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# Evaluating Conservation Policy: Integrated Conservation and Development in Bwindi Impenetrable National Park, Uganda

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# Abstract

Integrated conservation and development has been adopted for the management of protected areas throughout the tropics. Evaluating this policy is therefore critical. Most evaluations to date have focused on impacts on local communities, particularly on attitudes towards conservation. In contrast, impacts on biodiversity and on threats to biodiversity are little studied. Consequently, the most critical aspect of the effectiveness of the integrated approach for protected area conservation has yet to be determined.

The mountain gorillas of Bwindi Impenetrable National Park are the prime tourist attraction of Uganda and the flagship species for efforts to conserve the forest. Various integrated strategies have been adopted at Bwindi to reduce threats to the gorillas from snares set for bushmeat, and from conflicts between conservation managers and local communities over lost access to resources and crop raiding by wild animals. Bwindi has been a National Park for over ten years and has been hailed a success in protected area management through its integrated approach. In particular, the establishment of harvest zones within the National Park for sanctioned resource collection was key in reducing conflicts around Bwindi, and in improving the attitudes of local communities towards the National Park. However, impacts of harvest zones on biodiversity or on reducing threats to biodiversity have not been determined.

In this thesis I evaluate the integrated approach for protected area conservation. I determine the distribution of bushmeat poaching in Bwindi over the periods of National Park gazettement and sanctioned resource harvesting, the interactions between local communities and law enforcement rangers during gazettement and after harvest zones were established, and the distribution of gorillas in relation to illegal activity and harvest zones. The analysis was based on law enforcement data from 1986-2000, which covered the period of national park designation and establishment of harvest zones.

Following the gazettement of Bwindi as a National Park, poachers entered the forest less frequently but set larger snare clusters while inside the forest. After harvest zones were established when local attitudes towards the National Park improved, poachers avoided heavily patrolled high harvest zones but continued their activities in the less well-patrolled interior forest and low and medium harvest zones. Overall however, law enforcement was most significant to patrol encounters with poaching.

Most poachers in Bwindi are Bakiga agriculturalists hunting bushmeat with snares, mainly for domestic consumption. The activities of poachers over the gazettement and harvest zone periods indicates that the integrated programme failed to reduce threats to gorillas from snares, despite gaining local support for conservation. However, anecdotal records suggest that beekeepers of the harvest programme refrained from poaching after harvest zones were established. Several factors including law enforcement and impacts of sanctioned resource harvesting could have influenced the poachers. Therefore, while law enforcement appears central to the conservation strategy of Bwindi, further study of the benefits that poachers received from Bwindi's integrated programme is necessary to determine the effectiveness of the integrated approach in protected area conservation.

Incidents of violent conflict between local communities and staff of Bwindi during gazettement primarily occurred because of the arrest of miners and pit sawyers, and were largely instigated by villagers. Thus the loss of income from gazettement was a major cause of conflict. After establishment of harvest zones, beekeepers of high harvest zones and communities adjacent to high harvest zones demonstrated their support for the National Park by reporting illegal activity to rangers. However, most interactions between communities and rangers after establishment of harvest zones were complaints about crop raiding, particularly by communities who received little assistance from the National Park with mitigating crop raiding by baboons. Therefore, substituting lost income and problem animal control would be appropriate strategies to alleviate conflict between local communities and managers of Bwindi, and reduce the threat that this conflict poses to gorillas.

The establishment of harvest zones at Bwindi was in contrast to the more traditional methods of law enforcement employed for the mountain gorilla National Parks of the Virungas. The harvest zones were also controversial. Before Bwindi was gazetted a National Park, human disturbance from mining and pit sawing was considered a primary factor restricting gorillas to forest interior areas. After establishment of harvest zones, disturbance from harvesters and possible increases in illegal activity from allowing local communities into the National Park, could limit the forest areas utilised by gorillas. Gorillas remained concentrated in forest interior areas after establishment of harvest zones. In addition, gorillas continued not to utilise boundary areas of high harvest zones. Other species sensitive to human disturbance were also negatively associated with high harvest zones. Impacts from harvest zones were difficult to determine because several factors influence wildlife distribution in Bwindi, including ecological and demographic factors and historical human use of the forest. Nonetheless, disturbance from sanctioned resource harvesting on species of conservation concern appears an important consideration for managers of protected areas.

In conclusion, a dual strategy of law enforcement and sanctioned resource harvesting is recommended for the conservation of Bwindi. Law enforcement was most significant to activities of local poachers, while sanctioned resource harvesting promoted community support for National Park conservation.

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## General Introduction

*The tourist campsite run by local community members at Buhoma, the headquarters of Bwindi*

*(J. Baker)*

# Chapter One

# 1 General introduction

In this thesis, I aim to evaluate the effectiveness of integrated conservation and rural development for protected area conservation, and examine the establishment of harvest zones in Bwindi Impenetrable National Park, Uganda as a case study of the ICDP approach. Previous research in Bwindi had already documented that the attitudes of local communities had improved following the establishment of the harvest zones in the National Park. However, it was not known if the establishment of harvest zones had reduced levels of bushmeat poaching or improved the status of Bwindi's flagship species, the mountain gorilla. Using long-term data on law enforcement patrols, the specific objectives of this study are to investigate whether two key events, those of National Park gazettement in 1991 and of establishing harvest zones between 1994 and 1995, affected the activities of poachers seeking bushmeat, the interactions between law enforcement rangers and local communities, and the distribution of mountain gorillas.

## 1.1 Conservation policy

The formulation of policies for biodiversity conservation has become increasingly important to international conservation efforts. The Convention on Biological Diversity established a framework for national conservation agencies to adopt policies with clearly defined goals and courses of action to achieve target objectives (Glowka *et al*, 1994). Much emphasis has since been placed on the role of policy in improving the practice of conservation (Agrawal and Gibson, 1999; Walls *et al*, 1999; Salafsky *et al*, 2002) and directing funding into the more effective strategies (Tisdell, 1995; Peuhkuri and Jokinen, 1999). The appropriate investment of conservation funds is crucial because programmes, in particular those of protected areas in developing countries, must be adequately funded to achieve conservation goals (Leader-Williams and Albon, 1988; Balmford and Whitten, 2003; Balmford *et al*, 2003). In recent years, stricter demands by donors for accountability (Tisdell, 1995) have instigated calls for empirical evaluation of conservation programmes (Salafsky *et al*, 2002). Evaluations determine how well a programme has performed and its success or failure in achieving policy objectives (Barrow *et al*, 2000). As conservation policy impacts both upon wildlife populations and upon the social and economic frameworks of people living around protected areas, multi-disciplinary evaluations are necessary to account for these multiple perspectives. However, such evaluations are rarely undertaken (Agrawal and Gibson, 1999) and the result has been a gradual and inefficient response by decision-makers to poor conservation outcomes, such as the "fences and fines" management approach of protected areas, which many now accept have failed to preserve valuable flagship species in the tropics (e.g. Bell and McShane-Caluzi, 1986; Leader-Williams and Albon, 1988). Protected areas are the most widespread measure used to conserve biodiversity, yet threats and conflict continue (Lewis, 1996). A variety of strategies have been proposed to address problem issues. However, the lack of formal evaluations limits understanding of successful conservation, and debate continues over the most effective policy for protected area management.

### 1.1.1 The change to integration

There is increasing evidence that areas of outstanding conservation importance coincide with dense human settlement. This situation is common in sub-Saharan Africa, where areas of high conservation value are under threat from rising populations whose livelihoods depend upon the natural resource base (Balmford *et al*, 2001). Throughout Africa, protected areas are central to conservation and have proven effective in protecting many ecosystems and species (Bruner *et al*, 2001). However, the strictly protectionist approach has given way to a radical change in policy that encompasses the role of local communities in conservation. Hence, the fundamental basis of fully protected areas has been questioned, and the adoption of community-based conservation (CBC) has arisen from a greater understanding of linkages between protected areas and rural development. The 1980 World Conservation Strategy first focussed international attention on the relationship between conservation threats and the poverty of surrounding populations (IUCN, 1980). This was given further emphasis by the World Congress on National Parks in 1982, which highlighted the importance of local economic activities to national park management, and led to conservationists prioritising conflict between national parks and local communities as an issue to address by increasing park support to local communities.

A variety of measures for this support have been proposed and in some cases implemented, which include revenue sharing, management participation, development schemes and access to natural resources (McNeely and Miller, 1984; McNeely, 1988; McNeely, 1994; du Toit, 2002; Stem *et al*, 2003). CBC adopted these principles and was formed on the premise that communities will protect and conserve wildlife if it is in their interest to do so (Hackel, 1999). The policy was seen as the most practical approach to address biodiversity loss in developing countries, as the main objectives were the active participation of local communities in resource management and the equitable sharing of conservation benefits (Gibson and Marks, 1995). However, many projects failed to achieve community participation and heightened conflict occurred where attempts at compensation through alternative livelihoods or hand-outs were inadequate or unequally distributed (Agrawal and Gibson, 1999; Songorwa, 1999). Doubts over the effectiveness of CBC led to further revision of conservation policy. The concept of integrated conservation and development emerged, based on the hypothesis that conservation and development are mutually dependent and failure of one will result in failure of both. The concept was formalised as a conservation strategy by the introduction of integrated conservation and development programmes (ICDPs) in 1985 by the World Wide Fund for Nature (WWF), as part of their Wildlands and Human Needs Program (Larson *et al*, 1997).

### 1.1.2 Integrated conservation and development programmes

ICDPs were introduced as a radical new approach that held great promise for overcoming major obstacles to conservation efforts. The programmes attracted considerable funding and were rapidly implemented within protected areas across the world. The first ICDPs aimed to conserve biodiversity by improving the quality of life of rural people through projects that integrated natural resource management with grass-root economics (Larson *et al*, 1997). In practice, attempts were made to reduce threats to protected areas and improve the attitudes of local communities through the provision of social services, including schools, health clinics and roads, as compensation for the costs they incurred on behalf of conservation. The Beza Mahafaly Special Reserve in southern Madagascar became the focus of an early ICDP, which incorporated various development activities that included constructing a school, providing agricultural extension services and developing a community health programme (Larson *et al*, 1997). This and similar ICDPs became large, multi-institutional efforts that relied on external expertise. Concerns soon arose over the long-term funding requirements (Kremen *et al*, 1998) and, as the development interventions bore no relation to conservation, that ICDPs were too focused on rural development (Wells *et al*, 1992). The programmes were widely considered as large, complex experiments that alienated communities from resource management (Kremen *et al*, 1998) and failed to link conservation and development (Wells *et al*, 1992).

In response to criticism, a second generation of refined ICDPs was developed. Based on the principle that local populations will only abide by conservation measures once their own socio-economic well-being is assured (Kremen *et al*, 1998), the aim was to provide communities with sustainable economic alternatives to destructive harvesting and land use practices (Wells and Brandon, 1993; Alpert, 1995). Particular emphasis was given to resolving conflict between protected areas and communities by a broad array of strategies to alleviate local conservation costs and ensure local benefits.

Collaborative management was one of the strategies promoted to address conflict issues, as these efforts seek to share the benefits, responsibilities and decision-making powers among stakeholders of the resource (Wells and Brandon, 1993). Collaborative management can also involve communities in resource management for sustainable use, although the degree to which communities are brought into the decision-making process is determined by the ecological and social context of ICDPs (Borrini-Feyerabend, 1996). Sustainable resource-use strategies aim to reduce the cost of resource loss for local communities and gain their support for protected areas (Wild and Mutebi, 1996). Local resource use can effectively alleviate conflicts that are frustrating conservation efforts (Scott, 1998) and are commonly implemented through a system of buffer zones. Buffer zones were originally adjacent to protected areas for the harvesting of wildlife and non-timber forest products (Mackinnon *et al*, 1986), but have since been accepted by some as harvest zones inside a protected area (Wells and

Brandon, 1993). Several projects in tropical forests have implemented harvest zones for the collection of minor forest products, which include wild plant resources, honey and bamboo (Boot and Gullison, 1995), as these products provide rural communities with vital basic needs, such as building materials, fuel, food and medicines, and important cultural traditions (Cunningham, 1996).

The initial enthusiasm and support for ICDPs continued with this second generation of projects. The projects varied in size and budget from a small marine park in Haiti with a budget of several thousand dollars, to national level support for the ICDP approach in Namibia, which involved $10 million over 10 years (Larson *et al*, 1997). However, despite refinements, criticism has continued, as has debate on whether the integrated approach to reconcile conservation and development objectives is the most effective to conserve protected areas (Barrett and Arcese, 1995).

### 1.1.3. The ICDP debate

The rapid implementation of ICDPs raised concerns that projects were based on untested biological and economic assumptions (Wells and Brandon, 1993). Many criticisms, from both biological and socio-economic perspectives, have since followed.

The biological arguments consider the harvesting of wildlife and non-timber forest products from protected areas. Some conservationists argue that incorporating resource extraction into a protected area management strategy will compromise conservation objectives because of the difficulties inherent in resource harvesting (Barrett and Arcese, 1995; Scott, 1998). Managers of wildlife cropping schemes require information on the number, social system, survival and reproductive rate of the species (Caughley, 1997; du Toit, 2002), which for many African mammals is difficult and costly to obtain (Bell and McShane-Caluzi, 1986). Wildlife cropping has been promoted for some ICDPs with no emphasis on monitoring. As a result, the ability of managers to response to fluctuating wildlife populations and ensure sustainable harvest levels is in doubt (Barrett and Arcese, 1995; du Toit, 2002).

Similar concerns have been raised for harvests of non-timber and minor forest products. Although the collection of such products is considered the least harmful extractive use of forests (Jacob, 1988), resources can be over-exploited without guidelines or adequate regulations (Scott, 1998). The likelihood of over-exploitation depends on demand, supply, the part of the plant harvested and growth form (Cunningham, 1996). The most frequent cause of over-use documented in the literature is an increased demand by harvesters, such as the destruction of medicinal plants and dye resources by ring-barking and uprooting in Africa (Cunningham, 1987; 1990), the depletion of copal and rattan resources in the Philippines (Conelly, 1985) and the over-exploitation of two species of palm fruits in the Peruvian Amazon (Vasquez and Gentry, 1989; Peters, 1990). Managers of ICDPs that incorporate resource harvesting must address the risk of over-exploitation by achieving an optimum balance between the number of harvesters and the conservation value of the species (Cunningham, 1996). With such difficulties, resource harvesting could be detrimental to fragile ecosystems or endangered species, yet many projects employ this strategy because of the benefits to local communities and their involvement in resource management.

Community participation is another fundamental component of many ICDPs that has been heavily criticised. Political ecologists declare that ICDPs have failed to devolve wildlife management authority to local communities (Ghimire, 1994). Indeed, an internal WWF review found that many ICDP projects had not incorporated the interests of key stakeholders and that participation was particularly difficult in forest-based ICDPs, where local resource use is intensive (Larson *et al*, 1997). In particular, forest projects which are managed through a centralised body have not been successful in meeting either conservation goals, or the needs of local people (Fisher, 1995). Controlled resource access aims to ensure that the people who pay the costs of conservation receive a share of the benefits through either subsistence or commercial use (Scott, 1998). The commercial use of protected area resources can involve products for local and international markets. Several conditions must be met for this type of conservation-based enterprise to succeed, among which the most important are access to markets and the ability of producers to obtain a significant share of the eventual retail price. It is also difficult to ensure economic viability from maximum production, whilst maintaining the ecological integrity of the resource base (Larson *et* *al*, 1997). Much criticism of ICDPs has focused on these enterprises because of the threat to conservation if local economies have priority over ecological principles (Hackel, 1999; Oates, 1999). Barrett and Arcese (1995) explored the issues of conservation-based enterprises and emphasised concern over continuing the local dependence on protected area resources, and whether present-day benefits could meet future demands with rising human populations. They recommended great caution when enterprises are the primary economic incentive to conservation.

The use of economic benefits as a conservation tool is a common feature of the ICDP approach. However, the various critics of ICDPs all recognise that more must be done to link economic benefits directly to wildlife survival (Wells and Brandon, 1993). Linking economic benefits to wildlife conservation is difficult, especially where wildlife is endangered and local poverty is acute (Archabald and Naughton-Treves, 2001). Various strategies have been promoted as providing economic benefits and securing conservation. These include sustainable agriculture, agroforestry and the sharing of tourism revenue, as well as conservation-based enterprises. Revenue sharing is common at sites where charismatic species attract large numbers of tourists. This non-consumptive means of generating local income is employed to offset conservation costs and build protected area support by transferring economic benefits to local communities (Wunder, 2000; Walpole and Goodwin, 2001; Walpole and Leader-Williams, 2002). Revenue schemes can improve local attitudes towards conservation (Archabald and Naughton-Treves, 2001). However, the success achieved by these programmes is mixed (Stem *et al*, 2003) and distribution issues commonly frustrate managers because of the difficulty in deciding who should receive the revenue and how to disburse it equally. The solution generally adopted is to share revenue with communities who most immediately affect, and are affected by, the protected area (Wells, Brandon and Hannah, 1992; Western and Wright, 1994; Ross and Wall, 1999). However, those who have the greatest impact on conservation are not necessarily the same as those suffering the greatest costs (Barrett and Arcese, 1995), and the uneven distribution of costs and benefits impedes efforts to ensure the benefits of conservation reach the local level (Archabald and Naughton-Treves, 2001).

It is now over 15 years since ICDPs were established in various protected areas across the world. A notable feature in many of the evaluations of ICDPs is the lack of successful examples (Smith *et al*, 1998; UNDP, 2000). This could be because of the short time period since ICDPs were first introduced, or because efforts to reconcile conservation and development are more likely to achieve a best compromise and only the problems have been documented (Hughes and Flintan, 2001). However, many agree that ICDPs have failed to link conservation and development (Wells, Brandon and Hannah, 1992; Malleson, 2002), although the advocates of ICDPs maintain that integrated conservation and development efforts are essential to conserve biodiversity. They claim this slow and complex process of changing the way people manage resources and earn their livelihoods means that ICDPs can only develop and improve gradually (Larson *et al*, 1997; Abbot *et al*, 2001; Browder, 2002). The debate therefore continues, but is restricted in many instances by the lack of monitoring and evaluation.

Monitoring projects requires a multi-disciplinary approach that includes ecological and socio-economic impacts if it is to be determined that integration of conservation and development objectives can protect wildlife (Larson and Svendsen, 1995). However, few ICDPs employ a comprehensive monitoring system and judgements are based on anecdotal accounts of programme activities (Larson *et al*, 1997). A major barrier to monitoring efforts has been the view of project managers that monitoring is a burden that adds to their workload, and requires time and funding to implement (Borrini-Feyerabend, 1996). Further barriers include the lack of guidelines to design and conduct efficient monitoring systems (Larson and Svendsen, 1995; Abbot and Guijt, 1998), and the reluctance of managers to discuss project weaknesses for fear that funding will be discontinued (Brown and Wyckoff-Baird, 1994).

ICDPs are currently viewed as biodiversity conservation projects with rural development components that aim to meet development priorities and conservation goals, with the use of socio-economic tools as a conservation strategy. There are now over three hundred ICDPs worldwide that account for a large proportion of international conservation funding. For example, the protected area network in Indonesia is supported by donor funds for ICDP programmes that total US$130 million (Hughes and Flintan, 2001). Yet, despite this wide implementation and substantial funding, debate as to whether ICDPs can effectively conserve protected areas continues. Until the barriers to monitoring are overcome and rigorous evaluations conducted, the ICDP debate will remain difficult to conclude.

## 1.2 Policy in Uganda

### 1.2.1 Regulating wealth

Different ruling regimes have imposed changes on policies for managing Uganda's wealth of natural resources. Uganda is similar to other African countries where traditional systems of resource use were overturned by the centralised administration during colonial rule. However, throughout Uganda's history the policies have, in conservation terms, often been earnest and far-sighted attempts to guide best practice for resource use, and have greatly influenced the conservation status of the forests and wildlife.

The written history of rule in Uganda dates back to the fifteenth century when the first kingdom of Bunyoro was established around Lake Victoria. After two centuries of domination by Bunyoro, the governor of the western Buganda area declared his independence and his kingdom. Two smaller kingdoms, Ankole and Toro, were formed in the north and Uganda was ruled as the four kingdoms of Bunyoro, Buganda, Ankole and Toro. Land was divided among the nobility, who administered their agricultural economy based on peasant farming, which was mainly by shifting cultivation (Varady, 1982). Land tenure within villages was under a system whereby each person had equal rights to the land and could use their surrounding forest and wildlife resources freely (Kamugisha, 1993). This aspect of the traditional system of resource use was changed under colonial rule.

The first Europeans to visit Uganda were the British explorers John Hanning Speke and James Grant, in 1862, during their search for the source of the Nile. As part of the scramble for African territory by European nations, Uganda was declared a British Protectorate in 1894. The first act of the colonial administration was to control local resource use. Large areas were designated as Crown property where people were forbidden to enter and collect resources. A policy for the management of forests and wildlife was also established. The first policies founded the principles of natural resource management in Uganda, and those that followed were only amendments to original concepts. Hence, there is no benchmark year or era of radical change in resource management in colonial Uganda. Even after Independence in 1962, many of the first principles remained fundamental to the country's forest and wildlife policies.

### 1.2.2 National and local demand for forest resources

Forests were the first resource to be managed by the colonial administration. A forestry service was created in 1898, primarily to direct production but also to manage the Crown forests. The service established harvesting systems and administered agreements with each kingdom regarding prohibitions on local access to Crown forests. Commercial activity began in 1902 with wild rubber collection and was quickly followed with other minor forest products including fibres, palms and edible fruits (Osmaston, 1959). The forestry service expanded its policy of production when it began harvesting timber around 1910. Timber was harvested mainly by pitsawing, but was without a defined policy or long-term planning. Timber production continued until 1929, when a report was published on forestry in Uganda (Nicholson, 1929), which had a profound effect on the practice. The report laid out a structure for the Forestry Department, which was then established, and the Department's primary goal became to safeguard the forest resources of Uganda. Nicholson (1929) emphasised the value of forests in benefiting Uganda and in protecting the environment by their influence on climate and water reservoirs. Accordingly, he declared that the main duties of the Forestry Department were to establish the national forest estate by reserve selection, and to conduct research and afforestation schemes.

Nicholson (1929) also recognised that rural communities depended heavily on forest resources. He recommended that local supplies of firewood, poles and sawn timber be guaranteed by encouraging farmers to grow trees, and by establishing small plantations under local administrative control. The report was incorporated into the first official forest policy of 1948, although the emphasis on the benefit of forests was changed from environmental protection to agricultural production. This decision was made in response to the demand for food and cash crops that followed the Second World War, and limited the Department's acquisition of land to allow adequate areas for farming. Forest cover in each district sought to encompass the minimum area that would achieve management aims. These areas were calculated on the basis of wood consumption per head and district population size, with adjustments made for production capacity and land use pressures within each district. The policy did follow Nicholson's (1929) guidelines on reserve management and established a two-tier system. Large central reserves were placed under the control of the government, in order to serve regional needs. In contrast, smaller reserves were put under the control of local administration so as to cater for local demands. Nicholson's (1929) principle that the responsibility for meeting village-level wood requirements should rest at local level was applied, as local administration was considered more cost-effective and efficient, as well as generating a public interest in forestry (Forest Department, 1955). During this period, the government relinquished timber extraction and processing to the private sector, and established a licensing system to regulate the volume and type of timber harvested. Commercial firms applied for exclusive felling licences for a defined area over a certain period and paid fees to the Forestry Department for the volume cut (Hamilton, 1984).

From 1930 to 1960, the achievements of the Forestry Department in harvesting tropical forests won Uganda international acclaim. Research findings on cropping methods developed techniques for managing tropical forests for timber production by a system of grading trees based on commercial values. Forests were defined as areas of even-aged crops, which were divided into compartments and harvested in rotation to provide a continuous supply of timber. This system overcame the difficulty of harvesting forests in Uganda that typically contain a high number of trees with different timber values. The Forestry Department became renowned for its high annual timber production and development of plantations. The Department also oversaw the management of local reserves and supplied some rural needs from larger reserves, by allowing people to enter the compartments and collect waste left by millers and pit-sawyers (Hamilton, 1984).

In the 1960s, following independence, international agencies (UNESCO, 1964; FAO, 1967) reviewed wood consumption in Uganda and projected large increases in demand. Their reports recommended continued timber production from natural forests and the expansion of softwood plantations to meet future demand. However, no consideration was given to local demand, despite findings that the majority of local use was fuel and poles rather than the more processed forms such as sawn timber. All management of local supply ended when the local reserve system was abolished in 1967, amid struggles for political power.

Forest services run by district administrations were absorbed into the centrally organised Forestry Department, and the 3060 $km^2$ of local reserves were integrated into the central reserves, which covered 11590 $km^2$. Only small reserves of less than 0.2 $km^2$ were left to the districts. Shortly afterwards, the 1948 forest policy was revised into the policy of 1971. The new policy maintained the priority given to commercial forestry, which gave impetus to forest industries, as well as the colonial principles of reserving land as forest estate, managing the estate for the maximum economic return and encouraging farmers to grow their own trees. However, this policy was not fully implemented because the capacity of the Forestry Department rapidly declined following the reduction in financial support during the years of civil war. International aid was withdrawn and the government directed more expenditure towards security instead of national services, which included the Forestry Department (Jorgensen, 1981). Without adequate funding, the Forestry Department was unable to maintain its authority in the forest reserves and consequently, there was a sharp rise in illegal activities.

Illegal activities had started to increase during the 1960s, although Forestry Department's reports indicate that this was not then a serious problem. The Forest Department Annual Report of 1964 details the increase of illegal activities, but maintains the levels were still low and that the activities only concerned poles stolen from plantations, settlement and a few cases of violence against the staff. Increases are evident in the 1964-68 reports (Forest Department, 1968), which describe the common theft of poles and firewood and the rise of encroachment throughout the country. Encroachment on forest reserves for agricultural land soon became widespread, and preceding reports document violence against staff who attempted eviction (Forest Department, 1974). There was an upsurge in pitsawing within reserves, which resulted from the corruption found at all levels in the Forestry

Department. The 1981 ban on pitsawing in forest reserves and on public land had little impact and, when political stability was regained, there had been a large reduction in forest cover. The Department resumed its activities although, as corruption continued among reserve staff, pitsawers exceeded their timber allowances. A new policy was formulated in 1988, which maintained the priority given to market production and added emphasis to pulp and paper exports. The policy also maintained the Forestry Department's goals of conservation and research, and included a new goal of providing recreational forests for tourism. During the last decade, with international support, the Forestry Department established six tourism projects in reserves on the popular tourist routes. The projects were set up in collaboration with the surrounding communities and have been considered successful in generating local revenue through employment and in supporting community-based development projects (Gombya-Ssembajjwe, 1995). The Department also initiated a national biomass assessment to provide baseline data on the natural resources of Uganda (Davenport *et al*, 1996), and has resumed timber harvesting of local hardwoods and plantation schemes of pine species (Kanabahita, 2001).

The forest cover of Uganda is currently around 20% of the country's surface area, which is high when compared with other East African countries (FAO, 2000). More than 30% of the forests are within the country's protected area system, and reserves of high conservation value have been gazetted as National Parks. Recent efforts to adopt a multi-disciplinary management approach have been successful and, after the years of incompetence and corruption, the reserve system is now based on a policy of sustainable forestry. However, Uganda has the highest deforestation rate in East Africa, and the main causes are local needs. Fuel is the primary use of wood and Uganda's forests supply 90% of the country's energy demand. Another important factor is the conversion of forests to agriculture because of the high demand for land (FAO, 2000). This dependency of the rural population on forest resources, whose use was once controlled by the forest policy, now poses the primary threat to conservation.

### 1.2.3 Hunting, controlling and conserving wildlife

The first efforts of the colonial administration to manage the wildlife resources of Uganda were similar to those adopted for the forests. In the 1890s, land was designated as hunting reserves to control local resource use and introduce trophy hunting for foreigners. Rural communities were prohibited from hunting in reserves without a Native's licence, which was abolished in 1900 although the prohibitions remained. For trophy hunting, a licence system was introduced that was based on developments in Kenya, and hunting in Uganda soon became popular among colonial society. However, during the early 1900s, the colonial government's interest in wildlife changed from hunting to control.

Under the Game Ordinance of 1906, measures were introduced to halt the damage caused by elephants to crops and property. The right to cull these "*shamba-destroyers*" was granted to hunters through a "*50% licence*", where half of the proceeds from the ivory sales went to the hunter, and half to the government. The government also sought to prevent a mass slaughter of elephants by restricting farmers to killing no more than two crop-raiding individuals per shoot. The "*50% licence*" resulted in a high cull of elephant numbers, but failed to achieve the main objective of eradicating shamba destruction, and was subsequently abolished. The surge of protests and reports of crop-damage that followed led the government to introduce a second round of elephant licences in 1923. This was ended after a few months because of a similar problem, as licence holders shot elephants with large tusks rather than "*the real culprits*" (Uganda Game Department Archives, 1923-1994:1925). Failure of both control measures led the British Governor of Uganda to form an Elephant Control Department, which was established as the Game Department in 1924. The Game Department's primary duty was to prevent crop-raiding and local guards were employed to shoot shamba-destroying elephants. The secondary duties of game preservation and reserve management resulted in a strengthening of the game laws, and an increase in the penalties for illegal activities (Uganda Game Department Archives, 1923-1994:1926). The Department soon made progress in the three areas that have influenced wildlife policy in Uganda: revenue generation, crop-raiding control and conservation.

The economic importance of wildlife was a prominent feature in the policies of the Game Department, which has made significant contributions to the national economy throughout its history, with the exception of the civil war period. Revenue was first generated from game licence fees and the sale of trophies, which expanded from ivory, rhino horn and hippo teeth to include skins and bird eggs. In the 1950s, tourism was introduced as a secondary source of revenue from wildlife. This foreign exchange income became more important and wildlife is today the main tourist attraction of Uganda.

The potential offered by wildlife for the generation of revenue remained central to policy, from the era of trophy hunting under the Game Department to the period of conservation of protected areas, as has the primary motivation of ensuring adequate funds for the management of wildlife. The Game Department invested its high annual profits into elephant control. Wardens monitored the success of local guards by the protection given to farms, rather than the amount of ivory sent in (Uganda Game Department Archives, 1923-1994:1926). Control measures were applied to other animals, which were classified as vermin depending on their ability to destroy human life, crops, livestock or property. The vermin included bushpigs, duikers, buffaloes, and baboons which were "*destructive creatures responsible for a considerable amount of damage*". Vermin guards were employed around all reserves, although local communities were expected to take some responsibility for their crops. The efforts of the Game Department in wildlife control did reduce crop damage, and became important as a means of improving relations with the communities. The meat from animals shot raiding farms was given to rural farmers, and officials co-operated with communities to establish the most effective measure of control. In return, local citizens assisted game guards in combating illegal activities (Naughton-Treves, 1999). However, farmers became reliant on the Department for protection and soon the "*public all over the country requested assistance to protect their crops against wild game and vermin*" (Uganda Game Department Archives, 1923-1994:1979). The requests for assistance were also a means of obtaining free meat, as one Warden reported that "*the amount of genuine damage caused by elephants is small, but the same cannot be said for the number of complaints, the vast majority of which are instigated by a desire for meat*" (Uganda Game Department Archives, 1923-1994:1953). Despite these problems, the control measures continued until eventually during the civil wars, the Game Department "*could not satisfy the outcry for crop protection*" when its capacity was restricted (Uganda Game Department Archives, 1923-1994:1980).

As well as the hunting and control of wildlife, the Game Department was also concerned with conservation. Rare species were protected by hunting bans, and sites of conservation value were assigned protected area status. Wildlife sanctuaries, introduced under the 1930 Game Ordinance, were the first designations in Uganda that classified protected areas solely for conservation. Seven wildlife sanctuaries were established between 1938 and 1959 which now account for 2% of the protected areas in Uganda. The National Parks Ordinance of 1952 established the Uganda National Parks (UNP) as the government organisation responsible for the management and protection of the new designation of National Parks. Two former game reserves were upgraded to this designation and have remained the largest National Parks in Uganda. Villagers within the new National Parks were evicted and UNP enforced strict protection measures to uphold the bans on hunting, natural resource collection and grazing by domestic animal, as well as increasing the penalties of fines and prison terms for offenders. Poaching rapidly increased within National Parks and officials of UNP recognised that two types of offenders, major and minor offenders, were undertaking poaching. Major offenders were town or national hunters seeking game trophies for international markets, whereas minor offenders were from rural communities hunting mainly for subsistence needs (Uganda Game Department Archives, 1923-1994:1952).

Officials of the Game Department recognised that law enforcement was ineffective against poaching. Therefore, the Chief Game Warden introduced a scheme to share the Department's revenue with local governments in 1952 (Uganda Game Department Archives, 1923-1994:1952). A portion of the income from game licence fees and tourism went to the district administrations to generate an interest in wildlife and encourage assistance with law enforcement. The scheme was partly successful, as local chiefs gave information to game guards on the offenders and became involved in capturing poachers. However, the poaching continued and one Warden concluded "*a far greater awareness of the value of game and animals has been shown by the*

*Kingdom Governments and District Administrations, but on the whole they have not made any significant effort to stamp out poaching*" (Tennant, 1963).

The Game Department's decision to recognise the importance of local communities in gaining support for conservation had a significant influence on subsequent wildlife policy. The first formal wildlife policy of 1958, which maintained the priority given to game hunting and formed the basis for the Game (Preservation and Control) Act of 1959, defined the aims as giving district chiefs a responsibility for conservation, and as demonstrating the advantage of wildlife conservation to local citizens. This new direction came when poaching and corruption among staff, which led to hunting exceeding the quotas, were the greatest threats to wildlife. The Department recognised that "*the future of wildlife in this country will largely depend on the attitude of the people*" (Uganda Game Department Archives, 1923-1994:1966).

Nevertheless, more conservation areas were gazetted under strict protection and without extra resources, which is now widely considered to have exacerbated the threats to wildlife (e.g. Bell and McShane-Caluzi, 1986; Leader-Williams and Albon, 1988). In the period following independence, one National Park, two nature reserves, nine game reserves and fourteen controlled hunting areas were established. Villagers within or surrounding these areas were evicted to make place for tourism, which had become the primary source of revenue, and both UNP and the Game Department continued their efforts against poaching. Wire snares were the most widely used hunting technique, as shotguns and other such weapons common elsewhere in Africa were rare in Uganda (Howard, 1991). However, UNP and the Game Department lost the majority of their income during the 15 years of civil war and were subsequently unable to enforce the game laws. Rural farmers reclaimed land in protected areas for agriculture.

Poaching also increased, first by members of the Ugandan army and then by villagers using the rifles and machine guns left by retreating soldiers towards the end of the war, (Howard, 1991). After political stability was achieved following the end of the civil war, efforts were initiated to control poaching and re-establish an effective protected area network. With support from international donors, three National Parks were established in 1991, two of which were on former forest reserves in the southwest (Butynski, 1991). The new gazettements and the increased law enforcement in existing parks did reduce poaching, but also stopped the collection of resources by surrounding communities. The loss of resources, coupled with the limited assistance from park staff with crop-raiding wildlife, resulted in hostility between communities and the parks. Many parks reported violence against staff and deliberately lit fires, and conflict became the greatest threat to conservation. To address the problem, multi-disciplinary management techniques, using both biological and socio-economic tools, were adopted for the National Parks. Community-based schemes and integrated conservation and development projects were introduced, which included revenue sharing, infrastructure development, sustainable harvest schemes and local participation in natural resource management. The implementation process was facilitated by the grassroots political system that was introduced after the war. The system, which comprises five levels from the village to the district, devolved decision-making to the village level and this decentralisation of political power was vital to the uptake of community projects in protected areas (Wild and Mutebi, 1996). Uganda's National Parks now comprise a broad variety of approaches, which have been hailed a success in resolving park-community conflict. International agencies cite the achievements in Uganda in developing a holistic approach for National Park management, and in the adoption of integrated programmes for conservation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996; Borrini-Feyerabend, 1997; Hamilton *et al*, 1999; Makombo, 2003).

There are currently ten National Parks in Uganda (Figure 1.1). The Uganda Wildlife Authority (UWA) is the government organisation responsible for the management and conservation of the wildlife resources and protected areas. UWA was established in 1996 under the Uganda Wildlife Statute, by the merger of UNP and the Game Department, and its current policy reflects the holistic approach to conservation in Uganda (UWA, 1999). The policy advocates the use of collaborative management and community incentives to conserve wildlife, and the importance of improving community relations and resolving land-use conflicts for the successful management of protected areas.

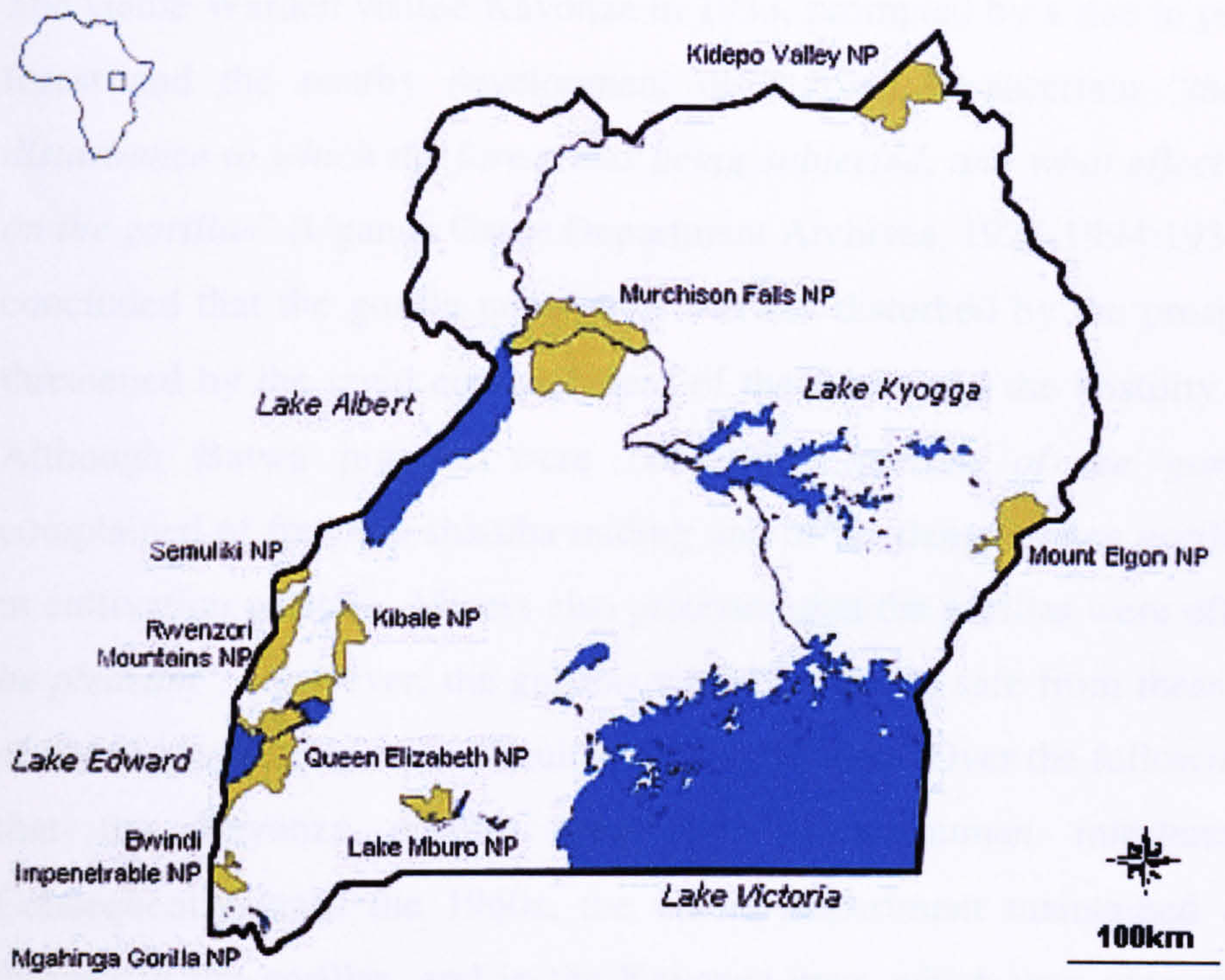


Figure 1.1 National Parks in Uganda

## 1.3 Conserving the Impenetrable

Bwindi is renowned for its population of mountain gorillas that are the prime tourist attraction of Uganda. The gorillas have also been the flagship species for efforts to conserve the forest (McNeilage *et al*, 2001). In 1924, the Game Department legally protected this animal that was described as being "*comparatively harmless, yet of considerable rarity*" (Uganda Game Department Archives, 1923-1994:1925). In Bwindi forest, which was then known as Kayonza, the presence of gorillas was not confirmed until 1929 (Uganda Game Department Archives, 1923-1994:1929). Shortly afterwards, in 1932, two separate areas of Kayonza were designated as Crown Forests: the Kasatoro Crown Forest, which covered 181 $km^2$ in the southern sector; and the Kayonza Crown Forest of 26 $km^2$ in the northern sector. The Forestry Department had jurisdiction over both Crown Forests but the Game Department was responsible for the gorillas.

