae, Cyperaceae* and *Tiliaceae*.

Livestock keepers lack diversified means of coping with shortages of fodder during the dry season, the most common solution being free range grazing. Fodder is not stored, and currently there is no market available for fodder. The study did not focus on fodder productivity, abundance and composition in Nyungwe Forest. Field observation and household interviews revealed that, apart from patches of fodder along roads and in some gaps inside the Forest, Nyungwe Forest was poor in fodder quality and quantity. This was so because the herb layer is densely occupied by ferns and lianas, most of which are not eaten by livestock.

The insufficient grazing resources outside the Forest could explain the perception of the respondents of the Forest as a source of fodder and pasture. Gapusi (1999) reported cases of uncontrolled and excessive grazing in the Forest. Livestock population around Nyungwe Forest is on the increase owing to the demand for manure (from cattle) and income (from goats and sheep). There is a need for a well-defined national policy on grazing to sustain fodder supply by non-forest sources and by instituting change in livestock composition and grazing practices.

4.1.2.6 Beekeeping

Beekeeping has a low impact on the forest, as has been the case at Bwindi Impenetrable and Mgahinga Gorilla National Parks of Uganda (Wild and Mutebi, 1996). Beekeeping in Nyungwe Forest was controlled by forest projects, and activities of beekeeper's groups were guided by contracts and regulations (Barbier, 1992). The only concern was possible fires that could be set by the honey collectors.

Due to low production, honey is used for subsistence needs of the household in the study area, with only small quantities sold on the local market. In some countries, large quantities of honey are produced by a considerable number of beekeepers. In Malawi, some 8 000 beekeepers produce 1 000 tonnes and 150 tonnes of honey and beeswax per annum respectively (Chanyenga, 1999). The average export of honey and beeswax in Ethiopia is estimated at 3.05 tonnes and 270.34 tonnes per year, respectively (Deffar, 1998).

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The low productivity of honey in Rwanda could be due to the use of traditional production technologies. Production can be increased if improved methods, including the use of modern beehives, are used. Honey production also depends on the availability of certain plant species that are associated with bees. Known bee forage species listed by the respondents were less diverse compared to those found in the Forest and reported by Habiyambere (1999). Forest disturbances could be one of the reasons for the loss of tree species favoured by bees. Increasing bee forage species would certainly boost honey production. Past experiences based on agreement between beekeeper's associations and forest projects could guide decisions over beekeeping in the Forest for the benefit of the local communities.

4.1.2.7 Wild foods

Although an assessment of the availability of wild foods has not been conducted in the Forest, the households adjacent to Nyungwe Forest mentioned a number of seasonal wild foods that supplement the diet or are used as a source of income. The ranking of these non-wood products in relation to the other resources showed that these products were not of great importance to the population. Practical examples demonstrate how fruit and mushroom harvesting could be integrated into local forest management plans and can constitute sources of income for the population. The harvesting of wild foods appears to be sustainable or to have low impact. This is because:

- Harvesting of wild vegetables, mushrooms and fruit is a seasonal activity, and practised by the poorest people. For wild vegetables, edible leaves of *Amaranthus spp*. and *Solanum nigrum* are collected during the rainy season;
- The use of the fruit of *Myrianthus holstii* encourages the conservation of the female tree (Cunningham, 1996) and the population around Nyungwe Forest has planted this species on their farms;
- Farmers in the area produce fruit and vegetables in their gardens (for example: *Amaranthus spp*., cabbages, carrots, onions), and thus do not rely entirely on the foods from the Forest.

As the gathering of wild foods has relatively little impact on the forest dynamics, this is one category of resources that the management of Nyungwe Forest could allow local people to access, as a way of their gaining benefit from the conservation of the Forest. Mutual trust between parties would be essential here, however, to ensure that other, restricted, resources are not harvested at the same time.

4.2 CHARACTERISTICS OF THE PREFERRED TREE SPECIES

Due to time and financial constraints, the study concentrated on the assessment of the standing stock of the most preferred tree species for timber, poles, and medicinal plants. These species were assessed for their density, size-class distribution and regeneration using plots in areas of the Forest adjacent to local people. As no data were available for the population biology of the preferred tree species, their distribution and responses to exploitation, the maximum sustainable yield could not be determined (see Lund, 1998; Ruiz Pérez and Arnold, 1996). The information provided by this study can only be used to understand the importance of Nyungwe Forest in the livelihoods of local communities as well as to justify the management policies of the Forest.

To be able to determine sustainable levels of resource use requires information about the density, the distribution of the resources within the forest, the population structure, the productivity of these resources and the ecological impact of different harvesting levels (Cunningham, 1999). In this study, plots were localised, and therefore particular tree species that are restricted to certain habitats could have been missed. However, as the plots were located in areas of the Forest near the local communities, the study provides baseline data on the availability, abundance, size-class distribution and regeneration of the tree species of relevance to local people. This study can also be used to inform managers about the impact of illegal use of the species and as an aid to developing potential management strategies for future use.

The impact of illegal logging in Nyungwe Forest could be partly reflected in differences in densities of seedlings and medium trees between the study sites. These differences could also be attributed to environmental conditions and types of disturbances including fire and grazing. The periphery of the Forest has been altered;

this has been substantiated by the chi-square analysis of the densities of trees of different sizes among and within the study sites. The presence of many small individuals of the preferred tree species at many sites suggests that the periphery of Nyungwe Forest is in the process of secondary succession. It is likely that some species including *Polyscias fulva, Neoboutonia macrocalyx* and *Macaranga neomildbraediana* which are characteristic of secondary forests (ORINFOR, 1978) will become more common where human use is heavy.

The total stem density of all species and the density of the trees of the preferred species determined the relative abundance of each species within each category of product. The density of preferred trees can only convey an impression of available resources because the majority of the species were preferred for various products. The densities provided could be used as conservative criteria to set harvesting quotas which do not rely on an estimate of maximum sustained yield. A resource plant may be abundant but for some reason not sufficiently appropriate for use for different products. For instance, preferred tree species for timber and poles do exist in the Forest but the densities of quality stems were sometimes in low proportion relative to the stem densities of some species classified as potentially utilisable for timber and poles. Other characteristics including size-class distribution and regeneration should be examined in order to determine sustainable utilisation of the species.

Size-class distributions of trees may be used to predict the age structure and state of a forest (Lorimer, 1980), to determine the regeneration status of dominant tree species (Geldenhuys and Muray, 1992), and as an indicator of natural or human disturbance history (Lorimer, 1980). Size-class distributions of trees prior to harvesting provide important baseline information for future monitoring work (Cunningham, 1999). A comparison of the size-class distribution prior to and after harvesting indicates changes in the rate of seedling and sapling establishment in the harvested population (ITFC-EMP, 1999).

The analysis of size-class distributions of the preferred tree species indicated that many populations examined were unstable, with variable transitions from one size class to the next. A stable population is characterised by low ratios of change between successive size classes (Taylor and Walker, 1984), corresponding to marginally convex curves without clear inflections (Knowles and Grant, 1983). Usually size-class information is analysed in terms of a negative exponential distribution (e.g. Midgley *et al.,* 1990). With the exception of *Carapa grandiflora* and *Symphonia globulifera*, most of the species did not conform to this ideal. Since they showed a negative exponential distribution, the populations of *Carapa grandiflora* and *Symphonia globulifera* had more juvenile than adult trees, indicating they were more stable in densities and were self-replacing (Geldenhuys, 1992; Hall and Bawa, 1993). The depicted size classes for the remaining species represented unstable populations.

Some species exhibited either the loss of reproductives or had temporarily variable recruitment. Peters (1994) attributed the resulting size-class distribution in undisturbed stands to sporadic or irregular seedling establishment where the level of regeneration maintains the population with the 'infrequency' of occurrence causing 'peaks' and 'valleys' in the size class distribution. The populations which exhibit this pattern are commonly species that depend on canopy gaps for regeneration or whose regeneration has been interrupted by seed mortality, physical damage to seedlings or lack of pollinators or dispersal agents (Armesto and Fuentes, 1988; van Wyk *et al.,* 1996).

E*ntandrophragma excelsum* has shown exception in that it lacks seedlings. Midgley *et al.* (1995) expressed concern at the apparent absence of regeneration of some trees in Southern African forests. They speculated that there might be some recent changes in disturbance regimes in these areas. In retrospect, the lack of regeneration of *E. excelsum* could be due to the lack of major disturbances like those caused by elephant and buffalo when their herds were present in Nyungwe Forest. The low density of large trees of *E. excelsum* could also be due to intensive pitsawying of the species for valuable timber in the past (Habiyambere, 1999). Being a primary species, the population of this species could permanently disappear from the Forest if the current conditions do not change.

Size-class distributions of the preferred tree species indicated predominantly that a few number of species were in natural or unharvested condition. Many species exhibited a size-class distribution frequently encountered among light demanding, early pioneer species, which require large canopy gaps for regeneration. In the absence of such a disturbance, these species whose regeneration is limited (e.g. *Parinari excelsa, Pauridiantha paucinervis, Casearia runssorica* and *Cassipourea ruwenzoriensis*) may temporarily disappear from the Forest, their populations being represented only by seeds lying dormant in the soils. The results of the study concur with the findings of Zimmermann *et al.* (1994) that regeneration in tropical wet forests is an important life history attribute of the species.