The Game Warden visited Kayonza in 1933, prompted by a rise in prospecting in the forest and the nearby development of a road, to ascertain "*the extent of the disturbance to which the forest was being subjected, and what effect this was having on the gorillas*" (Uganda Game Department Archives, 1923-1994:1933). The Warden concluded that the gorilla population was not disturbed by the prospecting, but was threatened by the rapid encroachment of the forest and the hostility of local people. Although Batwa pigmies were "*extremely tolerant of the gorillas*", villagers complained of frequent shamba raiding and of the danger when gorillas came to feed in cultivation patches. Miners also protested that the gorillas were often "*too close to be pleasant*". However, the gorillas were considered safe from these threats because of the rugged terrain and difficult access to the area. Over the following years, reports that the Kayonza gorillas were free from human interference continued. Consequently, until the 1960s, the Game Department maintained only a minimal interest in the gorillas, and in the Kayonza area, which was supported only limited trophy hunting and had little need for elephant control.

The Forestry Department, as the primary managers of Kayonza, changed the status and configuration of the reserve after the two Crown Forests were initially gazetted. In 1942, the two Crown Forests were combined and extended, forming the larger Impenetrable Crown Forest of 324 $km^2$. The boundaries were marked by natural features and, where such features were absent, by cypress trees. The Crown Forest was reduced by 26 $km^2$, in 1948, and regazetted as the Impenetrable Central Forest Reserve for national timber production (Leggat and Osmaston, 1961). In 1950, two local forest reserves were established on the boundary of the Crown Forest, for the supply of forest resources to surrounding communities. The reserves were Bikingi of 7.6 $km^2$ in the south; and Ishaya of 13.8 $km^2$ in the northwest.

Local people could enter these areas and collect major forest products, such as firewood and building poles, and minor non-wooden forest products, such as honey, basket-making materials and bamboo (Cunningham, 1996). This resource collection was later prohibited when Bikingi and Ishaya were incorporated into the Impenetrable, as part of the national decree that consolidated local forest reserves into the central management system. The Impenetrable then covered approximately 320 $km^2$ in two sectors, a northern and a southern sector, which were joined by a small neck of forest at the centre. Timber production continued and the reserve was designated as a wildlife sanctuary for the protection of the gorillas in 1961. Under dual status as a forest reserve and wildlife sanctuary, the Impenetrable was managed by both the Forestry and Game Departments.

Prior to the 1960s, the Impenetrable had not been heavily exploited. The mountainous terrain of the area restricted the activities of miners, who mainly operated in the southern sector and around the centre, and of timber merchants. Timber was only produced by pit sawing, after attempts by sawmill had failed (Leggat and Osmaston, 1961). Following the increase in pit sawing throughout Uganda after the Second World War, the Forestry Department regulated the number of pit sawyers in the Impenetrable. When the Impenetrable gained status as a wildlife sanctuary, 85 pit sawyers were operating between three forest stations around the southern sector. Their activities were supervised by the forest staff of the Impenetrable, consisting of three forest guards and nine patrolmen (Butynski, 1984). Also that year, the Forestry Department produced the first working plan of the Impenetrable, for increasing timber production (Leggat and Osmaston, 1961). One compartment, from two to four hundred acres, was established by each forest station for timber felling, and requirements were introduced for pit sawyers to stamp boards with their licence number (Howard, 1991). The Forestry Department did designate two small areas in the Impenetrable as Nature Reserves, where resource harvesting was prohibited. However, the main aim of increasing timber production was achieved. From 1961 to 1971, timber production in the Impenetrable averaged 710 $m^3$ per annum (Howard, 1991). This rose to 940 $m^3$ per annum from 1972 to 1983, but the records underestimate actual exploitation because of the extent of illegal pit sawing (Butynski, 1984).

Illegal exploitation of the Impenetrable escalated rapidly during the country's political upheavals from 1996 to 1986, when the success of Museveni's coup against Obote restored peace in Uganda. In the Impenetrable, there were signs of human activity in 84% of the reserve by 1984. Pit sawing was the most widespread activity, and 57% of the 140-280 people engaged in pit sawing or wood carrying were operating illegally. Poaching by wire snares was also common throughout the Impenetrable, but mining was restricted to certain rivers, and the grazing of livestock mainly occurred on the forest boundary.

The illegal activities during the civil wars had a severe impact on the Impenetrable, as 61% of the reserve was heavily exploited, and 29% was moderately exploited (Howard, 1991). After the wars, the high level of illegal activities continued because of corrupt forest staff and ineffective law enforcement patrols by game guards. The number of game guards was too small for the size of the area, with only five game guards and one vermin guard, and the guards received inadequate financial and logistical support from the game wardens (Butynski, 1984).

The exploitation of the Impenetrable was a major threat to the gorilla population. The large numbers of pit sawyers, miners and local villagers entering the forest were likely to encounter a gorilla group and, where these encounters provoked the gorillas to charge, the people would harm or kill the gorillas in self-defence. The gorillas were also threatened by the loss of habitat from pit sawing. The majority of snares in the Impenetrable were set for bushmeat and, although the gorillas of the Impenetrable were rarely hunted in comparison with the high levels of gorilla poaching in Rwanda and the DRC, snares set for bushmeat were also a major threat to the gorilla population (Butynski, 1984). Two projects were established for conserving the gorillas and the forest. In 1986, the Impenetrable Forest Conservation Project (IFCP) was founded, with funding from WWF-US and USAID. IFCP initiated a programme of ecological research and gorilla monitoring, and constructed a research station and a new game camp in the east Ruhija area of the Impenetrable. The new game camp was part of IFCP's support to the Game Department for law enforcement activities, which also involved the supply of equipment and manpower. With this support, the number of law enforcement patrols substantially increased, and police and district officials were involved in the punishment of offenders. The patrols reduced illegal activities in the Impenetrable and large numbers of pit sawyers, miners and villagers were arrested. As well as research and law enforcement, another aim of IFCP was raising awareness of conservation issues among local communities, and twenty Conservation Education Assistants undertook educational work in villages neighbouring the Impenetrable.

The second project, Development through Conservation (DTC), was an Integrated Conservation and Development Programme established by CARE-Uganda, with funding from USAID. The primary goal of DTC was building the capacity of rural communities in agriculture and income generation. From 1987 to the completion of the project in 2002, DTC staff worked in villages within 10 km of the forest boundary and, as well as expanding the agroforestry and education activities of IFCP, initiated a variety of training programmes on sustainable agricultural techniques, including soil conservation and improved crop management (Malpas *et al*, 2002). Both IFCP and DTC accentuated the international pressure for the designation of the Impenetrable as a National Park. UNP first recommended that the Impenetrable be gazetted in 1971, but it was not until 1989 that the Ugandan government accepted a proposal that had been amended to include plans of tourism. In August 1991, the Forest Reserve and Gorilla Sanctuary were declared the Bwindi Impenetrable National Park. Under National Park status, the prohibitions on human activity in the forest and the subsequent loss of employment and forest resources, fuelled anger among local people towards the National Park. Game guards were refused food and community services from villagers, and were often attacked by angry mobs of pit sawyers and miners. Soldiers also threatened guards when the guards tried to stop the illegal trade of coffee and cattle to Rwanda. The resentment of the National Park by local people also resulted in direct threats against the gorillas, and the deliberate setting of forest fires (Wild and Mutebi, 1996).

Harvesting natural resources from protected areas was recommended as a conservation strategy in the first workshop on the conservation of afromontane forests (Butynski, 1989). Following this workshop, local collection of minor forest products in the National Park was proposed as a conflict resolution strategy for Bwindi, primarily because of the high dependency of local communities on forest resources for most of their subsistence needs. The objectives were to foster the ability of local people to co-manage Bwindi with UNP to ensure biodiversity conservation and sustainable resource use, and to ensure that individuals living adjacent to the forest are granted limited access to forest resources. In addition, it was considered that UNP would benefit as local communities adopted greater responsibility for protecting the forest (UNP, 1994).

Harvest zones for sanctioned harvesting of natural resources by local communities were established in Bwindi by collaborative management between National Park officials and local communities, with support from DTC staff (Bensted-Smith *et al*, 1995). A trial of sanctioned collection of minor forest products from Bwindi was initiated as the first stage of the harvesting programme. Beekeepers were selected for the trial, primarily because beekeeping has minimal impact on the forest and also because detailed forest inventories were not required to establish beekeeping zones. The trial was implemented following gazettement of Bwindi in 1992 with beekeepers of the eastern Ruhija area permitted access to the forest, and with the formation of Bwindi Impenetrable Beekeepers Association with a membership of 300 beekeepers. Also during 1992, studies were conducted to determine the distribution and abundance of forest resource proposed for utilisation (Scott, 1992), and provide baseline information on ethnobotanical resources used by local populations (Cunningham, 1992). Following success of the beekeeping trial, UNP designated 20% of Bwindi (66 $km^2$) as harvest zones, which were the areas for sanctioned resource collection. Designation of the harvest zones, which extend from the National Park boundary into the forest for a maximum of 2 km, were based on the studies by Scott (1992) and Cunningham (1992), boundaries between the National Park and community parishes, and natural physical barriers, such as hills and rivers, in the forest.

UNP and DTC staff then initiated a participatory planning process with local communities, and conducted participatory rural appraisals to identify local needs from the forest. From the appraisals (Wild and Mutebi, 1996) and research on specialist resource users around Bwindi (Cunningham, 1992), three pilot parishes were selected for the harvest zone programme. The parishes were Rutugunda, which comprises a large population that borders a small area of the northern sector, Mpungu, which comprises a relatively small population that borders a large area around the centre of Bwindi, and Nteko, which comprises a large population that borders a large area in the west of the southern sector (Bensted-Smith *et al*, 1995). Between 1993 and 1994, communities from each parish nominated the resource users and established a forest society for each harvest zone as the committee responsible for recording the species and quantities harvested, and for reporting illegal activities to rangers. Forest societies were formed from existing community structures including Resistance

Committees and Stretcher Societies, and were involved with the intensive process of marking harvest zones in the forest. In 1994, each of the three forest societies signed a Memorandum of Understanding (MoU) with UNP that defined the roles and responsibilities of resource users, particularly regarding the records of harvested resources and reporting of illegal activity. Much emphasis was placed on the role of resource users as guardians of the forest, particularly on their role to report illegal activities to rangers, throughout the implementation process. Following the MoUs, the pilot zones were established for the collection of herbal medicines by 44 users, the collection of basket making materials by 71 users, and for forest access for 300 beekeepers (Bensted-Smith *et al*, 199; Wild and Mutebi, 1996).

This pilot programme enabled UNP to decide whether other parishes should be included in the harvest zone programme, and whether it should include other forest resources (Wild and Mutebi, 1996). The harvest zone programme has since been extended to other parishes, with MoUs signed between 1994 and 1995, but has not included other forest resources. Although the programme was set-back by management problems within UNP (Cunningham, 2000), sanctioned resource harvesting was considered the key factor that reduced conflict around Bwindi, and improved the attitudes of local communities towards the National Park (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996; Blomely, 2003; Makombo, 2003). There are currently 14 harvest zones that cover 20% (66 $km^2$) of Bwindi in boundary sectors of the forest (Figure 1.2).

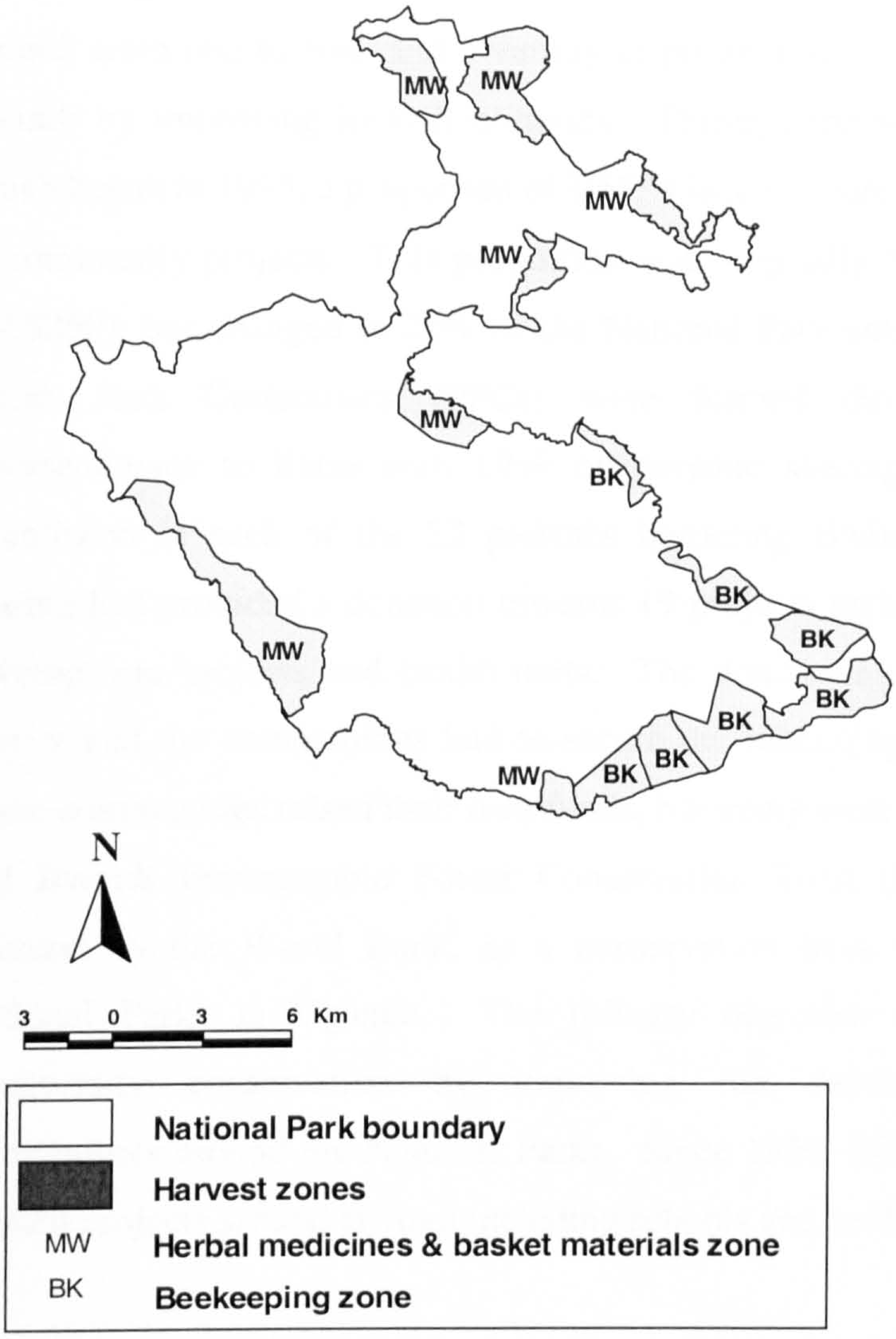


Figure 1.2 Harvest zones in Bwindi Impenetrable National Park for the sanctioned harvesting of natural resources by local communities

Harvest zones are the leading component of the integrated conservation and development programme at Bwindi (Makombo, 2003). Other integrated strategies have been initiated including a resource substitution programme to reduce local dependency on forest resources. The programme was implemented during 1993 and 1994 with assistance from WWF's People and Plants Programme. By 1995 over 1,200,000 trees had been planted for timber, building poles and specialist needs including carving materials, bamboo planting was established and planting of vines, medicinal plants and shrubs was in experimental stages (Bensted-Smith *et al*, 1995).

Also during 1995, UNP increased the number of Community Conservation Rangers at Bwindi from one to five, and a variety of programmes were initiated for conserving Bwindi by improving local livelihoods. Through the revenue sharing programme, which began in 1995, a proportion of UNP's income from gorilla tourism was donated to community projects. This proportion was originally 8% of the gorilla permit fee (US$250), but changed to 20% of the National Park entrance fee (US$20) in 1998. Parish Park Committees (PPCs) were formed during 1994 as community representatives to liaise with UNP on revenue sharing projects. One PPC was established in each of the 22 parishes bordering Bwindi, and, by 1999, revenue sharing had provided a donation towards 19 projects including primary schools, road development projects and health units. The donations were a contribution to each project and the communities had to secure the remaining funds from other sources. Some communities raised their own funds, but many were supported by the Mgahinga and Bwindi Impenetrable Forest Conservation Trust (MBIFCT). MBIFCT was founded by the World Bank, as a conservation trust for both Mountain Gorilla National Parks in Uganda. The primary objective of MBIFCT is to secure biodiversity conservation by improving the development infrastructure of communities around the National Parks. Since 1996, MBIFCT has funded a variety of such projects around Bwindi including schools and health clinics.

While an array of conservation strategies was focused on local development, strict law enforcement measures continued inside the National Park, as did the gorilla monitoring programme. The Institute of Tropical Forest Conservation (ITFC) was developed from IFCP with the primary goals of gorilla monitoring and ecological research. Subsequently, ITFC has given less support to the National Park for law enforcement activities, although it provided assistance to the harvest zone programme and gorilla tourism. The International Gorilla Conservation Programme (IGCP) also supported gorilla tourism at Bwindi, which began with Mubale gorilla group in 1993 and Katendegyere gorilla group in 1994. Gorilla trekking quickly became the most popular attraction for tourists visiting Uganda, and Bwindi was the largest source of foreign exchange earnings for UNP. However, the attack on Bwindi by the Rwandan extremist militia the Interahamwe in 1999 had a severe impact on tourism in Uganda. In 2000, the number of tourists visiting Bwindi had started to increase although even it was still below the level prior to the attack by 2002. During 2002, a third gorilla group was selected for tourism and the cost of a gorilla permit was raised from $250 to $275. The role of IGCP also includes supporting law enforcement activities of the National Park, and co-ordinating conservation efforts for mountain gorillas between Uganda, Rwanda and the DRC (Muruthi *et al*, 2000).

Bwindi has an extensive history of management (Figure 1.3) and now has been a National Park for over ten years. Gorilla conservation remains a primary goal for the newly created UWA and the other institutions working in and around the forest. Bwindi is hailed a success in protected area management by the integrated approach, following the reduction in conflict between National Park staff and local communities after the adoption of integrated conservation and development programmes (Borrini-Feyerabend, 1997). However, impacts of integrated programmes on illegal activity and on wildlife distribution are not known. Consequently, many questions remain about the effectiveness of the integrated policy for conserving Bwindi and the gorillas.

| | |
|---|---|
| 1924 | Mountain gorillas in Uganda legally protected |
| 1929 | Presence of Mountain gorillas in Kayonza confirmed |
| 1932 | Two separate areas of Kayonza designated as Crown Forests |
| 1942 | One Impenetrable Crown Forest formed from the two Crown Forests |
| 1948 | A smaller Impenetrable Central Forest Reserve re-gazetted for national timber production |
| 1950 | Two boundary reserves established for resource collection by local communities although later dissolved |
| 1961 | Gained dual status as a Wildlife Sanctuary and Crown Forest |
| | Forest Department produced the first Working Plan to increase timber output |
| | Two forest interior reserves established with prohibitions on harvesting |
| 1960s-1970s | Timber production increased |
| 1971 | First proposal for National Park gazettement |
| 1980s | Illegal exploitation escalated during Uganda's political upheavals |
| 1989 | Proposal for National Park gazettement with gorilla tourism accepted |
| 1986 | Impenetrable Forest Conservation Project (IFCP) established |
| 1987 | Development through Conservation project established |
| 1991 | Gazettement of Bwindi Impenetrable National Park |
| | Institute of Tropical Forest Conservation founded from IFCP |
| | Habituation process began for two mountain gorilla groups |
| 1991-1992 | Local hostility to the National Park |
| 1992 | Pilot sanctioned resource harvesting trial for beekeepers |
| 1993-1994 | Mountain gorilla tourism opened |
| | Three pilot parishes selected for sanctioned resource harvesting |
| | Forest resource substitution programme implemented |
| 1994 | Designated a UNESCO Natural World Heritage Site |
| | Pilot parishes signed Memoranda of Understanding to begin harvesting |
| | Parish Park Committees formed in each parish bordering Bwindi |
| 1994-1995 | Sanctioned resource harvesting expanded to other parishes |
| 1995 | Revenue Sharing established with 8% of gorilla permit fee (US$250) |
| 1996 | Mgahinga and Bwindi Impenetrable Forest Conservation Trust established |
| 1997 | UWA formed from UNP |

| | |
|---|---|
| 1998 | Revenue Sharing changed to 20% of park entrance fee (US$20) and may project received additionally funds from MBIFCT |
| 1999 | Interahamwe attack Buhoma |
| 2000 | Gorilla tourism starts to increase |

Figure 1.3 The history of Bwindi Impenetrable National Park from 1924 to 2000

## 1.4 Rationale for the study

The integrated approach for protected area conservation is currently favoured among international donors funding efforts to conserve tropical biodiversity, and has been adopted by managers of protected areas throughout the tropics (Hughes and Flintan, 2001). Integrated programmes, including sanctioned use of natural resources, have been shown to improve local attitudes towards conservation and reduce conflict between local communities and conservation managers (Lebonetse, 1996; Scott, 1998; Straede and Helles, 2000). In contrast, impacts of integrated programmes on biodiversity and on threats to biodiversity are little studied. Consequently, the most critical aspect of the effectiveness of the integrated approach for protected area conservation has yet to be determined.

## 1.5 Aims of the study

The aim of this study is to evaluate the effectiveness of integrated conservation and development for protected area conservation. To address this aim the study comprises three main objectives:

- to determine bushmeat poaching over the periods of National Park gazettement and establishment of harvest zones
- to determine interactions between local communities and law enforcement rangers and factors affecting the interactions
- to determine the distribution of gorillas in relation to harvest zones and illegal activities

## 1.6 Thesis organisation

In this thesis, I first examine the incidents of violent conflict between local communities and staff of Bwindi when Bwindi was designated a National Park, which led to the adoption of the integrated approach for conservation (Chapter 3). I next determine the distribution of bushmeat poaching within Bwindi over the period of National Park gazettement and establishment of harvest zones for sanctioned resource use (Chapter 4). In addition, I examine the current distribution of illegal activity in Bwindi (Chapter 5). Having then examined the direct threats to biodiversity, next I seek to determine the indirect threats. I examine crop raiding activities by wild animals (Chapter 6) and problem animal control by law enforcement rangers (Chapter 7), and investigate interactions between local communities and rangers regarding crop raiding (Chapter 7) and positive and negative responses by local communities to rangers on law enforcement patrol (Chapter 8). I then determine the distribution of the gorilla population before and after harvest zones were established (Chapter 9), and the current distribution of other key wildlife species in Bwindi (Chapter 10). The summary of the findings of the study, and recommendations for conservation managers, are presented in the final Chapter (Chapter 11).

# Chapter Two

# -

# Study Area and General Methods


*Entrance gate to Bwindi Impenetrable National Park*

*(J. Baker)*

# Chapter Two

# 2 Study area and general methods

## 2.1 Bwindi Impenetrable National Park

### 2.1.1 Dark and impenetrable

Bwindi Impenetrable National Park (hereafter Bwindi) has undergone a series of name changes during its history. The first name of Kayonza was given in 1935, but soon changed to Impenetrable-Kayonza and then to Impenetrable in 1942 when two neighbouring reserves were gazetted as the Impenetrable Crown Forest Reserve (Leggat and Osmaston, 1961). Local communities protested because they thought the use of "*impenetrable*" meant their access to the forest would be prohibited (Namara, 2000). In 1968, the Chief Conservator of Forests decreed that the forest should be given a local name and forest guards were sent to consult the local communities. Bwindi, which means "*dark, fierce and isolated*", was favoured as representing the name of a large swamp that was an important meeting place between western and northern areas, and where hunters found abundant wildlife (Namara, 2000). The District Forest Officer endorsed the communities' proposal and also recommended Bwindi because "*it is short and easy to spell*". The reserve then became known as Bwindi forest, which then changed to Bwindi Impenetrable after National Park gazettement in 1991. Nevertheless, communities consider the use of one name for the whole forest to be an invention of the foreigners (Namara, 2000) and continue to use traditional names, or toponyms, for different areas within the forest. Some of these toponyms refer to people that once lived in an area. However, most describe a particular feature, such as a hill, ridge, valley or river. For example, a large hill in the south of Bwindi is called Nyeiguru, which means "*raised to the heavens*". Toponyms are useful indicators for the location of past wildlife and human activity, and remain important as part of the cultural heritage of Bwindi.

## 2.1.2 Location

Bwindi is located in south-west Uganda at the edge of the Western Rift Valley (0°53′-1°08′N; 29°35′-29°50′E). The forest is situated on the Kigezi Highlands and ranges in altitude from 1160 m in the north to 2607 m in the east. There are three administrative districts of Kabale, Kisoro and Rukungiri that border the National Park. Kisoro town lies 18 km to the south and Kabale town lies 29 km to the east, but the poorly maintained murram roads render access to the area difficult, and isolated from major traffic routes. The western National Park boundary lies on the Ugandan border with the DRC, while the southern boundary is approximately 25 km from Rwanda (Figure 2.1).

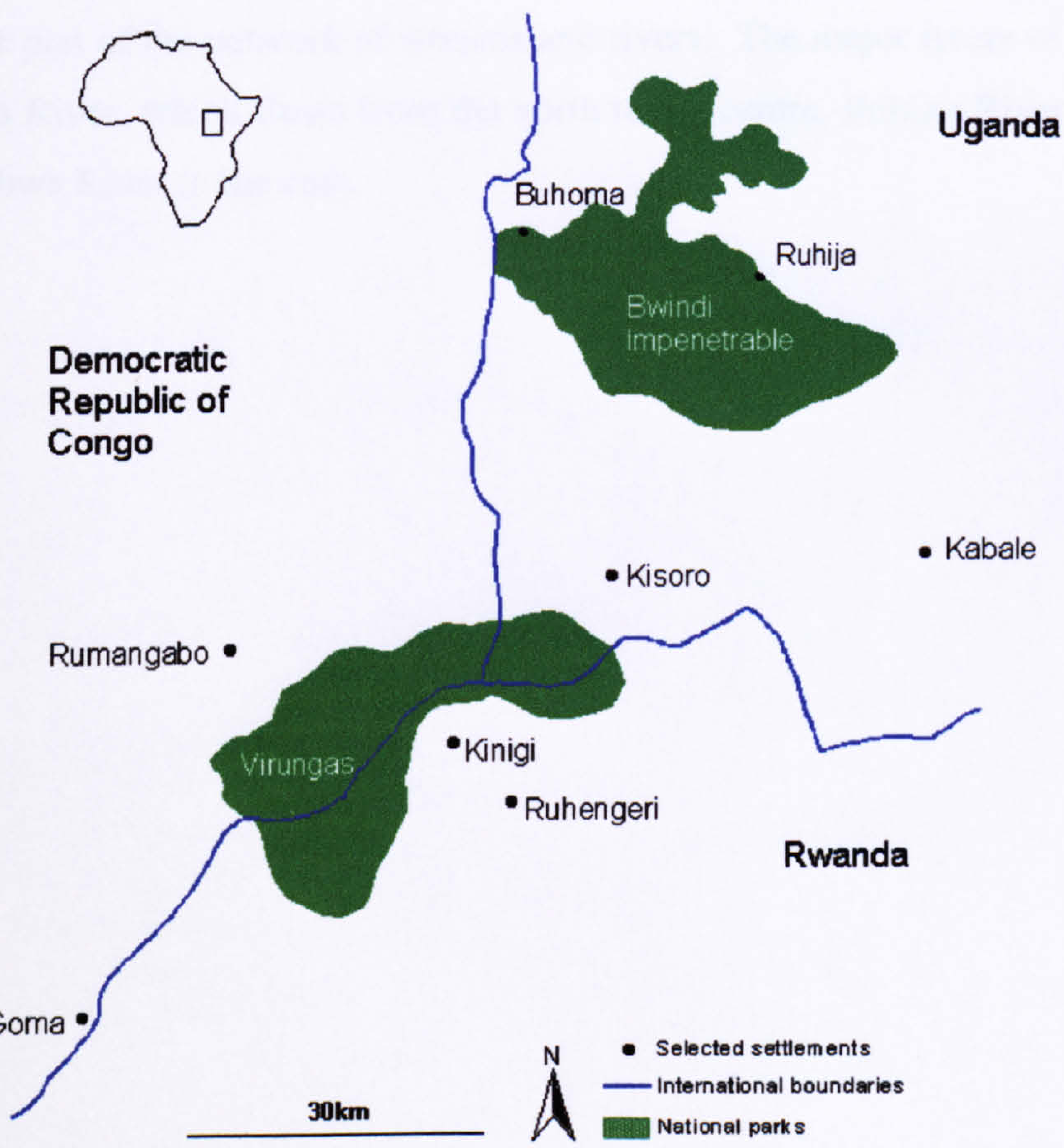


Figure 2.1 A map showing the location of Bwindi Impenetrable National Park in south-west Uganda

The National Park is approximately 321 $km^2$ in area. The forest is sub-divided into a northern and a southern sector by a central narrow neck 1 km in length, which is traversed by a road. The northern sector has a lower altitude, gentler topography and higher temperature than the southern sector. These differences result in distinct variations in the flora and fauna (Howard, 1991). There is one ranger outpost in the northern sector and six disbursed around the southern sector. The western outpost in Buhoma is also the headquarters of Bwindi and the tourist centre, while the eastern outpost in Ruhija is adjacent to the research institute ITFC. The outposts are linked by trails in the forest (Figure 2.2). The terrain of Bwindi is extremely rugged with a series of steep-sided hills and narrow valleys. Deep sediment accumulations are common in the valleys and result from the high precipitation and cool temperatures (Marchant *et al*, 1997). These form swampy areas that occur throughout the forest and are part of the network of streams and rivers. The major rivers of Bwindi include Ishasha River, which flows from the north to the centre, Ihihizo River in central parts and Mbwa River in the east.

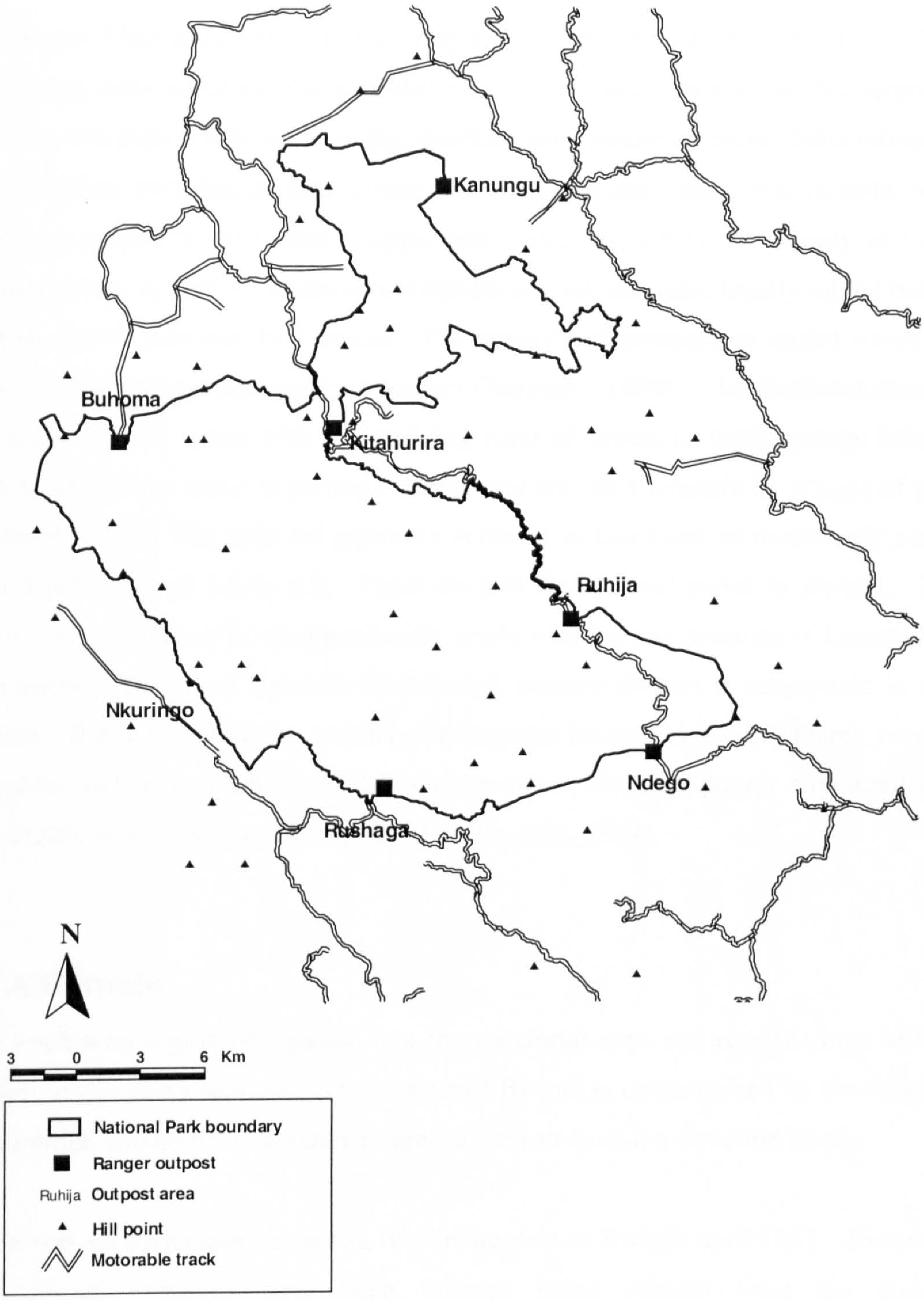


Figure 2.2 The ranger outposts, hill points and roads of Bwindi Impenetrable National Park

### 2.1.3 Soil

The Kigezi Highlands were formed by upwarping of the Western Rift Valley. The underlying rocks are of the Karagwe-Ankolean system and comprise the characteristic phyllites and shales, with some quartz, quartzite and granitic outcrops. Mineralisation of this parent rock has formed metals and semi-precious stones that include gold, wolfram, copper, tin and mica (Leggat and Osmaston, 1961). A variety of these minerals occur in pockets scattered throughout Bwindi and were legally mined before Bwindi gained National Park status. The majority of prospectors mined rivers for gold in both northern and southern sectors (Butynski, 1984). The dominant soils of the forest are red loams with an overlying layer of brown to black spongy humus. Blue to grey clays occur in swampy valleys and are often overlaid by a layer of peat (Howard, 1991). The soils are generally deficient in bases and so moderately acidic with a pH range of 3.5 to 5.0. There are two distinct soil series in Bwindi. The Mafuga series consists of weathered rock rubble with varying amounts of latosols and clay loams. The weak structure of this dark horizon renders it susceptible to soil erosion. The Ntendule series, which comprises clay loams and silt clay loams, is paler in colour and more acidic than the Mafuga series, but also poorly structured and susceptible to soil erosion (Harrop, 1960 in Butynski, 1984).

### 2.1.4 Climate

The south-west region of Uganda is in the equatorial zone and receives high annual rainfall in two rainy seasons. The climate of Bwindi is characterised by the region's high rainfall and by the cool temperatures that result from the elevation levels.

There was no systematic recording of climate data in Bwindi until 1987. However, past climatic patterns have been inferred using records from the Kabale Meteorological Department since 1918, and records from the Forest Department of rainfall measurements from 1963 to 1983 (Bitariho *et al*, 2000).

### 2.1.4.1 Rainfall

Rain in Bwindi falls in two seasons, one from March to May and the other from September to November, and there are two dry seasons, one from December to January and the other from June to August. The months of August, September and October receive the greatest amount of rainfall, while June to August is the longer and more severe dry season (Figure 2.3). The average annual rainfall is 1450 mm, and falls over 122-177 rain days, with a mean of 148 rain days per year. This average is high when compared to other highlands in Uganda (Tukahirwa and Pomeroy, 1993) and appears to have remained constant around 1440 mm since the 1960s (Butynski, 1984). Since 1987, the wettest year at Bwindi was 1988 and the driest year was 1999 (Bitariho *et al*, 2000).

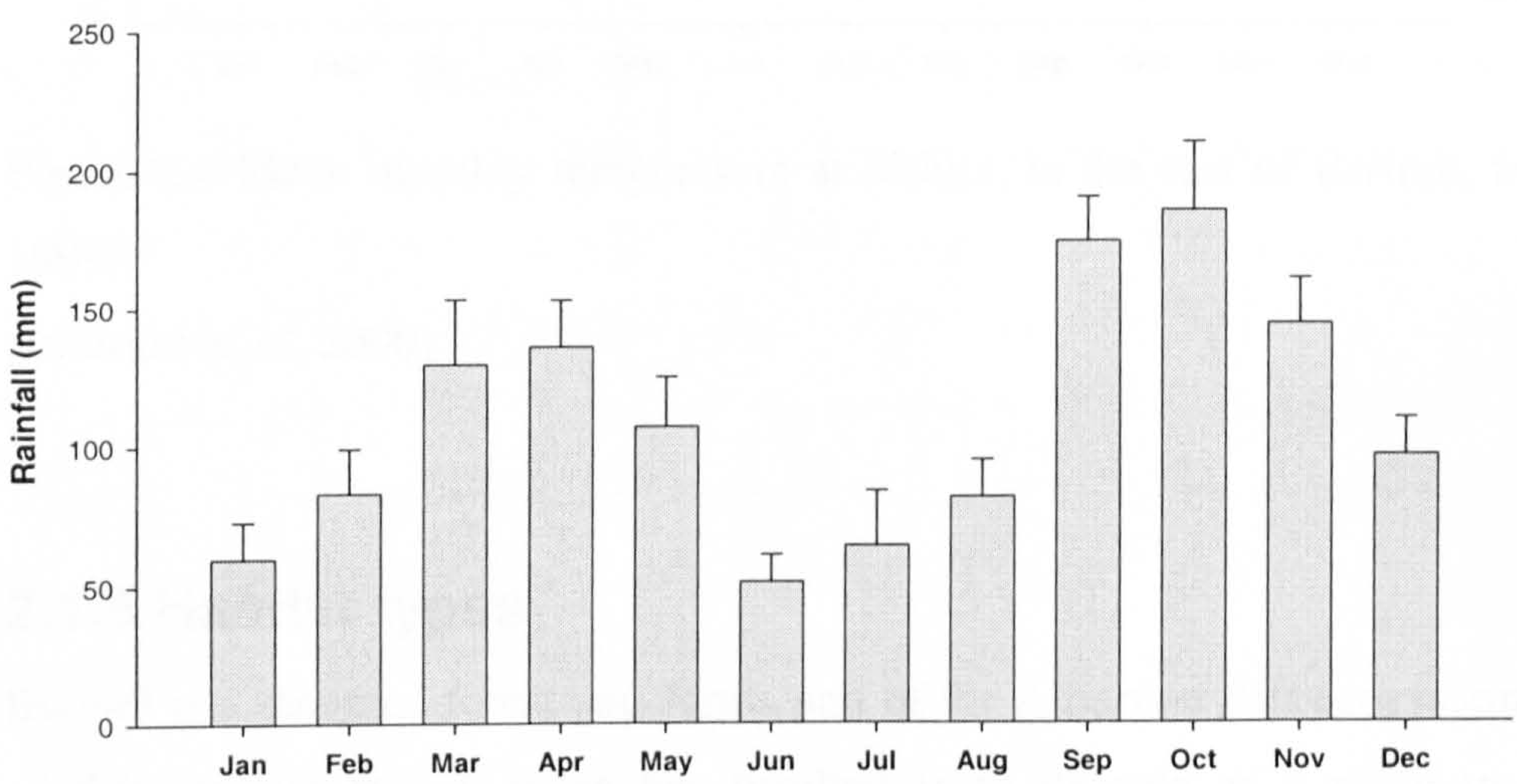


Figure 2.3 Mean±SE monthly rainfall at Ruhija, in the east of Bwindi, from 1987 to 1999
(Bitariho *et al*, 2000)

### 2.1.4.2 Temperature

The mean annual temperature of Bwindi is 16°C with a mean daily minimum of 14°C and a maximum of 19°C. The mean monthly temperature varies less than 4°C throughout the year. The warmest months are September and March, while the coldest are June and July, which correspond to the rainy and dry seasons respectively (Figure 2.4). The temperature appears to have remained fairly stable since the 1960s based on regional records, which estimates the mean annual temperature at 13ºC, and a mean daily minimum of 7ºC and a maximum of 20ºC (Butynski, 1984).

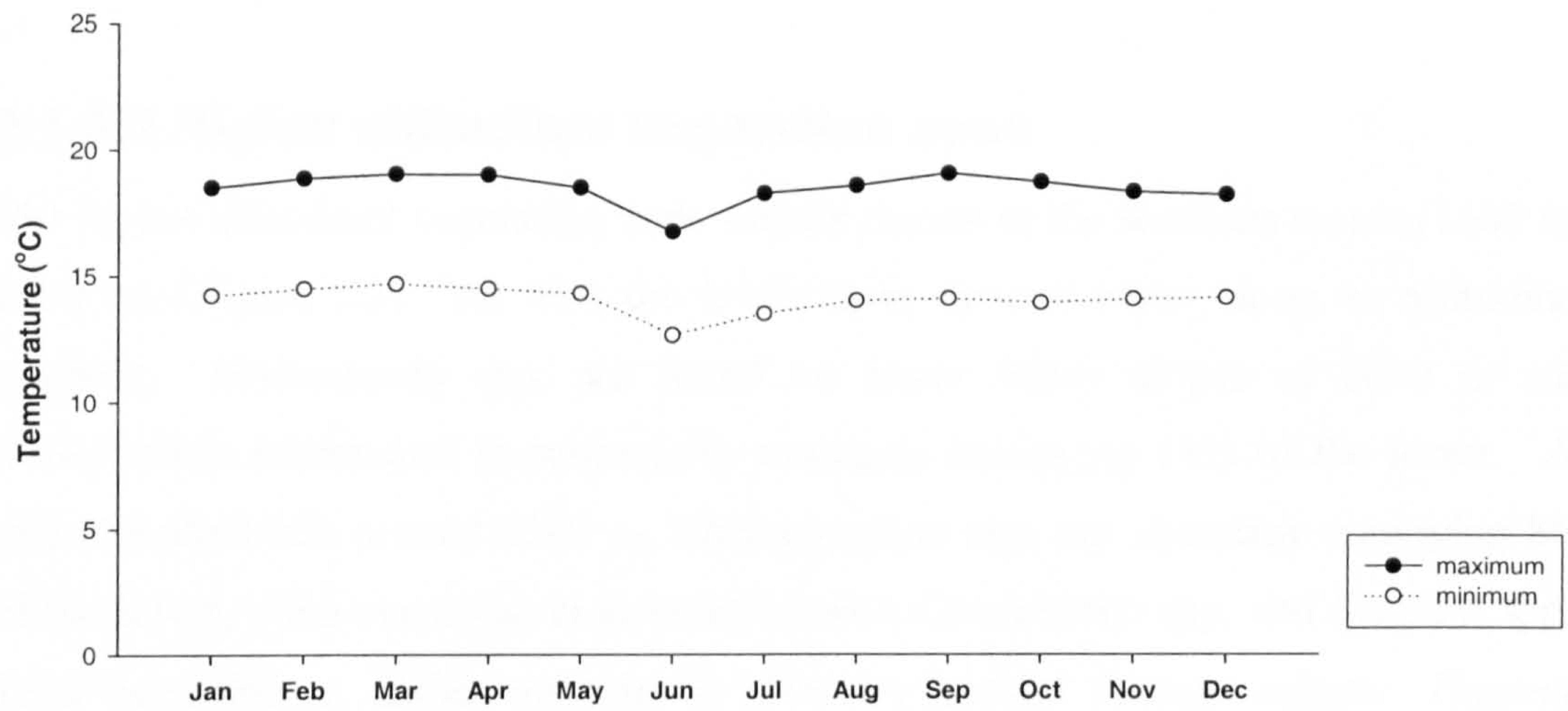


Figure 2.4 Mean monthly temperature at Ruhija, in the east of Bwindi, from 1987 to 1999
(Bitariho *et al*, 2000)

## 2.1.5 Habitat types

Bwindi is a montane forest and forms part of the Albertine Rift ecosystem. A mosaic of different vegetation types has resulted from its role as a refugium during the Pleistocene-Holocene transition and from the wide altitudinal range (Marchant *et al*, 1997). In addition, past human activity has affected the distribution of vegetation. The vegetation can be broadly classified into two zones based on altitude.

### 2.1.5.1 Lower altitudinal vegetation zone

The lower altitudinal zone occurs mainly in the northern sector (1200 m-1750 m). The vegetation is described as medium-altitude moist evergreen forest (Langdale-Brown *et al*, 1964) and species occur along an altitudinal gradient. Strands of *Parinari excelsa* dominate valleys and low-lying areas below 1500 m, which occupy 10% of Bwindi (Butynksi, 1984). Common species above 1500 m include *Entandrophragma* spp., which is typically associated with *Newtonia* spp. and

*Symphonia* spp.. Large strands of *Syzygium guieense* occur in swampy areas. The northern sector also contains grassland and herbaceous communities in areas that were previously burnt or under cultivation (Howard, 1991).

### 2.1.5.2 Higher altitudinal vegetation zone

The higher altitudinal vegetation zone mainly occurs in the southern sector (1500 m-2600 m) (Figure 2.5). As with the lower zone, species occur along an altitudinal gradient. *Neoboutonia* spp. are found on lower valley slopes of 2000 m and *Neoboutonia buchananii* is particularly common, occupying 11% of the forest. At mid-altitude levels around 2200 m, *Chrysophyllum* spp. are abundant occupying 8% of the forest, often occurring in association with *Cassipourea* spp. and *Syzgium* spp.. Taxa occurring at higher altitudes (>2200 m) include *Faurea saligna, Hagenia abyssinica* and *Nuxia congesta*, while those common on ridges and hilltops include *Podocarpus milanjianus* and *Olea capensis* (Howard, 1991). An area of Mountain bamboo (*Arundinaria alpina*) less than 0.4 $km^2$ is located in the east of Bwindi. The bamboo extends to the National Park boundary and is traversed by a road that connects the south and east park gates (Butynski, 1984). Mubwindi swamp is also in the south-east and is the largest swamp in the forest (1 $km^2$). The dominant swamp grass is interspersed with several species of fern and tree heather (Marchant *et al*, 1997).

Figure 2.5 Forest of the southern sector of Bwindi

### 2.1.5.3 Habitat modification by past human activity

Pit sawyers formerly operated throughout Bwindi and selected large, mature trees, primarily of the 29 species listed as highly desirable for timber, which included *Carapa grandiflora, Fagara macrophylla* and *Strombosia scheffleri* (Forest Department, 1967). Pit sawing was the most prevalent human activity in Bwindi between 1947 and 1991 and resulted in 61% of the forest being intensively pit sawn and 29% selectively pit sawn (Howard, 1991). This disturbance created communities of secondary forest growth and large cleared areas, which are now dominated by a dense ground cover of herbaceous and semi-woody climbers (Babassa *et al*, 2001). Exotic tree species were planted along the forest boundary in both north and south sectors, although many have since been cut for timber. A colonising mixture of *Albizia* spp., *Milletia* spp. and *Canthium* spp. now dominates the National Park boundary (Howard, 1991). Strands of colonising species also occur in areas previously cleared by the timber extraction process of pit sawing.

## 2.1.6 Fauna

### 2.1.6.1 Mammals

Bwindi contains a high diversity of 120 recorded mammal species that includes primates, carnivores and ungulates. There are ten primate species in Bwindi (Howard, 1991), the most famous of which is the Mountain gorilla (*Gorilla gorilla beringei*) (Figure 2.6). Mountain gorillas are the rarest of the three gorilla subspecies and number approximately 600-650 individuals (Robbins *et al*, 2001), divided into two populations, one in the Virunga Volcanoes of Rwanda, Uganda and the DRC, and the other in Bwindi Impenetrable National Park (McNeilage *et al*, 1998). There is debate as to whether the Bwindi and Virunga populations are separate subspecies, both because of phenotypic differences and differences in ecology and behaviour (Sarmiento *et al*, 1996). However, genetic evidence has indicated that the gorillas do not differ significantly (Garner and Ryder, 1996), but this limited work requires further study to be conclusive (Robbins *et al*, 2001).

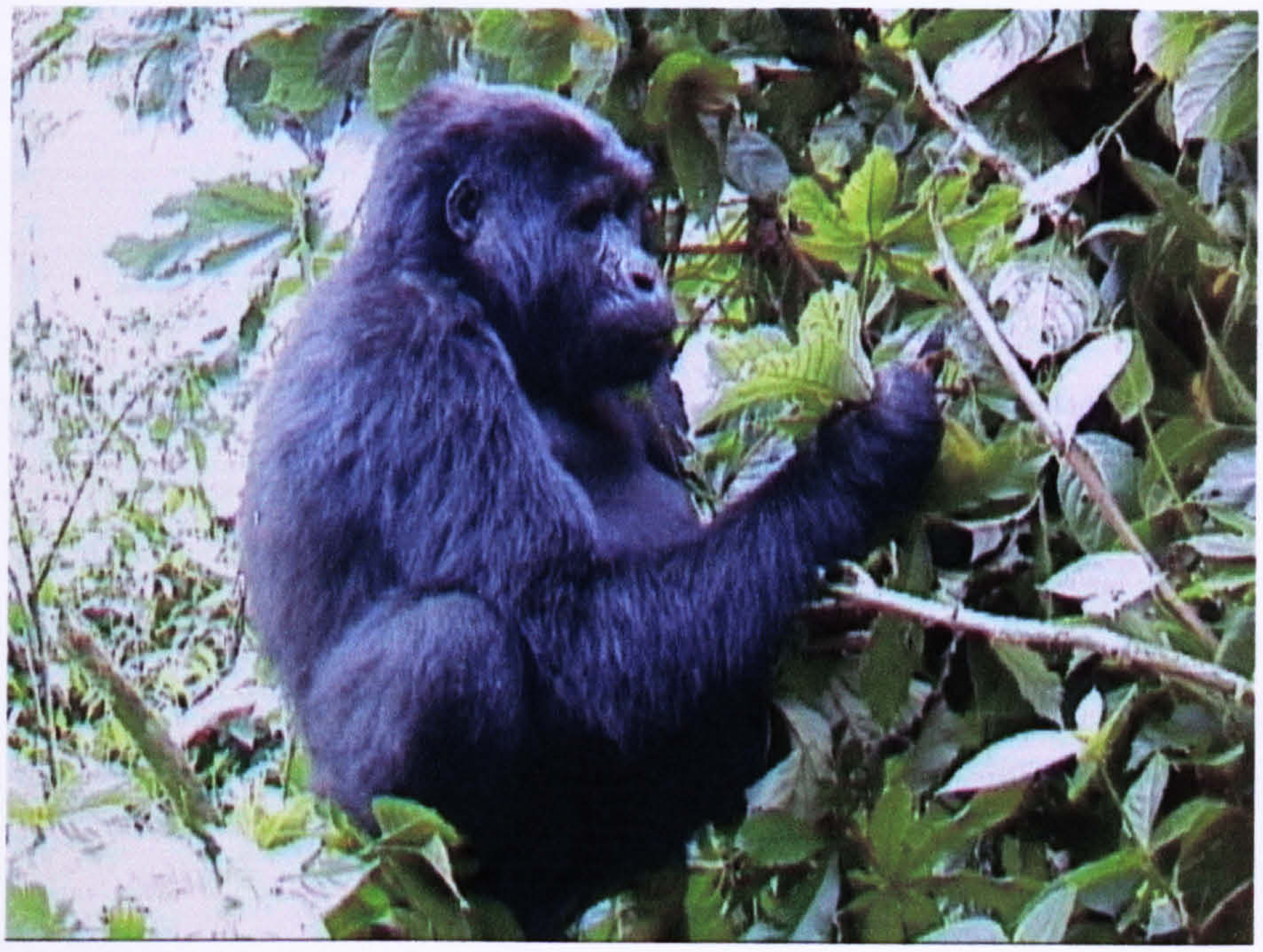

Figure 2.6 Rukundo, an adult female of the Mubale Mountain Gorilla Group at Bwindi (*Gorilla gorilla beringei*)

Besides the gorilla, there are six other diurnal forest primates including the chimpanzee (*Pan troglodytes*) and l'Hoesti's monkey (*Cercopithecus l'hoesti*), both listed as threatened, and the olive baboon (*Papio anubis*). The most abundant primate in Bwindi is the red-tailed monkey (*Cercopithecus ascanius*) although its distribution is restricted to lower altitudes. The most widely distributed primate is the blue monkey (*Cercopithecus mitis*), which occurs at all altitudes in Bwindi (Butynski, 1984). All monkeys frequent the forest periphery, whereas gorillas and chimpanzees occur mainly in the interior (Butynski, 1984; McNeilage *et al*, 1998). There are also three species of nocturnal primate comprising the potto (*Perodicticus potto*), Demidoff's galago (*Galago demidovii*) and the needle clawed galago (*Galago inustus*).

The number of carnivores in Bwindi remains uncertain. Preliminarily surveys suggested ten species *including* the golden cat (*Profelis aurata*), side-striped jackal (*Canis adustus*) and African civet (*Viverra civetta*) (Butynski, 1984). However, a recent study found four species not previously recorded (Andama, 2000). These species, comprising the clawless otter (*Aonyx capensis*), spotted neck otter (*Lutra* *maculicullis*), honey badger (*mellivora capensis*) and the African wild cat (*Felis sylivestris*), were rare and found only in the forest interior (Andama, 2000). The most abundant carnivores are the slender mongoose (*Herpestes sanguineus*), genet (*Genetta* spp.), side-striped jackal and African civet. Nevertheless, these species differ in their distributions, with the mongoose and genet occurring in the forest interior and boundary areas, while the jackal and civet are most frequent in the forest boundary and surrounding villages (Andama, 2000). The leopard (*Panthera pardus*) is the only known carnivore to be extinct in Bwindi. Game guards reports indicate that the leopard disappeared in Bwindi during the 1970s (Butynski, 1984). However, local communities estimate an earlier time between 1945 and 1968 (Andama, 2000). The main causes of its extinction are thought to be hunting for leopard skin, which was sold in Rwanda and the DRC, and the poaching of ungulates that were the main prey (Andama, 2000).

Poaching for bushmeat has resulted in greatly reduced abundances of forest ungulates in Bwindi (Butynski, 1984). Ungulates are now most common in the east of the southern sector (Butynski, 1984) where the denser ground vegetation provides a greater availability of food (McNeilage *et al*, 1998). Several species occur, including the black-fronted duiker (*Cephalophus nigrifrons*), yellow-backed duiker (*Cephalophus sylvicultor*), bushpig (*Potamochoerus porcus*) and bushbuck (*Tragelaphus scriptus*). Bushbucks are rare and limited to areas around Mubwindi swamp (Butynski, 1984; McNeilage *et al*, 1998). The population of bushpigs is estimated at 690 and the density of small duikers at 6.7 per $km^2$ (McNeilage *et al*, 1998). The giant forest hog (*Hylochoerus meinertzhageni*) and African buffalo (*Syncerus caffer*) are both extinct in Bwindi because of poaching (Butynski, 1984). A survey in 1984 recorded one encounter with a giant forest hog in a remote forest area (Butynski, 1984) and this species has been considered extinct since the 1990s (Howard, 1991). No sightings or signs were found during the 1997 gorilla census (McNeilage *et al*, 1998). The extinction of buffalo occurred during the 1970s (Howard, 1991). Buffalo were common throughout Bwindi and local people report their presence in the west and south of the south sector until the 1940s, and in the north sector until the 1950s (Namara, 2000). The last buffalo sign was recorded in 1970 in the bamboo forest of the south sector (Butynski, 1984).

African elephants (*Loxodonta Africana*) in Bwindi were once at risk from poaching (Butynski, 1984). However, since the 1980s their numbers appear stable around 25 (Butynski, 1984; McNeilage *et al*, 1998; Babassa, 2000). The elephants commonly inhabit the bamboo forest and Mubwindi swamp in the east (Butynski, 1984), but recently have been recorded in the west (McNeilage *et al*, 1998). The population is estimated to range over an area of 61 $km^2$ (Babassa, 2000).

The records of five species of shrew and 20 rodents in Bwindi is likely to be incomplete because of the limited work on small mammals. These species include four Albertine rift endemics: Woosnam's brush-furred rat (*Lophuromys woosnami*), Ruwenzori mouse shrew (*Myosorex blarina*), Delany's swamp mouse (*Delanymys brookski*) and the montane forest rat (*Thamnomys venustus*) (Davenport *et al*, 1996). Other small mammals include hyraxes, pangolins, insectivores, bats and rodents (Butynski, 1984).

### 2.1.6.2 Reptiles and amphibians

Bwindi supports a rich reptile fauna, comprising 14 species of lizard and 14 species of snake, and 28 recorded amphibian species (Drewes *et al*, 1992; Greene, 1992). Bwindi is the only known location in Uganda for the chameleon (*Chameleo adolfifriderici*) (UNP, 1995).

### 2.1.6.3 Birds

Bwindi is considered among the richest forests in Uganda for its avifauna and as one of the top ornithological sites in Africa (Butynski and Kalina, 1993; Davenport *et al*, 1996). The high diversity of bird species is becoming an increasingly popular tourist attraction. The extensive surveys undertaken have recorded a total of 348 species, which include many endangered and endemic species. 23 of Uganda's 24 Albertine rift endemics occur in Bwindi as well as four species listed as vulnerable, comprising the African green broadbill (*Pseudocalyptomena graueri*), Grauer's rush warbler (*Bradypterus graueri*), Chapin's flycatcher (*Muscicapa lendu*) and Shelley's crimson-wing (*Cryptospiza shelleyi*). The African green broadbill occurs between 1760 m and

2480 m and is found in the east, whereas Grauer's rush warbler inhabits swamps throughout the forest (Davenport *et al*, 1996).

## 2.1.7 People

### 2.1.7.1 History of settlement and Ethnic groups

The Batwa belong to the hunter-gatherer group collectively known as "*the forest peoples*", or pygmies, of forests within central Africa (Kabananukye and Wily, 1996). Batwa pygmies have occupied the forests of south-west Uganda for a similar period to that which the Mbuti pygmies have occupied the Ituri forests in neighbouring DRC, spanning some 32,000 to 40,700 years. The Batwa were once nomadic hunter-gatherers with a subsistence based on a variety of resources from forests and wetlands. It is likely the Batwa used fire to manipulate the forest for honey hunting and to stimulate plant growth in dry seasons, although there is no evidence of this from the Kigezi Highlands (Cunningham, 1992). A major forest clearance occurred throughout the highlands at a later date, approximately 2200 years ago (Taylor, 1990), which coincided with an influx of agriculturalists comprising mainly Bakiga. The early farming systems were primarily based on finger millet and sorghum. The gradual introduction of crop varieties would have stimulated trade and further settlement in the south-west region (Cunningham, 1992).

The south-west region of Uganda is now dominated by one ethnic community. The Bakiga account for 94% of the population, while the two other main communities, the Bafumbira and the Bahororo, account for 3% and 2%, respectively. The remainder of the population consists of several small ethnic groups that include the Batwa (Tukahirwa and Pomerory, 1993).

### 2.1.7.2 Population growth

The population of Uganda has increased rapidly since the early 1900s (Table 2.1). In 1921, the population density was 15 people per km$^2$ and had increased to 85 in 1991 and to 124 in 2002. Over 90% of the population is rural and over 50% is under 14 years of age (Population and Housing Census, 2002).

Table 2.1 Population and population density per km$^2$ in Uganda

| Year | Male population | Female population | Total population | Population per km$^2$ |
|---|---|---|---|---|
| 1921 | | | 3,000,000 | 15.2 |
| 1969 | 4,811,428 | 4,723,623 | 9,535,051 | 48.4 |
| 1980 | 6,259,837 | 6,376,342 | 12,636,179 | 64.1 |
| 1991 | 8,185,747 | 8,485,958 | 16,671,705 | 84.6 |
| 2002 | 12,124,761 | 12,624,216 | 24,748,977 | 124.0 |

Howard (1991); Population and Housing Census (2002)

The south-west region of Uganda accounted for a large proportion of this growth, because of both the highly fertile volcanic soils and immigration from Rwanda and DRC. The region remains one of the most densely populated in Uganda with an average density of 227 people per km$^2$ (Table 2.2), nearly three times the current national average. High population densities occur across the Kigezi Highlands and there has been rapid population increase in the three districts around Bwindi. From 1948 to 1980, populations of Kabale and Rukungiri increased 90% (Butynski, 1984).

Table 2.2 Land area and population of Kabale, Kisoro and Rukungiri districts in 2002

| | Kabale | Kisoro | Rukungiri |
|---|---|---|---|
| Land area (sq km) | 1729.6 | 729.7 | 2858.9 |
| Population density (per km$^2$) | 273 | 301 | 108 |

Population and Housing Census (2002)

### 2.1.7.3 Communities and their traditional organisation

The three administrative districts of Kabale, Kisoro and Rukungiri that border the National Park contain 20 community parishes (Figure 2.7). In these predominantly rural communities, the household is the basic dwelling unit. Typical housing consists of a detached house with iron roof sheeting, pole and mud walls and a floor of rammed earth. The majority use firewood for cooking fuel and protected wells are the main source of safe drinking water (Population and Housing Census, 1991). Each household owns a number of small plots that are scattered around their village area, which has resulted in fragmented landownership (Tukahirwa and Pomeroy, 1993). Households attach great importance to the amount of land owned, which is an important symbol of wealth within the community.

Communities, which average 150 households, were traditionally governed by its Abataka. The Abataka comprises all the adults within each community and a leadership drawn from community elders, which includes a chairman, secretary and treasurer. Their main role is to solve law offences and the Abataka are the lowest level of court (Wild and Mutebi, 1996). The administrative system of the Resistance Councils (RCs) was introduced in Uganda during the 1980s. The system consists of five levels from the village (RC1), which is the next level from the Abataka, to the district (RC5). Within a community every adult is a member of the RC1 council, which elects a RC1 committee of nine members to manage village affairs. All RC1 committees form the RC2 parish council and elect a RC2 committee of nine members. This system continues through the RC3 (sub-county), RC4 (county) to RC5 (district) council. Another important institution to rural communities is the stretcher society. All households pay a monthly fee for the stretcher societies to provide an ambulance service to the nearest clinic, which in remote areas can be more than 50 km distance. The society also provides funeral services and can deal with small offences, such as land disputes (Tukahirwa and Pomeroy, 1993).

#### 2.1.7.4 Economy

Subsistence farming is the main source of household livelihood. In the three districts of Bwindi, subsistence farming accounts for an average 82% of household income (Tukahirwa and Pomeroy, 1993). There are a variety of traditional crops because of the fertile soils, high rainfall levels and wide altitudinal range. These include sweet potatoes, maize, sorghum, beans, matoke and cassava (Cunningham, 1992) and a household with surplus produce will trade at local weekly markets. There is little trade to external markets because most villages are far from urban centres. However, in recent years the growth of coffee, tea and tobacco in the three districtsbordering Bwindi has increased. Coffee and tobacco are taken to larger town markets and tea is grown in areas where the Rukungiri tea factory collects the picked leaves. Livestock rearing and dairy farming are also common for subsistence and local trade, and in certain areas fishing provides an important income source (Wild and Mutebi, 1996). Employment and family support follow as the next source of household income. Pit sawing also provides much employment in the three districts. Town traders employ men from the villages to pit saw trees into timber, which is then taken to national markets. Agriculture is a smaller source of employment, as wealthy farmers employ labourers to gather crops during harvest and prepare the land for planting (Tukahirwa and Pomeroy, 1993). Key limitations to the socio-economic development of Kabale, Kisoro and Rukungiri include soil erosion and transport (Rwabwoogo, 2002). Soil erosion has a significant impact on the rural-based communities and results from poor agricultural techniques and fragmented land ownership. The mountainous terrain and high rainfall levels of the districts often cause landslides during heavy rainy seasons (Tukahirwa and Pomeroy, 1993). The poor transport infrastructure limits access to larger town markets and greatly restricts trade possibilities for the districts (Rwabwoogo, 2002).

### 2.1.7.5 The Batwa

When Bwindi was first gazetted a reserve in 1932, many of the Batwa moved from the forest interior to the fringes and entered the reserve for resources such as wild fruits, tubers, game meat and honey (Kenrich, 2000). The Batwa's intimate knowledge of the forest was recognised and officials would employ Batwa guides for their staff or visitors wishing to see gorillas (Butynski, 1984). In 1961, 100 Batwa were estimated to live in Bwindi (Leggat & Osmaston, 1961) and they were evicted in 1964 by the Forest Department (Wild and Mutebi, 1996). After eviction with little or no compensation, the Batwa were landless and began to squat on Bakiga land. Many Bakiga allowed this in return for agricultural work and the collection of forest resources (Kenrich, 2000). This agreement continued and the employment of Batwa as cheap labour soon involved a variety of work that included gold diggers, pit sawyers, porters, vermin controllers and craftsmen. The Batwa also continued to exchange forest resources, such as honey and game meat, for money or food (Butynski, 1984). However, the Batwa and Bakiga cultures remained distinct and the Batwa became increasing unpopular because of stealing, livestock rustling and begging for food and money (Wild and Mutebi, 1996). The Batwa are now isolated in many communities and commonly suffer discrimination, such as the refusal of health care (Kenrich, 2000). In 1984 there were approximately 300 Batwa in 30 to 50 families around Bwindi, in two concentrations in the western Mukono parish and in the southern Rubuguli parish. These concentrations have increased and in 1991 there were an estimated 600 Batwa around the periphery of Bwindi (Kenrich, 2000).

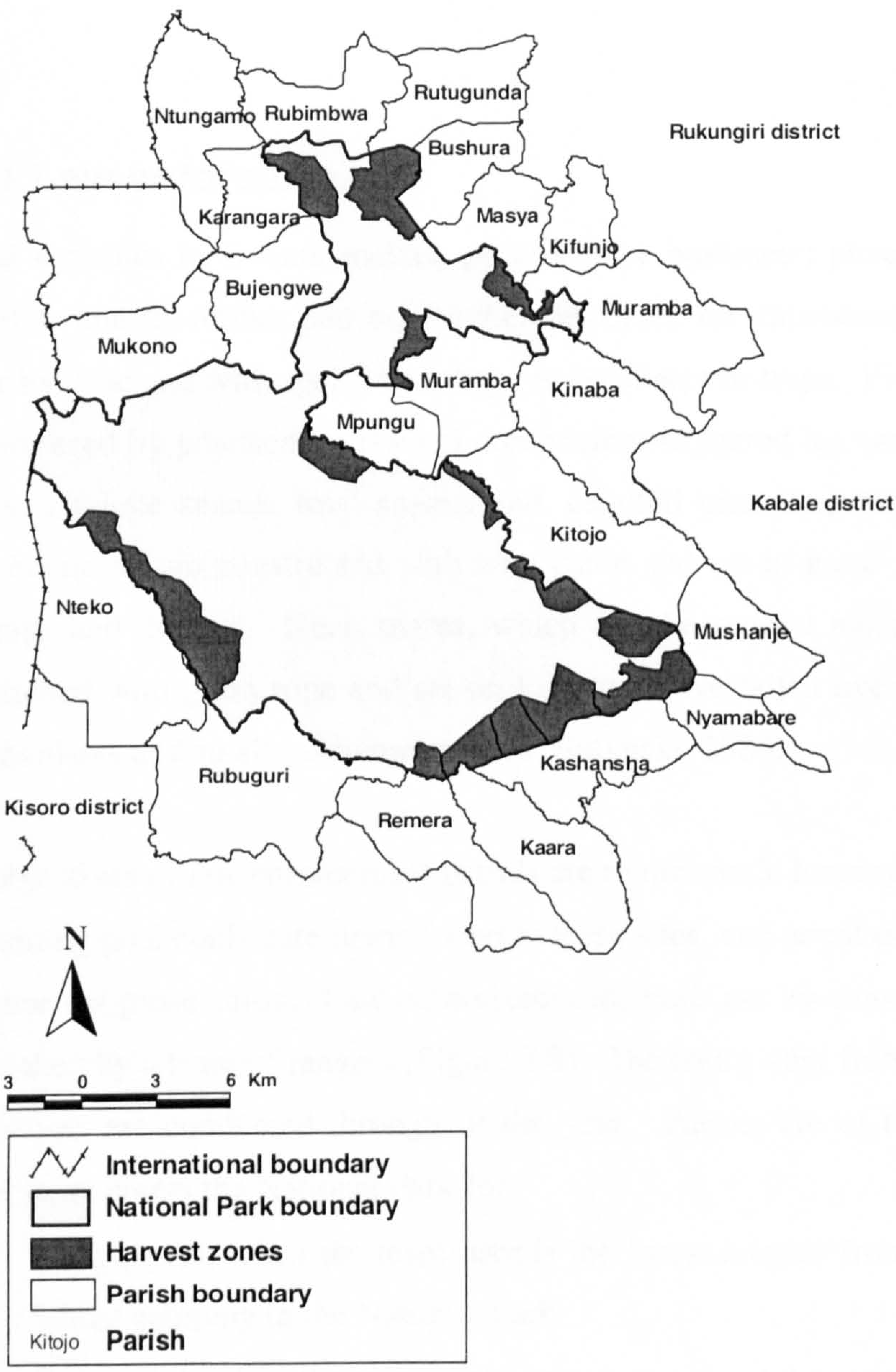


Figure 2.7 Districts and parishes bordering Bwindi Impenetrable National Park, and the harvest zones that were established in the National Park between 1994 and 1995

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## 2.2 General methodology of the study

Detailed description of material and methods, as well as of data analysis techniques, are presented in the relevant chapters. Data were analysed using Microsoft Excel 97 and SPSS Version 11.0 for Windows. Maps were produced using ArcView GIS Version 3.2 for Windows. This section presents an overview of field data collected and the analytical methods used throughout the thesis.

### 2.2.1 Law enforcement

Illegal activities in Bwindi include poaching for bushmeat; pitsawing; mining; and, the collection of timber and non-timber resources for subsistence use. Hunting is either by poachers with spears and dogs, or by snares or traps. Five types of snare or trap are used by poachers in Bwindi comprising: triggered leg snares; triggered neck snares; antelope snares; fowl snares; and, deadfall pits. Leg snares, which are the most common, are constructed with wire cable and set in game trails, primarily for bushpigs and duikers. Neck snares, which are the second most common trap, are constructed with grass rope and set on logs that have fallen over a stream or pit, to trap monkeys and small carnivore species (Butynski, 1984).

The objectives of law enforcement patrols are to dismantle hunting traps, pit saw sites and mining pits, confiscate items found at these sites, and arrest offenders and collect evidence for prosecution. Law enforcement methods are by conventional foot patrol undertaken by a team of rangers (Figure 2.8). The teams vary from two to ten rangers and patrols are conducted throughout the year. Patrols are of two types when the ranger team enters the National Park for

- Long patrol, when the team patrols the forest interior from two to eight days whilst camping in the National Park
- Day patrol, when the team patrols the area around the outpost for a single day and then returns to the outpost

Rangers encounter illegal activities either as they walk along an existing human trail or animal path in Bwindi, or by responding to a report given by any of the following: paid informers, Community Conservation Rangers, field assistants of ITFC, resource users of the harvest zone programme or members of local communities. When rangers encounter illegal activity inside the forest, they conduct a thorough search of the area for other activities as, for example, pit sawyers may set snares nearby their saw site. After encountering a cluster of snares, rangers concentrate their activities on locating all snares of that cluster. Rangers on long patrol deep in the forest interior will usually establish camp to be able to thoroughly search the area for snares. This may add an extra day to the patrol (personal observation).

Rangers are armed with AK47 rifles and are only permitted to shoot in the air when apprehending offenders, as the offenders rarely carry firearms and are typically armed with traditional weapons, such as spears or arrows. After an arrest, rangers take evidence of the illegal activity to the National Park headquarters, and take the offenders to the court of the local authorities. The courts are either local at the village and parish level, or at the higher level of the county or district. In general, minor offences, which include the collection of forest produce for subsistence use, are tried at a village or parish court. In contrast, the major offences of poaching, pit sawing and mining are tried at higher courts. Rangers attend the hearing at both local and higher courts to present evidence, but the judgement is made, and sentencing handed down, by the court. Consequently, punishments vary between community areas around Bwindi and between the level of court. Offenders taken to village or parish courts are most likely to be given a fine, whereas offenders taken to county or district courts are more likely to receive a prison term. Local courts receive 10% of the fines and the remaining amount is taken to the National Park headquarters of Bwindi. In addition, rangers take all dismantled hunting traps to the National Park headquarters (Bayenda, oral communication; personal observation). From 1986 to 1995, rangers were paid a bonus for each trap collected, although there was no information on these payments in the law enforcement records.

A report is written after every patrol. The patrol report consists of information regarding the patrol, which comprises: date; rangers involved; days on patrol; and, areas patrolled; in addition to encounters with illegal activities; and, wildlife observations inside and outside Bwindi. In addition, rangers are required to account for their use of ammunition. Rangers note the use of firearms during a patrol in the patrol report, and record the number of bullets fired and the reason for using a firearm in ammunition records kept by the Head Ranger.

The format of the patrol report changed from before National Park gazettement to after harvest zones were established. However, information collected regarding illegal activities remained consistent. The report format was amended in 1996 to include two additional pieces of information. The first concerned crop raiding by wild animals and rangers recorded incidents of crop raiding by wild animals and of problem animal control during patrols along the National Park boundary. The second concerned interactions between rangers and members of the local community. Rangers recorded interactions with, and observations of, members of local communities when patrolling the National Park boundary or when returning to the outpost through community land. Thus all community responses were made outside the National Park. These records were collected under the heading of "*community response*" and consisted of descriptive notes detailing conversations with community members, and general observations made by the rangers on the attitude of local communities towards the National Park.

The ranger in charge of the outpost usually makes the report. Rangers are made the "*in charge*" of the outpost after gaining several years of experience as a law enforcement ranger at Bwindi. There is a core team of between ten and fifteen rangers who are in charge of the outpost. Other experienced rangers are only made an "*in charge*" when one of the team retires or leaves Bwindi (Bayenda, oral communication). Thus patrol recording is undertaken by a fairly consistent small group of rangers with experience of patrolling Bwindi. In general, men from local communities of Bwindi are employed as rangers.

Figure 2.8 Ranger on law enforcement patrol in Bwindi

#### 2.2.1.1 Retrieval of law enforcement reports

Law enforcement patrol reports were retrieved from Bwindi for a historical analysis, following methods used previously (e.g. Bell, 1986; Leader-Williams, Albon and Berry, 1990; Jachmann and Billiouw, 1997). During the attack on Bwindi in 1999 by the Interahamwe, the Rwandan extremist militia who launched attacks into Rwanda from the then Zaire, the National Park headquarters at Buhoma were looted. Consequently, only an incomplete set of patrol reports dating from 1997 to 2000 was immediately available.

I located earlier reports by consulting staff of the National Park, and retired staff of the Forestry and Game Departments who had knowledge of the reports kept throughout the history of law enforcement at Bwindi. Over the course of fieldwork for this study, patrol reports and other records at Bwindi, which included reports by Game Department staff, National Park wardens and staff of the conservation authorities, were gradually retrieved from a variety of sources that included outposts of the National Park and offices of Care-DTC and of ITFC. Reports written in the local language of Rukiga were translated into English. The total sample of patrol reports and records eventually retrieved spanned the period from August 1986 to December 2000, although no records were found for 1990 or 1991. The absence of records for these years was likely a consequence of the gazettement process, particularly the transition in management from the Forest Department to UNP, as it was possible that records went missing while being transferred between offices of both authorities. Records could have also been mislaid during the transition in management from UNP to UWA.

#### 2.2.1.2 Verification of rangers' recording

Verification of the data recorded by rangers from December 2000 to December 2001 was undertaken during fieldwork to assess the reliability of the patrol reports. Rangers were accompanied on a total of 121 patrols in all areas of Bwindi and throughout the year. Independently of, and unknown to, the rangers, encounters with illegal activities and wildlife were noted using the same recording format as the rangers' patrol reports. Descriptive notes on interactions between rangers and members of local communities were also made. First, I assessed the accuracy of rangers' recording of their encounters with illegal activities and wildlife from nine criteria that included missing data and inaccurate records, for example, the location of illegal activity in relation to harvest zones (Table 2.3). Patrol reports with three or more errors were considered to be inaccurate records of the patrol. Second, I assessed the accuracy of rangers' recording of the community response by assigning categories that were to be employed for the analysis (Table 8.1) both to the rangers' and to my own description of the community response. I then determined whether the same categories had been assigned by the rangers and by myself.

Most (83%) patrol reports comprised two or less errors in the recording of encounters with illegal activities and wildlife (Figure 2.9). Errors most common in the recording were inaccurate recording of the day that the patrol was conducted, although the month of the patrol was accurately recorded, and missing data regarding offenders particularly the village or parish of the court for arrested offenders, the judgement made by the court and, if a fine was issued, the amount of money fined. Rangers did not consistently record details of arrested offenders, such as parish of origin, sex and age, although were consistent in recording whether offenders were arrested or escaped. In addition, rangers did not consistently record numbers of an illegal activity encountered, for example number of beanstakes cut, and of animals encountered, for example number of baboons sighted. However, rangers were consistent in recording the encounter and thus the analysis was based on patrol encounters with illegal activity and wildlife, rather than the actual number of the activity or species encountered. There were two exceptions where rangers did accurately record numbers per encounters and both concerned poaching, which was likely because poaching is a major threat to mountain gorillas. First the number of snares that rangers collected following an encounter with a cluster of snares, and second the number of poachers that rangers encountered in the forest. This permitted analysis on the number of snares per snare cluster, as an indication of snare density, and on the size of poachers' groups.

Most (89%) categories assigned to rangers' recording of community response matched the categories assigned to my recordings of the response. I tended to record the interactions in greater detail than rangers, although rangers' recordings were sufficient to assign each interaction to the appropriate category. The verification also confirmed the scale that was assigned to the categories for analysis. For example, communities' requests for compensation, vermin guards or land purchase because of crop raiding by wild animals ranked very negative, whereas communities' complaints about crop raiding animals ranked negative. The higher level of conflict associated with requests in comparison with complaints was evident from the discussions with staff of Bwindi from which the scale was constructed, and was observed during the verification survey.

A further consideration for validating patrol reports is the possibility that the accuracy of rangers' recording changed over time, as changes in the experience, training and motivation of each ranger may influence recording ability. For example, it could be expected that rangers' recording skills would improve with an increase in time spent patrolling from experience gained, with training in law enforcement techniques and with motivating factors such as salary increases. Conversely, a decline in recording accuracy could be expected from factors negatively affecting motivation, such as the removal of bonuses. Rangers at Bwindi have received training and salary increases, and a bonus for collecting snares was stopped following National Park gazettement. It is therefore possible that the accuracy of rangers' recording changed over time. However, as previously described (section 2.2.1), the management system in Bwindi is such that patrol recording is undertaken by a fairly consistent small group of rangers with experience of patrolling. Therefore, most patrol reports from 1986 to 2000 reports were accepted as sufficiently accurate for analysis, although reports made by rangers who submitted less than ten reports in total were omitted from the analysis.