Significant differences in the abundance of seedlings of different species across sites indicated poor regeneration and recruitment of some species in some sites. This may be caused, in addition to differences in environmental conditions (e.g. soils, rainfall) and the ability of the species to reseed, by differences in canopy cover or light gaps in the Forest (Armesto and Fuentes, 1988). Fire is reported to be the most common disturbance in Nyungwe Forest (Gapusi, 1999) and could have affected differently the part of the Forest being surveyed.

4.3 POTENTIAL SUPPLY AND VULNERABILITY OF THE PREFERRED TREE SPECIES TO EXPLOITATION

The discussion in section 4.2. has attempted to show that Nyungwe Forest has different species with a variety of ecological characteristics that make sustainable harvesting a very difficult objective. The major problems identified by the study are the high diversity and low population density, the unstable size-class distribution and the low density of regeneration of many species. Ignoring these characteristics could cause an unsustainable exploitation of timber, poles and medicinal materials.

According to Hall and Bawa (1993), extraction is considered sustainable if the impact of harvesting has no significant effect on the reproduction and regeneration of the population being harvested. A combination of criteria including density, size-class distribution and regeneration could convey an impression about the vulnerability of tree species to exploitation (Tables 4.1a and 4.1b).

Table 4.1a. Classification of the preferred timber and pole species into 'vulnerable' and 'non-vulnerable' categories.

Tree resources	Vulnerable	Non-vulnerable
Timber		
Carapa grandiflora		x
Entandrophragma excelsum	x	
Newtonia buchananii	x	
Parinari excelsa		x
Polyscias fulva	x	
Strombosia scheffleri		x
Symphonia globulifera	x	
Syzygium parvifolium	x	
Poles		
Carapa grandiflora		x
Casearia runssorica		x
Cassipourea ruwenzoriensis		x
Macaranga neomildbraediana	x	
Strombosia scheffleri		x
Symphonia globulifera		x
Syzygium parvifolium		x

Table 4.1b. Classification of the preferred medicinal tree species into 'vulnerable' and 'non-vulnerable' categories

Tree resources	Vulnerable	Non-vulnerable
Medicinal tree species, large tree category		
Carapa grandiflora		x
Entandrophragma excelsum	x	
Maesa lanceolata	x	
Newtonia buchananii	x	
Oxyanthus troupinii	x	
Parinari excelsa		x
Pauridiantha paucinervis	x	
Symphonia globulifera	x	
Syzygium parvifolium	x	
Tabernamontana johnstonii	x	
Medicinal species, medium tree category		
Canthium oligocarpum	x	
Carapa grandiflora		x
Newtonia buchananii	x	
Oxyanthus troupinii		x
Parinari excelsa	x	
Pauridiantha paucinervis	x	
Symphonia globulifera		x
Syzygium parvifolium		x

As the information provided is a baseline data, the grouping of these species into vulnerable and non-vulnerable categories could serve as a benchmark for describing the initial ecological conditions that have to be monitored in the process of resource exploitation. Obviously, abundant species with many seedlings (e.g. *Carapa grandiflora, Symphonia globulifera* and *Strombosia scheffleri*) are less vulnerable to exploitation. More important than the overall abundance of the preferred tree species is the size-class distribution of individuals of each species.

Stem densities of some species including *Cassipourea ruwenzoriensis* and *Newtonia buchananii* were dominated by the preponderance of small trees, large trees being very few. The exploitation of such species could not be maintained on a sustained yield basis and therefore species which approximate an inverse J-shaped curve are recommended for exploitation. Felling of large trees of species including *Entandrophragma excelsum, Newtonia buchananii* and *Syzygium parvifolium* for timber could eliminate these species from the Forest in a much shorter period of time because of low densities of their stems and instability of their populations. For many species including *Carapa grandiflora, Symphonia globulifera, Strombosia scheffleri* and *Cassipourea ruwenzoriensis*, poles were more abundant compared to the densities of harvestable individuals for timber.

Another criteria, part of plant used, could be added to the three criteria in order to determine the vulnerability of harvesting medicinal materials. As no data was available on the impact of harvesting medicinal materials from the species, the information about vulnerability of medicinal species to exploitation is incomplete. In addition, it is clear that many of the tree species are favoured for more than one products, which might lead to overexploitation as observed by Fedlmeier (1998).

Harvesting methods also have an impact on the sustainability of the resources. Geldenhuys (1998) proposed methods of timber harvesting based on single tree selection in the management of natural forest in South Africa. The methods include harvesting trees selected from a stand on the basis of mortality rates and harvesting of dead and dying trees of commercially valuable species. The harvesting of over-mature and dying trees in Nyungwe Forest can be applied with the aim of maintaining a stable population of the preferred tree species. As a way of achieving this, a silvicultural system that could be employed would exploit products from overstocked size-classes as it has been applied in the South African forests (Geldenhyus, 1992). However, as for all natural forests, the system should aim to increase growing space for faster growth of useful stems and to establish the regeneration of the desirable species to replace the stem removed in logging (Baur, 1964; Roach, 1974). If the removal of trees across the different size classes is proportional to the relative densities of the stems in each size class, then there will be no change in the size-class distribution of the species at a time when absolute densities are declining. Information on the life history of the species can guide decision over exploitability of species, as the removal of some trees might not enhance the regeneration of shade-tolerant species.

Other factors such as growth rate and coppice response to exploitation of products need to be considered in order to determine species that are either vulnerable or not vulnerable to exploitation. It can be hypothesised that vulnerable species are those highly preferred for timber and poles, with slow growth rate and weak coppicing ability. Species that are likely to be less vulnerable would be those with relatively fast growth rate. No data are available on growth rate and coppicing ability of the species studied, and this need to be investigated.

Monitoring operations and harvesting adjustments enable to determine the sustainability of harvesting levels (Peters, 1994). The most important characteristic that must be monitored is the density of regeneration. In the case of low seedling densities, Peters (1994) recommends remedial treatments including enrichment planting, selective weeding, cutting and removal of woody vines from the crown of adult trees. These treatments could result in reducing competition and increasing of light levels into the understorey. The periphery of Nyungwe Forest surveyed requires such treatments in order to improve the availability and recruitment of seedlings of the majority of the species including for instance *Casearia runssorica, Cassipourea ruwenzoriensis, Parinari excelsa, Pauridiantha paucinervis* and *Syzygium parvifolium*. Species such as *Entandrophragma excelsum* require enrichment planting or the re-introduction of locally extinct herbivores (e.g. elephant, buffalo) that will induce disturbances needed for the regeneration of the species.

4.4 POTENTIAL FOR JOINT MANAGEMENT OF NYUNGWE FOREST

After recounting the needs, problems and preferences of local communities as well as the potential supply of preferred tree species from Nyungwe Forest, the potential for community participation in the protection and management of the Forest is assessed.

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The discussion is guided by the experiences of joint forest management (JFM) or collaborative management in countries where these techniques have been applied.

In Rwanda, JFM or collaborative management of protected forests has not previously existed. In the case of Nyungwe Forest, however, there have been programmes of social forestry that dealt with development activities in the rural areas adjacent to the Forest (Barbier, 1992; Labrousse, 1992). These were provided as incentives for conservation and to reduce dependence of local communities to the forest resources.

Deforestation has been reported to continue at an alarming rate (e.g. Gapusi, 1999; MINITERRE, 2000) to provide in the daily food needs of the adjacent household to the Forest. Cutting of trees for various uses is an important cause of deforestation, arising from poverty and insufficient land to establish sources of tree products. This degradation causes a decline of species suitable for wooden goods, furniture, and basketry materials. The consultancy work by Gapusi (1999) indicated a number of wrong perceptions which relate to the meaning of sustainability and the dependence of adjacent households to the Forest. This accentuates the need for implementation of collaborative resource management strategies in the adjacent areas to the Forest.

The effective and meaningful involvement of local communities in natural resource management has been attempted under JFM in India by linking socio-economic incentives and forest management (Badola, 1999; Tewari, 1992). Many countries in the world have undertaken a series of initiatives aimed at devolving management, control and ownership of natural forest and woodland resources to local communities. In India, resource degradation has led the government to enter into partnership agreements with communities whereby the responsibility for forest management is placed with communities. In return, these communities are allowed to harvest certain species in certain areas and to receive a fixed percentage of revenues from harvesting by the state forest department (Mukerji, 1992).

Other countries in Africa have changed their national forest policies toward community-based forest management. In Ghana, for instance, a collaborative management scheme has been adopted in order for the community to benefit from the forest resources (Prah, 1997). In Zimbabwe, the CAMPFIRE programme insures that revenues derived from wildlife reach councils and communities (Scoones and Matose, 1993).