Table 2.3 Criteria for assessing the accuracy of rangers' patrol reports of encounters with illegal activities and wildlife

| **Missing data or inaccurate recording:** |
|---|
| Date of the patrol |
| Number of rangers on patrol |
| Number of patrol days |
| Forest area of the patrol by toponym |
| Type, number and location of illegal activity encounter |
| Outcome of the illegal activity encounter |
| Type, number and location of wildlife encounter |
| Type, number and location of wildlife crop raiding encounter |
| Type, number and location of problem animal control |

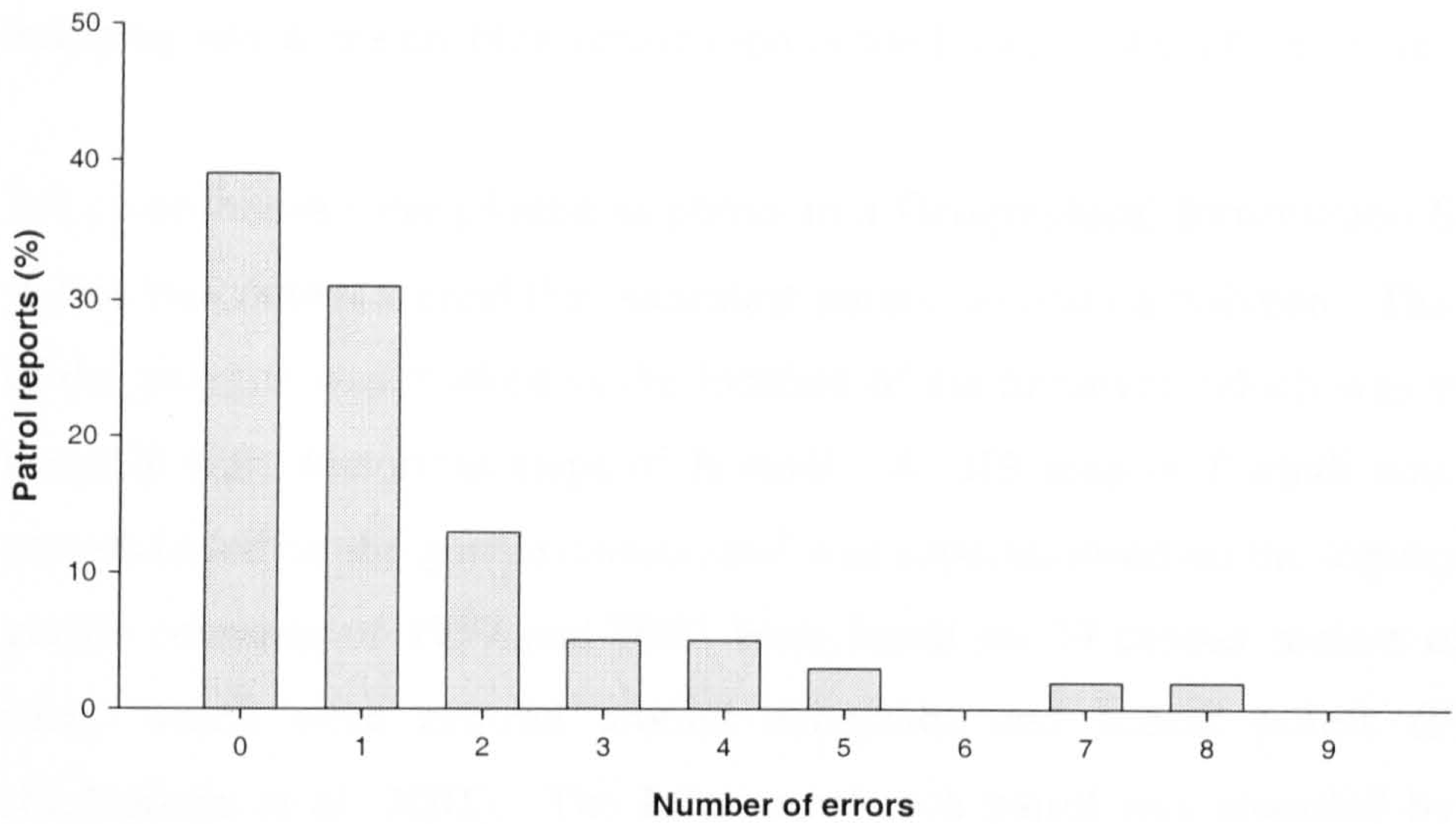



Figure 2.9 Errors in rangers' patrol reports of encounters with illegal activities and wildlife

### 2.2.1.3 Toponym map

Rangers recorded their patrol route by toponyms, which are local names of areas in the forest. I observed consistency in the use of toponyms between different recorders while accompanying rangers on patrol. Thus use of toponyms by rangers appeared to be stable and a map of the toponyms was constructed to plot patrol route and incorporate forest area in the analysis. Over 300 toponyms appeared in the patrol reports. National Park staff were consulted on the most commonly used toponyms, as several toponyms could refer to the same area, and on the correct written form, as the same toponym could be spelt differently, while certain letters could indicate the position of the toponym. For example, "*omu*" placed before the toponym means "*the area of* (*the toponym*)". Forest surveys were conducted to obtain co-ordinates of the area and boundary of each toponym for constructing the toponym map. The surveys were conducted with two field assistants of ITFC and co-ordinates were taken with a Global Positioning System. A total of 84 surveys were conducted that covered an estimated 124.6 km of Bwindi, using the method employed for the reconnaissance survey to calculate distance (section 2.2.2). In addition to the surveys, toponym co-ordinates were also obtained whilst participating in the 2002 census of the mountain gorilla population, and from the monitoring records from 1995 to 2000 of ITFC of the gorilla groups in the east Ruhija area of Bwindi. The variety of sources used for mapping toponyms enabled verification of the location of each toponym.

All co-ordinates were plotted as points in a Geographical Information System (GIS). A line was drawn around the outermost points to create a polygon. The central point of the polygon was marked as the location of the toponym, which was verified where possible from historical maps of Bwindi. A GIS map of Bwindi was divided into sectors based on the gorilla census, and was superimposed on the toponym map. The gorilla censuses of 1997 and 2002 were based on 39 census sectors of 5 - 10 $km^2$ each, which were centred around campsites and access points (Figure 2.10a) (McNeilage *et al*, 2001). The location of each patrol was recorded by locating the toponym according to the census sectors (hereafter referred to as sectors). If a patrol covered several toponyms that occurred in one sector, the sector was recorded only once. For example, a patrol in the toponyms of "*Bitanwa*" (sector T), "*Rwanzo*" (sector AA) and "*Kisya*" (sector AA), was recorded as having covered sectors T and AA. If a patrol covered toponyms in different sectors with no linking sector in-between, the patrol route was estimated from existing forest trails and the linking sector was assumed to have been part of the patrol.

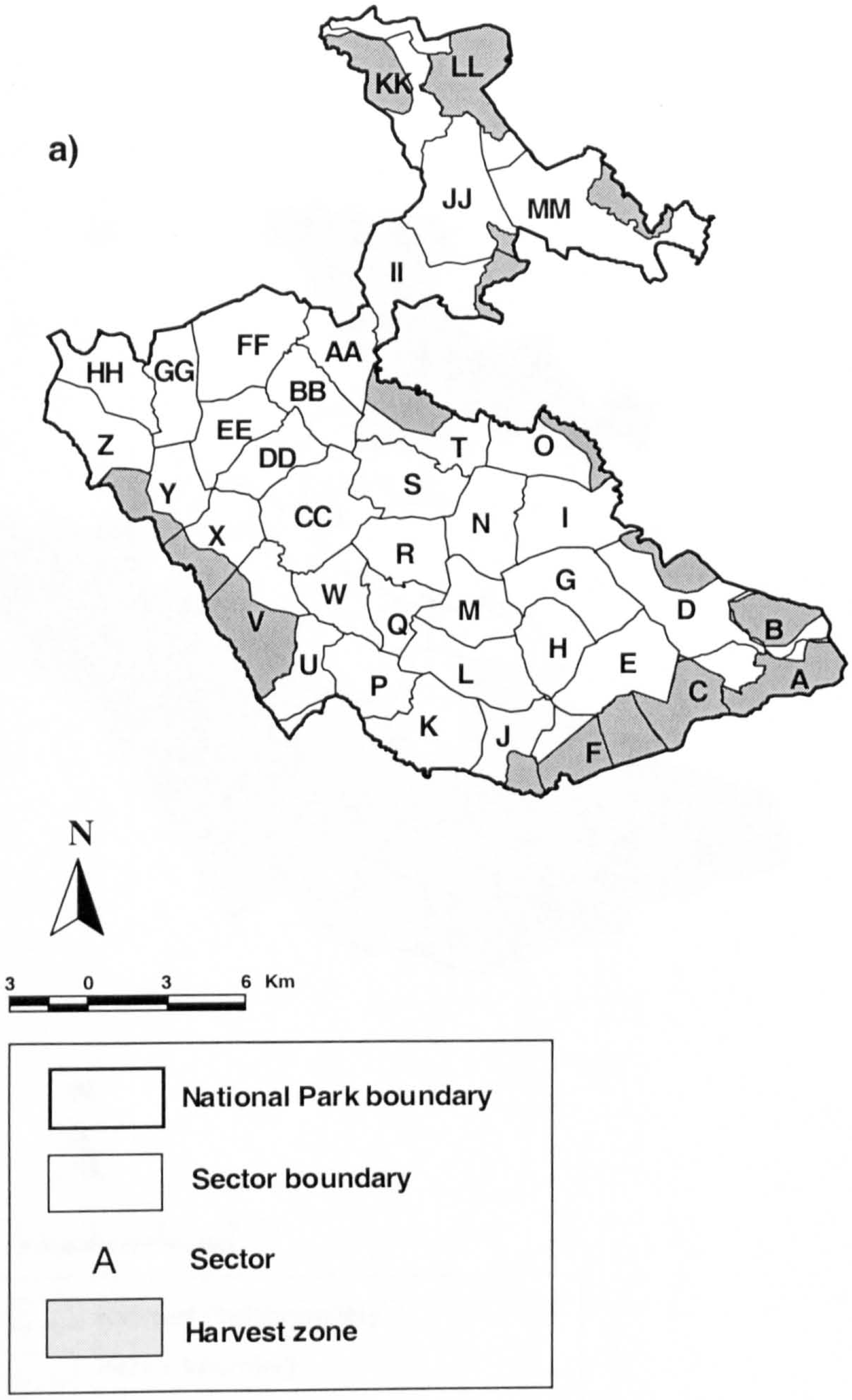
The sectors were grouped into five areas of Bwindi selected on the basis of the most common patrol routes, comprising: north; centre; east; south; and, west (Figure 2.10b). Sectors within each area were categorised as either interior or boundary (those with a boundary at the exterior of the National Park) and, for boundary sectors, as either with or without future harvest zones (Table 2.4). The patrol areas were then categorised according to the proportion of forest (low, medium or high) designated as future harvest zone (Table 2.5).

Table 2.4 Area of Bwindi categorised by interior and boundary sectors and whether a harvest zone (HZ) was established between 1994 and 1995

| Area of Bwindi | Forest sector | | |
|---|---|---|---|
| | Interior | Boundary HZ | Boundary non HZ |
| North | | JJ, KK, LL, MM | |
| Centre | BB, N, S | II, T, O | AA, FF |
| East | E, G, H | A, B, C, D, F | I |
| South | L, M, R, Q, W | J | K, P, U |
| West | CC, DD, EE | V, X, Y | GG, HH, Z |

Table 2.5 Area of Bwindi categorised by the proportion of forest designated as harvest zone (HZ) between 1994 and 1995

| Area of Bwindi | Boundary area ($km^2$) | Boundary HZ area ($km^2$) | Proportion HZ | Category HZ |
|---|---|---|---|---|
| North | 41.41 | 16.51 | 0.40 | High |
| Centre | 45.15 | 3.61 | 0.08 | Low |
| East | 55.98 | 26.33 | 0.47 | High |
| South | 26.92 | 1.50 | 0.06 | Low |
| West | 46.46 | 12.86 | 0.28 | Medium |


a)
KK
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National Park boundary
Sector boundary
A Sector
Harvest zone

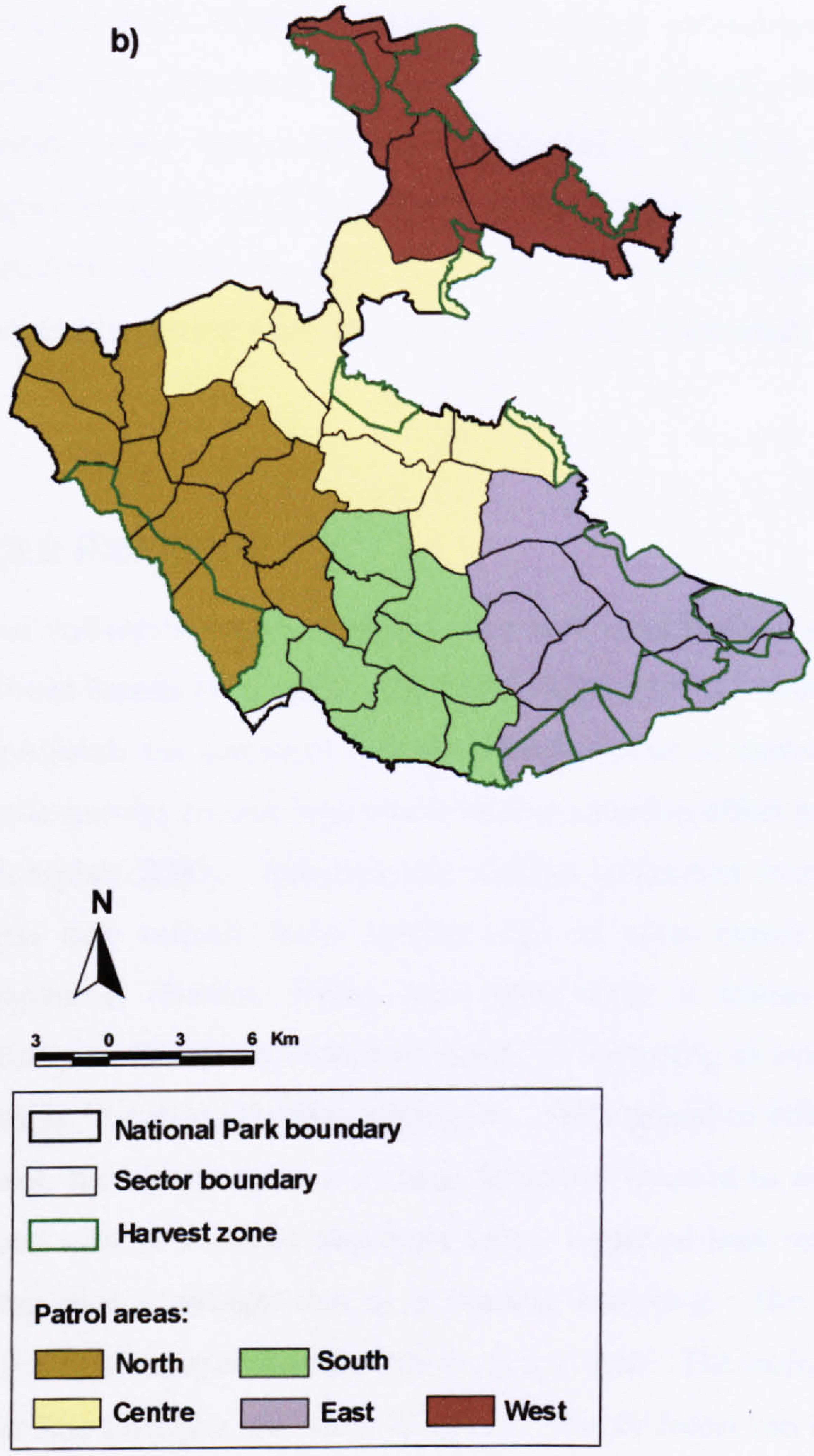


Figure 2.10 a) Sectors of Bwindi based on the gorilla census and b) patrol areas of Bwindi

### 2.2.2 Archival material

Records regarding mountain gorillas, and conflict between local communities and staff of Bwindi, were obtained wherever possible from the variety of records that were retrieved from Bwindi. These included law enforcement patrol reports; monthly reports and anecdotal records by the Head Ranger, National Park wardens and Forestry staff; letters between National Park Wardens, staff of non-governmental organisations (NGOs) and chiefs of local parishes and villages; and, reports and anecdotal records by staff of NGOs. In addition, annual reports of the Game Department dating from 1921 were employed for the study.

### 2.2.3 Fieldwork

Line transect survey techniques have been employed to estimate primate density in African forests (Whiteside *et al*, 1988; White, 1994). However, line transects are not appropriate for mammals that are seldom visible or elusive or difficult to encounter, as the surveys require high precision and sampling effort to be confident of the results (Plumptre, 2000). Subsequently indirect estimation techniques, typically counting signs that animals leave behind such as nests (apes) (White, 1994) and dung (elephants) (Barnes, 1993), have been used in forests where visibility is poor (Plumptre, 2000). A further difficulty of surveying in tropical forests is travelling a straight line through dense vegetation. With regard to difficulties of observation and travel, the reconnaissance method (hereafter referred to as recce) was developed for forest surveys whereby observers follow a path of least resistance through the forest, rather than a straight line as in transect sampling. The path of least resistance is typically an existing human trail or animal path. The main advantages of recce walks over line transects are that a far greater area of forest can be surveyed than would be possible with line transects, and that the walks require less cost and time than standard sampling methods (Walsh and White, 1999), which is particularly important for conservation managers limited by financial constraints in establishing monitoring systems (Kremen *et al*, 1999).

There are limitations associated with this relatively crude survey technique and with using indirect counts to estimate mammal density. A census from paths in the forest will give a biased estimate of population density, as there are possible biases towards mammals that tend to use existing forest paths and towards areas of less dense vegetation that are easier to move through. However, this bias can be corrected by undertaking recce walks in conjunction with line transects to calibrate the functional relationship between recce and transect encounter rates (Plumptre, 2000). Regarding use of indirect counts, estimating decay rates for nests and dung, which are necessary to convert estimates of sign abundance to animal abundance, is difficult in tropical ecosystems because rates vary according to factors such as seasons, habitat and diet. Thus estimation of sign production rate must be addressed on a case by case basis, and retrospective rates should be used instead of prospective rates (Laing *et al*, 2003).

Recce walks and indirect counts have proven reliable for examining wildlife abundance by encounter rates per km (Barnes, 2002; Plumptre *et al*, 2002; Balcomb *et al*, 2000). Both were considered appropriate to examine the distribution of illegal activity and wildlife for this study, as comparisons between counts from recce walks and line transects undertaken in Bwindi have established the recce method as a reliable technique for estimating distributions of wildlife and illegal activity in Bwindi (McNeilage *et al*, 1998). In addition, age categories of wildlife and human signs employed for this study were those used in the 1997 gorilla census, as the census categories were developed from estimated decay rates based on environmental conditions of Bwindi (McNeilage *et al*, 1998). There were also benefits from using recce walks and indirect counts, as a greater area of Bwindi could be surveyed than that possible with line transects, and as comparisons could be undertaken between this study and the 1997 census to assess distributions of wildlife and illegal activity in Bwindi over time.

Recce walks were undertaken in the dry season of December 2000 to February 2001. The walks were conducted in the forest interior along an irregular network of existing human trails and animal paths (interior recce walks), and along the National Park boundary (boundary recce walks). The recce walks were undertaken in areas of Bwindi that were selected to represent different habitat types (Figure 2.11). Recordings were made on incidents of illegal human activity and on encounters with wildlife that were observed by two field assistants walking at a pace of 1km/hour. To address limitations of recce walks, the walks followed at random paths of elephants and primates, trails of pit sawyers, miners and gorilla monitoring teams, and patrol routes. In addition, heavily used human trails, such as trails established by harvesters within harvest zones, were avoided, pilot recce walks were first conducted, and field assistants with extensive experience of survey work in Bwindi, including the recce walks undertaken for the 1997 gorilla census, were employed for the survey.

The distance of each recce walk was measured by readings from a Global Positioning System (GPS), which were taken every twenty minutes. The readings were plotted as points in a GIS map of Bwindi, and the points of each walk were converted into a polyline. This map was overlaid by a theme of the sectors used for the gorilla census (McNeilage *et al*, 1998), when the area of Bwindi was divided into 39 small sectors of between five and ten $km^2$ each (Figure 2.11). Each polyline was clipped to the corresponding sector and the distance walked in each sector was estimated. This technique underestimated actual distance, but provided a consistent calculation that met the requirements of an analysis to compare encounter rates of illegal activity between different areas within Bwindi. The technique also enabled a greater number of recce walks to be undertaken than would have been possible using more complex methods to calculate actual distance. The sectors of Bwindi were grouped into northern and southern sectors. Southern sectors, comprising all of the east, south and west areas of law enforcement patrols and centre sectors apart from sector II (Figure 2.10b), were categorised as forest interior or boundary (those with a boundary at the exterior of the National Park), and boundary sectors were further categorised as harvest zone or non-harvest zone sectors. For the survey, 64 recce walks were conducted that totalled 106.7 km. A total of 35 walks covered forest interior sectors, with a mean of 1.6 km (range 0.6 – 4.7 km) per walk, and 29 walks covered boundary sectors, with a mean of 1.5 km (range 0.5 – 5.2 km) per walk.

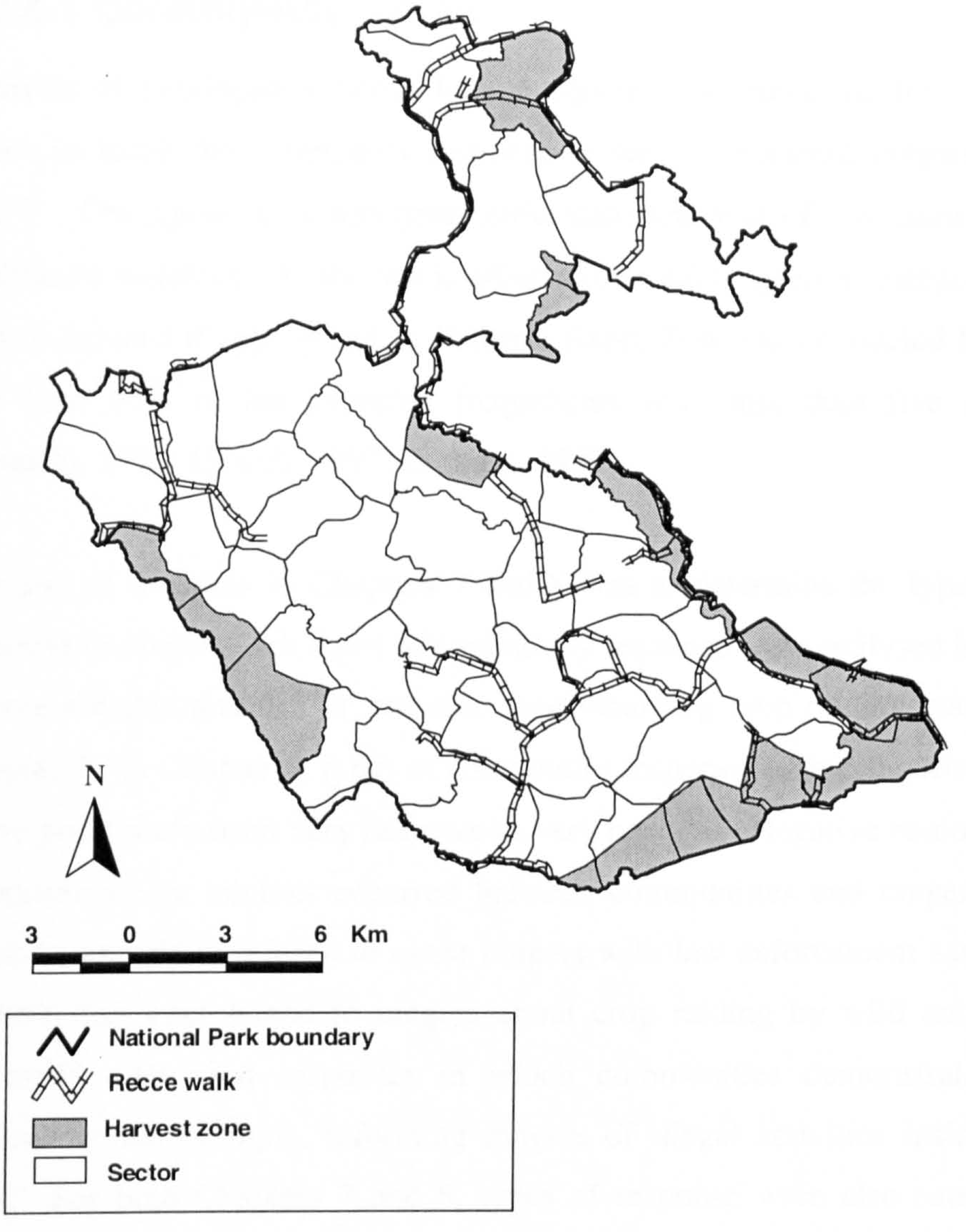


Figure 2.11 Recce walks in Bwindi

## 2.2.4 Data analysis

Univariate tests were undertaken using parametric and non-parametric tests according to the way the data were distributed, and following procedures in Zar (1996). For non-significant results, exact values are given for $P$ values $< 0.1 > 0.05$, and $P$ values $> 0.1$ are reported as $> 0.05$. For significance results, $P$ values are reported as $< 0.05$, $< 0.01$ or $< 0.001$ (Dytham, 1999).

### 2.2.4.1 Contingency tables

Analysis of contingency tables by chi square was employed for categorical data, which included the community response to law enforcement rangers of Chapters 7 and 8. Chi square is a non-parametric statistical test of association between two qualitative variables. As the test is affected by total frequency, categories of the table were combined if appropriate or Fisher's Exact Test was conducted for tables where less than 20% of the expected frequencies were less than five (Camilli, 1990; Delucchi, 1993; Howell, 1997; Dytham, 1999).

The aim of analyses in Chapters 7 and 8 was to determine the type of community response to rangers. All types of community response were analysed in Chapter 8 and a more detailed analysis of response type regarding crop raiding was undertaken in Chapter 7. In Chapter 8, types of community response were categorised according to a five-point scale from very negative to very positive. Negative responses comprised responses where conflict occurred between communities and rangers, for example when communities refused to assist rangers with law enforcement activities or when communities complained to rangers about crop raiding by wild animals. Positive responses comprised responses in which communities demonstrated support for Bwindi by for example, informing rangers of illegal activities inside the National Park. For both Chapters 7 and 8, types of response were also categorised by the community member making the response and by patrol area. Contingency tables (2 x 2) were constructed firstly with type of response and community member, and secondly with type of response and patrol area for analysis by chi square. The aim was to determine whether certain community members or areas of Bwindi were associated with a particular type of response.

### 2.2.4.2 Logistic regression

Logistic regression analysis formed part of the analysis of encounters by law enforcement patrols with incidents of bushmeat poaching (Chapter 4) and with sightings and indirect signs of gorillas (Chapter 9), of encounters with wildlife during recce walks (Chapter 10), of incidents of problem animal control undertaken by rangers while on law enforcement patrol (Chapter 7) and of type of community response to law enforcement rangers (Chapter 8).

Logistic regression was considered appropriate as the form of regression analysis because of the fewer assumptions about data than those of the Model I regression, which were important given the limitations of the law enforcement data, which included distributions significantly different from normal.

Logistic regression analysis was used to identify factors that best explained the likelihood of either a patrol or recce encounter, to rank the relative importance of the factors and to determine the percent of variance in the dependent variables explained by the factors. The binominal variate (1 = encounter; 0 = no encounter) formed the dependent variable. This variable was examined for outliers to identify data points outside the general linear pattern. Outliers with residuals greater than +2 standard deviations were examined to determine whether the outliers were explained by variables not in the model and required a separate model, or whether additional explanatory variables needed to be brought into the model. The forward stepwise procedure was used to determine which factors best explained the encounters, with entry and exit of factors determined by the Wald statistic with P values of 0.05 and 0.1, respectively. Model performance was evaluated by calculating the area under the curve (AUC) of Receiver Operating Characteristics plots (Pearce and Ferrier, 2000). AUC values range from 0.5 to 1.0, with values above 0.7 indicating a good model and values above 0.8 indicating a highly accurate model fit (Swets, 1998). In addition, the percentage of variation in the data accounted for by the final model was assessed by the Nagelkerke R square value. The importance of explanatory variables included in the final regression model was examined by significance of the Wald Statistic.

Relationships between explanatory variables were examined to determine possible inter-correlations, as problems of multicollinearity within regression analysis can create difficulties in identifying true casual factors (MacNally, 2000). The tolerance, variance inflation factor (VIF) and eigenvalues of the variables were also examined to identify multicollinearity. Tolerance values range from zero to one and reflect the percentage of variance in a given predictor that cannot be explained by other predictors. Thus small tolerance values close to zero indicate that standard errors of the regression coefficients will be inflated. VIF values, which range from one to infinity, express the degree to which collinearity among the predictors degrades the precision of an estimate. High VIF values indicate instability of b and beta coefficients. Values greater than four were used to indicate multicollinearity. Several eigenvalues close to zero with condition indices greater than 15 used also to identify multicollinearity (Cohen and Cohen, 1993; Menard, 1995).

### 2.2.4.3 Log linear analysis

With count data, such as conflict incidents per year in Chapter 3, community responses on crop raiding in Chapter 7, and incidents of crop raiding encountered by rangers on patrol in Chapter 6, no negative values exist, as the data comprises only integers including many values constrained at zero, which violates the assumptions of normality and constant variance. Thus the use of traditional forms of power multivariate analyses (Cohen, 1988; Zar, 1984), including linear regression methods, is not appropriate because the assumption that the variance of all observations is the same does not hold for count data. Hence, count data were analysed by log linear analysis, under the assumption of a Poisson distribution, using the hierarchical approach and specifying a log link function.

The aim of the log linear analysis was to identify the most parsimonious model that best explained the data with the least number of terms in comparison with the saturated model, which contained the highest-level interaction and all lower order terms. Dummy variables were generated by setting the parameter that corresponded to the last category of each factor to zero. The factors were examined using the backward elimination procedure with the probability for removal set at 0.05. Expected cell frequencies were calculated by maximum likelihood using the Newton-Raphson method, and the fit of the model to the actual cell frequencies was measured by the likelihood ratio ($G^2$) value. Models were evaluated by the statistical significance of the $G^2$ value in comparison with the saturated model, using a chi square test. The model with the least number of terms that exhibited a low deviance value, and which did not significantly differ from the saturated model, was selected as the final model. Parameters of the final model were examined by the ratio of the standardised lambda values, which were calculated from the parameter estimates to explain variance in the expected log cell frequencies. The lambda values indicate additions (positive values) or reductions (negative values) in the expected log cell frequencies as a result of the parameter, and thus the values explain variance in cell frequencies. Also, the size of the value indicates the contribution of the parameter to the model relative to the reference parameter, and large lambda values (> 1.96) flag the most significant terms in the model (Everitt, 1977; Upton 1978, 1986).

Having established the general methods of the study, I now seek to examine the incidents of violent conflict between local communities and staff of Bwindi when Bwindi was designated a National Park, which led to the adoption of the integrated approach for conservation at Bwindi.

# Chapter Three

# -

# Conflict during the Period of National Park Gazettement

*Homestead in Buhoma, the village neighbouring the headquarters of Bwindi*

*(J. Baker)*

# Chapter Three

# 3 Conflict during the period of National Park gazettement

## 3.1 Introduction

Conflict is defined as emerging when "*the interests of two or more parties clash and at least one of the parties seeks to assert its interest at the expense of another party's interests*" (FAO, 1998). Thus, although underlying causes of conflict can be complex, the perception that one group is gaining at the expense of another is central to conflict issues. In general terms, conflict can be considered a function of sociological, political or economic perspectives (Bennett *et al*, 2001), and can be explained by key factors of demographic change, natural resource competition, developmental pressures and structural injustices (Warner, 2000).

Analysis of natural resource conflicts has largely concerned fisheries. Two approaches for conflict analysis of fisheries have emerged of a post-modernist approach that provides detailed information on a specific area or situation, and a theorist approach. The theoretical approach has advanced the study of conflict since the inception of conflict theory during the immediate post-war period. Firstly new frameworks have been developed for incorporating sociological, economic and anthropological aspects within natural resource conflict analysis. Adopting such frameworks enables an assessment of the causes of conflict, for example, whether conflicts arise as a result of social structure, power relations or individuals seeking to maximise personal gain from limited resources (Bennett *et al*, 2001). Secondly typologies developed for identifying conflict types allows for hypothesis formation based on a multitude of factors placed under general categories (Charles, 1992). Producing a typology increases understanding of the nature of conflict, which has been particularly important for conflict analysis of fisheries in developing countries (Bennett *et al*, 2001).

Conflict between local communities and conservation managers is a primary threat to biodiversity conservation in tropical countries (IUCN, 1980). Conflict can occur once local access to natural resources is lost following the designation of a protected area, and the resulting negative local attitudes can inhibit conservation efforts. Therefore, resolving conflict issues is a priority for protected areas managers (Davey, 1998). A variety of strategies have been proposed for conflict resolution and for gaining local support for protected areas. Many involve the provision of local community benefits, such as the distribution of conservation revenue from tourism to community development projects (Wunder, 2000; Archabald and Naughton-Treves, 2001), direct payments for compensating local costs of conservation (Ferraro, 2001), development interventions including the construction of schools and health clinics and access to natural resources (McNeely and Miller, 1984; McNeely, 1988). These strategies have been particularly successful in changing negative attitudes towards conservation (Archabald and Naughton-Treves, 2001; Infield and Namara, 2001). However, there is debate as to whether strategies providing local benefits can reduce threats to conservation, particularly the level of illegal activity within protected areas (Infield and Namara, 2001). Consequently, even when benefits are shared, conflict resolution still remains a major challenge for managers of protected areas.

One assumption underlying strategies for alleviating conflict is that conflict arises because communities have lost access to resources upon which they depend for subsistence (Lewis, 1996; Scott, 1998). However, rural communities are not homogenous entities and different resource user groups will have different interests in natural resources that will be influenced by social, economic and political factors (Archabald and Naughton-Treves, 2001; Infield, 2001; Gottret and White, 2002). In comparison with conflict analysis of fisheries, the formation and nature of conflict of protected areas is little studied, particularly differences in stakeholder interest and external influences to the conflict. Yet, understanding conflict is vital for protected area managers to select appropriate resolution strategies and to evaluate the impact of these strategies on biodiversity conservation (Davey, 1998).

Violent conflict between local communities and staff of Bwindi occurred during the period of National Park gazettement. Rangers were harassed by community members and were often refused food for sale and, in some areas, membership of stretcher groups, which are traditional institutions that provide local ambulance and burial services (Blomley, 2001). The conflict escalated during the years preceding gazettement when effective law enforcement was first introduced at Bwindi. The conflict reached a peak in the year after gazettement when forest fires were deliberately started by local communities to destroy the National Park (Wild, 1992; Wild and Mutebi, 1996; Hamilton *et al*, 1999; Blomley, 2001; Kasangaki *et al*, 2001).

Conservation managers at Bwindi adopted the integrated approach for management of the National Park in response to the conflict. Evidence from attitude surveys and anecdotal accounts of community-park interactions (Wild and Mutebi, 1996), and the decline in deliberate forest burning (Hamilton *et al*, 1999), indicate that the integrated approach for conservation has improved local attitudes towards the National Park. However, there is an assumption that conflict arose from the loss of local access to natural resources (Wild and Mutebi, 1996; Hamilton *et al*, 1999; Blomley, 2003; Makombo, 2003). Consequently, with no assessment of the causes of conflict, evaluations of the success of integrated programmes in improving local attitudes towards Bwindi, and in reducing threats to conservation, are limited.

Hence, the aim of this chapter is to examine incidents of violent conflict between local communities and staff of Bwindi during the period of National Park gazettement. The main objective is to determine the factors that best explain conflict incidents. To address the objective, I seek to determine the following research questions:

- In which gazettement period did most conflict incidents occur?
- In which area of Bwindi did most conflict incidents occur?
- Which community members instigated most conflict incidents?
- Which type of incident most commonly occurred?
- What is the relative significance of gazettement period, area of Bwindi, instigator of conflict and type of incident to the conflict incidents?

## 3.2 Materials and Methods

### 3.2.1 Data collection

The retrieval of archival records from Bwindi, and the retrieval and means of verifying law enforcement patrol reports, were described in Chapter 2.

The archival records and law enforcement patrol reports of Bwindi contained descriptive notes on interactions between local communities and law enforcement rangers, and between local communities and conservation authorities. Data were extracted from archival records and patrol reports on incidents of violent conflict between local communities and staff of Bwindi. Thus data on incidents of violent conflict were extracted from a variety of records that included law enforcement patrol reports; monthly reports and anecdotal records by the Head Ranger, National Park wardens and Forestry staff; letters between National Park Wardens, staff of non-governmental organisations (NGOs) and chiefs of local parishes and villages; and, reports and anecdotal records by staff of NGOs.

An incident of violent conflict was defined as a direct attack on the rangers or conservation authorities. Deliberate fire setting within Bwindi was also included because, although the action did not involve a direct attack, fire setting is considered an important measure of the conflict at Bwindi over the period of gazettement (Blomely, 2003; Makombo, 2003). The archival records contained a myriad of descriptions regarding violent conflict incidents. The most salient features of the descriptions were listed to develop a typology of violent conflict incidents. Developing a typology enabled unification of the descriptions under general categories for analysis (McKinney, 1992). Each incident of violent conflict was categorised by area, instigator and cause. For the category of area, Bwindi was divided into five: north; centre; east; south; and west (section 2.2; Figure 2.10b). For the category of instigator, five types were identified: villagers; offenders; councillors of local authorities which were village and parish chiefs; members of the army and staff of the Forest Department. Offenders comprised those arrested by rangers for undertaking illegal activities within Bwindi, and the type of offence committed was noted. For the category of the cause of conflict, five types were defined based on descriptions in the law enforcement records and patrol reports (Table 3.1).

Table 3.1 Types of violent conflict between local communities and staff of Bwindi during the period of National Park gazettement

| Type of conflict | Definition |
|---|---|
| Attack rangers | Unprovoked attack on rangers or on the families of rangers |
| Fight arrest | Attack rangers to escape arrest |
| Rescue offenders | Attack rangers to forcibly rescue apprehended offenders |
| Attack authorities | Unprovoked attack on conservation authorities |
| Set fire | Deliberate fire setting within Bwindi forest |

Staff of Bwindi recorded 48 incidents of violent conflict from 1986 to 2000. The first stage of the study was to verify the occurrence and type of each incident of violent conflict. The same incident had often been recorded in different archival records and this enabled descriptions of each incident to be compared between records. An incident was accepted for analysis when the same categories of area, instigator and cause were assigned from descriptions from two or more records. However, comparisons were not made between records that were based on one another. For example, National Park wardens often based their monthly reports on records kept by the Head Ranger. All incidents of rescue offenders (n = 24) and attack authorities (n = 1) were triangulated between two or more data sources. Most incidents of attack rangers (86%) and of fight arrest (89%) were also triangulated between two or more data sources. The remaining incidents of attack rangers (n = 3) and fight arrest (n = 1) were only recorded in law enforcement patrol reports and were omitted from analysis, as these records could not be triangulated. Fewer (67%) incidents of deliberately set fire were triangulated between two or more data sources. However, all deliberately set fire incidents (n = 4) were included in the analysis because the occurrence of fire in Bwindi is a major event recorded by National Park wardens (personal observation), and because a report had been written by the Junior Game Assistant specifically to detail incidents of deliberately set fires over the gazettement period.

### 3.2.2 Data analysis

Incidents of violent conflict were summed per year from 1986 to 2000, although no records on conflict were available for 1991. The absence of records for this year may have been a consequence of the gazettement process, as it was possible that records went missing during the transition in management from the Forest Department to UNP.

Years were pooled into three periods of before gazettement (1986-1988), during gazettement (1989-1992) and after gazettement (1993-2000). The first analysis aimed to examine possible differences in conflict incidents between period of gazettement, area of Bwindi, instigator of conflict and type of incident. Conflict incidents were examined by the percentage of incidents per gazettement period, area, instigator and type.

The second analysis aimed to identify associations between conflict incidents and the factors of gazettement period, area, instigator and type of incident, that best explained incidents of violent conflict at Bwindi. The number of conflict incidents per year was categorised by the factors of gazettement period, area, instigator and type of incident in a four-way contingency table. The data were analysed by log linear analysis, under the assumption of a Poisson distribution, using the hierarchical approach and specifying a log link function (section 2.2.3.3).

## 3.3 Results

The first incident of violent conflict recorded by staff of Bwindi from 1986 to 2000 (Figure 3.1) was December 1986 and the last incident was August 1998. Most incidents (45.8%) occurred during the period of National Park gazettement. Within this period, there were particularly high levels of conflict during 1989, which was the year before gazettement, and during 1992, which was the year that followed gazettement. Violent conflict incidents during the period before gazettement (33.4%) were higher than during the period after gazettement (20.8%). Conflict incidents after gazettement were particularly low after harvest zones were established.