Elsewhere in Africa, community based approaches to forest management have been adopted: in Tanzania in the Duru-Haitemba and Mgori forests (Sjoholm and Wily, 1995; Wily and Haule, 1995), in the Bwindi and Mount Elgon forests of Uganda (Wily, 1993), the Kilum and Ijim montane forests of Cameroon (Nurse *et al.*, 1994), the forests of the Senegal Valley (Diouf, 1994), the Toumousseni forest in Burkina Faso (Hagberg, 1992), the Gshaka Gumti Park in Nigeria (Dunn, 1994), woodlands near Mopti in Niger (Kerkhot, 1990), the El Ain woodlands of Sudan (El Din and Shanks, 1992) and the woodlands in Mali (Skinner, 1988). JFM is also emerging as a strategy for conservation and sustainable use of forests as in Sri Lanka (Carter *et al.*, 1994), Thailand and the Philippines (Poffenberger and McGean, 1998).

Joint forest management approaches that work elsewhere may not be applicable to Rwanda in the context of the current legal and policy provisions of forests, particularly for protected areas, including Nyungwe Forest. Currently, the major focus is on the conservation of biological diversity and integrity. The presence of a unique wealth of biodiversity makes Nyungwe Forest an extremely sensitive area. The high conservation status, however, does not imply the exclusion of local communities to access certain resources and to participate in the management of the Forest. The collaborative management at Bwindi Impenetrable and Mgahinga Gorilla National Parks in Uganda is an example of community use of wood and non-wood products (Wild and Mutebi, 1996; Cunningham, 1996). The conservation and management of Nyungwe Forest could follow the examples of the Uganda National Parks and allow access to some resources, including those identified by this study.

Many factors favour the development of JFM in Nyungwe Forest. Firstly, communities adjacent to Nyungwe Forest have used products from the Forest in the past. Secondly, the Action Plan for the conservation and management of natural forests in Rwanda adopted in 1984, conceived a three-zone system as follows (Fimbel and Kristensen, 1994):

- Forest fringe zone where some timber harvesting was permitted (10% of all the forest area);

- Natural reserve zone where minimal use was allowed (40% of all the forest area);
- High protection zone, where resource use was restricted (50% of all the forest area).

The subdivision of Nyungwe Forest into different zones approximated the system of buffer zones adopted in Uganda (see Wild and Mutebi, 1996). The restriction of resource access to the buffer zone can imply the loss of access to some resources, for example bamboo, which is found in the south-eastern part of Nyungwe Forest. However, since bamboo can be grown in gardens, it is possible to produce this resource outside the Forest.

Thirdly, the decentralisation of power and authority by the central government aims to involve local people and their leadership in the management of all affairs related to socio-economic development in their regions. The role of community leadership is one of the important factors affecting the success of collaborative management (Wild and Mutebi, 1996). The survey of the respondents' perceptions of potential institutions for the management of utilisation found different organisations that could operate at local level for the management of the Forest. These organisations, including administrative District, Sectors and Cells, work with or have a direct relationship with the government structures and interact already with the forest authorities and conservation services. Due to its power, authority, organisational structure and mandate, a District could be one of the actors involved in management and conservation of the Forest. The various categories of institutions listed by the respondents as being more appropriate show the importance of having various stakeholders including both users and non-users in forest management.

Fourthly, the conservation services do not exercise adequate control over the harvesting of resources, which leads to overexploitation and loss of biodiversity. Since 1994, there has not been effective management of the Forest. The conservation project staff is too small, without resources and therefore ineffective (WCS and ORTPN, 1995). There is patrolling of the Forest, but still there is intense illegal activities going on. Without effective management, the Forest will continue to be exploited, albeit illegally, by adjacent communities. The lack of an approach toward developing partnership between the conservation services and local organisations could exacerbate current conflicts over resource use and access.

The local use of resources from the Forest can be based on the subdivision of the Forest into different management zones and on the vulnerability of some resources to exploitation (Peters, 1996). Because collaborative forest management or JFM involves agreement between resources users and the owner of the forest (in this case the government), further clarification of who can use the resources and who will be responsible for the management of the Forest may be required. Obviously, as has been the case in other countries, the foremost users are those people who live next to the Forest, but they need to be organised into user groups.

People living in the environs of the Forest already work in associations or groups in various sectors such as crop production, livestock farming and beekeeping, among others. These associations provide opportunities for the formation of users groups for collaborative management. However, because the users are many and the Forest is large, the use of the resources could be demarcated following administrative boundaries, instead of natural boundaries as has been the case in Tukucha and Banskharka panchayats of Nepal (Hobley, 1987). This could enable the involvement of local administration in decision-making regarding utilisation and management of the part of the Forest falling within its boundaries. In order to make use of the Forest sustainable, it is desirable to link the forest produce with local enterprises, for both wood and non-wood products (Encarnacion, 1999). The development of alternatives to resource use could be an important complementary strategy for improving the livelihoods of the adjacent communities.

Enabling access to some resources in the Forest alone cannot solve the livelihood problems of the population. Substitution activities can provide for some of the preferred and requested resources as a remedial strategy to low resource availability. Alternative activities could include local cultivation of indigenous tree and shrub species for the production of medicinal plants, basketry materials, poles, and wooden and woven products, following the example of the Guira Banso project in Ghana (Prah, 1997).

Incentives for community involvement in forest protection and management can also come in the form of income, goods, and power to control the forest by local communities. Ecotourism in Nyungwe Forest could potentially provide sustainable financial activity, thus encouraging local people in the sustainable management of forest resources as has been the case for Budongo Forest Reserve in Uganda (Langoya and Long, 1998). In the long-term, the communities that live in the area surrounding the Forest can benefit directly from wildlife. This may be either through protein off-take or from financial benefit from revenue taken from tourists visiting to view wildlife. Such strategies are akin to the CAMPFIRE programme set up in Zimbabwe or the community conservation programmes successfully running in Kenya. In return for the benefit that local communities gain from wildlife, they can act to conserve the wildlife.

A revenue sharing scheme has to be installed as a one of the means for resolving conflicts between forest authorities and adjacent communities. Money that is accrued from the Forest, once it has moved towards self-sustainability, can be used to answer to the immediate development needs of the local communities. Until the conservation service of the Forest has sufficient income from ecotourism revenues, the Rwanda Government in partnership with the donor community can have to work closely with the local human populations.

In response to wood requirements, local communities could be encouraged, trained and provided with appropriate materials to establish their own sources of wood products. Forest projects in the region would, for example, aim at reducing the fuelwood and pole requirements. An alternative to fuelwood can be kerosene. The provision of efficient kerosene cookers and a campaign to familiarise people with its use would reduce the fuelwood requirements. If charcoal is used, then people could be trained how to produce efficient cookers.

The most difficult, but most important aspect for the adjacent communities can be for the projects to induce a change from agriculture and livestock based economy to a monetary economy. The reasons for this change are as follows: (a) many aspects of households will increasingly need to acquire things that require money (e.g. clothing, school fee, house construction, medical fee); (b) the long-term impacts of the present economic system will prove to lead to reductions in farm sizes and heavy use of pastures, resulting in the households to become increasingly poor. Micro-economic projects that facilitate this move could be encouraged and subsidised.

Such projects can also provide incentives for protection and conservation of the Forest through the development of local enterprises such as the production of bricks and roofing tiles, and the production of efficient ceramic cookers that could reduce the amount of fuel and building wood that is required by the households adjacent to the Forest. Incentives can be in the form of credits provided by projects to support the management of the Forest, as was done by the SAFIRE (Southern Alliances for Indigenous Resources) project in Zimbabwe (Grundy and Le Breton, 1998). The management of Nyungwe Forest should seek to diversify livelihood opportunities as much as possible among the communities living adjacent to the Forest.

In the process of collaborative management, communities could be employed in the rehabilitation and enrichment planting of the degraded areas and in other silvicultural treatments inside the Forest. This tactic has shown success in some projects in India where local people were used as a source of labour (Anderson *et al.*, 1998; Poffenberger *et al.,* 1990). In return, communities could benefit from employment and rights to harvest certain abundant species sustainably.

In order to avoid overexploitation, agreements between communities and forest managers are needed and could establish resource users, species and quantities to be harvested by each user and monitoring activities for managing resource use. It is possible to develop a joint venture between some resource user groups and the forest management authority to harvest some resources on sustainable basis, integrated with other forest management activities. The Forest authority can control the harvesting of resources through a permit system, but ensuring that permit rates do not exceed what the people can afford to pay, which could reduce illegal activities.

5 CONCLUSION AND RECOMMENDATIONS

This research has shown that Nyungwe Forest is important to the livelihoods of many people living on its periphery, through the provision of wood and non-wood forest products. The preference and demand for forest products result from declining levels of soil fertility and the lack of livelihood alternatives in the study area. As a result of the demand for more livelihood alternatives, the managers of Nyungwe Forest are faced with a difficult situation arising from the effect of population pressure and rural poverty (Mitchell, 1997). This has led to illegal cutting of trees for various uses, and poaching of animals for food, gathering of wild vegetables and fruit, the harvesting of medicinal plants and mining in the valleys of the Forest.