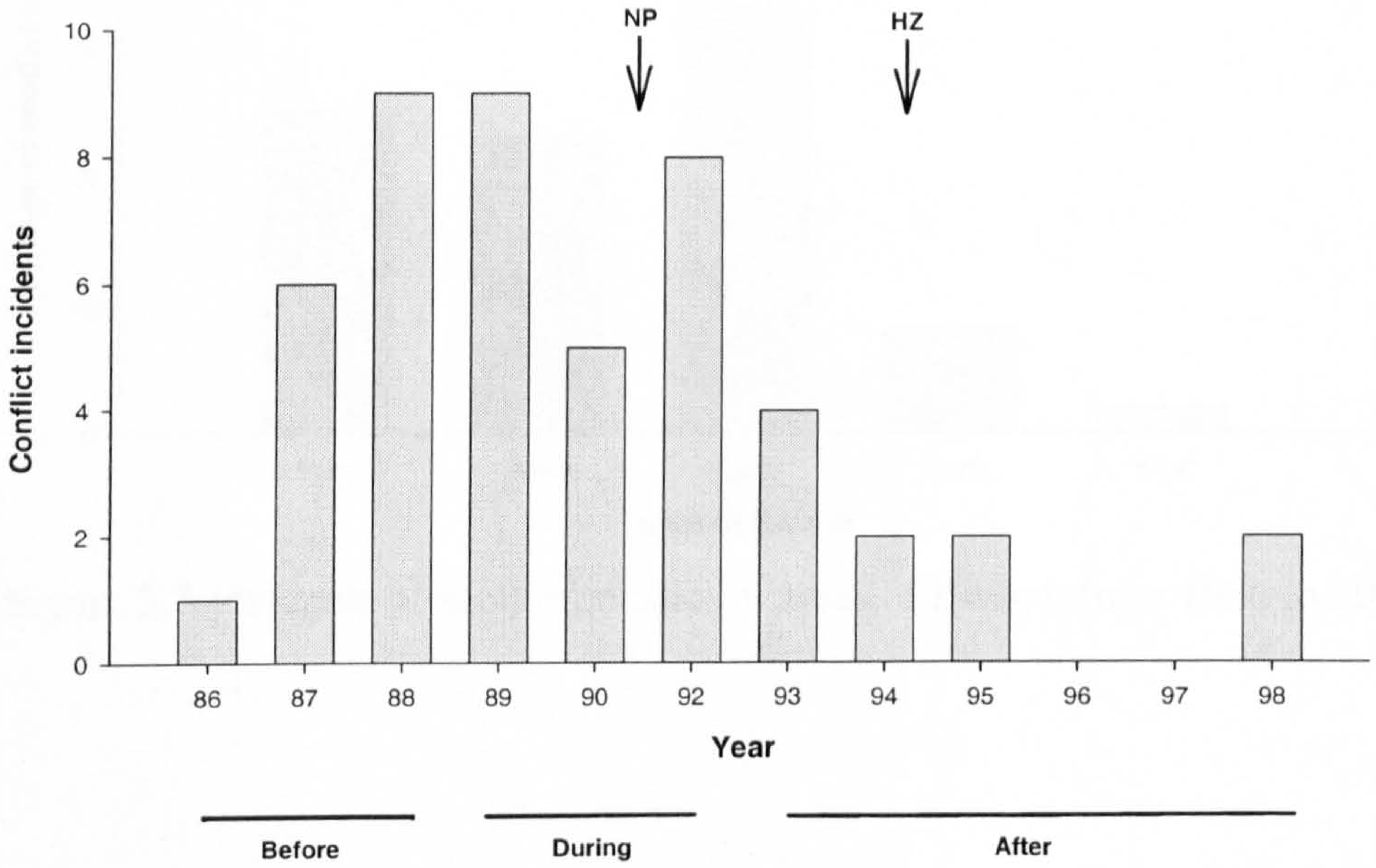


Figure 3.1 Incidents of violent conflict at Bwindi before, during and after National Park gazettement from 1986 to 2000

NP: National Park gazettement

HZ: establishment of harvest zones

### 3.3.1 Area of conflict

The east area of Bwindi recorded most incidents of violent conflict (Figure 3.2). Within the east, conflict was concentrated within the parishes of Kitojo (50.0% of the incidents) and Kashasha (45.0% of the incidents), and also occurred in the forest interior (5.0% of the incidents). Elsewhere in Bwindi, incidents of conflict in the north and centre were similar. However, incidents in the north occurred in a number of different parishes with the highest number in Bujengwe parish (33.3% of the incidents), whereas incidents in the centre were concentrated in Mpungu parish (91.1% of the incidents). Other incidents of conflict in the centre occurred in Bujengwe parish (8.9% of the incidents). The south and west recorded the lowest incidents of conflict, which occurred in Rubuguli parish and in Nteko parish respectively (Figure 3.3).

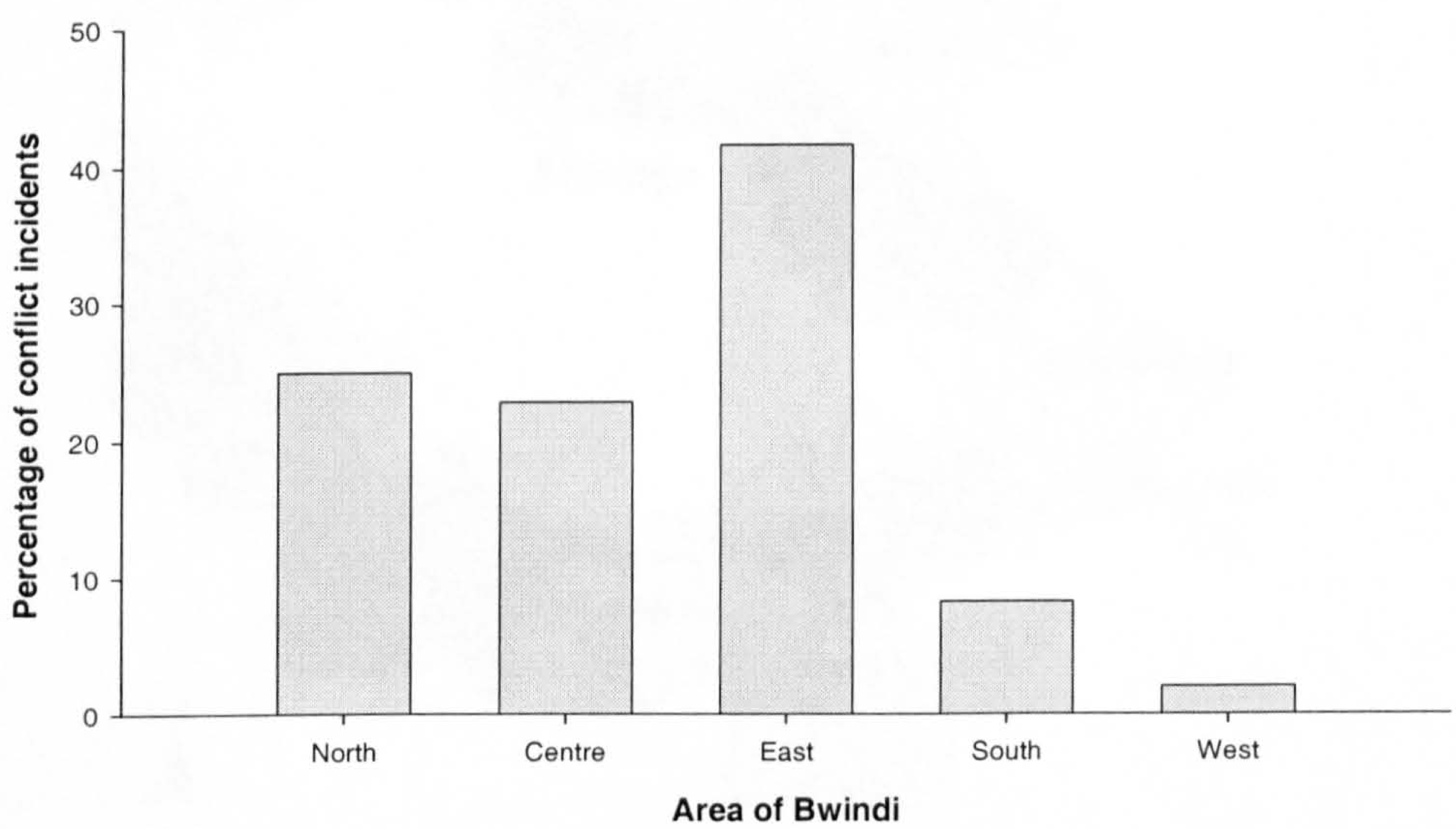


Figure 3.2 Incidents of violent conflict in areas of Bwindi from 1986 to 2000

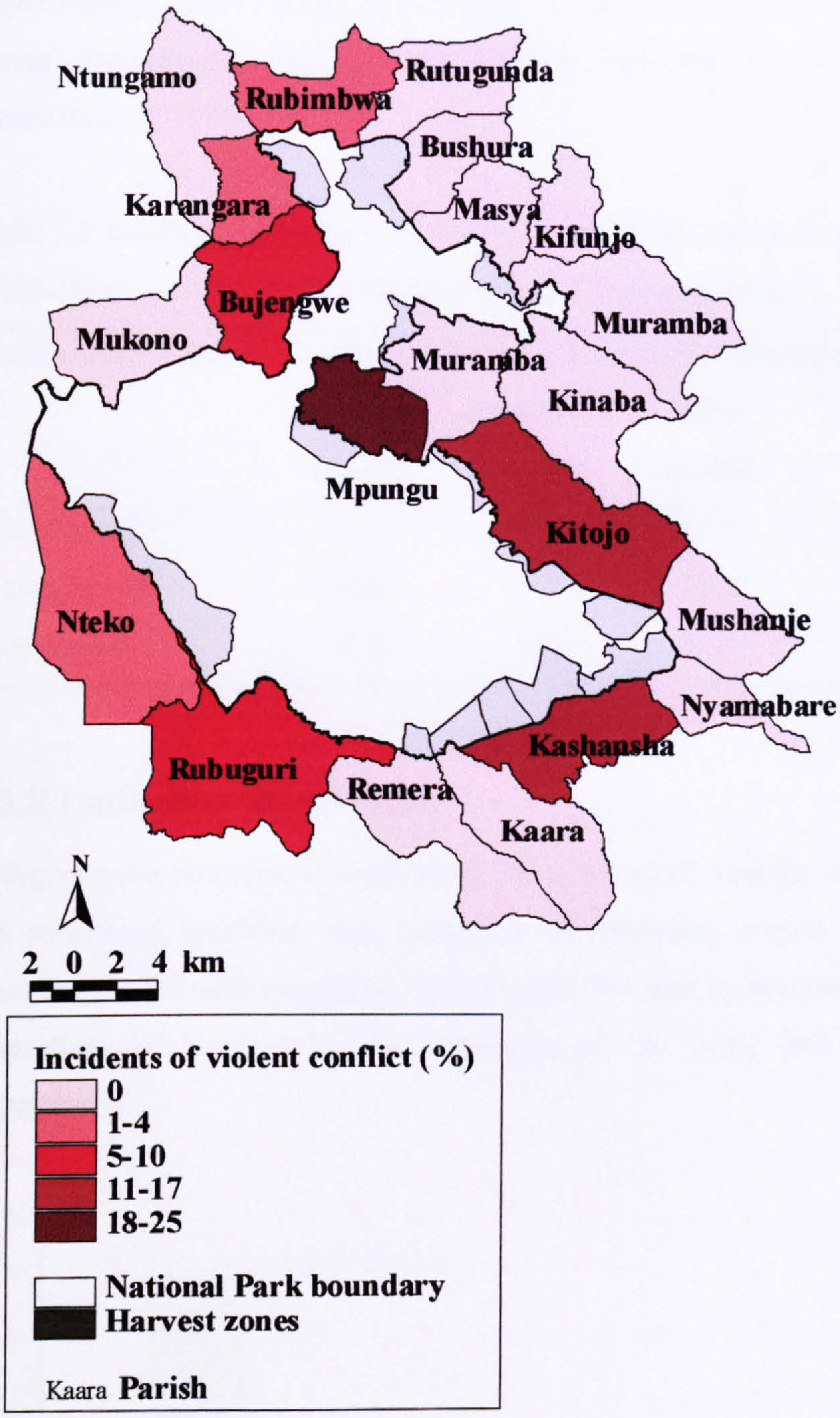


Figure 3.3 Incidents of violent conflict in parishes neighbouring Bwindi from 1986 to 2000

Incidents of conflict in the north, centre and east were recorded within each gazettement period (Table 3.2). Conflict in the south was only recorded before and during gazettement, and the one incident recorded in the west occurred after gazettement in 1995.

Table 3.2 Incidents of violent conflict in areas of Bwindi before (1986-1988), during (1989-1992) and after (1993-2000) National Park gazettement

| **Gazettement Period** | **Area of Bwindi (% of total incidents)** | | | | |
|---|---|---|---|---|---|
| | **North (n=12)** | **Centre (n=11)** | **East (n=20)** | **South (n=4)** | **West (n=1)** |
| Before (n=16) | 4.2 | 12.5 | 12.5 | 4.2 | 0.0 |
| During (n=22) | 16.6 | 4.2 | 20.7 | 4.2 | 0.0 |
| After (n=10) | 4.2 | 6.3 | 8.3 | 0.0 | 2.1 |

### 3.3.2 Instigator of conflict

Villagers were recorded as instigating the majority of conflict incidents (Figure 3.4). The remaining incidents were instigated by offenders, which were miners (4.2%), poachers (4.2%) and smugglers taking cattle for sale in Rwanda (4.2%), as well as councillors of local authorities, members of the army and staff of the Forest Department.


Figure 3.4 Instigators of the incidents of violent conflict at Bwindi from 1986 to 2000

Villagers instigated incidents of conflict before, during and after gazettement (Table 3.3). Offenders also instigated conflict within each gazettement period. Miners, poachers and cattle smugglers were responsible for incidents before gazettement, whereas only miners and poachers instigated conflict during gazettement, and cattle smugglers instigated the one incident involving offenders after gazettement, which occurred in 1998. Most incidents started by local authorities and by the army occurred during gazettement, although conflict instigated by local authorities also occurred before gazettement whereas conflict by the army also occurred after gazettement. Staff of the Forest Department only instigated conflict in 1989, which was the period during gazettement when the Forest Department relinquished the management of Bwindi to the Ugandan National Parks.

Table 3.3 Incidents of violent conflict at Bwindi by instigator before (1986-1988), during (1989-1992) and after (1993-2000) National Park gazettement

| **Gazettement Period** | **Instigator of conflict (% of total incidents)** | | | | |
|---|---|---|---|---|---|
| | **Villager (n=33)** | **Offender (n=6)** | **Local Authority (n=5)** | **Army (n=3)** | **Forest Staff (n=1)** |
| Before (n=16) | 25.0 | 6.3 | 2.1 | 0.0 | 0.0 |
| During (n=22) | 27.1 | 4.2 | 8.2 | 4.2 | 2.1 |
| After (n=10) | 16.6 | 2.1 | 0.0 | 2.1 | 0.0 |

### 3.3.3 Type of conflict incident

An attack on rangers by community members to forcibly rescue offenders from arrest was the most frequent type of conflict incident at Bwindi from 1986 to 2000 (Figure 3.5). These attacks occurred when rangers were taking offenders to court for punishment, or when rangers were arresting offenders who would call to neighbouring villagers for help. Pit sawyers (34.8%) and miners (26.2%) were the main types of offenders that were rescued, while the rescue of poachers (13.0%), cattle smugglers (13.0%) and minor offenders (13.0%) was less common. Unprovoked attacks on rangers or on the families of rangers were a more frequent type of conflict incident than attacks on rangers by offenders escaping arrest, and also deliberate attempts to set fire within Bwindi forest. There was one incident of an unprovoked attack on conservation authorities.

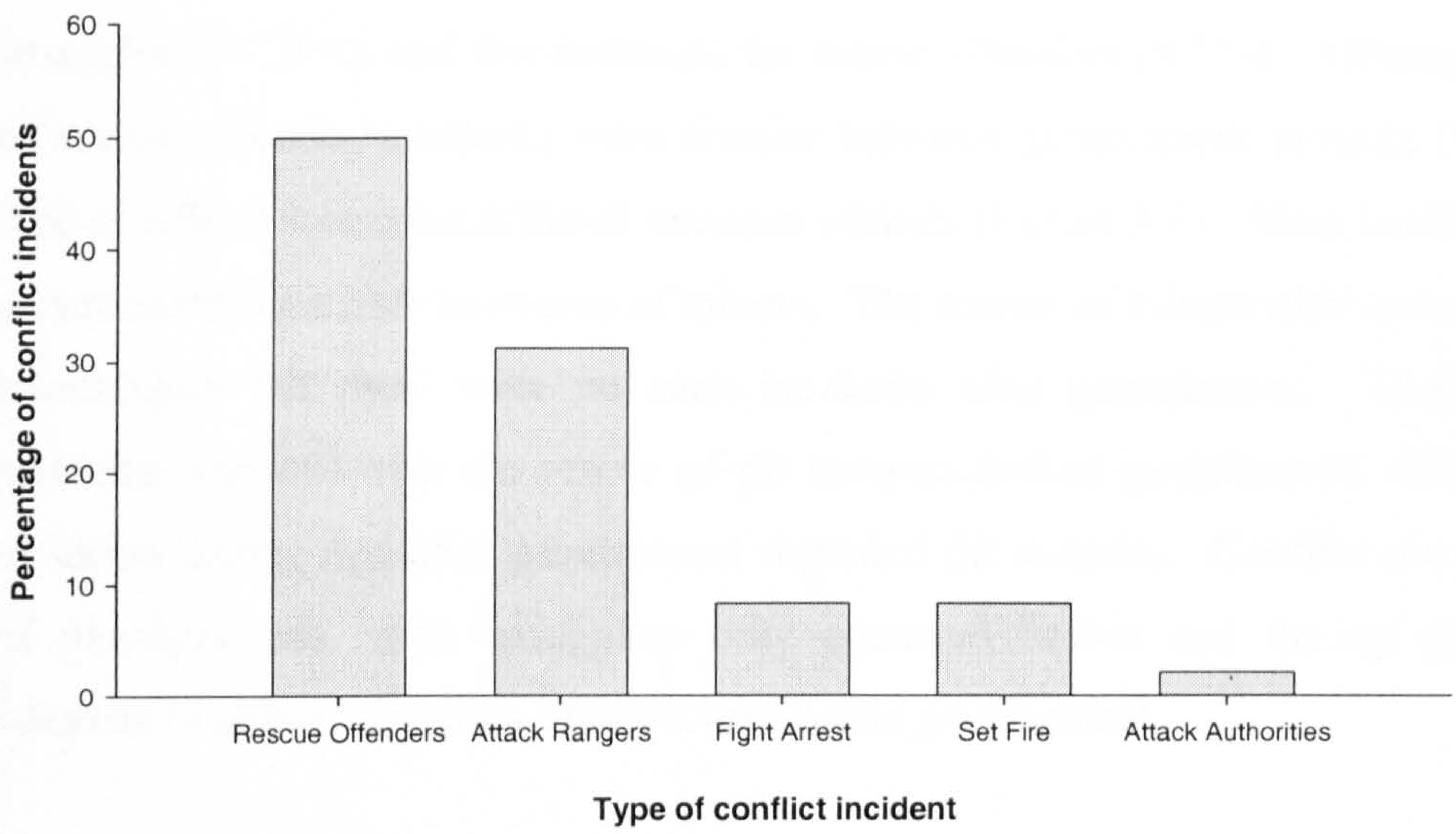


Figure 3.5 Type of incident of violent conflict at Bwindi from 1986 to 2000

Conflict incidents initiated over the rescue of offenders occurred before, during and after gazettement, and there were similar numbers of incidents between gazettement periods (Table 3.4). Unprovoked attacks on rangers or on the families of rangers also occurred within each gazettement period, although most were during gazettement. Conflict incidents caused by offenders escaping arrest occurred within each gazettement period, although most were before gazettement. Deliberate fire setting only occurred during gazettement in 1992, and the incident of an unprovoked attack on conservation authorities occurred in 1990, which was the year prior to gazettement.

Table 3.4 Incidents of violent conflict at Bwindi by type of incident before (1986-1988), during (1989-1992) and after (1993-2000) National Park gazettement

| **Gazettement Period** | **Type of conflict incident (% of total incidents)** | | | | |
|---|---|---|---|---|---|
| | **Rescue Offenders (n=24)** | **Attack Rangers (n=15)** | **Fight Arrest (n=4)** | **Set Fire (n=4)** | **Attack Authorities (n=1)** |
| Before (n=16) | 18.8 | 10.4 | 4.2 | 0.0 | 0.0 |
| During (n=22) | 16.6 | 16.6 | 2.1 | 8.3 | 2.1 |
| After (n=10) | 14.6 | 4.2 | 2.1 | 0.0 | 0.0 |

From all conflict incidents initiated over the rescue of offenders (n = 24), miners (33.3%) and pit sawyers (33.3%) were the most common offender type rescued from arrest. There were similar numbers of incidents for poachers (12.6%) and cattle smugglers (12.5%), and few incidents for minor offenders (8.3%). Although numbers of rescue offender incidents were similar between gazettement periods (Table 3.4), type of offender rescued differed between periods (Figure 3.6). Most incidents before gazettement regarded the rescue of miners. The rescue of miners also occurred during gazettement but there were no such incidents after gazettement. There were no incidents initiated over the rescue of pit sawyers before gazettement, although most incidents during and after gazettement regarded pit sawyers. Conflict over the arrest of poachers and cattle smugglers only occurred before and during gazettement, whereas of minor offenders only occurred after gazettement.

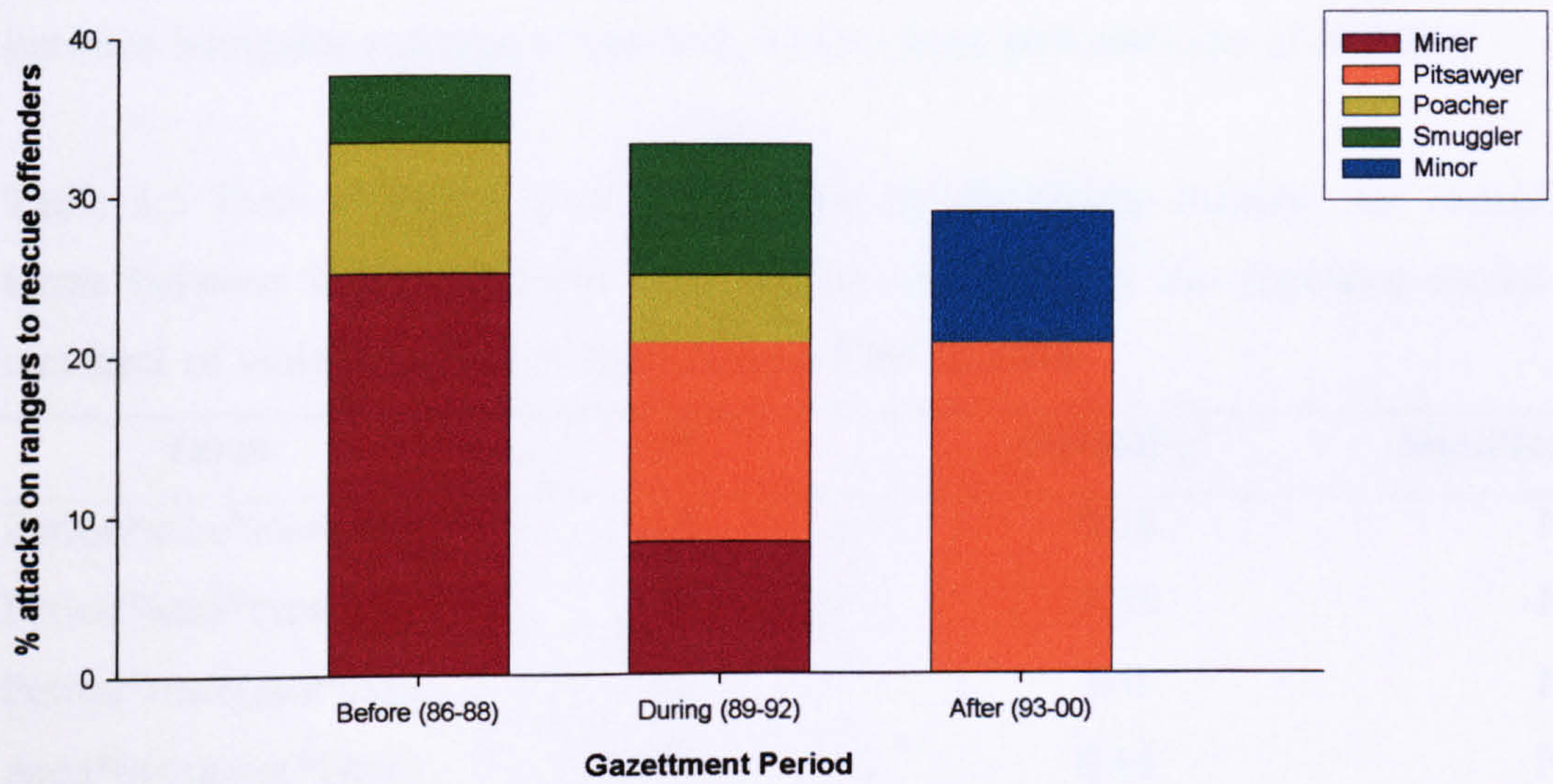


Figure 3.6 Percentage per offender type from conflict incidents initiated over the rescue of offenders in Bwindi before, during and after National Park gazettement from 1986 to 2000

### 3.3.4 Factors explaining the likelihood of incidents of violent conflict between local communities and rangers

Categories containing a small number of records were omitted for the analysis. These were the west area (n = 1), unprovoked attacks on conservation authorities (n = 1), and conflict instigated by staff of the Forest Department (n = 1). A four-way (3x4x4x4) contingency table was constructed for the log linear analysis with the factors of gazettement period, area of Bwindi, instigator of conflict and type of incident. The final model proved a good fit to the data, as the model exhibited a low deviance value that did not significantly differ from deviance value of the saturated model ($G^2 = 6.43$; df = 12; $p > 0.05$), and was therefore a more parsimonious explanation of the data than the saturated model. The final model was defined by two two-way interaction terms comprising instigator*type and area*type. Tests for partial associations of terms in the saturated model revealed the importance of the interactions and main effects of area, type of incident and instigator, through significance of the chi square value (Table 3.5). The final model therefore indicates that the associations between instigator and type of incident, and between area and type of incident, best explained variation in the number of incidents of violent conflict at Bwindi. None of the terms in the final model exhibited high (>1.96) standardised lambda values and thus further investigations were undertaken on the association between instigator and type of incident, and between area and type of incident.

Table 3.5 Tests of partial association, using the chi square statistic, for interaction terms between factors and the main effects of factors in the saturated model for incidents of violent conflict in Bwindi from 1986 to 1998

| **Term** | **df** | **Partial $\chi^2$** | **Significance of $\chi^2$** |
|---|---|---|---|
| Period*area*instigator | 18 | 9.16 | NS |
| Period*area*type | 18 | 7.35 | NS |
| Period*instigator*type | 18 | 0.0 | NS |
| Area*instigator*type | 27 | 0.15 | NS |
| Period*area | 6 | 5.66 | NS |
| Period*instigator | 6 | 9.63 | NS |
| Area*instigator | 9 | 9.12 | NS |
| Period*type | 6 | 8.41 | NS |
| Area*type | 9 | 22.04 | < 0.01 |
| Instigator*type | 9 | 29.86 | < 0.001 |
| Period | 2 | 4.98 | NS |
| Area | 3 | 10.68 | < 0.05 |
| Instigator | 3 | 37.81 | < 0.001 |
| Type | 3 | 22.96 | < 0.001 |

### 3.3.5 Instigator and type of incident

The association between instigator and type of incident revealed that villagers primarily instigated conflict by attacking rangers to rescue offenders from arrest (Table 3.6). Villagers were also responsible for unprovoked attacks on rangers and for deliberately setting fire within Bwindi forest. Both the army and local authorities were involved with rescuing offenders from arrest and with unprovoked attacks on rangers. Offenders, as expected, primarily started an incident by fighting rangers to escape arrest and were also responsible for unprovoked attacks on rangers.

Table 3.6 Type of conflict incident instigated by villagers, offenders, councillors of local authorities and members of the army, at Bwindi from 1986 to 2000

| **Type of incident** | **Instigator (% of total incidents n=45)** | | | |
|---|---|---|---|---|
| | **Villager (n=31)** | **Offender (n=6)** | **Local authority (n=5)** | **Army (n=3)** |
| Rescue offenders (n=22) | 40.1 | 0.0 | 4.4 | 4.4 |
| Attack rangers (n=15) | 20.0 | 4.4 | 6.7 | 2.2 |
| Fight arrest (n=4) | 0.0 | 8.9 | 0.0 | 0.0 |
| Set fire (n=4) | 8.9 | 0.0 | 0.0 | 0.0 |

The type of offender that was rescued from arrest differed between villagers, local authorities and the army. Villagers attacked rangers over the arrest of miners (31.6%), pit sawyers (26.3%), poachers (15.8%), minor offenders collecting forest resources for subsistence needs (15.8%) and cattle smugglers (10.5%). In comparison, members of the army initiated conflict over the arrest of pit sawyers (50.0%) and cattle smugglers (50.0%), while local authorities only initiated conflict over the arrest of pit sawyers.

### 3.3.6 Area and type of conflict incident

The association between area and type of incident showed that over half of the incidents in the centre, and exactly half in the north, were attacks on rangers to rescue offenders (Table 3.7). Furthermore, rescuing offenders was the only type of incident in the south. In comparison, most conflict in the east comprised unprovoked attacks on rangers. The north area of Bwindi was the only area where deliberate fires were set within Bwindi forest.

Table 3.7 Type of conflict incident in areas of Bwindi from 1986 to 2000

| **Type of incident** | **Area (% of total incidents n=45)** | | | |
|---|---|---|---|---|
| | **North (n=11)** | **Centre (n=11)** | **East (n=19)** | **South (n=4)** |
| Rescue offenders (n=22) | 11.2 | 13.3 | 15.6 | 8.9 |
| Attack rangers (n=15) | 4.4 | 6.7 | 22.2 | 0.0 |
| Fight arrest (n=4) | 0.0 | 4.4 | 4.4 | 0.0 |
| Set fire (n=4) | 8.9 | 0.0 | 0.0 | 0.0 |

Conflict incidents initiated over the rescue of offenders within each area of Bwindi showed that miners were mainly rescued in the centre and south (Figure 3.7). In comparison, pit sawyers were rescued in the north, east and centre. Poachers were rescued in the south and east, minor offenders were only rescued from the east and cattle smugglers were rescued from the north, centre and east.

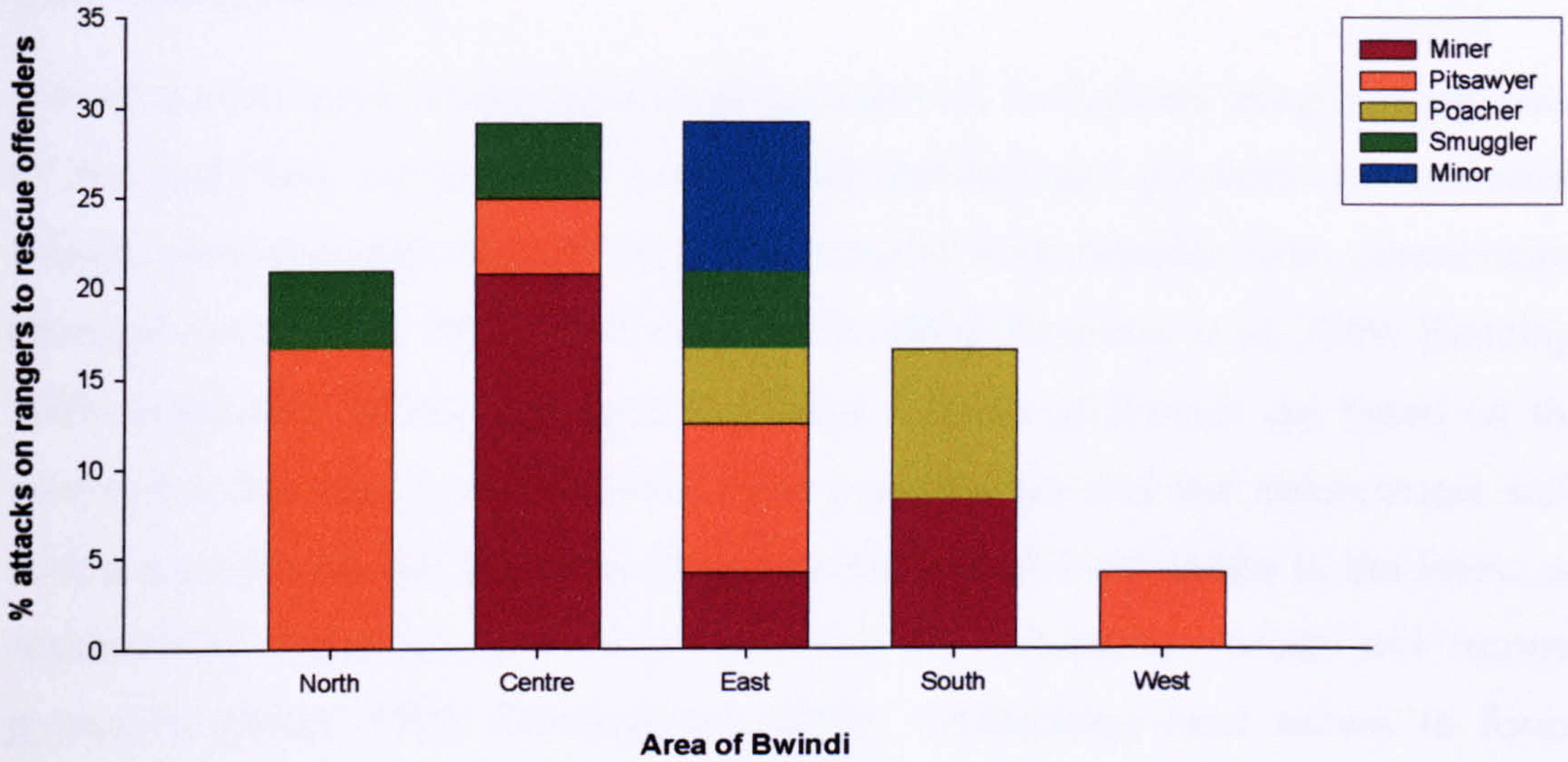


Figure 3.7 Percentage per offender type from conflict incidents initiated over the rescue of offenders in areas of Bwindi from 1986 to 2000

## 3.4 Discussion

Bwindi is considered successful in resolving conflicts through the integrated approach to National Park management, where local development priorities are addressed through initiatives that provide rural communities with benefits from conservation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996; Hamilton *et al*, 1999; Blomley, 2003; Makombo, 2003). Nevertheless, these reviews of Bwindi are based on the assumption that the conflict between local communities and law enforcement staff during gazettement was primarily caused by the loss of local access to the forest, as communities depended upon forest resources for subsistence needs and income generation (Scott, 1992; Cunningham, 1996). Prohibiting local access to forest resources did indeed cause resentment among communities towards the National Park (Scott, 1992; Wild and Mutebi, 1996; Docherty, 1996; Namara, 2000). However, it is the incidents of violent conflict, especially the deliberate setting of forest fires, that have been used to illustrate conflict resolution at Bwindi (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996; Hamilton *et al*, 1999; Blomley, 2001; Makombo, 2003) and are therefore important to understand.

This study is the first to assess incidents of violent conflict at Bwindi over the period of gazettement. There are limitations to the analysis, particularly the use archival records. It is possible that conflict incidents were not located in the archives and that some incidents were not recorded, particularly by rangers regarding incidents of minor harassment if such incidents commonly occurred. Furthermore, rangers may not have recorded assaults by local communities from fear that their families would be attacked, as most rangers are from communities neighbouring Bwindi. However, consultations with staff of the National Park and retired staff of the Forestry and Game Departments during fieldwork revealed that the authorities placed great emphasis on documenting physical assaults on staff, and encouraged their staff to report such incidents. Thus, although occurrences of minor harassment were recorded by staff of Bwindi, only incidents of violence were selected for analysis to limit possible bias within the data. There were possible sources of bias in the data including the location of the National Park headquarters in the east of Bwindi. This concentration of rangers may have led to a high number of conflict incidents and to the occurrence of certain types of incidents in the east, such as unprovoked attacks on conservation authorities that were visiting the headquarters. A bias may also have resulted from the data source, as most records were from authorities of Bwindi and incidents described by authorities, particularly assaults on rangers, may have been viewed differently by local communities. The few records from local communities largely comprised letters written by parish and village chiefs to authorities, which has implications for this study. Firstly local chiefs may have only written letters when major events occurred, such as crop raiding by gorillas, and not for minor incidents. Secondly the absence of records on assaults on local communities by staff of Bwindi, which occurred during the period of study (Bayenda, oral communication), limits the analysis because such harassment may have led local communities to retaliate, which could have been categorised as unprovoked attacks on rangers in this study. Assessing both aspects of conflict regarding authorities and local communities is therefore important to determine patterns of conflict. Given the verification of the data and analysis of only incidents of violence, this study indicates type of conflict incident on staff by local communities during the gazettement period of Bwindi.

### 3.4.1 Causes of conflict

Testing associations between the factors of area, instigator and type of conflict incident revealed that violent attacks on law enforcement rangers primarily occurred because of the arrest of miners and pit sawyers. Furthermore, villagers instigated the majority of these attacks, which mainly occurred around the north, centre and south of Bwindi. Attacks on rangers to rescue offenders typically involved a group of villagers surrounding and harassing the rangers. For example, the first incident of conflict at Bwindi, which was recorded in the law enforcement records, occurred before gazettement in December 1986, following the arrest of illegal gold miners from the centre Ihihizo area. As the two rangers took the arrested miners to the chief of the adjacent Mpungu parish for punishment, a group of 20 men surrounded the rangers, released the miners and the items that the rangers had confiscated from the miners, and then ordered the rangers back to the Game Department headquarters in the east Ruhija area. Furthermore, the second conflict incident, which occurred during January 1987, was also in Mpungu parish and again resulted from the arrest of illegal gold miners. This incident involved a group of between 30 to 40 men armed with spears and pangas, who freed the miners by surrounding and threatening the rangers. The attacks also involved stone throwing, for example in the east of Bwindi in 1998, when villagers threw stones at rangers taking illegal pit sawyers to village court for punishment, and attempts to steal the law enforcement rifles, which were often during attacks instigated by local authorities. For example, in 1988, the game warden of Bwindi wrote to the district officer of Rukungiri about three village chiefs neighbouring the north areas of Bwindi, as the chiefs were encouraging their residents to break the rangers' rifles. Also, in 1995, the arrest of two men collecting bamboo in the east of Bwindi led to an incident where the village chief and his residents stole the rangers' rifles to free the offenders.

The analysis indicated common rescue attack types per offender between gazettement periods. The most common rescue attack is likely a function of the proportion of arrests that each offender represents. It is therefore necessary to determine whether the proportion of types rescued differed from the proportion arrested. Staff of the National Park, and retired staff of the Forestry and Game Departments, were consulted during fieldwork for their perceptions on types of offender arrested over time. The staff perceived that miners were the most common offender arrested before gazettement, as the small number of mining localities in Bwindi could be easily targeted by law enforcement patrols. Rangers then targeted pit sawyers, as locating pit saw sites was relatively easy from the size of the sites and noise of the activity, and cattle smugglers, as patrols could ambush the small number of trading routes through Bwindi. Arrests of poachers during gazettement were lower in comparison because locating poachers was mainly by chance encounter in the forest, and because the rangers targeted the higher numbers of miners and pit sawyers in Bwindi before and during gazettement. The staff perceived that arrests of miners declined during gazettement and of pit sawyers after gazettement when minor offenders became more frequently arrested. Patterns of rescue attacks for each offender type over gazettement shown by this study therefore appear to represent the proportion of arrests that each offender type represented, particularly for miners and pit sawyers. However, data on the number of arrests per offender type per gazettement period is required to confirm such findings.

### 3.4.2 Arrests of miners

The attacks on law enforcement rangers over the arrest of offenders followed the implementation of intensive law enforcement patrols at Bwindi to reduce illegal forest exploitation, in particular mining and pit sawing. Gold mining was a localised activity in Bwindi and mainly occurred in the centre and south areas, covering an estimated 8-10% of the total forest area (Butynski, 1984). Groups of miners averaged between 15 and 20 men, and these men were villagers hired by town traders, or by co-operative societies such as the southern Rubuguli Co-operative Savings and Credit Society which was granted a gold mining licence in December 1988 (Tukahirwa and Pomeroy, 1993). Thus mining provided income for villagers from employment, and for town traders from the trade in gold, and so was profitable for both groups. For example, the Rubuguli Co-operative had 200 members and employed between 15 and 20 labourers per month (Tukahirwa and Pomeroy, 1993). In 1989, based on the hire of 18 labourers per month, the society's monthly wage for a labourer was 2,902.78 Uganda shillings and monthly income for a member was 4,531.67 Uganda shillings (Table 3.8). By comparison, in 1989, IFCP's staff comprised 12 trained game guards and 22 trainees, and the monthly wage for a game guard was 1,567 Uganda shillings (data from law enforcement records). Therefore, although mining was not a major source of income for local residents neighbouring Bwindi (Tukahirwa and Pomeroy, 1993), the trade was important in the centre and south areas.

Table 3.8 Value of gold mined by the Rubuguli Co-operative Society from 1989 to 1992

| Year | Quantity (grams) | Value (000 Shs) | Costs – labour (000 Shs) | Net Profit (000 Shs) |
|---|---|---|---|---|
| 1989 | 113 | 11503 | 627 | 10876 |
| 1990 | 145 | 14760 | 185 | 14575 |
| 1991 | 200 | 20359 | 425 | 19934 |
| 1992* | 70 | 7126 | 120 | 7006 |

* Data from Jan-June only; Shs: Uganda shillings

(Tukahirwa and Pomeroy, 1993)

### 3.4.3 Arrests of pit sawyers

There is a similarity between mining and pit sawing in that both are primarily undertaken for income by villagers, who are hired as labourers by town traders. The demand for pit saw labour involves a variety of workers, including sawyers and timber carriers, and villagers can work on a part-time basis and so gain higher financial rewards relative to their investment of time, particularly compared with profits from agricultural produce.

Before its gazettement, the majority of villagers neighbouring Bwindi were dependent for their income on pit sawing (Tukahirwa and Pomeroy, 1993) and this dependence could have increased during the period of gazettement, as rural communities throughout Uganda were turning to non-farm activities for income because of the decline in the agricultural trade (Tukahirwa and Pomeroy, 1993).

Pit sawing was the most prevalent form of illegal activity in Bwindi following gazettement (Butynski, 1984). Arrests of both pit sawyers and miners in Bwindi, which followed the implementation of effective law enforcement, led to violent conflict between local communities and law enforcement rangers. Similar situations have been observed elsewhere in Africa, where the enforcement of wildlife conservation law resulted in conflict between rural communities and conservation authorities (Mann, 1995; Sibanda, 1995; Infield and Namara, 2001). These studies identify the loss of natural resources as the main cause underlying conflict. However, at Bwindi, the importance of mining and pit sawing as sources of income indicates that conflict over the arrest of miners and pit sawyers was because of the loss of income rather than the loss of forest resources.

Differences were evident between attacks on law enforcement rangers over the arrest of miners and pit sawyers. Attacks over miners were the first incidents of violent conflict at Bwindi and were primarily instigated by villagers. Rangers commonly noted that families of the arrested miners were responsible for the attacks. Therefore, the concentration of violent incidents in the parishes of Mpungu and Rubuguli is explained by the localised importance of mining within these areas. Furthermore, alternative mining areas outside Bwindi were limited, as Bwindi was the main source in the region of alluvial gold and other minerals including wolfram (Tukahirwa and Pomeroy, 1993). Although not possible from the data available, further understanding would be gained by correlating origins of villagers with location of rescues attempts, and by correlating values of forest resources with the number of rescue attempts over time. Nonetheless, it is noted that in comparison with attacks to rescue miners whereby mainly villagers were involved, the army and local authorities were involved with attacks to rescue pit sawyers and that their involvement illustrates the scale of the trade in timber from Bwindi.

### 3.4.4 Arrests of cattle smugglers

The army and local authorities also took part in the attacks to rescue cattle smugglers, as members of both the army and local authorities were involved in the illegal trade of cattle to Rwanda. Villagers were hired as herdsmen to transport cattle through Bwindi from the east Ruhija area, along the main forest route which passes MuBwindi swamp, to the south Rushaga area where the herders left Bwindi to proceed to Rwanda. Bwindi was therefore an important access route for international trade which, as well as cattle, involved coffee and the locally brewed wariege drink.

The extent of cattle smuggling across the Uganda-Rwanda border is not documented, although an indication exists from the law enforcement records of Bwindi. For example, in December 1986, rangers on patrol around Mubwindi swamp commented "*it seems that people drive cattle through Bwindi at least once a month*". The loss of this trading route because of National Park gazettement, and the consequent loss of income, led to the attacks on law enforcement rangers over the arrest of cattle smugglers and was therefore a cause of violent conflict.

There were fewer attacks over cattle smugglers than over miners and pit sawyers, although the arrest of cattle smugglers led to the most violent attack on law enforcement staff at Bwindi. In 1989, rangers arrested herders who were transporting 28 cattle through the east area of Bwindi for sale in Rwanda. The rangers reported that they were later robbed and beaten by a group of soldiers in an attack that continued the following day. This incident resulted in a series of unprovoked attacks on rangers in the east area. These included the imprisonment and beating of a ranger ordered by his village chief "*for no apparent reason*" when the ranger returned home to Ruhija for Christmas in 1989; the only attack on conservation authorities, which was in 1990 when villagers of Ruhija threw stones at the IFCP vehicle; and an attack in 1992 on rangers by villagers of Ndego when the rangers passed through their village. In 1990, the ranger in charge of the east outpost noted "*threats against us have become many after the interception of the cattle passing to Rwanda in December last year*". Thus the association in the analysis between unprovoked attacks on rangers and the east area of Bwindi can be explained as a consequence of the violent attack instigated by the army over the loss of the international cattle trade. Unprovoked attacks on law enforcement rangers and their families did occur in other areas of Bwindi, although to a lesser extent. These included the centre area in 1987, when the brother of a ranger was beaten by gold miners, and in the north area, also in 1987, when the children of a ranger were harassed at school by their teachers and the other school children.

### 3.4.5 Crop raiding by gorillas

Violent conflict in the west area of Bwindi was less frequent than in other community areas around the forest. Just one incident occurred between 1986 and 2000, which was when village chiefs of Nteko attacked rangers over the arrest of illegal pit sawyers in 1995. However, villagers of the west made threats against both the rangers and the gorillas during the period of gazettement from 1989 to 1992, although these threats were not followed by direct attacks and thus not considered incidents of violent conflict. Nevertheless, this indication of conflict in the west, as with conflict within other areas of Bwindi, can be explained by money. During gazettement, villagers of the west sought compensation from National Park officials for damage caused by gorillas to their banana plantations. The requests for compensation were often made to rangers patrolling the National Park boundary, and the threats against rangers and gorillas resulted when no compensation was given. For example, rangers patrolling the west in 1992 reported "*people whose banana plantations were destroyed by gorillas have reached the extent of attacking us rangers, as maybe the warden gave the money to us and we have used it. The village chiefs are backing them* *saying that they were promised by high officials from this park that any farmer whose crops destroyed by gorillas automatically will be compensated for. From my observation, if these farmers do not get money for their bananas, as they were told publicly, they may harm the gorillas next time the animals come to banana plantations.*" Furthermore, rangers patrolling the west during the following month reported "*farmers were not happy because of not being paid in time and again they were saying that if they do not pay them, the next time they will kill the gorillas*".

The fact that there were no direct attacks in the west might have resulted from the villagers' hope of financial payment for gorilla crop raiding. In addition, they also had expectations of economic benefits from tourism, as talks began during gazettement between conservation authorities and villagers about gorilla tourism in the west Buhoma area. As the warden of Bwindi stated in his monthly report for April 1991 "*the opening of gorilla tourism will play a major role in changing positively the local people's attitude towards the park, as the change in status to National Park will be justified*".

There were few incidents of violent conflict between villagers and conservation authorities and the north was the only area where villagers deliberately started forest fires to destroy the National Park. The setting of fire illustrates the resentment of the communities towards the gazettement of the forest and that the conflict at Bwindi resulted from a complex variety of social and economic factors.

### 3.4.6 Summary

Thus in summary, this chapter has shown that associations between instigator and type of conflict incident, and between area and type of conflict incident, explain patterns of violent conflict at Bwindi over the gazettement period. The analysis firstly provides a basis for understanding patterns of conflict, which could contribute to improving the practice of conservation by enabling managers of protected areas to select appropriate strategies for resolving conflict and gaining local support for conservation. At Bwindi, for example, the primary cause of conflict was the loss of income as a result of National Park gazettement. Therefore, implementation of income-generating activities to allow communities to benefit from the National Park is appropriate, particularly to replace mining and pit sawing.

The analysis secondly raises questions about the effectiveness of the integrated approach for National Park conservation, particularly the effectiveness to alleviate conflict between local communities and managers of protected areas. At Bwindi, the integrated approach has been considered successful in resolving conflict because violent incidents declined after harvest zones were established. However, the analysis indicates that violent incidents primarily occurred because of loss of income rather than loss of resources, as most conflict arose from prohibitions on the mining and timber trades. Loss of income is hard to distinguish from loss of resources and subsequently, additional or alternate factors, such as a gradual acceptance over time by local communities of the National Park, may have influenced the pattern of conflict shown by this study.

This chapter established the historical context of relations between local communities and staff of Bwindi. This provides a basis for analysis of the response of local communities to rangers on law enforcement patrol (Chapter 8), and of factors affecting community response to rangers. Factors considered in this thesis comprise: law enforcement and activities of poachers seeking bushmeat (Chapter 4); crop raiding by wild animals (Chapter 6); problem animal control by law enforcement rangers (Chapter 7); and, community benefits from the integrated programme of Bwindi (Chapter 8).

Having established the historical context of relations between local communities and staff of Bwindi, I now seek to determine the distribution of bushmeat poaching within Bwindi over the period of National Park gazettement and establishment of harvest zones for sanctioned resource use.

# Chapter Four

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# Bushmeat Poaching over the Periods of Gazettement and Harvest Zones

*Ranger on law enforcement patrol in Bwindi*

*(J. Baker)*

# Chapter Four

# 4 Bushmeat poaching over the periods of gazettement and harvest zones

## 4.1 Introduction

Protected areas in tropical countries face a variety of biological, social and economic threats (Wells *et al*, 1992; Tisdell, 1995; Muller and Albers, 2004). Overexploitation of natural resources is a primary concern for managers of forested protected areas in the tropics (IUCN, 1980), particularly hunting animals for bushmeat. This threatens not only target species, which typically comprise ungulates (Wilkie and Carpenter, 1999a; Newing, 2001; Wilkie *et al*, 2000; Apaza *et al*, 2002), but also non-target species that are of conservation concern from accidental trapping, particularly flagships such as the great apes (Plumptre and Williamson, 2001).

Various conservation policies exist for reducing illegal resource use in protected areas. The policy of patrolling and law enforcement has shown relatively successful in protected area conservation (Bruner *et al*, 2001; Muller and Albers, 2004). However, the policy has failed to preserve valuable flagship species in the tropics (e.g. Bell and McShane-Caluzi, 1986; Leader-Williams *et al*, 1990), in part because of the cost of effective law enforcement (Leader-Williams and Albon, 1988) and because of the conflict between conservation managers and local communities that can arise from enforcement (Lewis, 1996).

Integrated conservation and development has recently been promoted as an alternative approach for conserving protected areas by improving the welfare of local communities (Wells *et al*, 1992). Sanctioned resource harvesting is central to the integrated approach, achieving both development and conservation goals by providing benefits to rural communities and maintaining cultural traditions, and by improving local attitudes towards conservation (Wells and Brandon, 1993; Infield, 2001). There are a number of examples of the success of resource harvesting in resolving conflict between local communities and conservation managers. In Nepal, the grass-cutting programme of Royal Chitwan National Park (RCNP) has been successful in gaining local people's acceptance of the National Park (Straede and Helles, 2000). In Botswana, community-park relations were improved after the communities were granted access to water sources, thatching grass and areas for grazing domestic animals within National Parks (Lebonetse, 1996). In Niger, allowing local residents limited access to resources in the Air-Tenere National Nature Reserve reduced tensions between the residents and conservation staff (Slavin, 1996). Furthermore, in Uganda, formal agreements between communities and authorities at Mount Elgon National Park for community members to collect bamboo and medicinal plants from the forest, have been hailed as a pioneering resource use programme that maintained traditional practices and achieved conservation through conflict resolution (Scott, 1998; Hinchely *et al*, 2000).

Despite the success stories, however, concerns have been raised about the risks of resource harvesting, including the risk of destructive resource exploitation (Barrett and Arcese, 1995; du Toit, 2002), which has led to the now extensive literature on sustainable forest harvesting (Peters, 1994). Another concern is the possible increase in threats to biodiversity, particularly from the illegal collection of natural resources (Barrett and Arcese, 1995; Butynski and Kalina, 1998). However, impacts on illegal resource collection from harvesting programmes are not well studied (Barrett and Arcese, 1995). There is also a lack of data for testing the assumption underlying harvesting programmes that, by improving attitudes of local communities towards protected areas and their relations with conservation authorities, the communities will refrain from collecting resources illegally (Wells and Brandon, 1993; Holmes, 2003; du Toit, Walker and Campbell, 2004). Therefore, while resource harvesting has proven successful in conflict resolution, this success has rarely been evaluated in relation to threats to biodiversity, particularly illegal activities within protected areas. Consequently, its effectiveness in biodiversity conservation has yet to be established.

Evaluating conservation policy is hindered by the difficulty in choosing indicators and monitoring methods for protected areas (Kleiman *et al*, 2000). Furthermore, ecological monitoring in tropical forests requires an intensive survey effort to achieve the necessary precision (Plumptre, 2000; Walsh, 2001). Nevertheless, data from law enforcement patrols are a possible, yet little used, monitoring tool for conservation managers. Previous studies have shown that patrol data can provide acceptable indices of illegal activities for monitoring conservation threats and evaluating the success of law enforcement efforts (Arcese *et al*, 1995; Leader-Williams *et al*, 1990; Jachmann and Billiouw, 1997; Caro *et al*, 2000; Linkie *et al*, 2003). However, a limitation in using patrol reports is the availability of reliable data on law enforcement and resource allocation, and on the related levels of illegal activity (Jachmann and Billiouw, 1997). This lack of reliable patrol data has been assumed to apply to Bwindi (McNeilage *et al*, 2001).

Bwindi has already been acknowledged as an example of the success of integrated conservation and development in conflict resolution and in improving local attitudes towards conservation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996; Blomely, 2003; Makombo, 2003). However, the evaluations to date are based on attitude surveys of local communities and on anecdotal accounts of relations between local communities and conservationists. There is no evaluation of impacts on illegal activity, particularly bushmeat poaching, which is a primary threat to the population of mountain gorillas (Plumptre and Williamson, 2001; McNeilage *et al*, 2001). Consequently, whether the integrated approach has contributed to conserving flagship species of the National Park has yet to be determined. Furthermore, evaluating impacts of the harvest zones will address the concern that allowing local communities into protected areas leads to an increase in illegal resource use (Barrett and Arcese, 1995; Butynski and Kalina, 1998).

The aim of this chapter is to evaluate the success of law enforcement in deterring bushmeat poaching in Bwindi, during both National Park gazettement and establishment of the harvest zones. The objectives are to assess impacts of gazettement and sanctioned resource harvesting on bushmeat poaching, and compare impacts on poaching with the acknowledged changes in local attitude towards conservation initiatives. To address the objectives, I seek to determine the following research questions:

- Were there differences in days patrolling and ranger teams over the period of study?
- Were there differences in patrol coverage of the forest?

- Were differences in law enforcement and patrol coverage related to the establishment of harvest zones?
- Were there differences in the types of bushmeat poaching encountered?
- Were differences in poaching encounters related to periods of gazettement or harvest zones?
- In which forest areas were rangers most likely to encounter poaching?
- Was the distribution of poaching related to law enforcement?
- Was the distribution of poaching related to harvest zones?
- Were there differences in the area of origin of the poachers during gazettement and harvest zone establishment?
- Were there differences in the outcome of patrol encounters with poachers during gazettement and harvest zone establishment?
- What is the relative significance of gazettement, harvest zone, forest area and law enforcement to bushmeat poaching?

## 4.2 Materials and Methods

### 4.2.1 Data collection

The operations of law enforcement patrols in Bwindi, the rangers' patrol reports and the retrieval and means of verifying the patrol reports, were described in Chapter 2. Rangers recorded encounters with illegal bushmeat poaching, which comprised snare clusters, poaching signs of recent trails and snare setting, and poachers. Numbers of snares and snared animals that rangers collected from each cluster of snares were recorded, although not consistently. Rangers also recorded year, month, number of rangers on patrol, number of effective patrol days, type of patrol whether long or day patrol, and area toponym(s), which were assigned to the corresponding sector or sectors within the different areas of Bwindi (north, centre, east, south and west) (section 2.2.1.3). An effective patrol day (hereafter referred to as 'patrol day') is a day spent in the active pursuit of illegal activities, thereby excluding days spent travelling to and from the patrol area (Bell, 1986).

Rangers recorded information on details of poachers comprising the sex, age (adult or child) and area of origin of the poachers. In addition, rangers noted the parish in which poachers neighbouring Bwindi were resident, and whether these poachers were Bakiga agriculturalist or indigenous Batwa.

Data were extracted from records of law enforcement patrols that comprised 765 days on long patrols, and 3067 days on day patrols carried out from 1986 to 2000, except for the lack of reports from 1990 to 1991. Thus, the data covered 13 years. Law enforcement and poaching encounters per patrol day were summed for the north, centre, east, south and west of Bwindi, per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol in each area were included for analysis (1986-2000 monthly totals across all areas; n = 558). The monthly totals in each area were then grouped into three periods, comprising before gazettement (1986-1989 monthly totals n = 137); after gazettement and before harvest zones were established (1992-1994 monthly totals n = 144); and after harvest zones were established (1995-2000 monthly totals n = 277). Rangers did not consistently record information on details of poachers (1986-2000 patrol reports with poacher information; n = 138). The analysis was based on two periods of before (1986-1994) and after (1995-2000) harvest zones were established.

The distribution of total patrol days per month from the dataset 1986-2000 (monthly totals n = 558) (Figure 4.1) illustrates the average of seven patrol days per month (mean patrol days per month = 6.87$\pm$0.2SE). In addition, the distribution of total poaching information recorded by rangers per month from the dataset 1986-2000 (monthly totals n = 558) (Figure 4.1) illustrates that on average rangers recorded two poaching encounters per month (mean poaching encounters per month = 1.64$\pm$0.1SE).

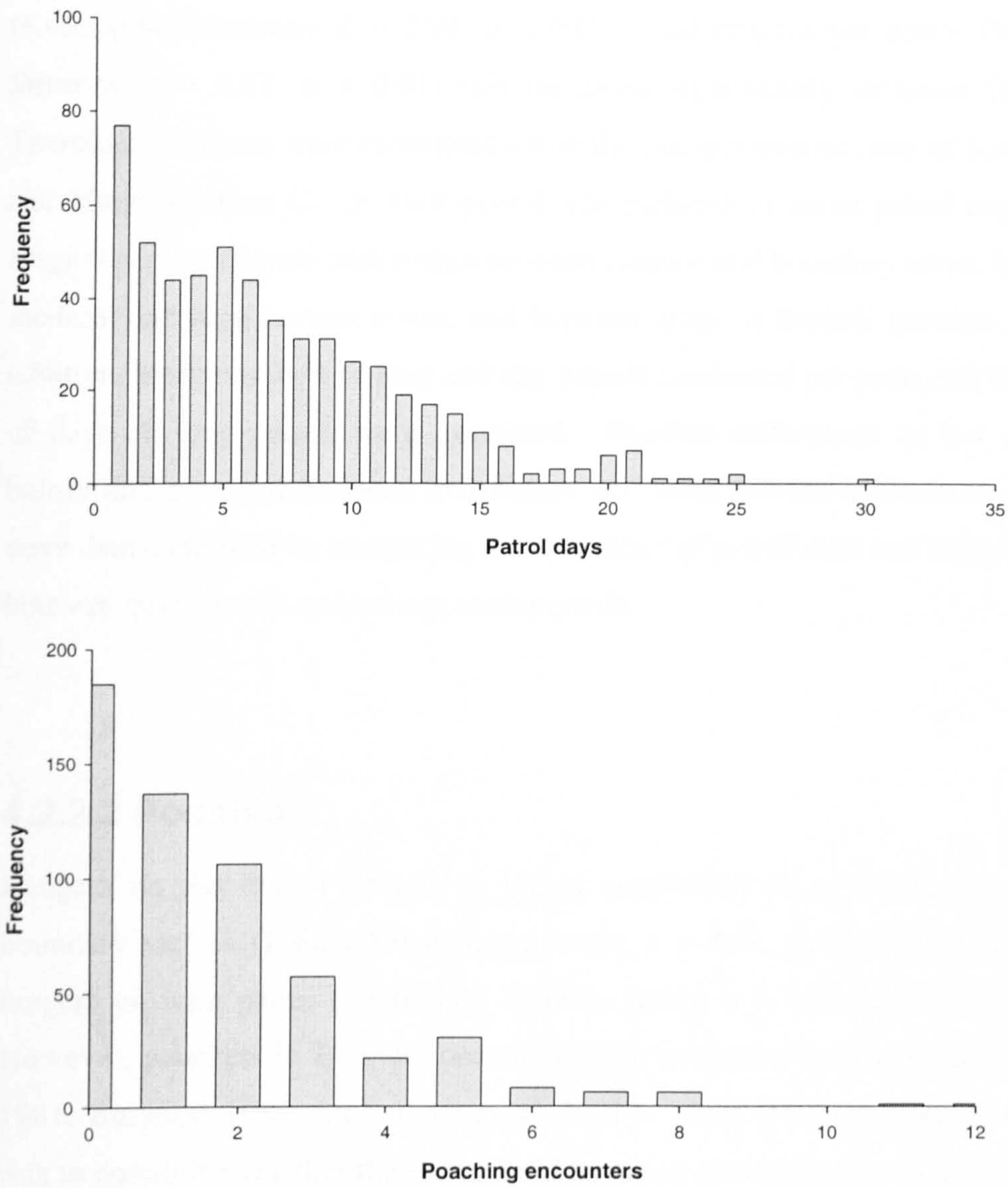


Figure 4.1 Frequency distribution of patrol days and of poaching encounters recorded by rangers per month from 1986 to 2000

## 4.2.2 Data analysis

### 4.2.2.1 Law enforcement

The aim of the analysis was to conduct univariate tests to examine possible differences in law enforcement between areas of Bwindi before and after the periods of gazettement and of harvest zone establishment. Numbers of patrol days and rangers per patrol were log transformed, but the distribution of patrol days (Kolmogorov-Smirnov $Z = 2.94$; $p < 0.001$) and rangers per patrol (Kolmogorov-Smirnov $Z = 1.87$; $p < 0.01$) still remained significantly different from normal. Therefore, analyses were conducted using the non-parametric tests of Kruskal-Wallis and Mann Whitney U. In each period, comparisons of mean patrol days and mean rangers per patrol were undertaken between interior and boundary areas, between low, medium and high harvest zones, and between areas of Bwindi (section 2.2.1.3). In addition, mean numbers of long and day patrols conducted per year, and mean number of days on long patrol, were examined. Possible differences in law enforcement before and after gazettement, and before and after harvest zones were established, were then examined by comparing mean number of patrol days and rangers per patrol between gazettement and harvest zone periods.

### 4.2.2.2 Poaching

Rangers on day patrol covered a higher proportion ($z = -20.50$; $p < 0.001$) of boundary sectors (1986-2000 monthly totals; $n = 428$; mean$\pm$SE $0.99 \pm 0.001$) than rangers on long patrol (1986-2000 monthly totals; $n = 130$; mean$\pm$SE $0.68 \pm 0.02$). However, poachers in Bwindi concentrate their activities in interior areas (Harcourt, 1981; Butynski 1984; McNeilage *et al*, 2001). Thus, the first stage of the analysis was to determine whether there was a difference in poaching encounters between long and day patrols. Rangers on long and day patrol covering the same forest area recorded similar poaching encounters (Appendix A). Therefore, long and day patrols were pooled for the analysis, as area of Bwindi appeared more important than type of patrol to poaching encounters by rangers on patrol.

The second stage of the analysis was to determine the most appropriate variable of patrol effort for adjusting poaching encounters into a "catch per unit effort" index (Bell, 1986), from which to examine an encounter rate of poaching. Bell (1986) describes several measures of patrol effort and recommends using the number of patrol days and the distance covered by patrols. However, a limitation of the Bwindi patrol data was the absence of patrol distance. Previous studies illustrate the use of various combinations of time, manpower and distance, for example, the number of rangers x patrol days (Leader-Williams *et al*, 1990), patrol distance ($km^2$) per ranger (Jachmann and Billiouw, 1997) and the number of patrols (Walpole, 2002). The variables of patrol days and rangers on patrol were considered possibilities for the Bwindi data. Patrol days (1986-2000 monthly totals; n = 558; $r_s = 0.33$; $p < 0.001$) were positively correlated with poaching encounters. However, no linear relationship was evident between poaching encounters and number of rangers on patrol (1986-2000 monthly totals n = 558; $r_s = 0.07$; $p > 0.05$). Therefore, poaching encounters were adjusted by patrol days to arrive at a catch per unit effort index. This index of poaching was log transformed, but the distribution still remained significantly different from normal (Kolmogorov-Smirnov Z = 4.50; $p < 0.001$). Therefore, poaching encounters divided by patrol days formed the dependent variable for analyses conducted using the non-parametric tests of Kruskal-Wallis and Mann Whitney U.

Sizes of snare clusters were examined by the number of snares that rangers collected per snare cluster (1986-2000 monthly totals n = 258). It could be expected that numbers of snares per cluster would be positively correlated with days on patrol, as rangers on long patrol will often spend an extra day searching for snares when they encounter a snare cluster (section 2.2.1). However, the number of snares per cluster was not correlated with patrol days ($r_s = 0.06$; $p > 0.05$) and was therefore employed for analysis. The number of snared animals collected by rangers was also examined, although the small number of patrol reports with numbers of snared animals did not permit statistical analysis (1986-2000 patrol reports n = 41).



The first analysis aimed to conduct univariate tests to examine possible differences in encounters with poaching between areas of Bwindi before and after the periods of gazettement, and harvest zone establishment. In each period, comparisons were undertaken of mean poaching encounters between interior and boundary areas, between low, medium and high harvest zones and between areas of Bwindi. The comparisons were undertaken as follows: separately for each type of encounter comprising snare clusters, poaching signs and poachers; for these encounters pooled into a combined encounter rate; and, for the number of snares per snare cluster. Comparisons between areas of Bwindi only comprised encounters pooled into a combined encounter rate because of small sample sizes. Possible differences in encounters with poaching between periods of before and after gazettement and harvest zone establishment were then examined by comparing mean encounters pooled into a combined encounter rate and mean number of snares per snare cluster, between the periods. Sizes of snare clusters were also examined by the annual mean number of snares per snare encounter from 1986 to 2000.

The second analysis aimed to identify which factors best explained the likelihood of encountering poaching on law enforcement patrol in Bwindi. Multivariate analysis using actual number of encounters was limited because of the distribution of the data. A more robust analysis was achieved by converting patrol encounters with poaching per month into binary data comprising months with (1986-2000 monthly totals; n = 373), and months without (1986-2000 monthly totals; n = 160), an encounter. Thus although converting encounter number into binary data lost information from the data, this enabled confidence in the analysis. The binary data formed the dependent variable in a stepwise logistic regression analysis, using the forward stepwise procedure (section 2.2.3.2). In order to determine the primary factors driving law enforcement encounter with poaching, the main effects of explanatory variables were included in the regression model with no interaction terms specified. The explanatory variables comprised patrol days and factors deemed significant from the univariate tests of gazettement and harvest zone period; interior and boundary area; low, medium and high harvest zone; and, area (north, centre, east, south and west) of Bwindi. Periods and areas were entered in the regression model as categorical variables. In addition, numbers of patrol days and ranger teams required to encounter poaching were examined by comparing mean poaching encounters between five categories of the monthly averages of patrols days and rangers on patrol.

The final analysis aimed to examine characteristics of the poachers and outcomes of patrol encounters with poachers. For each of the two periods, poachers' sex, age and area of origin were examined. In addition, sizes of the poacher groups were examined by the number of poachers that rangers encountered. The mean numbers of Bakiga and Batwa poachers per encounter were compared by Mann Whitney U test. Associations between Bakiga and Batwa poachers, and low, medium and high harvest zones, were examined by Chi Square.

Rangers made descriptive notes on the outcome of their encounter with poachers. Four categories of outcomes were defined based on the descriptions (Table 4.1). In each period, associations between Bakiga and Batwa poachers and the outcomes were examined by Chi Square. An assessment of the court and punishment administered to arrested poachers was made, although the few patrol reports including these data did not permit statistical analysis (1986-2000 patrol reports; n = 52).

Table 4.1 Types of outcome of a patrol encounter with poachers

| Type of outcome | Definition |
|---|---|
| Escape | All poachers escaped |
| Arrest | All poachers arrested and taken to court |
| Arrest&Escape | Some poachers arrested and some poachers escaped |
| Release | All poachers arrested and released with warnings |
| Unknown | Outcome not recorded |

# 4.3 Results

## 4.3.1 Patterns of law enforcement

### 4.3.1.1 Before National Park gazettement

Patterns of law enforcement at Bwindi changed from 1986 to 2000 (Table 4.2; Figure 4.2). Patrols before National Park gazettement consisted of an average team of four rangers (Figure 4.1a) and most patrol days took place on long patrol (Figure 4.1c). Long patrols ranged from 2 to 13 days in length, with an average of 4 days per long patrol. Thus most patrols before gazettement covered interior areas of Bwindi. In terms of future harvest zones, most time patrolling was in future high harvest zones, although ranger teams were largest in future low harvest zones (Table 4.3). There were also differences in law enforcement between areas of Bwindi (Table 4.4). Patrol days were highest in the east and lowest in the centre. The largest ranger teams were in the south and the smallest were in the north.

Table 4.3 Mean±SE patrol days and mean±SE rangers per patrol per month in future harvest zones of Bwindi from 1986 to 1989, before National Park gazettement

| **Parameter** | **Future harvest zone** | | | **Kruskal-Wallis** | ***P*** |
|---|---|---|---|---|---|
| | **Low (n = 60)** | **Medium (n = 22)** | **High (n = 55)** | **$\chi^2$ (df=2)** | |
| **Patrol days** | 2.78±0.2 | 2.73±0.2 | 4.47±0.4 | 9.20 | < 0.01 |
| **Rangers** | 4.71±0.2 | 4.29±0.3 | 3.70±0.2 | 15.63 | < 0.001 |

Table 4.4 Mean±SE patrol days and mean±SE rangers per patrol per month in areas of Bwindi from 1986 to 1989, before National Park gazettement

| Parameter | Area of Bwindi | | | | | Kruskal -Wallis | *P* |
|---|---|---|---|---|---|---|---|
| | North (n=20) | Centre (n=28) | East (n=35) | South (n=32) | West (n=22) | $\chi^2$(df=4) | |
| **Patrol days** | 3.45±0.7 | 2.43±0.2 | 5.06±0.6 | 3.09±0.4 | 2.73±0.5 | 14.31 | < 0.01 |
| **Rangers** | 3.45±0.3 | 4.59±0.3 | 3.84±0.2 | 4.81±0.3 | 4.29±0.3 | 17.03 | < 0.01 |

### 4.3.1.2 After gazettement and before harvest zones

There was an increase in law enforcement effort following the gazettement of Bwindi as a National Park, and before harvest zones were established (Table 4.2; Figure 4.1). Although the size of ranger teams did not change ($z = -1.57$; $p > 0.05$) from an average of 4 rangers per patrol (Figure 4.1a), and rangers mostly undertook long patrols (Figure 4.1b), there was an increase ($z = -2.02$; $p < 0.05$) in the annual mean proportion of days on long patrol (Figure 4.1c), and an increase ($z = -3.33$; $p < 0.01$) in the length of long patrols (Figure 4.2). Therefore, overall there was a large increase in the total number of patrol days in this period (Table 4.2; Figure 4.1c). Law enforcement in the future harvest zones was similar to the previous period (Table 4.5), although law enforcement in areas of Bwindi differed. Rangers spent most time patrolling the north and least time patrolling the centre, and the largest ranger teams were in the north and the smallest were in the west (Table 4.6).

Table 4.5 Mean±SE patrol days and mean±SE rangers per patrol per month in future harvest zones of Bwindi from 1992 to 1994, after National Park gazettement

| Parameter | Future harvest zone | | | Kruskal-Wallis | *P* |
|---|---|---|---|---|---|
| | Low (n = 56) | Medium (n = 19) | High (n = 69) | $\chi^2$ (df=2) | |
| **Patrol days** | 5.32±0.5 | 6.16+1.0 | 9.38±0.6 | 22.87 | < 0.001 |
| **Rangers** | 4.39±0.2 | 3.57+0.3 | 4.31±0.1 | 8.13 | < 0.05 |

Table 4.6 Mean±SE patrol days and mean±SE rangers per patrol per month in areas of Bwindi from 1992 to 1994, after National Park gazettement and before harvest zones were established

| **Parameter** | **Area of Bwindi** | | | | | **Kruskal -Wallis** | ***P*** |
|---|---|---|---|---|---|---|---|
| | **North (n=35)** | **Centre (n=27)** | **East (n=34)** | **South (n=29)** | **West (n=19)** | **$\chi^2$(df=4)** | |
| **Patrol days** | 10.14±1.0 | 4.78±0.7 | 8.59±0.7 | 5.83±0.6 | 6.16±1.0 | 24.72 | <0.001 |
| **Rangers** | 4.62±0.2 | 4.60±0.3 | 3.99±0.1 | 4.21±0.3 | 3.57±0.3 | 11.65 | < 0.05 |

### 4.3.1.3 After harvest zones

The number of day patrols increased after harvest zones were established (Table 4.2; Figure 4.1). Rangers undertook an average of over 350 day patrols per year in this period (Table 4.2), although there were fewer day patrols during 1997 when rangers took part in the mountain gorilla census, and during 1999 when the Rwandan extremist militia the Interahamwe attacked the National Park headquarters. Nonetheless, the total number of patrol days increased from the previous period to 2297 patrol days (Table 4.2). In contrast, there were only an average number of 30 long patrols per year (Figure 4.1b), although the length of long patrols did not change ($z = -0.77$; $p > 0.05$) from the previous period (Table 4.2). In addition, the size of the ranger teams declined ($z = -11.55$; $p < 0.001$) to an average of less than 3 rangers (Figure 4.1a). Thus law enforcement during this period was mainly by small ranger teams patrolling forest boundary areas for a single day. Days spent patrolling in the established harvest areas was similar to the previous period, although ranger teams were largest in medium harvest zones (Table 4.7). Law enforcement in areas of Bwindi differed between periods (Table 4.8). After harvest zones were established, rangers spent most time patrolling the east and least time patrolling the west, although ranger teams were largest in the west and were smallest in the centre.

Table 4.7 Mean$\pm$SE patrol days and mean$\pm$SE rangers per patrol per month in harvest zones of Bwindi from 1995 to 2000, after harvest zones were established

| Parameter | Future harvest zone | | | Kruskal-Wallis | *P* |
|---|---|---|---|---|---|
| | Low (n = 155) | Medium (n = 35) | High (n = 127) | $\chi^2$ (df=2) | |
| Patrol days | 7.89$\pm$0.4 | 4.63$\pm$0.6 | 9.67$\pm$0.6 | 24.01 | < 0.001 |
| Rangers | 2.66$\pm$0.1 | 3.13$\pm$0.2 | 2.85$\pm$0.1 | 8.25 | < 0.05 |

Table 4.8 Mean$\pm$SE patrol days and mean$\pm$SE rangers per patrol per month in areas of Bwindi from 1995 to 2000, after harvest zones were established

| Parameter | Area of Bwindi | | | | | Kruskal -Wallis | *P* |
|---|---|---|---|---|---|---|---|
| | North (n=62) | Centre (n=65) | East (n=65) | South (n=50) | West (n=35) | $\chi^2$(df=4) | |
| Patrol days | 9.23+0.8 | 8.08$\pm$0.4 | 10.09$\pm$0.8 | 7.64$\pm$0.7 | 4.63$\pm$0.6 | 25.33 | <0.001 |
| Rangers | 2.95$\pm$0.1 | 2.59$\pm$0.1 | 2.76$\pm$0.1 | 2.75$\pm$0.1 | 3.13$\pm$0.2 | 10.23 | < 0.05 |

Therefore ranging behaviour varied in time and space. Before National Park gazettement when the Game Department was supported by IFCP, law enforcement mainly comprised teams of four rangers patrolling the forest interior for an average of four days. The future high harvest zone of the east area was heavily patrolled, and the future low harvest zone of the centre area was least well patrolled. After gazettement and before harvest zones were established when UNP was supported by organisations involved with Bwindi, law enforcement increased and patrol coverage of the forest interior and future high harvest zones remained high. After harvest zones were established when UNP/UWA continued to receive external support, patrol effort in high harvest zones remained high although in the forest interior declined. Law enforcement during this period mainly comprised small ranger teams undertaking day patrols in forest boundary areas.

Table 4.2 Law enforcement in Bwindi during the periods of before National Park (NP) gazettement, after National Park gazettement and before harvest zones (HZ), and after the harvest zones were established

| **Period** | **Patrol days** | **Law enforcement (mean±SE)** | | | |
|---|---|---|---|---|---|
| | | **Rangers per patrol** | **N. Day patrols per year** | **N. Long patrols per year** | **Days per long patrol** |
| **Before NP** | 473 | 4.24±0.1 | 55.50±11.8 | 24.75±4.5 | 4.27±0.4 |
| **After NP, before HZ** | 1062 | 4.25±0.1 | 67.67±15.8 | 87.67±12.0 | 6.90±0.7 |
| **After HZ** | 2297 | 2.68±0.1 | 352.50±39.1 | 30.17±7.5 | 8.56±1.3 |

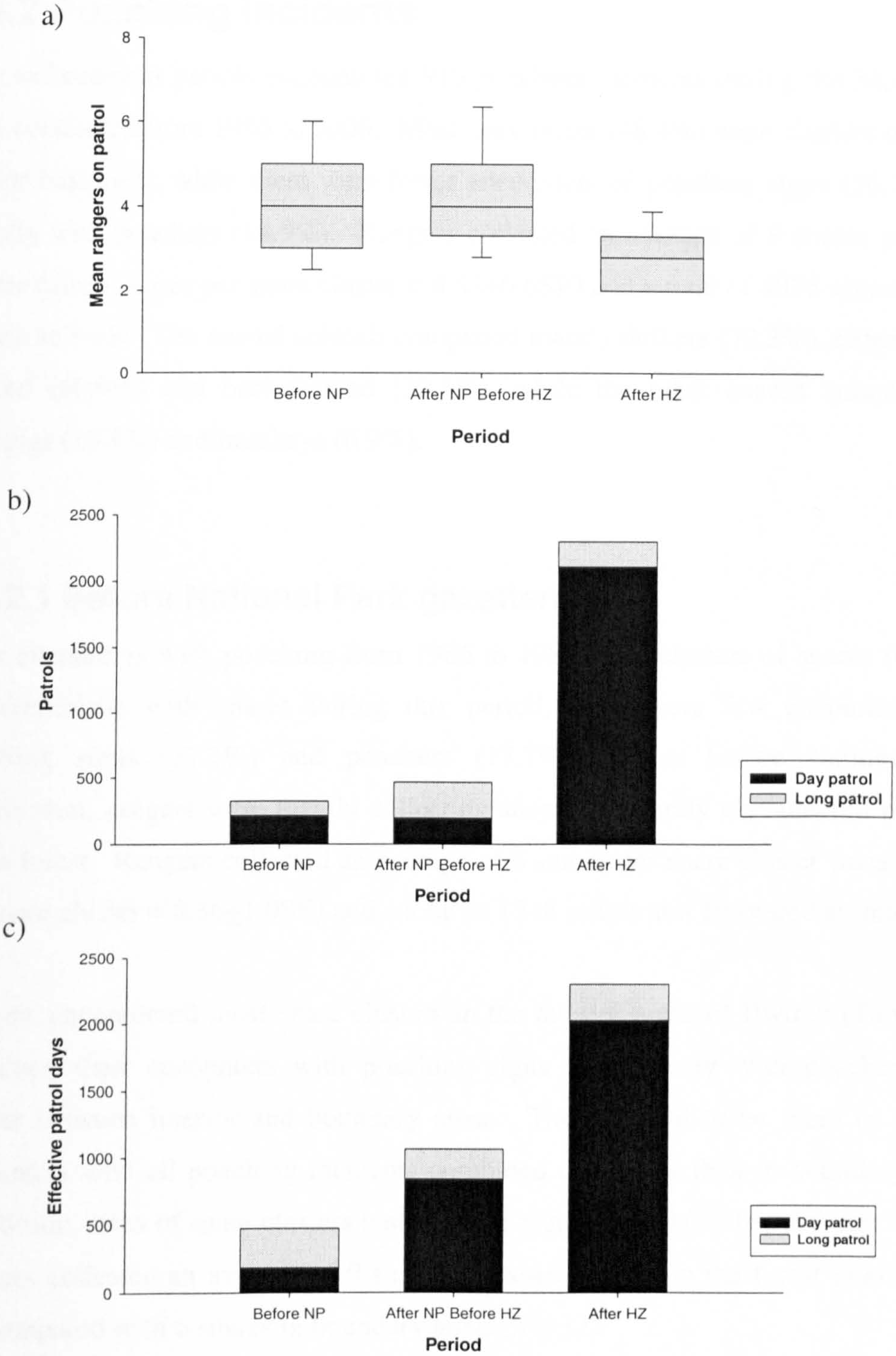


Figure 4.2 Law enforcement in Bwindi by (a) mean rangers per patrol, (b) the number of patrols, and (c) effective patrol days per month from 1986 to 2000, in periods before National Park (NP) gazettement, after National Park gazettement and before harvest zones (HZ) were established, and after the establishment of harvest zones

Boxplots: the boundary of the boxes closest to zero indicates the 25th percentile, the line within the boxes marks the median, the boundary of the boxes farthest from zero indicates the 75th percentile, and the whiskers showing 5th and 95th percentile

## 4.3.2 Poaching incidents

Law enforcement patrols encountered 915 poaching incidents during the 3832 patrol days conducted from 1986 to 2000. Most encounters (48.4%) were clusters of snares set for bushmeat, while there were fewer encounters of poaching signs (36.7%) and directly with poachers (14.9%). Rangers collected an average of 9 snares per snare cluster (mean snares per snare cluster = 8.58±0.6SE) and a total of 4036 snares and 58 snared animals. The snared animals comprised mainly duikers (79.3%), either yellow backed (60.9%) and back-fronted (39.1%), while the other snared animals were bushpigs (13.8%) and monkeys (6.9%).