Although communities adjacent to the Forest have farmed trees, the products are less diverse and not enough to cater for their needs, implying increased reliance on the Forest for their livelihoods. However, not all resources preferred by adjacent communities are found in the Forest, and many available resources are present in insufficient abundance to be recommended for sustainable utilisation. As more than 50% of the preferred tree species for various uses were vulnerable to exploitation, the periphery of Nyungwe Forest is now considered to be an area of low resource potential for timber, pole and medicinal materials.

Only a few tree species can be considered utilisable due to the fact that populations of many species were unstable. The uneven distribution of the range of size classes found for many species could be a cause for concern and has management implications. The removal of harvesting pressure for poles and timber may result in more stable populations of the preferred tree species (Shackleton, 1993). The effect of this is the development and the establishment of new seedlings at regular intervals leading to a standard size-class distribution of the species. The management of the preferred species for the sustainable supply of timber and poles can be achieved through appropriate silvicultural systems that maintain the characteristics of a stable population.

As the density of harvestable trees for timber was very low, a silvicultural system based on single tree selection could allow the production of timber from overstocked diameter size classes in a well-defined zone of the Forest. However, timber harvesting should be controlled in order to avoid overexploitation and adverse impact on the growth dynamics of the harvested population. As the densities of poles were more than those of timber trees, the area of the Forest surveyed had more potential for the supply of poles than timber.

Many tree species are favoured by local people for multiple uses. It is important to determine the use of each tree species if harvesting is to be sustainable. Many medicinal tree species have had their bark harvested for medicinal materials. Debarking of trees for the supply of medicinal material and using the same species for timber harvesting can adversely affect the regeneration and the genetic composition of the future population. Therefore tree species indicated for medicinal purposes should not be used for timber exploitation except if medicinal material is gathered only from the small trees or if the medicinal material is gathered before timber harvesting.

Other resources of importance to the livelihoods of local communities are also gathered from Nyungwe Forest and are used for household consumption. Sustainable utilisation of these products by local communities can be one of the possible means of establishing positive linkages between local households and conservation of Nyungwe Forest. The gathering of these resources should also be organised, regulated and monitored.

Substitutions have always been considered an important component of the management of forests. Some of the preferred tree species can be propagated on farms (example *Entandrophragma excelsum* for timber, *Arundinaria alpina* for basketry material and building purposes, *Alchornea hirtella* for bean stakes, *Casearia runssorica* for poles), which would reduce the pressure on these resources inside the Forest. Identification of alternatives to resources, which are less abundant and more vulnerable to exploitation, could be done in co-operation with the local communities.

This study suggests a way of achieving a balance between community utilisation and the conservation of Nyungwe Forest. Collaborative management of the Forest can be a viable arrangement given well-structured local institutions in which local people have confidence, the government policy of decentralising power and authority to the lowest administrative level, and past experiences in the management of Nyungwe Forest. This management option could draw on approaches adopted in other countries such as India, where JFM emerged, and Uganda's Bwindi Impenetrable National Park where resource use by local people is permitted on specified zones of the Park. The use of resources in the Forest requires an enabling policy environment with a view to addressing the conflicts over resource use and access, silvicultural problems, productivity, and benefit sharing, through participation of local communities.

Below is a summary of some suggestions regarding the use of Nyungwe Forest and areas for future research:

- The management of Nyungwe Forest could permit the gathering of edible wild foods in areas outside the strict conservation zone of the Forest. Studies aimed at providing information on the availability, identification, abundance, seasonality, distribution and harvesting impact for these products have to be carried out in order to guide the frequency and quantities of removals.

- Beekeeping can be a source of income to local communities. The current initiative of PCFN to stimulate the formation of beekeepers' associations which should use the resource should be encouraged. In this way, beekeepers can take the responsibility for preventing fires and avoiding the damaging use of the Forest. The traditional methods of honey production should be improved upon.

- Bamboo is mostly used by people in the southwest ridge of the Forest, where it is dominant. A limited number of harvesters could be licensed to use the resource until sufficient supplies can be grown on farms. Research is needed to provide information on the effect of continued harvesting on the production of biomass in order to ensure long-term sustainability of bamboo extraction.

- Mining can be carried out, but in accordance with the regulations of the Ministry of Commerce, Industry and Tourism and in areas defined by the conservation services. Local miners' groups can have access to the resource upon obtaining a mining title.

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- The illegal use of wood for the production of wooden items for household use has resulted in the scarcity of some tree species. This is a consequence of highly selective harvesting that removes the most fit individuals. Felling of these trees in the Forest should be stopped. Attention should be focussed on providing alternative sources of wood for wooden items, including, for instance, the planting of *Polyscias fulva* and *Markhamia lutea* outside the Forest or on farms.

- Timber harvesting can be done for those tree species which have more individuals at the larger diameter size class than expected (e.g. *Parinari excelsa, Strombosia scheffleri*). The removals should be regulated and based on selective harvesting.

- Indigenous pole species are preferred to exotic pole species. The indigenous poles are likely to be much sought after by the adjacent communities, leading to overharvesting. The management of Nyungwe Forest can determine harvesting cycles and the quantity of poles to be harvested for a particular species. The removal of poles as well as the harvesting of timber should ensure that the population of the species will perpetuate over time.

- Traditional healers' groups can be permitted to collect medicinal plants. Due to the effect of debarking, the gathering of leaf materials should be encouraged along with the use of growth form categories other than trees (e.g. climbers, shrubs). Research is needed to evaluate the response of preferred tree species to disturbance, including harvesting of fruits and bark.

- The management and conservation of Nyungwe Forest should promote the establishment of substitute resources, including the cultivation of preferred tree species, and assist the local communities to practice sustainable agriculture through the maintenance of productive cropping systems and the development of small, micro and medium enterprises based on cultivated resources.

- The periphery of Nyungwe Forest is a secondary forest as a result of disturbances. Highly disturbed sites need to be identified and studied in terms of species composition and size classes. This can provide useful information for forest rehabilitation and restoration.

- Studies on the ecology and the status of the preferred tree species should be carried out. This may involve the study of the dynamics, the constraints of life stages, productivity and growth rates, habitat requirements and spatial distributions. This can provide information on the management of the species for a sustainable supply of resources. The methods to be used should combine both plots and transects and should allow the evaluation of the spatial distribution of the preferred tree species along gradients and in different habitats.

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APPENDICES

Appendix 1. Questionnaire for household interviews

I. Background information of the respondent

1. Respondent Ref. No.____________ 2. Date of interview: ______________

3. Commune: ________________ Sector: ____________ Cell: ________________

4. Gender: __________________

5. Marital status: _____________

6. Age: _________ years

II. Socio-economics

7. What is the family size of your household? ______________ member(s)

8. What is your highest level of education?________________________________

9. Mention, in priority order, the enterprises undertaken by the household

1. ________________________ 4. __________________________
2. ________________________ 5. __________________________
3. ________________________

10. What is the most important source of your livelihood (survival strategy)?

____

11. Could you rank the sources of income for the household?

1. ________________________ 4. __________________________
2. ________________________ 5. __________________________
3. ________________________

12. How do you access to financial resources?

____

13. Do you belong to any group or association? If yes, which one? _______________

III. Land tenure and land use

14. What is the size of your farm? __________________________________

15. What is the process through which land has been acquired?

____

16. How do you rate the fertility of your farm?
   1. Very poor: _________
   2. Poor: _____________
   3. Moderate:__________
   4. High: _____________
   5. Very high: _________
   6. Don't know: _______

17. What is the status of soil fertility in the region during the last 5 years?
   1. Static ___________
   2. Increased ________
   3. Decreased _______
   4. Don't know ______

18. What are the causes of soil fertility decline, increase or stability?
   1. Stability : a_______________ b. _________________ c. ________________
   2. Increase: a_______________ b. _________________ c. _____ __________
   3. Decrease: a_______________ b. _________________ c. ________________
   4. Don't know: ______

19. How does the household solve land availability problems?

____

IV. Crops

20. What are the types of crops grown by the household?
   1. Cash crops: ____
   2. Food crops: ____
   3. Crops grown for food and cash income: ______________________________

21. For the most important, whether food or cash crops, could you tell us the number of bags yielded at harvest?

Most important Crops	Number of bags at harvest
1. ____________________________	______________________
2. ____________________________	______________________
3. ____________________________	______________________
4. ____________________________	______________________
5. ____________________________	______________________

22. Do you also farm fruit trees, medicinal plants and fodder plants? If yes, what are they?
   1. Fruit trees: a._______________ b._________________c.___________________
   2. Medicinal plants: a._____________b ________________ c.________________
   3. Fodder plants: a. _____________b ________________c.________________
   4. Other horticultural materials: a. _____________ b. _________c.____________

23. How do you compare revenues from crops with those from trees?

____

V. Livestock farming

24. What are the types of livestock kept and how many are they?

Livestock types	Numbers
1.__________________________	____________
2. _________________________	____________
3. _________________________	____________

25. What is the most important purpose of livestock kept?

Livestock types	Purpose
1.__________________________	_______________________
2. _________________________	_______________________
3. _________________________	_______________________
4. __________________________	___________________________
5.___________________________	___________________________

26. What is the average income from different animal products?

Animal products	Income (RWF)
1.__________________________	____________
2. _________________________	____________
3. _________________________	____________