### 4.3.2.1 Before National Park gazettement

Most encounters with poaching from 1986 to 1989 were clusters of snares (65.0%). In comparison with snares during this period, there were few encounters with poaching signs (17.3%) and poachers (17.7%). Thus before National Park gazettement, rangers were mainly collecting snares and rarely encountered poachers in the forest. Rangers collected an average of 8 snares per snare cluster (mean snares per snare cluster = 8.36±1.0SE) and a total of 1248 snares and 19 snared animals.

Rangers encountered most snare clusters in the interior areas of Bwindi (Table 4.9). However, their encounters with poaching signs and directly with poachers were similar between interior and boundary areas. There tended to be more ($p = 0.08$) encounters with all poaching incidents combined in interior than in boundary areas. In addition, sizes of snare clusters tended to be higher ($p = 0.08$) in the forest interior. Rangers collected an average of 9 snares per snare cluster in the forest interior ($n = 47$) compared with 6 snares in boundary areas ($n = 32$).

Table 4.9 Mean±SE encounters with poaching incidents and snares per snare cluster per month by patrols in interior and boundary areas of Bwindi from 1986 to 1989, before National Park gazettement

| Area and statistical comparison | Poaching incidents / patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All incidents | |
| **Interior (n = 66)** | 0.41±0.05 | 0.10±0.03 | 0.12±0.03 | 0.63±0.1 | 9.36±1.4 |
| **Boundary (n = 71)** | 0.29±0.1 | 0.08±0.02 | 0.11±0.03 | 0.47±0.1 | 6.88±1.5 |
| **Mann Whitney U (z value)** | -2.55 | -1.16 | -0.29 | -1.78 | -1.73 |
| ***P*** | < 0.05 | NS | NS | NS | NS |

Encounters with each type of poaching encounter, and with all poaching incidents combined, were similar between future low, medium and high harvest zones (Table 4.10). However, there were differences between future harvest zones in the size of snare clusters. Rangers collected an average of 15 snares per snare cluster in future medium harvest zones (n = 15), compared with 9 snares in future low (n = 30) and 5 snares in future high harvest zones (n = 34). Therefore, before National Park gazettement, encounters with poaching were no higher in future medium harvest zones, but rangers collected larger snare clusters in these areas than in future low or high harvest zones.

Table 4.10 Mean±SE encounters with poaching incidents and snares per snare cluster per month by patrols in future harvest zones of Bwindi from 1986 to 1989, before National Park gazettement

| Future harvest zone and statistical comparison | Poaching incidents / patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All incidents | |
| **Low (n = 60)** | 0.35±0.1 | 0.09±0.03 | 0.14±0.04 | 0.58±0.1 | 9.10±1.8 |
| **Medium (n = 22)** | 0.55±0.1 | 0.13±0.02 | 0.03±0.02 | 0.71±0.1 | 14.63±3.1 |
| **High (n = 55)** | 0.25±0.04 | 0.08±0.03 | 0.11±0.03 | 0.45±0.1 | 4.93±0.6 |
| **Kruskal-Wallis $\chi^2$ (df=2)** | 4.56 | 0.71 | 3.98 | 3.10 | 8.31 |
| ***P*** | NS | NS | NS | NS | < 0.05 |

Encounters with all poaching incidents combined differed between areas of Bwindi before National Park gazettement. Rangers encountered most poaching incidents in the south and west (Kruskal-Wallis $\chi^2 = 9.29$; df = 4; $p < 0.05$) (Figure 4.3).

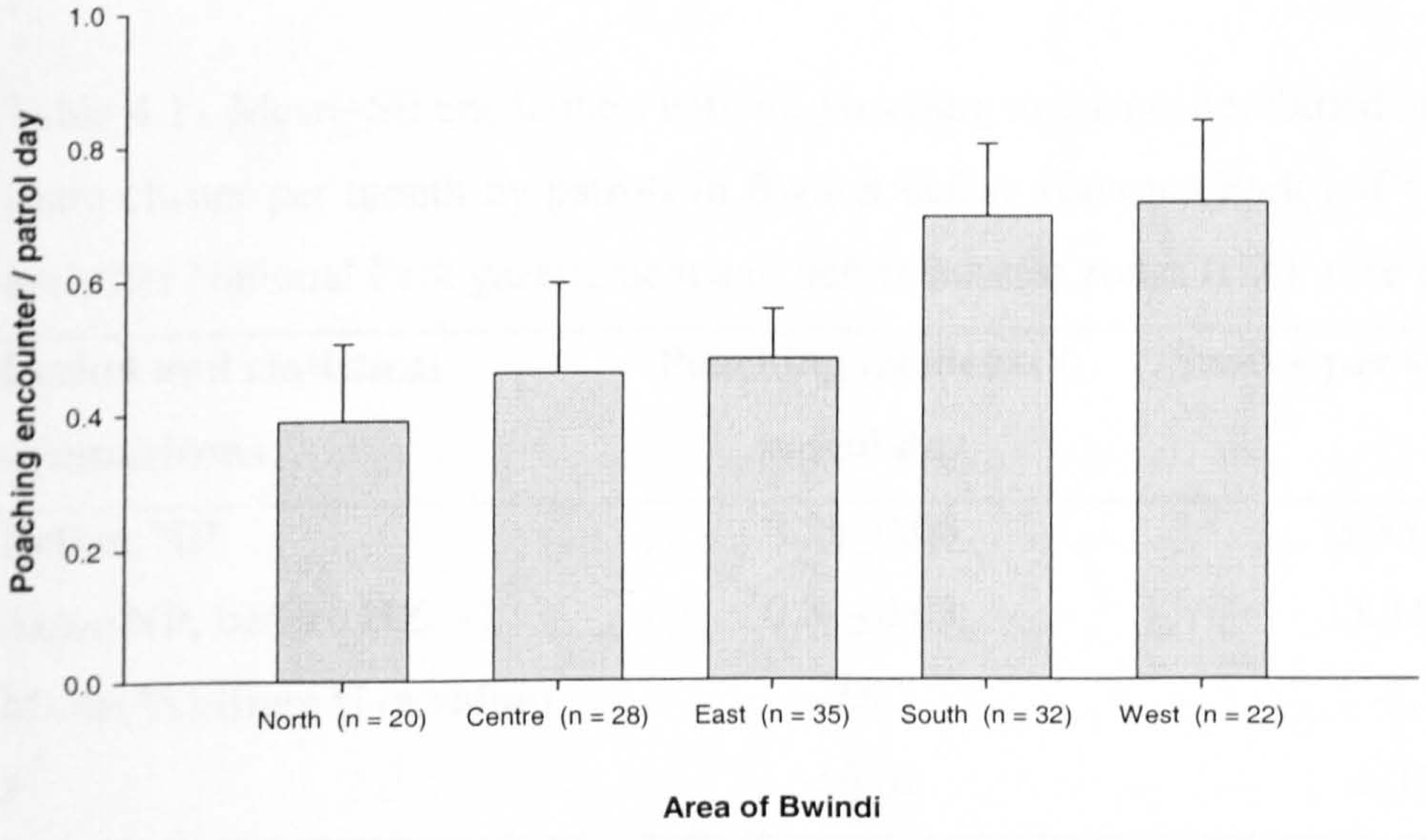


Figure 4.3 Mean±SE encounters with all poaching incidents combined per month by patrols in areas of Bwindi from 1986 to 1989, before National Park gazettement

Therefore, rangers mainly encountered clusters of snares before National Park gazettement when patrol teams covered forest interior areas, particularly in the east of Bwindi. Rangers encountered snare clusters most frequently in the forest interior, particularly the south and west, and collected the largest snare clusters in the future medium harvest zone of the west.

#### 4.3.2.2 After gazettement and before harvest zones

The types of poaching encounter after National Park gazettement and before harvest zones were established were similar to the types before gazettement. Most encounters were snare clusters (61.3%) and there were few encounters with poaching signs (23.1%) and fewer directly with poachers (15.6%). Rangers collected a total of 2085 snares and 16 snared animals during the period.

Patrols encountered poaching incidents less often after Bwindi gained National Park status and before harvest zones were established (Table 4.11). However, the sizes of snare clusters increased to an average of 13 snares per cluster. This indicated that poachers were entering Bwindi less frequently than before gazettement, but were setting larger snare clusters while in the National Park.

Table 4.11 Mean±SE encounters with all poaching incidents combined and snares per snare cluster per month by patrols in Bwindi before National Park (NP) gazettement, and after National Park gazettement and before harvest zones (HZ) were established

| Period and statistical comparisons | Poaching incidents / patrol day | Snares per snare cluster |
|---|---|---|
| **Before NP** | 0.55±0.05 | 8.36±1.0 |
| **After NP, before HZ** | 0.31±0.03 | 13.31±1.3 |
| **Mann Whitney U (z value)** | -2.92 | -3.73 |
| ***P*** | < 0.01 | < 0.001 |

Patrol encounters with all poaching incidents combined (Table 4.12a) remained constant in both interior and boundary areas following gazettement and before harvest zones were established. However, rangers collected larger snare clusters in both areas (Table 4.12b).

Table 4.12 Mean±SE encounters with all poaching incidents combined and snares per snare cluster per month by patrols in interior and boundary areas before National Park (NP) gazettement, and after National Park gazettement and before harvest zones (HZ) were established

| **a) Period and statistical comparisons** | **Area: poaching incidents / patrol day** | |
|---|---|---|
| | **Interior** | **Boundary** |
| **Before NP** | 0.63±0.1 | 0.47±0.1 |
| **After NP, before HZ** | 0.47±0.1 | 0.27±0.03 |
| **Mann Whitney U (z value)** | -1.11 | -1.52 |
| ***P*** | NS | NS |

| **b) Period and statistical comparisons** | **Area: snares per snare cluster** | |
|---|---|---|
| | **Interior** | **Boundary** |
| **Before NP** | 9.36±1.4 | 6.88±1.5 |
| **After NP, before HZ** | 17.70±2.9 | 11.56±1.3 |
| **Mann Whitney U (z value)** | -2.93 | -3.22 |
| ***P*** | < 0.01 | < 0.01 |

Before and after National Park gazettement before harvest zones were established, all poaching incidents combined declined in future high and medium harvest zones, but remained constant in future low harvest zones (Table 4.13a). In contrast, rangers encountered similar sized snare clusters in future low and medium harvest zones but larger snare clusters in future high harvest zones after Bwindi was gazetted a National Park (Table 4.13b).

Table 4.13 Mean±SE encounters with all poaching incidents combined and snares per snare cluster per month by patrols in future harvest zones before National Park (NP) gazettement, and after National Park gazettement and before harvest zones (HZ) were established

| **a) Period and statistical comparisons** | **Future harvest zone: poaching incidents / patrol day** | | |
|---|---|---|---|
| | **Low** | **Medium** | **High** |
| **Before NP** | 0.58±0.1 | 0.71±0.1 | 0.45±0.1 |
| **After NP, before HZ** | 0.41±0.05 | 0.32±0.1 | 0.23±0.04 |
| **Mann Whitney U (z value)** | -1.67 | -2.26 | -2.88 |
| ***P*** | NS | < 0.05 | < 0.01 |

| **b) Period and statistical comparisons** | **Future harvest zone: snares per snare cluster** | | |
|---|---|---|---|
| | **Low** | **Medium** | **High** |
| **Before NP** | 10.94±1.6 | 14.63±3.1 | 4.93±0.6 |
| **After NP, before HZ** | 12.00±1.3 | 12.71±3.0 | 14.82±2.3 |
| **Mann Whitney U (z value)** | -1.60 | -0.07 | -3.60 |
| ***P*** | NS | NS | < 0.001 |

There were more encounters with clusters of snares in interior than in boundary areas during the period after National Park gazettement and before harvest zones were established (Table 4.14). Encounters with poaching signs and directly with poachers remained similar between interior and boundary areas, although encounters with all poaching incidents combined were higher in interior areas. Thus poaching, particularly snare setting, remained concentrated in the forest interior. In addition, rangers encountered larger snare clusters in the forest interior. Rangers collected an average of 18 snares per snare cluster in interior areas (n = 24) compared with 12 snares in boundary areas (n = 60).

Table 4.14 Mean±SE encounters with all poaching incidents combined and snares per snare cluster per month by patrols in interior and boundary areas of Bwindi from 1992 to 1994, after National Park gazettement and before harvest zones were established

| Area and statistical comparison | Poaching incidents / patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All incidents | |
| **Interior (n = 31)** | 0.27±0.05 | 0.10±0.04 | 0.09±0.05 | 0.47±0.1 | 17.70±2.9 |
| **Boundary (n = 113)** | 0.16±0.02 | 0.05±0.01 | 0.05±0.01 | 0.27±0.03 | 11.56±1.3 |
| **Mann Whitney U (z value)** | -2.54 | -0.59 | -0.10 | -2.47 | -2.03 |
| ***P*** | < 0.05 | NS | NS | < 0.05 | < 0.05 |

Encounters with poaching signs and directly with poachers remained similar between future harvest areas after National Park gazettement and before harvest zones were established (Table 4.15). However, in contrast with the previous period, there was no difference between future harvest zones in encounters with snare clusters, although most encounters with all poaching incidents combined were in future low harvest zones. Also in contrast with the previous period, there was no difference between future harvest zones in the sizes of snare clusters. Rangers collected an average of 12 snares per snare cluster in future low harvest zones (n = 33), 13 snares in future medium zones (n = 12) and 15 snares in future high zones (n = 39). Furthermore, there was no difference (Kruskal-Wallis $\chi^2 = 7.42$; df = 4; $p > 0.05$) in encounters with all poaching incidents combined between areas of Bwindi (Figure 4.4).

Therefore, encounters with poaching declined in Bwindi, particularly in future high harvest zones, after National Park gazettement and before harvest zones were established when rangers concentrated their efforts in interior and future high harvest zones. Rangers encountered most poaching in the least well-patrolled future low harvest zones, and collected larger snare clusters in both interior and boundary areas, and in future high harvest zones. Snare clusters were the main type of poaching encounter during the period, and were most frequently encountered in the forest interior, and in south and centre areas.

Table 4.15 Mean±SE encounters with poaching incidents and snares per snare cluster per month by patrols in future harvest zones of Bwindi from 1992 to 1994, after National Park gazettement and before harvest zones were established

| **Future harvest zone and statistical comparison** | **Poaching incidents / patrol day** | | | | **Snares per snare cluster** |
|---|---|---|---|---|---|
| | **Snare clusters** | **Poaching signs** | **Poachers** | **All incidents** | |
| **Low (n = 56)** | 0.23±0.04 | 0.08±0.02 | 0.09±0.03 | 0.41±0.1 | 11.75±1.4 |
| **Medium (n = 19)** | 0.25±0.07 | 0.04±0.02 | 0.03±0.02 | 0.32±0.04 | 12.71±3.0 |
| **High (n = 69)** | 0.13±0.02 | 0.07±0.01 | 0.05±0.02 | 0.23±0.04 | 14.82±2.3 |
| **Kruskal-Wallis $\chi^2$ (df=2)** | 4.01 | 0.58 | 2.43 | 6.12 | 0.78 |
| ***P*** | NS | NS | NS | < 0.05 | NS |

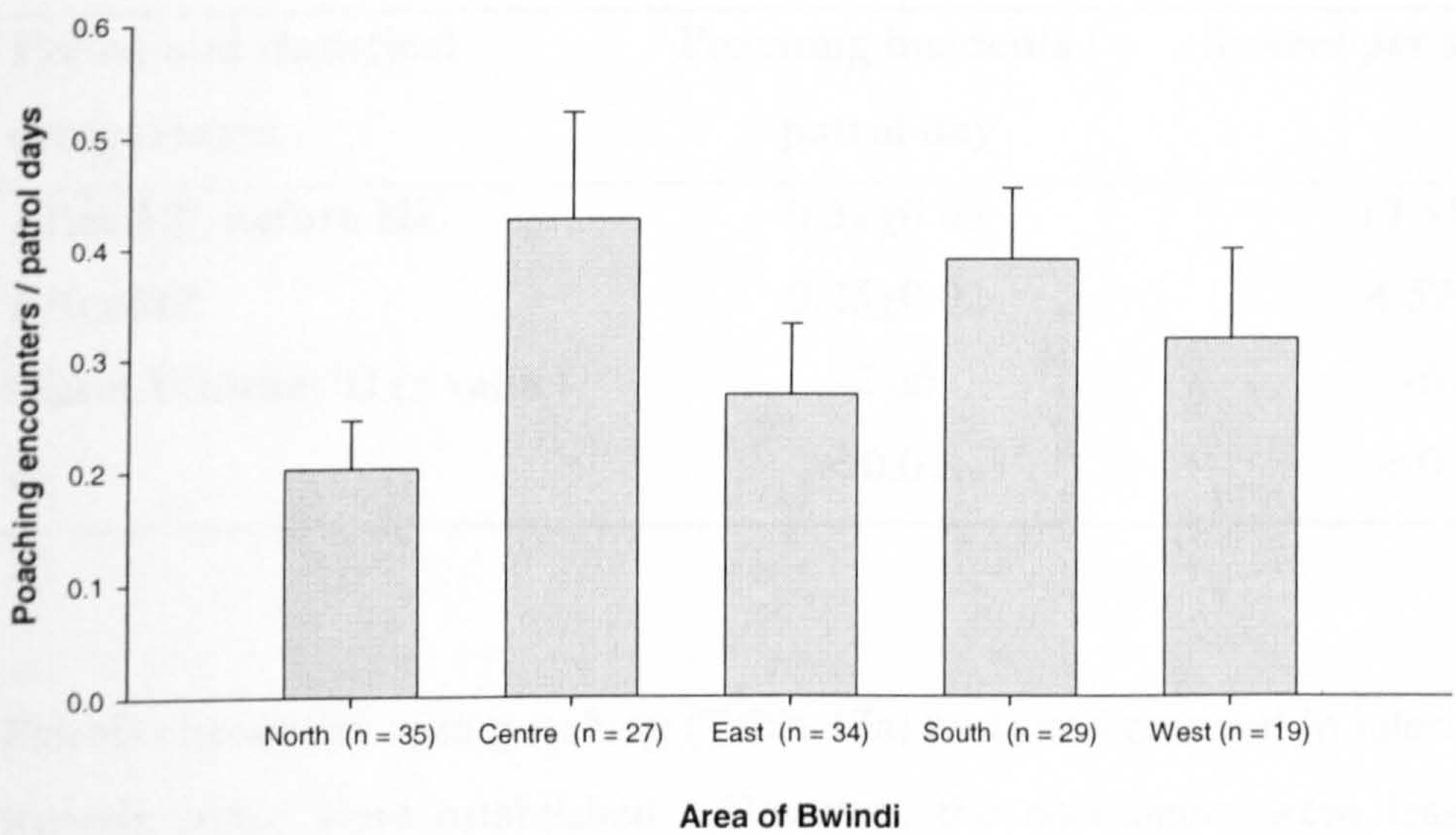


Figure 4.4 Mean±SE encounters with all poaching incidents combined per month by patrols in areas of Bwindi from 1992 to 1994, after National Park gazettement and before harvest zones were established

#### 4.3.2.3 After harvest zones

The types of poaching encounter after harvest zones were established differed from the previous period. Rangers encountered more poaching signs (54.7%) than clusters of snares (32.2%) or directly with poachers (13.1%). Rangers collected a total of 703 snares and 23 snared animals during the period.

Rangers encountered poaching incidents less often, and collected smaller snare clusters of an average of 5 snares per cluster, after harvest zones were established (Table 4.16). This indicated that poachers were entering Bwindi less frequently than before the harvest zones, and were setting smaller snare clusters in the areas patrolled by rangers.

Table 4.16 Mean±SE encounters with all poaching incidents combined and snares per snare cluster per month by patrols in Bwindi after National Park (NP) gazettement and before harvest zones (HZ) established, and after harvest zones established

| Period and statistical comparisons | Poaching incidents / patrol day | Snares per snare cluster |
|---|---|---|
| **After NP, before HZ** | 0.31±0.03 | 13.31±1.3 |
| **After HZ** | 0.25±0.02 | 4.57±0.4 |
| **Mann Whitney U (z value)** | -2.66 | -6.70 |
| ***P*** | < 0.01 | < 0.001 |

Patrols encounters with poaching (Table 17a) remained constant in interior areas after harvest zones were established. However, the encounters were less frequent in boundary areas. Furthermore, rangers collected smaller snare clusters (Table 4.17b) in both interior and boundary areas.

Table 4.17 Mean±SE encounters with all poaching incidents combined and snares per snare cluster per month by patrols in interior and boundary areas of Bwindi after National Park (NP) gazettement and before harvest zones (HZ) established, and after harvest zones established

| **a) Period and statistical comparisons** | **Area: poaching incidents / patrol day** | |
|---|---|---|
| | **Interior** | **Boundary** |
| **Before NP** | 0.46±0.1 | 0.27±0.03 |
| **After NP, before HZ** | 0.45±0.1 | 0.22±0.02 |
| **Mann Whitney U (z value)** | -1.18 | -1.98 |
| ***P*** | NS | < 0.05 |

| **b) Period and statistical comparisons** | **Area: snares per snare cluster** | |
|---|---|---|
| | **Interior** | **Boundary** |
| **Before NP** | 17.70±2.9 | 11.56±1.3 |
| **After NP, before HZ** | 6.70±1.3 | 4.14±0.4 |
| **Mann Whitney U (z value)** | -2.96 | -5.69 |
| ***P*** | < 0.01 | < 0.001 |

Encounters with poaching also remained constant in low and medium harvest zones after harvest zones were established (Table 4.18a). However, rangers encountered less poaching in high harvest zones. Furthermore, rangers collected smaller clusters of snares in all zones (Table 4.18b). Thus poachers continued their activities in the forest interior and in low and medium harvest zones after harvest zones were established, but were setting fewer snares during the period.

Table 4.18 Mean±SE encounters with all poaching incidents combined and snares per snare cluster per month by patrols in harvest zones of Bwindi after National Park (NP) gazettement and before harvest zones (HZ) established, and after harvest zones established

| **a) Period and statistical comparisons** | **Future harvest zone: poaching incidents / patrol day** | | |
|---|---|---|---|
| | **Low** | **Medium** | **High** |
| **After NP, before HZ** | 0.41±0.1 | 0.32±0.1 | 0.23±0.04 |
| **After HZ** | 0.34±0.05 | 0.33±0.1 | 0.15±0.02 |
| **Mann Whitney U (z value)** | -1.32 | -0.01 | -3.08 |
| ***P*** | NS | NS | < 0.01 |

| **b) Period and statistical comparisons** | **Future harvest zone: snares per snare cluster** | | |
|---|---|---|---|
| | **Low** | **Medium** | **High** |
| **Before HZ** | 12.00±1.3 | 12.71±3.0 | 14.82±2.3 |
| **After HZ** | 4.41±0.5 | 4.13±0.8 | 4.76±0.5 |
| **Mann Whitney U (z value)** | -5.34 | -2.29 | -4.14 |
| ***P*** | < 0.001 | < 0.05 | < 0.001 |

Most encounters with clusters of snares and poaching signs were in interior areas during the period after harvest zones were established (Table 4.19). There were similar numbers of encounters directly with poachers in interior and boundary areas. However, encounters with all poaching incidents combined were higher in interior areas. Rangers continued to collect larger snare clusters in the forest interior, collecting an average of 7 snares per snare cluster in interior areas (n = 16) compared with 4 snares in boundary areas (n = 79). Therefore, there was a decline in sizes of snare clusters after harvest zones were established, yet rangers continued to collect the largest clusters from interior areas where poaching activity remained high.

Table 4.19 Mean±SE encounters with poaching incidents and snares per snare cluster per month by patrols in interior and boundary areas of Bwindi from 1995 to 2000, after harvest zones were established

| Area and statistical comparison | Poaching incidents / patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All incidents | |
| Interior (n = 33) | 0.27±0.1 | 0.17±0.04 | 0.02±0.01 | 0.45±0.1 | 6.70±1.3 |
| Boundary (n = 244) | 0.08±0.01 | 0.13±0.01 | 0.03±0.01 | 0.22±0.02 | 4.14±0.4 |
| Mann Whitney U (z value) | -2.00 | -1.98 | -0.72 | -2.22 | -2.16 |
| *P* | < 0.05 | < 0.05 | NS | < 0.05 | < 0.05 |

Rangers encountered most poaching signs in low and medium harvest zones after harvest zones were established (Table 4.20). There were no differences between harvest zones in encounters with snare clusters or directly with poachers. However, most encounters with all poaching incidents combined occurred in low and medium harvest zones. Rangers collected similar averages of 5 snares per snare cluster in low harvest (n = 38) and high harvest zones (n = 45), and 4 snares in medium harvest zones (n = 12).

Table 4.20 Mean±SE encounters with poaching incidents and snares per snare cluster per month by patrols in harvest zones of Bwindi from 1995 to 2000, after harvest zones were established

| Future harvest zone and statistical comparison | Poaching incidents / patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All incidents | |
| Low (n = 115) | 0.13±0.04 | 0.17±0.02 | 0.04±0.01 | 0.34±0.05 | 4.50±0.6 |
| Medium (n = 35) | 0.10±0.03 | 0.23±0.1 | 0.01±0.01 | 0.33±0.1 | 4.13±0.8 |
| High (n = 127) | 0.07±0.02 | 0.05±0.01 | 0.03±0.01 | 0.15±0.02 | 4.76±0.6 |
| Kruskal-Wallis $\chi^2$ (df=2) | 0.49 | 25.08 | 2.61 | 18.02 | 0.04 |
| *P* | NS | < 0.001 | NS | < 0.001 | NS |

Encounters with all poaching incidents differed between areas of Bwindi after harvest zones were established. Rangers encountered poaching most frequently in the south and west (Kruskal-Wallis $\chi^2 = 25.09$; df = 4; $p < 0.001$) (Figure 4.5).

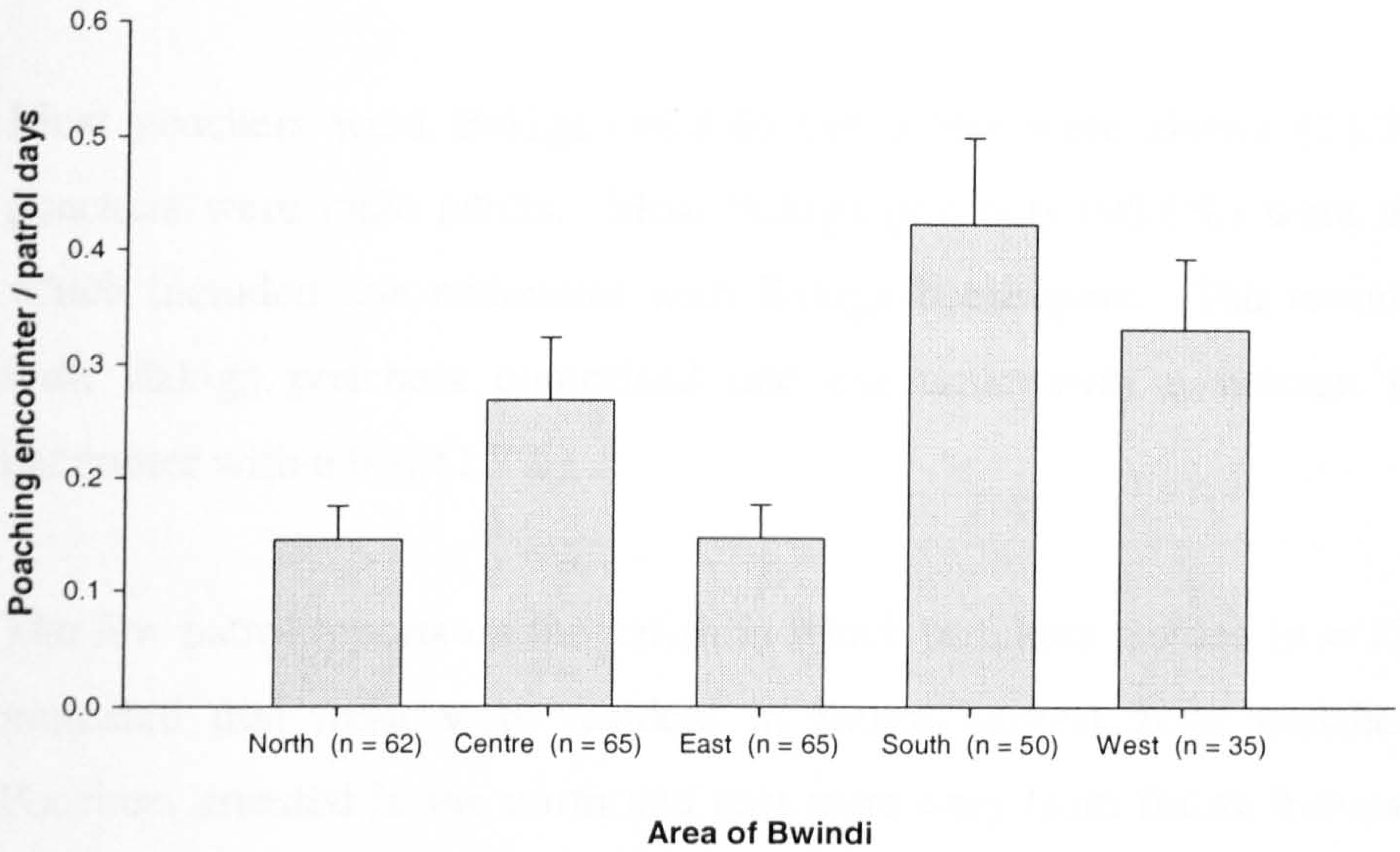


Figure 4.5 Mean±SE encounters with all poaching incidents combined per month by patrols in areas of Bwindi from 1995 to 2000, after harvest zones were established

Therefore, after harvest zones were established when rangers mainly conducted day patrols in boundary areas, particularly in high harvest zones, their encounters with poaching declined as well as the size of snare clusters that they found. The decline in poaching encounters largely occurred in high harvest zones, as poaching encounters remained constant in the less well patrolled interior and low and medium harvest zones. In contrast, sizes of snare clusters declined in all areas, although rangers continued to collect larger clusters in the forest interior. Rangers mainly encountered poachers' trials during the period, which were most frequent in the forest interior, and in low and medium harvest zones.

## 4.3.3 Encounters with poachers

### 4.3.3.1 Before harvest zones

There were 68 encounters directly with poachers in Bwindi before harvest zones were established, and all poachers were local community members. There were no encounters with Ugandans from outside the Bwindi region or with poachers from the DRC or Rwanda, although one patrol report in 1993 indicated the presence of foreign poachers in Bwindi, based on a poachers' trail in the north from which the rangers deducted that the poachers had travelled from the DRC.

Most poachers were Bakiga (86.8%) and a few were Batwa (13.2%). All Batwa poachers were male adults. Most Bakiga poachers (96.6%) were also male adults, which included one encounter with Bakiga beekeepers. The remaining encounters with Bakiga poachers comprised one encounter with a woman (1.7%) and one encounter with a boy (1.7%).

The few patrol reports on the parish in which poachers resided (n = 15) (Appendix B) indicated that most were resident in future harvest zone parishes (Table 4.24). Poachers arrested in the north and east were only from future harvest zone parishes. Poachers arrested in the east were also from future harvest zone parishes adjacent to the centre. Most poachers arrested in the centre were from future harvest zone parishes. In contrast, all poachers arrested in the south were from future non-harvest zone parishes. The Batwa poachers arrested in the west were from a future harvest zone parish.

The highest number of poachers that rangers encountered was 7 poachers. However, the average of two poachers per encounter (mean$\pm$SE poachers per encounter: $2.26\pm0.2$) indicates that most poachers hunted in small groups before harvest zones were established. There was no difference in the mean number of poachers per encounter between Bakiga (encounters; n = 59) and Batwa (encounters; n = 9) poachers (Table 4.21).

There were similar numbers of encounters directly with poachers between future harvest zones. However, there was a difference in the proportions of Bakiga and Batwa poachers between future harvest zones (Fisher's Exact Test = 6.97; $p < 0.05$) (Table 4.22). Almost all encounters in future high harvest zones were with Bakiga poachers. A higher proportion of Batwa poachers were encountered in future low harvest zones. Furthermore, the two encounters in future medium harvest zones only comprised Batwa poachers.

Most poachers escaped arrest from an encounter with rangers before harvest zones were established (Figure 4.6). There were fewer encounters when all poachers were arrested and taken to court, or when some poachers were arrested and some escaped, and when arrested poachers were warned and released. However, most Bakiga poachers escaped arrest (Table 4.23a) although most Batwa poachers were arrested and taken to court (Table 4.23b) ($\chi 2 = 13.75$; df = 3; $p < 0.01$).

There were few patrol reports on the court and punishment for arrested poachers before harvest zones were established (n = 18) (Appendix B). The patrol reports also showed that some poachers were arrested for hunting wild animals that were raiding their crops. For example, rangers patrolling the National Park boundary of the centre area in 1993 arrested a Bakiga man outside the National Park for carrying spears to chase baboons from his crops. There was also evidence of a local trade in bushmeat. In 1986, rangers patrolling the centre ambushed a trail inside the National Park that they noted was used every week on market day "*by people bringing meat from the forest*". Furthermore, in 1994, rangers patrolling the west arrested two Batwa poachers hunting for a local businessman who was paying them UgSh10,000 for each snared duiker.

Table 4.21 Mean±SE poachers per encounter with Bakiga and Batwa poachers in Bwindi before and after harvest zones were established

| Period | Poachers | | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| | Bakiga | Batwa | | |
| **Before HZ** | 2.21±0.2 | 2.89±0.4 | -1.68 | NS |
| **After HZ** | 1.67±0.1 | 2.00±0.4 | - | - |

Table 4.22 Encounters with Bakiga and Batwa poachers by patrols in harvest zones of Bwindi before and after harvest zones were established

| Period | Harvest zone | Poachers | |
|---|---|---|---|
| | | Bakiga | Bakiga |
| Before HZ (%) | Low | 76.0 | 24.0 |
| | Medium | 0.0 | 100.0 |
| | High | 97.4 | 2.6 |
| After HZ (%) | Low | 86.5 | 13.5 |
| | Medium | 33.3 | 66.7 |
| | High | 95.7 | 4.3 |

Table 4.23 Outcomes of encounters with a) Bakiga and b) Batwa poachers by patrols in Bwindi before and after harvest zones were established

| a) Period | Outcome of patrol encounter | | | |
|---|---|---|---|---|
| | Escape | Arrest | Arrest & Escape | Release |
| Before HZ (%) | 60.7 | 17.9 | 14.3 | 7.1 |
| After HZ (%) | 68.3 | 31.7 | 0.0 | 0.0 |

| b) Period | Outcome of patrol encounter | | | |
|---|---|---|---|---|
| | Escape | Arrest | Arrest & Escape | Release |
| Before HZ (%) | 12.5 | 62.5 | 12.5 | 12.5 |
| After HZ (%) | 75.0 | 0.0 | 25.0 | 0.0 |

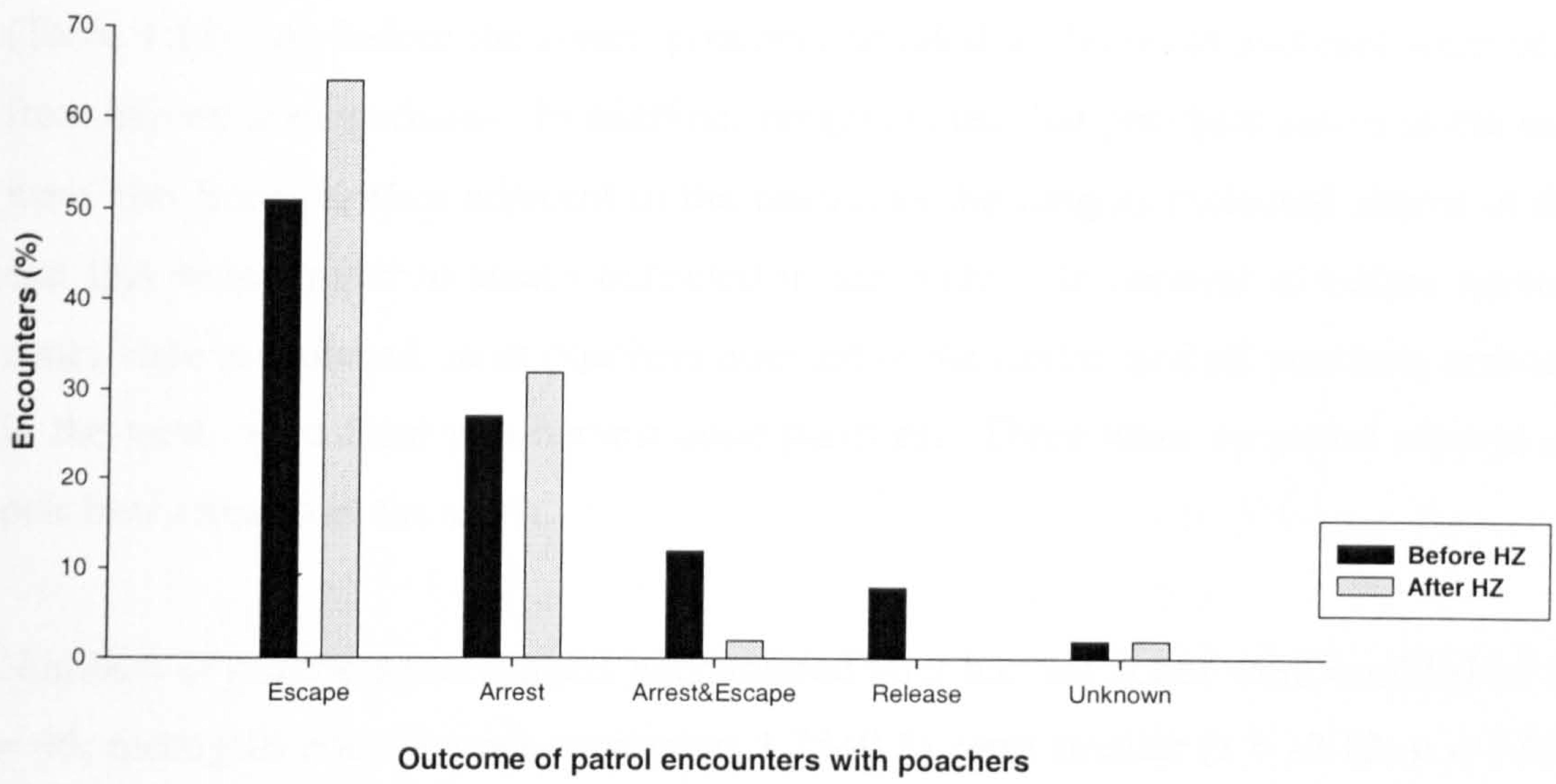


Figure 4.6 Outcomes of encounters with poachers by patrols in Bwindi before and after harvest zones were established

### 4.3.3.2 After harvest zones

There were 55 patrol encounters with poachers after harvest zones were established. As before harvest zones were established, all poachers were local community members and there were no encounters with Ugandans from outside the Bwindi region or with poachers from the DRC or Rwanda. However, two patrol reports in 1998 indicated the presence of foreign poachers in Bwindi, based on a poachers' trail in the west and on snares also in the west from both of which the rangers deducted that the poachers had travelled from the DRC.

As for the period before harvest zones were established, most poachers encountered after harvest zones were established were Bakiga (83.6%) and a few were Batwa (16.4%). All Batwa poachers and most Bakiga poachers (91.3%) were male adults. The remaining encounters with Bakiga poachers comprised one encounter with resource users of the harvest zone programme (2.2%), one encounter with a woman (2.2%) and two encounters with boys (4.3%).