27. How is grazing practised? (grazing practices)

____
____
____
____

28. What are the sources of fodder during critical periods?

____
____
____
____
____
____

29. List, in order of preference, the most three palatable tree and grass species that are found in Nyungwe Forest

Tree species	Grass species
1. __________________________	1. _______________________
2. __________________________	2. _______________________
3. _________________________	3. _______________________

30. What are the particular locations where these plants can be obtained in Nyungwe Forest? Why are they found there?

Tree species	Location	Reason for location
1.____________	1.____________	____________________
2. ____________	2. ____________	____________________
3. ____________	3. ____________	____________________

Grass species	Location	
1.____________	1.____________	____________________
2. ____________	2. ____________	____________________
3. ____________	3. ____________	____________________

VI. Availability and uses of natural resources

31. Do you own any tree crop? If yes, what is its size and species planted?

Area: ______________ species: _________________________

32. What is the most important purpose of the planted trees? __________________

33. What is the average income from tree products?

Tree products	Average income (RWF)
1. ________________________	________________________
2. ________________________	________________________
3. ________________________	________________________

34. What are the resources available in Nyungwe Forest?
1. ____________ 2. ____________ 3. ______________ 4. ____________
5. ____________ 6. ____________ 7. ______________ 8. ____________

35. Before Nyungwe Forest becomes a forest reserve, mention in order of importance the resources to which local people have had access.
2. ____________ 2. ____________ 3. ______________ 4. ____________
5. ____________ 6. ____________ 7. ______________ 8. ____________

36. To which resources do you have access to and use in Nyungwe Forest and in the Buffer zone?
1. Nyungwe Forest: a.____________ b. ____________ c.______________
2. Buffer zone: a. ______________ b. ____________ c. ______________

37. List in order of importance for your livelihood the resources present in Nyungwe Forest and in the buffer zone.
1. ______________ 2. ______________ 3. ________________

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38. For the above resources, could you tell how much is available using the scale of 1 to 5, where 1 means "very little and 5 "very abundant"?

Resources	Grade
1. ______	______
2. ______	______
3. ______	______
4. ______	______

39. What could be the different uses of these resources?

Resources	Uses
1. ______	______
2. ______	______
3. ______	______
4. ______	______

40. For timber, poles, medicinal plants, fodder and fruits, could you list in order of importance the preferred species present in Nyungwe Forest?

Timber: ______
Poles: ______
Medicinal plants: ______
Fruits: ______
Fodder: ______

41. How is each of the products above harvested?

Timber: ______
Poles: ______
Medicinal plants ______
Fruits: ______
Fodder: ______

42. If timber, poles, medicinal plants, fodder and wild fruits from Nyungwe Forest are used for commercial purposes, where do you normally sell them?

Products	Market location
1. ______	______
2.______	______
3.______	______
4. ______	______
5. ______	______

43. For marketed product, how much is sold and at what cost?

Products	Quantity	Cost (RWF)
1.______	______	______
2. ______	______	______
3. ______	______	______

44. Where are these resources most abundant in Nyungwe Forest?

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Timber: ______________________________
Poles: ______________________________
Medicinal plants: ______________________________
Fruits: ______________________________
Fodder: ______________________________

45. Who do the collection of timber, poles, medicinal herbs and fruit from Nyungwe Forest?
Timber: ______________________________
Poles: ______________________________
Medicinal herbs: ______________________________
Fruit: ______________________________
Fodder: ______________________________

46. Using a scale of 1 to 5, where 1 means "very little" and 5 "very high" could you tell us how much each key resource is harvested at a time?
Timber:_____ Poles: _____ Medicinal herbs:_____ Fruit: _____ Fodder:_____

47. For medicinal plants, which parts of plants are collected or harvested?

Medicinal plants	Parts of plant used
1. ____________	______________________
2. ____________	______________________
3. ____________	______________________
4. ____________	______________________
5. ____________	______________________
6. ____________	______________________
7. ____________	______________________
8. ____________	______________________

48. In which season, medicinal plants, fruit and fodder are most abundant?
Medicinal plants: ______________________________
Fruits: ______________________________
Fodder: ______________________________

49. Are there any changes that have occurred in Nyungwe Forest resources? If yes, why?

Changes	Resources concerned	Reason for change
1. ____________	____________	____________
2. ____________	____________	____________
3. ____________	____________	____________
4. ____________	____________	____________
5. ____________	____________	____________
6. ____________	____________	____________

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VII. Wildlife

50. What wild animals occur in Nyungwe Forest and how abundant are they?

Animal types	Rare	Moderate	Abundant	Very abundant	Most abundant	Don't know
1. ________	-1	-2	-3	-4	-5	-6
2. ________	- 1	-2	-3	-4	-5	-6
3. ________	- 1	-2	-3	-4	-5	-6
4. ________	-1	-2	-3	-4	-5	-6
5. ________	- 1	-2	-3	-4	-5	-6
6. ________	-1	-2	-3	-4	-5	-6
7. ________	- 1	-2	-3	-4	-5	-6
8. ________	- 1	-2	-3	-4	-5	-6
9. ________	-1	-2	-3	-4	-5	-6
10. ________	- 1	-2	-3	-4	-5	-6

51. What types and for what most important purposes are animal hunt? (Mention one for each)

Game | Most important purpose
1. ________________ ________________
2. ________________ ________________
3. ________________ ________________
4. ________________ ________________

52. What kind of change has occurred in animal population size and why?

Change | Wildlife species | Reason for change
1. ________ ________________ ________________
2. ________ ________________ ________________
3. ________ ________________ ________________
4. ________ ________________ ________________

53. For the major games, say when hunting is done?

Animal types | Time for hunting
1. ________________ ________________
2. ________________ ________________
3. ________________ ________________
4. ________________ ________________
5. ________________ ________________

VIII. Institutions

54. In the past, where there any local institutions that were responsible for the management of Nyungwe Forest? If yes, which ones?

1. ________________ 2. ________________ 3. ________________

55. What was the role of local leadership in the management and conservation of Nyungwe Forest resources during that time? (before Nyungwe became a forest reserve)
    1. ____________________
    2. ____________________
    3. ____________________

56. Give examples of some conflicts that arise in Nyungwe resource access and use.
    1. ____________________
    2. ____________________
    3. ____________________
    4. ____________________
    5. ____________________
    6. ____________________

57. Could you tell how each conflict is important using the scale of 1 to 4 where 1 means "not important" and 4 " most important"?

Nature of conflict	Importance of conflict
1. ____________________	__________
2. ____________________	__________
3. ____________________	__________
4. ____________________	__________
5. ____________________	__________

58. For each conflict, what is the most appropriate strategy to avoid it?

Conflict	Use of fine	Consultation/ meeting	courts	Customary approach	None
1. __________	-1	-2	-3	-4	-6
2. __________	- 1	-2	-3	-4	-6
3. __________	- 1	-2	-3	-4	-6
4. __________	-1	-2	-3	-4	-6
5. __________	- 1	-2	-3	-4	-6

59. How are the civil structures / institutions involved in sustainable use and conservation of natural resources
    a. ____________________
    b. ____________________
    c. ____________________

60. According to your opinion, which institutional arrangement could be responsible for management of the Forest for the benefit of local people and why?

____
____
____
____
____

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61. What might be the role of local institutions in the management of Nyungwe Forest resources?
    1. ______________________________
    2. ______________________________
    3. ______________________________
    4. ______________________________
    5. ______________________________

62. What would you do to improve and maintain availability of Nyungwe Forest resources in the future?
    1. ______________________________
    2. ______________________________
    3. ______________________________
    4. ______________________________
    5. ______________________________

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Appendix 2. List of on-farm medicinal plants mentioned by the respondents in the survey area.

Scientific name	Local name	Parts used
Asteracae spp.	Idoma	Leaves, whole plant
Barleria grandicalyx	Bugangabukari	Leaves
Cenecio cydoniifolius	Irarire	Leaves
Clematis simensis	Umunkamba	Leaves
Cynura scandens	Ikizimyamuriro	Leaves
Dychoriste tricocalyx	Akanyamapfundo	Leaves
Iboza riparia	*Umuravumba*	Leaves
Lysimachia ruhmeriana	Umuyobora	Leaves
Mitragyna rubrostipulosa	Umuzibaziba	Leaves, roots
Momordica foetida	Umwishya	Leaves
Ocimum swave	Umwenya	Leaves
Pentas decora	Isagara	Leaves
Physalis peruviana	Iperi	Leaves
Plecthranthus barbatus	Igicunshu	Leaves
Scrabera alata	Umubanga	Leaves
Solanum aculeastrum	Umutobotobo	Leaves
Solanum nigrum	Urusenda	Leaves
Strychnos usambarensis	Umuhoko	Leaves
Tephrosia vogelii	Umuruku	Leaves, roots
Vernonia amygdalina	Umubirizi	Leaves

Appendix 3. Palatable tree and grass species mentioned by 5 or more respondents in the survey area, n = 200.

Scientific name	Local name	Occurrence	% of responses
Panicum hochstetteri	*Ikirumbi*	Everywhere	73
Triumfetta cordifolia	*Umunaba*	Bottomland	25.5
Mariscus thomaiophyllus	*Igikerakezi*	Swamps	17.5
Digitaria hackelii	*Urwili*	Forest gaps	16.5
Ipomea involucrata	*Umuhurura*	Bush	14
Exotheca abyssinica	*Inyovu*	Forest gaps	13.5
Cynodon aethiopicus	*Umunigi*	Everywhere	11.5
Virectaria major	*Urukiryi*	Hilltops	11.0
Pennisetum purpureum	*Urubingo*	Disturbed area	10.5
Botriocline longipes	*Igihehe*	Everywhere	8.5
Ferns	*Ibishihe*	Hilltops	6.5
Arundinaria alpina	*Umugano*	Hilltops	5.0
Sericostachys scandens	*Umukipfu*	Everywhere	4.5
Eragrostis olivacea	*Ishinge*	Forest gaps	4.0
Cynodon nlemfuensis	*Umucaca*	Everywhere	4.0
Syzygium parvifolium	*Umugote*	Disturbed area	3.5
Rubus rigidus	*Umukeri*	Everywhere	3.0
Asystacia gangetica	*Ijojwe*	Everywhere	3.0
Hyparrhenia div. spp.	*Umukenke*	Forest gaps	3.0

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Appendix 4. List of preferred timber tree species by the respondents in the study area, n = 200.

Scientific names	Vernacular names
Afrocrania volkensii	Umujegeshi
Bersama abyssinica	Umukaka
Carapa grandiflora	Umushwati
Cassipourea ruwenzoriensis	Ingongo
Chrysophyllum gorungosanum	Umutoyi
Croton megalocarpus	Umunege
Dasylepsis racemosa	Umugoma, imbayu
Dichaetanthera corymbosa	Umuhube
Entandrophragma excelsum	Umuyove
Faurea saligna	Umutiti
Hagenia abyssinica	Umugeti
Macaranga neomildbraediana	Umusekera
Maesopsis eminii	Umuhumuro
Markhamia lutea	Umusave
Maytenus acuminata	Inembwe
Newtonia buchananii	Umukereko
Ocotea michelsonii	Umuganza
Ocotea usambarensis	Umutake
Oxyanthus troupini	Ingendajoro
Parinari excelsa	Umunazi
Podocarpus falcatus	Umufu
Podocarpus latifolius	Umuhulizi
Polyscias fulva	Umwungo
Prunus africana	Umwumba, rwamba
Rhamnus prinoides	Umusasa
Strombosia scheffleri	Umushyika
Symphonia globulifera	Umushishi
Syzygium parvifolium	Umugote
Zanthoxyllum gilletii	Umuturirwa

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Appendix 5. List of preferred medicinal plants found in Nyungwe Forest, as mentioned by the respondents.

Scientific name	Vernacular name	Part used	Occurrence
Asclepiadacae div. spp.	Indondori	Roots	O
Begonia meyeri-johannis	Irebe	Whole plant	ND
Bridelia brideliifolia	Umugimbu	Roots	F
Brillantaisia cicatricosa	Icyunga	Roots	ND
Canthium glabriflorum	Imvuvu	Bark	ND
Canthium oligocarpum	Umushabarara	Bark	F
Carapa grandiflora	Umushwati	Bark	F
Clerodendron div. spp.	Umukuzanyana	Leaves, roots	O
Crabbea velutina	Sinkangwinguma	Leaves	O
Croton megalocarpus	Umunege	Bark	ND
Cyathula polycephala	Igifashi	Leaves	ND
Dichaetanthera corymbosa	Umuhube	Bark	ND
Dichrostachys cinerea	Umunkamba	Leaves	O
Embelia schimperi	Umukaragata	Roots, wood	ND
Entada abyssinica	Umusange	Leaves, roots	ND
Entandrophragma excelsum	Umuyove	Bark	F
Eucalyptus sp.	Inturusi	Leaves	O
Fagaropsis angolensis	Umugomera	Bark	ND
Fagodia obovata	Umutanoga	Leaves, roots	ND
Faurea saligna	Umutiti	Bark	ND
Iboza riparia	Umuravumba	Leaves	O
Indigofera arrecta	Umutarabana	Roots	ND
Lantana trifolia	Umuhengeri	Leaves	ND
Maesa lanceolata	Umuhanga	Leaves, roots	F
Mikaniopsis tedlei	Umuhokoro	Bark	ND
Mitragyna rubrostipulosa	Umuzibaziba	Leaves, bark	F, O
Momordica foetida	Umwishywa	Leaves	O
Myrica kandtiana	Isubyo	Wood	ND
Neobutonia macrocalyx	Umwanya	Leaves	F
Newtonia buchananii	Umukereko	Bark	F
Ocotea michelsonii	Umuganza	Bark	ND
Ocotea usambarensis	Umutake	Bark	ND
Olea hochstetteri	Intobo	Bark	F
Oxyanthus troupini	Umutovu	Bark	F
Parinari excelsa	Umunazi	Bark	F
Pauridiantha paucinervis	Umusibya	Leaves	F
Pentas decora	Isagara	Leaves, bark	O
Prunus africana	Umwumba	Bark, leaves	ND
Rapanea melanophloes	Uruneke	Bark, leaves	F
Sericostachys scandens	Umukipfu	Leaves	F
Symphonia globulifera	Umushishi	Bark, leaves	F
Synadenum grantii	Umukoni	Roots	ND
Syzygium parvifolium	Umugote	Bark, leaves	F
Tabernamontana johnstonii	Umuronzi	Leaves, bark	F
Vernonia amygdalina	Umuravumba	Leaves	O
Zanthoxyllum usambarense	Intareyirungu	Bark	F
Zanthoxylum gilletii	Umubavu, umuturirwa	Bark	F

F= Forest; O = Outside Forest; ND = Not determined.

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Appendix 6. List of scientific and vernacular names of tree species recorded in all study sites.

Scientific name	Local name
Agauria salicifolia HOOK	Umukarakara
Alangium chinense REDHER	Intogota, umurangara, umuvugangoma
Albizia gummifera C.A. SMITH	Umusebeya
Alchornea hirtella BENTH.	Bwizabwishyamba
Allophylus kiwuensis GILG	Imbayu
*Bersama abyssinica*FRESEN.	Umukaka
Bridelia brideliifolia FEDDE	Umugimbu
Canthium oligocarpum HIERN	Umushabarara
Carapa grandiflora SPRAGUE	Umushwati
Casearia runssorica GILG	Umuhanda
Cassipourea gummiflua J. LEWIS	Intiritiri
Cassipourea ruwenzoriensis ALSTON	Ingongo
Chassalia subcordata ROBYNS	Ikibonobono
Chrysophyllum gorungosanum ENGL	Umutoyi
Chrysophyllum rwandense TROUPIN	Urushehe
Cleistanthus polystachyus HOOK	Umusamba
Combretum orophilum LIBEN	Urubabara
Cremaspora triflora SCHUMANN	Kanyabwoya
Dasylepis racemosa OLIVER	Ingomwa, urubumburi
Dichapetalum heudelotii BAILON	Umumenamabuye
Diospyros gabonensis GUERKE	Umunyakayumbo
Ekebergia capensis SPARRMAN	Umufumba, umujuga
Entandrophragma excelsum SPRAGUE	Umuyove
Galiniera coffeoides DELILE	Umubonobono
Grewia mildbraedii BURRET	Urushingati
Hagenia abyssinica J.F. GMELIN	Umugeti
Harungana montana SPIRLET	Umushayishayi
Ikinyarubabi	Ikinyarubabi
Ilex mitis RADLK.	Umunywande
Lindackeria kivuensis BAMPS	Umunywamazi
Macaranga neomildbraediana LEBRUN	Umusekera
Maesa lanceolata FORSSKAL	Umuhanga
Magnistipula butayei BRENAN	Intambasha
Maytenus acuminata LOES	Inembwe, umunembwe
Memecylon walikalense A. and R. FERNANDES	Umusuri
Millettia psilopetala HARMS	Umunaniranzovu
Myrianthus holstii ENGL.	Umwufe
Neoboutonia macrocalyx PAX	Umwanya
Newtonia buchananii GILBERT and BOUTIQUE	Umukereko
Ochna afzelii R. BR. ex OLIV.	Isanzu, urushingo
Olea hochstetteri BAKER	Intobo
Oricia renieri G. GLIBERT	Umuzo
Oxyanthus troupinii BRIDSON	Umutovu, umuyebe
Parinari excelsa SABINE	Inkungu, umunazi
Pauridiantha paucinervis BREMEK.	Umusibya
Pentadesma reyndersii SPIRLET	Umwasa
Pleiocarpa pycnantha STAPF	Ikinesha
Podocarpus falcatus PILGER	Umufu
Podocarpus latifolius RENDLE	Umuhulizi
Polyscias fulva HARMS	Umwungo
Rapanea melanophloeios MEZ	Uruneke
Rhamnus prinoides L'HERIT.	Umusasa
Rinorea gracilipes ENGL.	Umwicaranyenzi
Ritchiea albersii GILG	Umuhu
Rytigynia kiwuensis ROBYNS	Urusarabatemyi
Strombosia scheffleri ENGL.	Umushyika
Symphonia globulifera L. f.	Umushishi
Syzygium parvifolium MILDBR.	Umugote
Tabernamontana johnstonii PICHON	Umuronzi
Xymalos monospora BAILLON	Umuhotora
Zanthoxylum gilletii WATERMAN	Isoyo, umuturirwa
Zanthoxylum usambarense KOKWARO	Intareyirungu

Appendix 7. Relative frequencies of trees recorded within the large tree category.

Tree species	1	2	3	4	5	Total
Agauria salicifolia	5.60	0.00	0.00	0.00	0.00	**1.28**
Alangium chinense	0.80	0.00	0.00	0.47	0.85	**0.46**
Albizia gummifera	0.40	2.21	0.00	0.47	2.14	**1.00**
Alchornea hirtella	0.00	1.10	0.90	0.95	0.00	**0.55**
Allophylus kiwuensis	1.20	0.00	0.00	0.95	0.00	**0.46**
Bersama abyssinica	0.40	0.00	0.00	0.00	1.71	**0.46**
Bridelia brideliifolia	0.00	0.00	0.00	0.00	0.43	**0.09**
Canthium oligocarpum	0.00	0.00	0.90	0.95	0.00	**0.36**
Carapa grandiflora	9.60	12.71	13.12	14.69	8.12	**11.49**
Casearia runssorica	4.80	7.18	3.17	8.53	5.13	**5.65**
Cassipourea ruwenzoriensis	2.80	3.87	4.07	5.21	4.70	**4.10**
Chassalia subcordata	3.20	0.55	1.81	0.95	0.00	**1.37**
Chrysophyllum gorungosanum	2.40	4.42	0.00	2.84	2.99	**2.46**
Chrysophyllum rwandense	0.40	0.00	0.00	0.00	0.00	**0.09**
Cleistanthus polystachyus	0.00	3.31	24.43	0.00	3.42	**6.20**
Combretum orophilum	0.00	1.10	0.45	0.47	0.85	**0.55**
Cremaspora triflora	2.40	0.00	2.71	4.27	0.00	**1.91**
Dasylepis racemosa	0.40	1.10	0.00	0.47	0.00	**0.36**
Diospyros gabonensis	0.40	2.21	3.62	4.27	0.43	**2.10**
Ekebergia capensis	0.00	0.55	0.00	0.00	0.00	**0.09**
Entandrophragma excelsum	2.80	1.66	0.00	1.90	1.71	**1.64**
Galiniera coffeoides	0.00	0.55	0.00	0.00	0.43	**0.18**
Grewia mildbraedii	2.40	0.00	0.00	2.37	0.43	**1.09**
Hagenia abyssinica	0.40	0.00	0.00	0.00	0.00	**0.09**
Harungana montana	0.00	0.00	0.00	0.00	0.43	**0.09**
Lindackeria kivuensis	0.40	0.00	0.00	0.00	0.00	**0.09**
Macaranga neomildbraediana	9.60	1.66	0.45	0.00	1.28	**2.83**
Maesa lanceolata	7.20	0.00	0.00	0.00	1.28	**1.91**
Magnistipula butayei	0.80	0.00	0.00	0.47	0.00	**0.27**
Memecylon walikalense	1.20	0.55	0.00	1.42	0.43	**0.73**
Myrianthus holstii	6.80	4.97	2.26	8.06	8.55	**6.20**
Neoboutonia buchananii	0.00	0.55	4.07	0.00	0.85	**1.09**
Newtonia macrocalyx	0.00	0.00	0.00	4.27	1.28	**1.09**
non identified	0.40	0.00	0.00	0.47	0.00	**0.18**
Ochna afzelii	0.00	1.10	0.00	0.00	2.56	**0.73**
Olea hochstetteri	0.40	0.00	0.00	0.00	0.00	**0.09**
Oricia renieri	0.40	1.66	0.90	1.90	1.28	**1.19**
Oxyanthus troupiniii	4.00	0.00	0.45	4.27	0.00	**1.82**
Parinari excelsa	1.20	4.97	4.07	4.74	1.71	**3.19**
Pauridiantha paucinervis	2.80	0.00	1.36	1.42	0.00	**1.19**
Pentadesma reyndersii	1.60	0.00	0.45	0.00	0.00	**0.46**
Pleiocarpa pycnantha	0.00	0.55	0.45	0.47	0.00	**0.27**
Podocarpus falcatus	0.00	1.66	0.00	0.00	0.00	**0.27**
Podocarpus latifolius	0.80	0.00	0.00	0.00	0.00	**0.18**
Polyscias fulva	0.40	0.55	0.00	0.47	2.14	**0.73**
Rapanea melanophloeios	3.60	0.00	0.00	0.00	0.00	**0.82**
Rhamnus prinoides	2.80	0.00	0.00	1.90	0.00	**1.00**
Rinorea gracilipes	0.00	6.08	0.90	0.00	1.71	**1.55**
Ritchiea albersii	0.00	0.00	0.45	0.00	0.00	**0.09**
Strombosia scheffleri	6.00	25.41	24.89	17.06	27.78	**19.78**
Symphonia globulifera	3.60	3.31	1.36	2.84	9.83	**4.28**
Syzygium parvifolium	5.60	2.21	0.90	0.47	0.00	**1.91**
Tabernamontana johnstonii	0.00	1.66	1.81	0.00	5.13	**1.73**
Zanthoxylum gilletii	0.00	0.55	0.00	0.00	0.43	**0.18**
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**

1 = Musebeya; 2 = Nshili; 3 = Kagano; 4 = Mudasomwa; 5 = Busozo

Appendix 8. Relative frequencies of trees recorded within the medium tree category

Tree species	1	2	3	4	5	Total
Alangium chinense	0.00	2.30	0.35	0.50	0.00	**0.40**
Albizia gummifera	2.34	12.64	0.00	2.50	4.71	**3.02**
Alchornea hirtella	0.00	0.00	0.00	0.50	0.00	**0.10**
Allophylus kiwuensis	0.00	0.00	0.35	0.00	0.00	**0.10**
Bersama abyssinica	0.00	5.75	0.35	0.00	1.18	**0.80**
Bridelia brideliifolia	0.00	0.00	0.00	0.50	0.00	**0.10**
Canthium oligocarpum	7.42	0.00	0.00	1.00	0.00	**2.11**
Carapa grandiflora	8.59	13.79	6.03	8.50	8.24	**8.24**
Casearia runssorica	2.34	2.30	5.67	8.00	4.12	**4.72**
Cassipourea gummiflua	0.39	0.00	0.00	0.50	0.00	**0.20**
Cassipourea ruwenzoriensis	0.39	4.60	16.31	4.50	9.41	**7.64**
Chassalia subcordata	9.38	1.15	2.48	1.00	5.29	**4.32**
Chrysophyllum gorungosanum	3.52	6.90	1.77	4.50	2.94	**3.42**
Cleistanthus polystachyus	0.00	2.30	4.61	0.00	1.76	**1.81**
Combretum orophilum	0.00	0.00	0.35	0.00	8.82	**1.61**
Cremaspora triflora	3.13	0.00	1.42	2.50	0.00	**1.71**
Dasylepsis racemosa	0.00	0.00	0.35	0.00	0.00	**0.10**
Dichapetalum heudelotii	0.00	0.00	0.00	6.50	5.88	**2.31**
Diospyros gabonensis	0.00	0.00	1.42	2.50	1.18	**1.11**
Ekebergia capensis	0.39	0.00	0.00	0.00	0.00	**0.10**
Entandrophragma excelsum	1.17	0.00	0.00	1.00	0.00	**0.50**
Grewia mildbraedii	1.17	0.00	0.35	1.50	1.76	**1.01**
Unidentified 'Ikinyarubabi'	0.78	0.00	0.00	0.00	0.00	**0.20**
Ilex mitis	0.78	0.00	0.71	0.50	0.00	**0.50**
Lindackeria kivuensis	0.39	0.00	0.00	0.00	0.00	**0.10**
Macaranga neomildbraediana	2.34	2.30	1.42	1.00	1.76	**1.71**
Maesa lanceolata	0.39	0.00	0.00	0.00	0.00	**0.10**
Magnistipula butayei	0.39	0.00	0.71	0.50	0.00	**0.40**
Maytenus acuminata	4.69	0.00	0.35	0.50	0.00	**1.41**
Memecylon walikalense	0.39	0.00	0.00	0.00	0.59	**0.20**
Myrianthus holstii	0.78	1.15	0.35	2.50	5.29	**1.81**
Neoboutonia macrocalyx	0.00	0.00	0.00	0.00	0.59	**0.10**
Newtonia buchananii	3.13	4.60	0.00	5.00	5.88	**3.22**
Ochna afzelii	0.00	4.60	0.00	0.50	0.00	**0.50**
Olea hochstetteri	1.17	0.00	0.35	0.50	0.00	**0.50**
Oricia renieri	3.52	6.90	0.00	11.50	3.53	**4.42**
Oxyanthus troupiniii	11.33	1.15	10.64	9.00	0.59	**7.94**
Parinari excelsa	1.17	0.00	1.42	3.00	0.00	**1.31**
Pauridiantha paucinervis	0.78	0.00	1.42	1.50	1.18	**1.11**
Pentadesma reyndersii	0.00	0.00	0.71	0.00	0.00	**0.20**
Pleiocarpa pycnantha	0.00	3.45	3.55	0.50	1.18	**1.61**
Podocarpus latifolius	1.17	0.00	0.00	0.00	0.00	**0.30**
Polyscias fulva	0.00	6.90	0.35	0.50	0.59	**0.90**
Rapanea melanophloeios	1.17	0.00	0.00	0.00	0.00	**0.30**
Rinorea gracilipes	0.00	5.75	1.06	0.00	0.00	**0.80**
Ritchiea albersii	2.34	0.00	4.26	3.00	0.59	**2.51**
Rytigynia kiwuensis	6.25	0.00	0.00	0.00	0.00	**1.61**
Strombosia scheffleri	1.17	0.00	5.67	3.00	9.41	**4.12**
Symphonia globulifera	2.73	11.49	15.25	8.50	12.94	**9.95**
Syzygium parvifolium	5.86	0.00	8.16	0.50	0.00	**3.92**
Tabernamontana johnstonii	0.39	0.00	0.35	1.00	0.59	**0.50**
Xymalos monospora	6.64	0.00	0.00	0.00	0.00	**1.71**
Zanthoxylum gilletii	0.00	0.00	1.06	0.00	0.00	**0.30**
Zanthoxylum usambarense	0.00	0.00	0.35	1.00	0.00	**0.30**
Total	**100**	**100**	**100**	**100**	**100**	**100**

1 = Musebeya; 2 = Nshili; 3 = Kagano; 4 = Mudasomwa; 5 = Busozo

Appendix 9. Relative frequencies of small trees recorded within the small tree category.

Tree species	1	2	3	4	5	Total
Albizia gummifera	0.00	11.11	0.00	0.00	0.00	**1.21**
Alchornea hirtella	0.00	0.00	0.00	0.00	2.00	**0.40**
Carapa grandiflora	20.00	0.00	16.07	28.57	12.00	**15.38**
Casearia runssorica	3.33	7.41	1.79	0.00	2.00	**2.43**
Cassipourea ruwenzoriensis	0.00	0.00	3.57	0.00	4.00	**2.43**
Chassalia subcordata	20.00	0.00	0.89	0.00	4.00	**3.64**
Chrysophyllum gorungosanum	3.33	0.00	8.93	17.86	2.00	**6.88**
Cleistanthus polystachyus	0.00	7.41	6.25	0.00	0.00	**3.64**
Combretum orophilum	0.00	14.81	0.00	0.00	18.00	**5.26**
Dichapetalum heudelotii	0.00	3.70	0.00	3.57	4.00	**1.62**
Diospyros gabonensis	0.00	3.70	0.00	0.00	2.00	**0.81**
Ikinyarubabi	3.33	0.00	0.00	0.00	0.00	**0.40**
Macaranga neomildbraediana	0.00	0.00	0.89	0.00	2.00	**0.81**
Magnistipula butayei	0.00	3.70	0.00	14.29	0.00	**2.02**
Milletia psilopetala	0.00	0.00	0.00	3.57	0.00	**0.40**
Myrianthus holstii	3.33	7.41	0.00	0.00	10.00	**3.24**
Newtonia buchananii	0.00	0.00	30.36	0.00	0.00	**13.77**
Ochna afzelii	0.00	3.70	0.00	0.00	0.00	**0.40**
Olea hochstetteri	0.00	0.00	0.89	0.00	0.00	**0.40**
Oricia renieri	0.00	0.00	0.00	3.57	6.00	**1.62**
Oxyanthus troupiniii	23.33	0.00	2.68	0.00	2.00	**4.45**
Parinari excelsa	0.00	0.00	0.89	0.00	0.00	**0.40**
Pauridiantha paucinervis	3.33	0.00	0.00	3.57	2.00	**1.21**
Pentadesma reyndersii	0.00	0.00	1.79	0.00	0.00	**0.81**
Pleiocarpa pycnantha	0.00	3.70	0.00	0.00	0.00	**0.40**
Polyscias fulva	0.00	3.70	1.79	0.00	0.00	**1.21**
Rhamnus prinoides	0.00	7.41	0.00	0.00	2.00	**1.21**
Rinorea gracilipes	0.00	7.41	0.00	0.00	0.00	**0.81**
Ritchiea albersii	0.00	0.00	0.89	0.00	0.00	**0.40**
Strombosia scheffleri	0.00	3.70	0.89	7.14	8.00	**3.24**
Symphonia globulifera	6.67	11.11	16.96	17.86	16.00	**14.98**
Syzygium parvifolium	10.00	0.00	4.46	0.00	0.00	**3.24**
Tabernamontana johnstonii	0.00	0.00	0.00	0.00	2.00	**0.40**
Xymalos monospora	3.33	0.00	0.00	0.00	0.00	**0.40**
Total	**100**	**100**	**100**	**100**	**100**	**100**

1 = Musebeya; 2 = Nshili; 3 = Kagano; 4 = Mudasomwa; 5 = Busozo

Appendix 10. Basal areas of tree species within the large tree category in the sample area.

Tree species	Frequency	basal area, m^2	Relative basal area	mean basal area, m^2
Agauria salicifolia	14	1.9761	0.0176	0.1412
Alangium chinense	5	0.1251	0.0011	0.0250
Albizia gummifera	11	0.4490	0.0040	0.0408
Alchornea hirtella	6	0.0797	0.0007	0.0133
Allophylus kiwuensis	5	0.0605	0.0005	0.0121
Bersama abyssinica	5	0.1075	0.0010	0.0215
Bridelia brideliifolia	1	0.0839	0.0007	0.0839
Canthium oligocarpum	4	0.0468	0.0004	0.0117
Carapa grandiflora	126	9.2044	0.0820	0.0731
Casearia runssorica	62	4.4855	0.0400	0.0723
Cassipourea ruwenzoriensis	45	2.0773	0.0185	0.0462
Chassalia subcordata	15	0.6195	0.0055	0.0413
Chrysophyllum gorungosanum	27	3.9447	0.0352	0.1461
Chrysophyllum rwandense	1	0.0094	0.0001	0.0094
Cleistanthus polystachyus	68	7.9985	0.0713	0.1176
Combretum orophilum	6	0.0837	0.0007	0.0140
Cremaspora triflora	21	0.3294	0.0029	0.0157
Dasylepis racemosa	4	0.1261	0.0011	0.0315
Diospyros gabonensis	23	1.7815	0.0159	0.0775
Ekebergia capensis	1	0.1988	0.0018	0.1988
Entandrophragma excelsum	18	3.9164	0.0349	0.2176
Galiniera coffeoides	2	0.0247	0.0002	0.0123
Grewia mildbraedii	12	1.9279	0.0172	0.1607
Hagenia abyssinica	1	0.0314	0.0003	0.0314
Harungana montana	1	0.0326	0.0003	0.0326
Ikinyarubabi	2	0.0198	0.0002	0.0099
Lindackeria kivuensis	1	0.0082	0.0001	0.0082
Macaranga neomildbraediana	31	1.5163	0.0135	0.0489
Maesa lanceolata	21	0.7440	0.0066	0.0354
Magnistipula butayei	3	0.0888	0.0008	0.0296
Memecylon walikalense	8	0.2945	0.0026	0.0368
Myrianthus holstii	68	2.5679	0.0229	0.0378
Neoboutonia macrocalyx	3	0.0386	0.0003	0.0129
Newtonia buchananii	21	15.4484	0.1377	0.7356
Ochna afzelii	8	2.2266	0.0198	0.2783
Olea hochstetteri	1	0.0452	0.0004	0.0452
Oricia renieri	13	0.1820	0.0016	0.0140
Oxyanthus troupinii	20	0.7252	0.0065	0.0363
Parinari excelsa	35	12.3693	0.1103	0.3534
Pauridiantha paucinervis	13	0.8350	0.0074	0.0642
Pentadesma reyndersii	5	0.3354	0.0030	0.0671
Pleiocarpa pycnantha	3	0.0656	0.0006	0.0219
Podocarpus falcatus	3	0.2635	0.0023	0.0878
Podocarpus latifolius	2	0.1433	0.0013	0.0716
Polyscias fulva	8	0.9756	0.0087	0.1219
Rapanea melanophloeios	9	1.0812	0.0096	0.1201
Rhamnus prinoides	11	2.7289	0.0243	0.2481
Rinorea gracilipes	17	0.5200	0.0046	0.0306
Ritchiea albersii	1	0.0143	0.0001	0.0143
Strombosia scheffleri	217	17.8591	0.1592	0.0823
Symphonia globulifera	47	6.8172	0.0608	0.1450
Syzygium parvifolium	21	2.6544	0.0237	0.1264
Tabernamontana johnstonii	19	0.9918	0.0088	0.0522
Zanthoxylum gilletii	2	0.9033	0.0081	0.4517
Total	1097	112.1841	1.0000	0.1023