There were few patrol reports detailing the parish in which poachers neighbouring Bwindi were resident (n = 10) (Appendix C). These reports indicated that there were similar numbers of arrested poachers from harvest zone and non-harvest zone parishes (Table 4.24). As before the zones, poachers arrested in the north and east were only from harvest zone parishes. In addition, rangers noted that poachers active in the east were also from parishes adjacent to the centre, as the rangers collected snares in the east that were similar to snares collected in the centre. In contrast to before harvest zones were established, most poachers arrested in the centre, and all poachers arrested in the west, were from non-harvest zone parishes. There were no patrol reports on poachers arrested in the south.

Numbers of poachers that rangers encountered after harvest zones were established ($n = 46$; mean$\pm$SE poachers per encounter: $1.75\pm0.1$) were smaller ($z = -2.12$; $p < 0.05$) than before harvest zones were established. The highest number after harvest zones were established was 5 poachers. Numbers per encounter of Bakiga (encounters; $n = 42$) and Batwa poachers (encounters; $n = 4$) were similar, although the data did not permit statistical analysis (Table 4.21).

There were similar numbers of encounters with poachers between harvest zones. However, as before harvest zones were established, there was a difference in the proportions of Bakiga and Batwa poachers, although the data were insufficient for statistical analysis (Table 4.22). Most encounters in high harvest zones were with Bakiga poachers. A higher proportion of Batwa poachers were encountered in low and medium harvest zones.

Most poachers escaped arrest from an encounter with rangers after harvest zones were established, and there were no encounters when arrested poachers were warned and released (Figure 4.6). As before harvest zones were established, most Bakiga poachers escaped arrest (Table 4.23a), although the Bakiga resource users, woman and boys were all arrested. However, in contrast to before harvest zones were established, most Batwa poachers escaped arrest after harvest zones were established (Table 4.23b).

Patrol reports on the court and punishment for arrested poachers were limited ($n = 9$) (Appendix C). The reports showed that, as before harvest zones were established, poachers were arrested for hunting wild animals that were raiding their crops. For example, in 1994 rangers patrolling the National Park boundary of the centre arrested a Bakiga man for killing two monkeys that were feeding on his crops outside the National Park. Furthermore, in 1995 rangers patrolling the National Park boundary of the east arrested 5 boys and a Bakiga man both for killing duikers that were crop raiding outside the National Park.

Table 4.24 Resident parish of poachers encountered by patrols in Bwindi before (1986-1994) and after (1995-2000) harvest zones were established, with a summary of the resident harvest (HZ) and non-harvest zone (non-HZ) parishes

| **Harvest zone** | **Area of Bwindi** | **Resident parish** | **N. encounters with poachers** | |
|---|---|---|---|---|
| | | | **Before harvest zones** | **After harvest zones** |
| **Low** | Centre | HZ | 4 | 1 |
| | | Non-HZ | 1 | 4 |
| | South | HZ | 0 | - |
| | | Non-HZ | 3 | - |
| **Medium** | West | HZ | 2 | - |
| | | Non-HZ | 0 | 1 |
| **High** | North | HZ | 2 | 1 |
| | | Non-HZ | 0 | 0 |
| | East | HZ | 3 | 3 |
| | | Non-HZ | 0 | 0 |

Key: - (no patrol reports)

| **Resident parish** | **N. encounters with poachers** | |
|---|---|---|
| | **Before harvest zones** | **After harvest zones** |
| HZ | 11 | 5 |
| Non-HZ | 4 | 5 |

### 4.3.4 Snare clusters

Changes in the size of snare clusters in forest interior and boundary areas from 1986 to 2000 were similar. Snare clusters increased during the years prior to National Park gazettement from an average in 1987 of 6 and 2 snares per snare cluster in interior and boundary areas respectively, to a peak of 20 snares in interior areas in 1994 and of 17 snares in boundary areas in 1992, the year after gazettement. In both interior and boundary areas the clusters declined thereafter to an average of 4 snares in 1995 and 1996 after harvest zones were established. The clusters increased to 6 snares during 1997 and 7 snares during 1998, and then declined to 3 snares in 2000 (Figure 4.7).

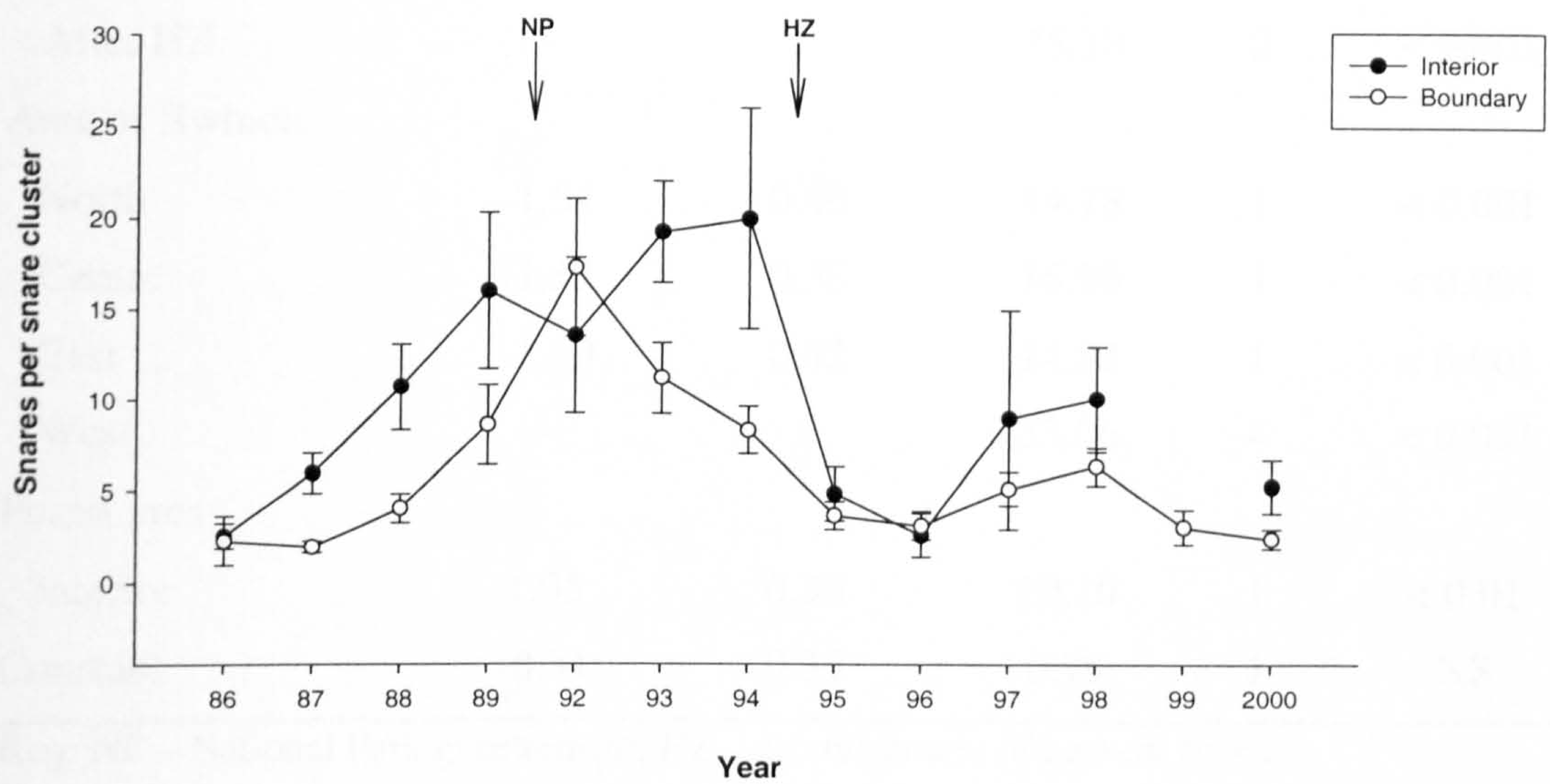


Figure 4.7 Mean±SE snares per snare cluster by collected rangers on law enforcement patrol in forest interior and boundary areas Bwindi from 1986 to 2000

Key: NP – national park gazettement; HZ - establishment of harvest zones

### 4.3.5 Factors explaining the likelihood of encountering poaching

The final regression model correctly classified 72.6% of the poaching encounters ($\chi 2 = 133.26$; df = 8; $p < 0.001$) and proved a good fit to the data (AUC = 0.80). The variables of the model accounted for 31% (Nagelkerke R square = 0.31) of the variation in the data (Table 4.25). The model predicted that encounters with poaching were best explained by the variables, in order of entry, patrol days, period of gazettement and harvest zone, area of Bwindi, and interior and boundary area.

Table 4.25 Parameters of the stepwise multiple logistic regression model for the likelihood of encounters with poaching by patrols in Bwindi from 1986 to 2000

| Parameter | Coefficient (B) | Standard error of B | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|---|
| Patrol days | 0.26 | 0.03 | 59.96 | 1 | < 0.001 |
| Period: | | | | | |
| Before NP | 1.14 | 0.30 | 14.43 | 1 | < 0.001 |
| After NP; before HZ | 1.30 | 0.30 | 19.29 | 1 | < 0.001 |
| After HZ | - | - | 25.10 | 2 | < 0.001 |
| Area of Bwindi: | | | | | |
| North | -1.54 | 0.40 | 14.78 | 1 | < 0.001 |
| Centre | -1.57 | 0.38 | 16.96 | 1 | < 0.001 |
| East | -1.60 | 0.42 | 14.82 | 1 | < 0.001 |
| West | - | - | 35.06 | 4 | < 0.001 |
| Forest area: | | | | | |
| Interior | 1.05 | 0.33 | 10.10 | 1 | < 0.01 |
| Constant | -0.31 | 0.35 | 0.79 | 1 | NS |

Key: NP – National Park gazettement; HZ – establishment of harvest zones

There was no indication of high multicollinearity in the model (Table 4.26). However, given the importance of interaction terms between variables as indicated from the previous analyses, particularly between period and patrol effort, assessing the relative importance of independent variables in the final model using beta weights was limited. Nonetheless, the model indicates that patrol effort, period and area around and within Bwindi are primary factors driving encounters with poaching activity. The model also indicates that the positive association confirmed between number of patrol days and poaching encounters per month (section 4.2) further emphasizes the importance of maintaining sufficient law enforcement effort for rangers to encounter poaching, and that significance of interior and boundary areas emphasizes the concentration of poaching in the forest interior and thus the importance for rangers to cover interior area.

Table 4.26 Collinearity statistics of parameters of the stepwise multiple logistic regression model for the likelihood of encounters with poaching by patrols in Bwindi from 1986 to 2000

| Parameter | Tolerance | VIF |
|---|---|---|
| Patrol days | 0.84 | 1.20 |
| Period | 0.78 | 1.08 |
| Area of Bwindi | 0.93 | 1.29 |
| Interior/boundary forest area | 0.86 | 1.17 |

### 4.3.5.1 Law enforcement

Difference in encounters with all poaching incidents combined (Kruskal-Wallis $\chi2$ = 70.52; df = 4; $p < 0.001$) (Figure 4.8) showed an increase from an average of 1 encounter for 1 and 5 days patrolling per month, to > 2 encounters for 11 and 15 days patrolling per month. Encounters with poaching did not increase for 11 to 15 days, 16 to 20 days and above 20 days patrolling per month (Kruskal-Wallis $\chi2$ = 4.32; df = 2; $p > 0.05$). There are other factors confounding the number of poaching encounters and patrol days (Table 4.2.5) and thus this analysis only indicates that optimum patrol length is between 11 and 15 days patrolling per month. Similarly, success of ranger teams in encountering poaching tended to increase from 2 to 4 rangers but to decline with larger teams comprising 5 and 6 rangers. Thus also given other confounding factors, this suggests that teams between 3 and 4 rangers are most effective, although there were no significant differences (Kruskal-Wallis $\chi2$ = 6.25; df = 4; $p > 0.05$). Therefore, it is indicated that effective law enforcement at Bwindi for encountering poaching requires teams of 4 rangers covering forest interior areas for an average between 11 and 15 days per month.

The cost of this law enforcement was calculated using the salary and food allowance of an ITFC field assistant because patrol costs from the Uganda Wildlife Authority were not available. The ITFC costs were 11,000 Uganda shillings per assistant per day in 2000, which is the equivalent to US$5.68 using current exchange rates (US$1 : 1940.04 Uganda shillings 01/01/04). Therefore, the cost of 4 rangers on patrol for 13 days per month can be estimated at 572,000 Uganda shillings per month, equivalent to US$294.84. This would be covered by a single day of two tourists tracking gorillas based on the cost of a gorilla permit in 2000, which was US$275.00.

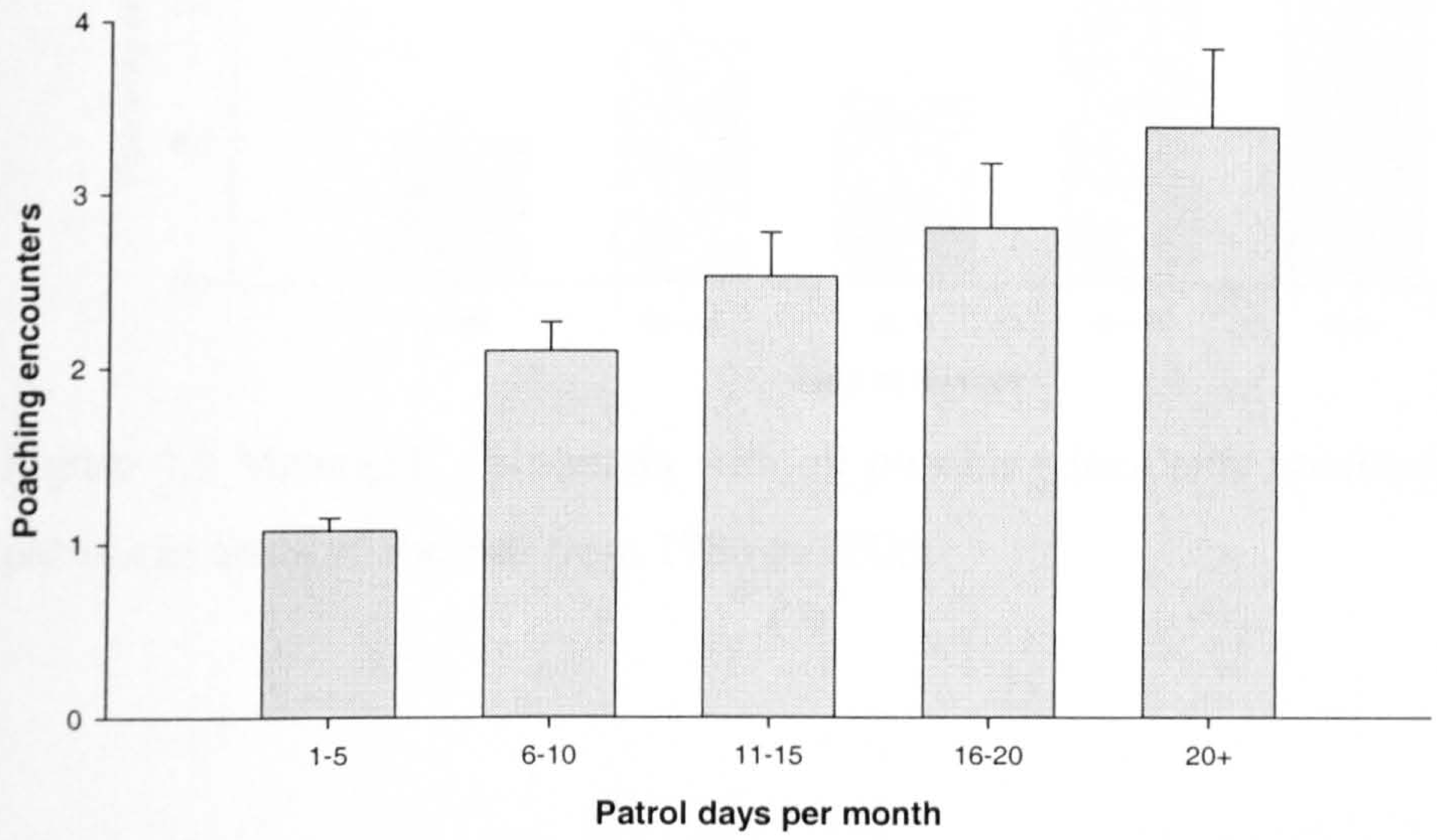


Figure 4.8 Mean±SE encounters with all poaching incidents combined by average patrol days per month in Bwindi from 1986 to 2000

### 4.3.5.2 Period and area

Periods comprising National Park gazettement and the establishment of harvest zones were significant in the regression model, although area categorised by harvest zone was excluded. The area of Bwindi was also significant, and the estimated coefficients in the model showed a negative association between poaching encounters and rangers patrolling the north, centre and east of Bwindi. The south was not significant (Figure 4.9). Thus the model indicates that factors characterising areas of Bwindi are more significant to the likelihood of encounters with poaching than the single factor of harvest zone.

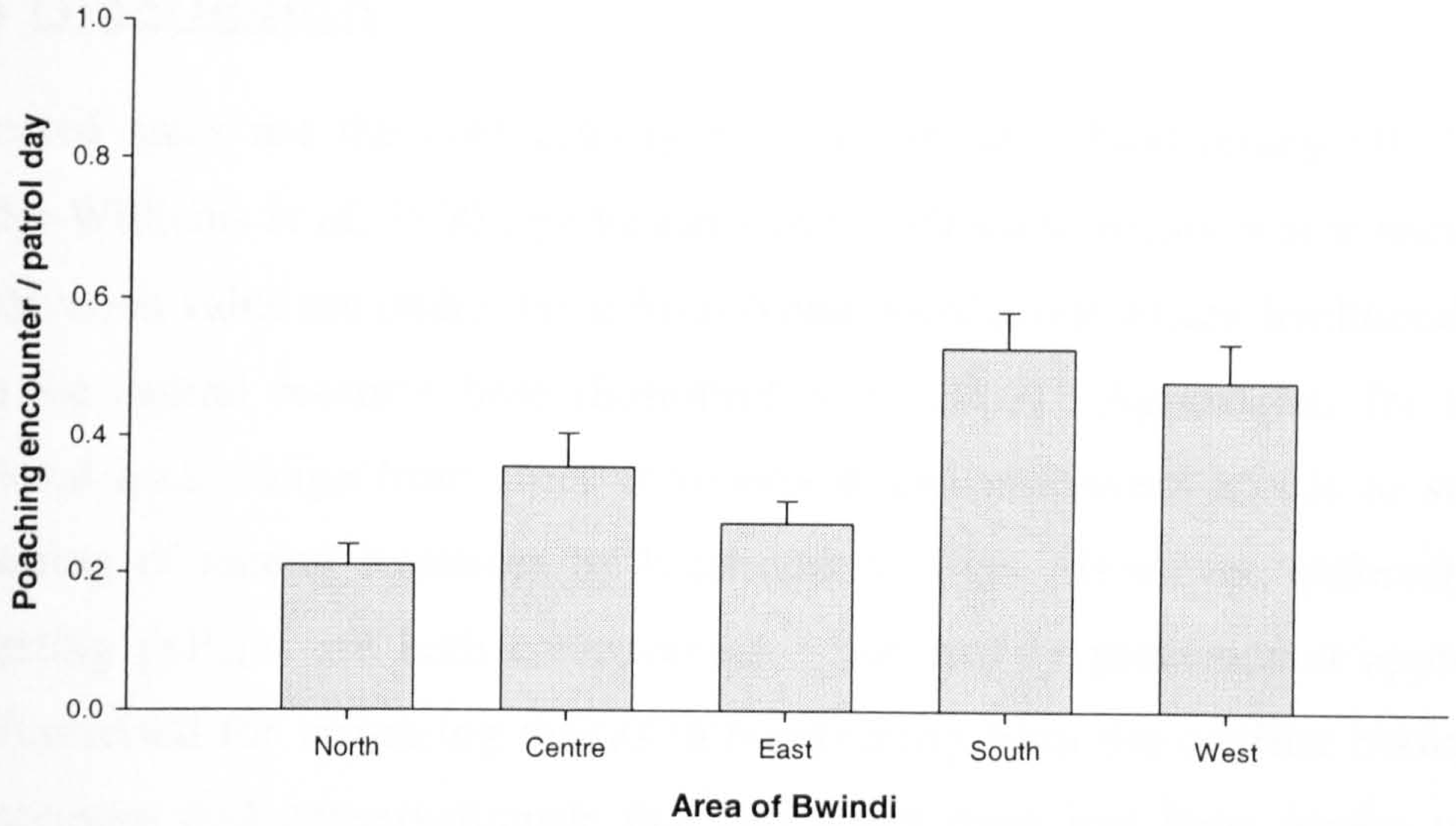

Figure 4.9 Mean±SE encounters with all poaching incidents combined per month by patrols in areas of Bwindi from 1986 to 2000

## 4.4 Discussion

Protected areas are the core activity used to conserve biodiversity (IUCN, 2003; Leader-Williams *et al*, 1990), particularly in sub-Saharan Africa where areas of high conservation value are under threat from rising populations whose livelihoods depend upon the natural resource base (Balmford *et al*, 2003). Approaches for managing protected areas range from strict enforcement and prohibited access to sanctioned harvesting of natural resources by local communities. However, enforcement and harvesting policies are both controversial. The strictly protectionist approach has been criticised for increasing threats to biodiversity from the conflict between local communities and conservationists that can result from lost local access to natural resources (e.g. Bell and McShane-Caluzi, 1986; Leader-Williams and Albon, 1988). The strategy of sanctioned resource harvesting has also been criticised, particularly for the limited benefits to local communities that will be unlikely to change community behaviour or reduce pressure on protected areas (Wells and Brandon, 1993) and for the fact that harvesting maintains local dependency on forest produce (Ghimire, 1994). Therefore, debate continues on the most effective approach for managing protected areas, particularly whether enforcement or community-based approaches should be the priority for the limited funds available for conservation (Thibault and Blaney, 2001; Wilkie *et al*, 2001; Ervin, 2003).

### 4.4.1 Success of law enforcement

This study is the first to examine law enforcement encounters with bushmeat poaching over the periods of National Park gazettement and establishment of harvest zones in Bwindi. The study assesses impacts of gazettement and sanctioned resource harvesting on subsistence bushmeat hunting by local communities. The study also contributes to the debate on the assumption that local communities who support conservation will refrain from illegal resource collection in protected areas, as the harvest zones in Bwindi have been considered key to the improvement in local attitudes towards conservation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996).

There were two important considerations for this study. First the limitations of the patrol data, and second the extent to which the patterns of poaching reflected change in law enforcement in Bwindi.

Limitations of the patrol data included the absence of patrol distance for calculating an index of poaching encounters, and the possibility of missing data if, for example, poachers bribed rangers for their release and the encounter was not recorded. However, it was considered that the limited number of rangers responsible for the patrol reports, the time scale of the data, and the verification of the accuracy of the rangers' recording during fieldwork (Chapter 2), permitted confidence in the data. A further consideration is whether the patrol encounters with poaching indicated actual poaching. This was addressed by the survey of illegal activities that I undertook in Bwindi (Chapter 5).

To determine the extent to which patterns of poaching reflected change in law enforcement in Bwindi, it is first important to examine ranging behaviour in Bwindi, which varied in time and space. The ranger in charge of the outpost decides on the number and location of patrols conducted per month (section 2.2.1). Rangers' motivation is therefore important to the effectiveness of law enforcement in Bwindi and subsequently, changes in management and support for law enforcement are likely factors affecting ranging behaviour. The increase in law enforcement immediately after gazettement probably resulted from change in management from the Game Department to UNP. UNP had a stronger policy of law enforcement than the Game Department, and received greater financial and logistic support for law enforcement from external organisations. Conversely, the decline in size of ranger teams and patrol coverage of interior areas after harvest zones were established may have resulted from a decline in rangers' motivation. Change from UNP to UWA would have caused disruption to rangers, as different systems and salaries were implemented by the new body responsible for the National Park. Changes in Warden of Law Enforcement and Head Ranger made by both UNP and UWA would also have caused disruption, and such disruptions were likely to negatively affect rangers' motivation. There is evidence from the patrol reports of a decline in ranger motivation after harvest zones were established, as complaints that rangers made to wardens in the reports, which included the lack of equipment, food and uniform, increased during this period (personal observation). Therefore the decline in size of ranger teams probably resulted from a decline in ranger motivation and consequently, the smaller led to the decline in long patrols, as long patrols require three to four rangers.

With regard to changes in law enforcement, I sought to examine whether patterns in law enforcement in Bwindi from 1986 to 2000 might explain the patterns of poaching shown by this study. In particular, reduced patrol coverage of forest interior areas after harvest zones were established probably resulted in the change in the type of poaching encounter. Snares were the most frequent type of poaching encounter when patrols covered interior areas before and immediately after National Park gazettement. In contrast, rangers mainly found poachers' trails when covering boundary areas after harvest zones were established. The rangers noted that the poachers' trails were leading to the forest interior. For example, rangers patrolling the south in 1998 reported "*poachers are now going deep into the forest and rangers must cover these areas*". A further limitation is that patrol encounters were made only in the areas patrolled by rangers. Consequently, the possible occurrence of poaching deep in interior areas could not be determined after harvest zones were established. Nonetheless, the results confirmed that most poaching activity in Bwindi was snares concentrated in interior areas, and that rangers rarely saw poachers in the forest (see also Butynski, 1984; McNeilage *et al*, 2001). The results also showed that poaching was concentrated in low harvest zones. Therefore, conservation managers in Bwindi need to prioritise removing snares during law enforcement activities and ensure that patrols target interior areas and low harvest zones. In addition, the results indicated that poaching declined after gazettement (see also McNeilage *et al*, 2001) and showed that this decline only occurred in certain areas of Bwindi.

Encounters with poaching in the forest interior tended to decline over the gazettement period, but remained constant after harvest zones were established. Although patrols did not cover deep interior areas after the harvest zones were established, the presence of fresh poacher trails in boundary areas indicated that poachers were still active in the forest interior. Therefore, the gorilla population could have continued to be under threat from bushmeat poaching during the period when attitudes of local communities towards Bwindi improved, as gorillas are most abundant in interior areas (McNeilage *et al*, 2001).

In addition to continued poaching in interior areas, the results also showed that encounters with poaching incidents remained constant in low and medium harvest zones, yet declined in high harvest zones after the zones were established. There are various factors that could explain why poachers continued their activities in interior and low and medium harvest zones, yet avoided boundary areas and high harvest zones. First, poachers favour interior areas of Bwindi, particularly Mubwindi swamp in the east and south interior, because of the abundance of ungulates (Butynski, 1984). Second, evidence that poachers in Bwindi change their activities in response to law enforcement suggests that the poachers avoided the heavily patrolled boundary and high harvest zones, and were more active in the less well-patrolled interior and low and medium harvest zones. Evidence of poachers' response to law enforcement comprised patrol reports and observations during fieldwork. Rangers noted that poachers developed an alarm system whereby one poacher remained on the National Park boundary to warn those inside the forest of an approaching patrol, as was also observed during fieldwork. Also, after gazettement rangers noted that poachers were setting snares over a wide area instead of in a single cluster, and concluded that this was in response to law enforcement. For example, rangers patrolling in the east of Bwindi in 1992 reported *"poachers have learnt a new system of setting traps, they set traps for a long distance from one to another meaning that when rangers are patrolling we cannot collect them all"*. There were also incidents when poachers entered the forest to remove their snares because of the patrols, including the incident recorded by rangers patrolling the east in 1994 *"the area was full of snare poaching but the previous patrol, which confiscated 64 snares, scared the poachers and they removed all their traps from the area."* Therefore, the results indicate that the focus of law enforcement on boundary areas, particularly high harvest zones, is likely to have contributed to the continued poaching in interior areas, and in low and medium harvest zones.

It is important to determine what size of snare cluster means in terms of poacher behaviour, and the trade-offs involved with cluster size. It could be expected that poachers increase the likelihood of capturing a target animal by setting more snares. However, setting a large snare cluster would also increase the likelihood of wastage, as non-target species could be captured and as the snares would be easier for rangers to find. It is therefore likely that poachers face a trade-off between probability of capture and wastage that influences the number of snares that they set. Cost and availability of snare materials are also likely influences, as poachers might be more inclined to set large clusters if snare materials are relatively easy and cheap to obtain locally. Determining poacher behaviour from size of snare cluster therefore requires information on animal capture rate and the value of snares as assets, for example, whether loss of a snare is just inconvenience or loss of catch, or is also a significant capital cost in terms of the financial and time cost per snare.

This study does indicate that snares are of value to poachers in Bwindi, as poachers tried to reduce the chance that rangers would find snares. Firstly from setting a concentration of snares in ungulate paths, poachers changed their strategy following high patrol effort to scatter snares over a wide area, which rangers noted was so that patrol teams had greater difficulty in finding snares within the dense forest vegetation. Secondly, also following high patrol effort, rangers found that poachers entered Bwindi to remove snares, which showed that poachers were willing to risk arrest to collect their snares. These findings indicate an interaction between patrol effort and poacher behaviour, with poachers changing hunting tactic in response to law enforcement levels, and poachers' preferred location for snares, as before effective law enforcement was implemented in Bwindi, rangers mainly found snare clusters in the paths of bushpigs and duikers. There are implications for gorilla conservation from the change in snare setting by poachers, if gorillas are more likely to encounter snares widely scattered over a large area in comparison with snares concentrated within a small area. Thus monitoring changes in poacher behaviour is important for conservation managers to target law enforcement effectively for gorilla conservation.

The regression model revealed the importance of the period of conservation policy and the results showed that size of snare cluster changed between periods. Thus impacts on poaching from National Park gazettement and sanctioned resource harvesting are important to consider. Before National Park gazettement when local communities could freely enter the forest, rangers collected an average of nine snares when they encountered a cluster of snares in the forest. National Park gazettement resulted in prohibited forest access for local communities, which led to severe conflicts between National Park staff and the communities that are considered to have led to an increase in illegal activities (Makombo, 2003; Mutebi, 2003). The findings presented here show that poachers entered Bwindi less frequently after gazettement before harvest zones were established, but set larger snare clusters while inside the National Park regardless of forest area. Thus size of snare cluster increased throughout the forest between periods before and after National Park gazettement before harvest zones were established. In addition to resentment over prohibited forest access, fear regarding loss of resources may also have driven poachers to set more snares. A previous study has shown that illegal resource collection increases following prohibitions on the access of local communities to natural resources (Western, 1987), and a similar response by poachers in Bwindi may have occurred.

Size of snare clusters declined after harvest zones were established. Poaching was not a deciding factor in setting up the level of harvest zone in the forest. The decline in snare clusters following harvest zones could therefore indicate that poachers' attitude towards the National Park improved after forest access was granted to communities, which in turn indicates positive conservation impacts from sanctioned resource harvesting. However, law enforcement after harvest zone were established mainly comprised small ranger teams patrolling boundary areas, particularly harvest zones. Therefore most snare clusters found by rangers were in boundary areas. Rangers continued to find larger snare clusters in interior areas and, in boundary areas, found an increase in poachers' trails leading to the forest interior. Given the influence of law enforcement on poacher behaviour, these findings indicate that poachers were setting most of their snares in the forest interior and that the decline in snare cluster size was a factor of reduced patrol coverage of interior areas.

An additional factor is the motivation of rangers. Rangers' bonuses for each snare collected were withdrawn after the harvest zones were established. A bonus system for rangers has been shown to increase the effectiveness of law enforcement in protected areas (Jachmann and Billiouw, 1997). Thus the smaller clusters could indicate the rangers' lack of motivation to search for snares. Therefore in conclusion, the increase in snare clusters following gazettement could indicate the response of poachers to the designation of Bwindi as a National Park. However, the decline in snare clusters in boundary areas following the harvest zones could have resulted from a variety of factors, including sanctioned resource harvesting.

### 4.4.2 Sanctioned resource harvesting

Sanctioned resource harvesting was key to the improved attitudes of local communities towards Bwindi (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). It could therefore be expected that poaching would decline after harvest zones were established because of the assumption that communities who support protected areas will refrain from illegal resource collection (Wells and Brandon, 1993). The results show that, in addition to sizes of snare clusters, patrol encounters with poaching in high harvest zones and sizes of the poacher groups that rangers encountered declined after harvest zones were established. Conclusions drawn so far indicate that law enforcement and patrol coverage of interior areas and harvest zones were significant. Thus possibly patrols within harvest zones contributed to the decline in poaching more than the zones themselves. However, there is evidence that the harvesting programme influenced the activities of poachers.

Few poachers apprehended by rangers were harvesters. In addition, the number of poachers resident in parishes adjacent to harvest zones declined after the zones were established. However, data on the poachers were limited and the small number of arrested harvesters could reflect the resource user groups of Bwindi, as the groups of the harvest programme may not be hunters. However, the patrol reports indicate a change in the poaching activities of beekeepers in the east of Bwindi. The beekeepers were permitted to enter the National Park to check their hives in the period after gazettement and before harvest zones were established (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). Rangers patrolling the east during this period found snares set by beekeepers. For example, in 1993, rangers found 12 snares in a beekeeper's trail and concluded "*the traps had been set by the beekeepers because the trails leading to those traps had all started from their hives.*" In 1994, rangers collected snares near beehives and noted "*the beekeepers are the ones destroying the park*" and "*some beekeepers are in the pretext of going to see their hives but go hunting*". Also in 1994, two men arrested for poaching were both beekeepers and, in 1995, rangers collected 13 snares near beehives. The decline in poaching encounters in eastern beekeeping zones after the zones were established could therefore indicate a decline in poaching by beekeepers. However, whether such a decline resulted from the beekeepers' support for Bwindi or from the law enforcement within eastern areas, is difficult to determine.

The regression model rejected area categorised by harvest zone but included areas of Bwindi. This suggests that factors that differentiate the areas had a greater influence on encounters with poaching than the single factor of harvest zone. These factors may include crop raiding by wild animals, mitigation of crop raiding by rangers, local community benefits from the National Park and human activity in the forest from tourism, which is concentrated in the west, and from gorilla monitoring, which is concentrated in the east. The impact of these factors on poaching requires further study, although the patrol reports indicate impacts from crop raiding.

### 4.4.3 Crop raiding by wild animals

Little is known about the threat to biodiversity from snares set for preventing crop raiding by wild animals. Plumptre *et al* (1997) found that snares set for bushmeat in the Parc National des Volcan, in Rwanda, was influenced by local perceptions of crop raiding by duikers. Patrol reports of Bwindi before and after harvest zones were established show that snares were set in the forest boundary for mitigating crop raiding activities of wild animals. For example, in 1994, rangers patrolling the west collected 17 snares on the National Park boundary, and five snares and four bushropes in the forest, that had been set for baboons by children guarding crops. Also in 1994, a man arrested adjacent to the centre area for killing two crop raiding monkeys was fined by his village court. Similarly, rangers apprehended local community members adjacent to the east area for hunting crop raiding animals. The first incident occurred in 1996 when five boys were arrested for killing a duiker that was outside the forest. The village court and beekeepers of the harvest zone programme fined the boys and ordered each boy to receive lashes. Also during 1996, a boy escaped arrest after rangers found him skinning a duiker in a sorghum field, and a man arrested for killing a crop raiding duiker was fined and given lashes by his village court. Furthermore, patrol reports of the north from 1993 to 1996 show that rangers collected snares on the National Park boundary for preventing baboons from crop raiding. These data therefore, although anecdotal, indicate that snares set for mitigation of conflict are a concern for conservation managers of Bwindi, particularly in the west where gorillas forage within community land (Guerrera *et al*, 2003). It is recommended that managers of Bwindi prioritise mitigation efforts to reduce the threat to wildlife that arises from poaching by farmers of crop raiding animals.

### 4.4.4 Poachers

Integrated strategies have been criticised for failing to provide benefits from protected areas to communities bearing conservation costs (Larson *et al*, 1997). This has also been considered a factor that could limit the success of the integrated approach at Bwindi (Makombo, 2003). Thus area of origin of the poachers is important information for conservation managers to ensure that integrated strategies for reducing threats to conservation, such as the compensation of or substitution for resources lost from gazettement, target appropriate communities.

Bwindi's rangers consider that the indigenous Batwa community is primarily responsible for poaching (personal observation). From patrol reports this study showed that most poachers were agriculturalists of the Baikga community. An important consideration is the possibility that rangers did not record incidents when poachers escaped, although from the findings, the perception of rangers regarding poachers may have been influenced by their encounters with poachers, as most Batwa poachers were arrested whereas most Bakiga poachers escaped.

The results also showed that most poachers encountered by rangers were local community members. In addition, there was evidence of a local bushmeat trade, as rangers' noted that poachers followed a routine of entering the forest on village market days and that local businessmen were paying the Batwa and villagers for duiker meat. The results support findings of a previous study that poaching in Bwindi is mainly undertaken for subsistence or local sale in village markets (Tukahirwa and Pomeroy, 1993). The study also found that trade in bushmeat provides a modest income for households neighbouring Bwindi and that poaching is primarily driven by local needs for bushmeat. However, findings that poachers live locally does not necessary mean a small-scale trade in bushmeat, and factors driving poaching in

Bwindi may have changed since 1993. For example, social and political changes in Rwanda and Congo may have increased demand for bushmeat from Uganda. Determining factors driving poaching is important for protected area managers to select appropriate conservation measures. Measures implemented at Bwindi have included resource substitution, financial compensation and provision of community benefits from the National Park, which has mainly comprised construction of schools and health clinics (Section 1.3). If poaching in Bwindi has continued to be driven by subsistence needs of local communities, then resource substitution measures to replace bushmeat lost because of gazettement are appropriate. Firstly, in comparison with financial compensation, as poachers seek meat primarily for subsistence rather than for income, and secondly, in comparison with community benefits, as lost bushmeat is primarily a cost faced by individual households than by the community as a whole.

The findings showed that greater effort of law enforcement, particularly the number of days patrolling the forest interior, results in higher encounter rates with poaching. This finding complements previous work on law enforcement in protected areas of tropical countries, as the conclusion from a variety of sites is that increasing patrol effort increases the patrol encounters with illegal activity and that a particular level of effort is therefore required for law enforcement to be effective (Leader-Williams, Albon and Berry, 1990, Jachmann and Billiouw, 1997; Abbot and Mace, 1999; Linkie *et al*, 2003). Bwindi provides an example of law enforcement by foot patrols within densely vegetated forests of mountainous terrain.

This chapter illustrated that four rangers patrolling the forest interior for an average between 11 and 16 days per month are required for law enforcement to be effective against bushmeat poaching. Law enforcement after the harvest zones were established was therefore insufficient. The change from long to day patrols at Bwindi primarily occurred because of concerns that allowing local communities into the National Park would lead to an increase in illegal resource collection (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). The harvest zones, which are in boundary areas that could be covered by day patrols, consequently became the target of law enforcement. However, as previously discussed, the decline in sizes of the ranger teams indicated a lack of motivation by the rangers, because the rangers arrange the patrol teams themselves on a daily basis. A lack of motivation was also evident by the higher proportion of poachers that escaped arrest after the harvest zones were established, in addition to complaints that rangers made in their patrol reports (personal observation).

Motivation is vital to the success of rangers enforcing conservation laws in protected areas (Forsyth, 1993; Hough, 1994). However, few studies exist on factors that influence ranger motivation. A study on the behaviour of conservation staff in Benin found that compensation measures alone, such as improved housing and an increase in salary, are unlikely to improve motivation whereas institutional development, particularly effective leadership and staff management, is a key factor (Hough, 1994). Staff of the Uganda Wildlife Authority have recently received new uniforms and equipment, and an increase in salary, to improve their motivation. It is therefore recommended that conservation managers of Bwindi review their law enforcement strategy, particularly the effort invested in day patrols, and direct funding towards institutional development for effective leadership and management.

### 4.4.5 Summary

In summary, patterns of patrol encounters with poaching showed the significance of law enforcement and of factors characterising areas of Bwindi to activities of local poachers hunting primarily for subsistence needs. Change in size of snare clusters indicated impacts from National Park gazettement and patrol forest coverage on snare setting behaviour. Also indicated from anecdotal records was an impact on poaching from harvest zones, namely that beekeepers of the harvest zone programme refrained from poaching after the zones were established. There was no data to show change in beekeeper behaviour or to assess whether such change resulted from positive conservation impacts of sanctioned resource harvesting, or from the high level of law enforcement within harvest zones. This is therefore an area for further research, particularly to establish beekeepers' perspectives regarding their activities in Bwindi over time.

This chapter determined impacts of National Park gazettement and sanctioned resource harvesting on illegal bushmeat poaching activities in Bwindi. This provides a basis for analysis of the impacts of harvest zones and bushmeat poaching on gorilla distribution (Chapter 9), and of the impacts of law enforcement and activities of bushmeat poachers on the response of local communities to rangers on law enforcement patrol (Chapter 8).

Having established the distribution of bushmeat poaching within Bwindi over the period of National Park gazettement and establishment of harvest zones for sanctioned resource use, I now seek to determine the current distribution of illegal activity in Bwindi.

# Chapter Five

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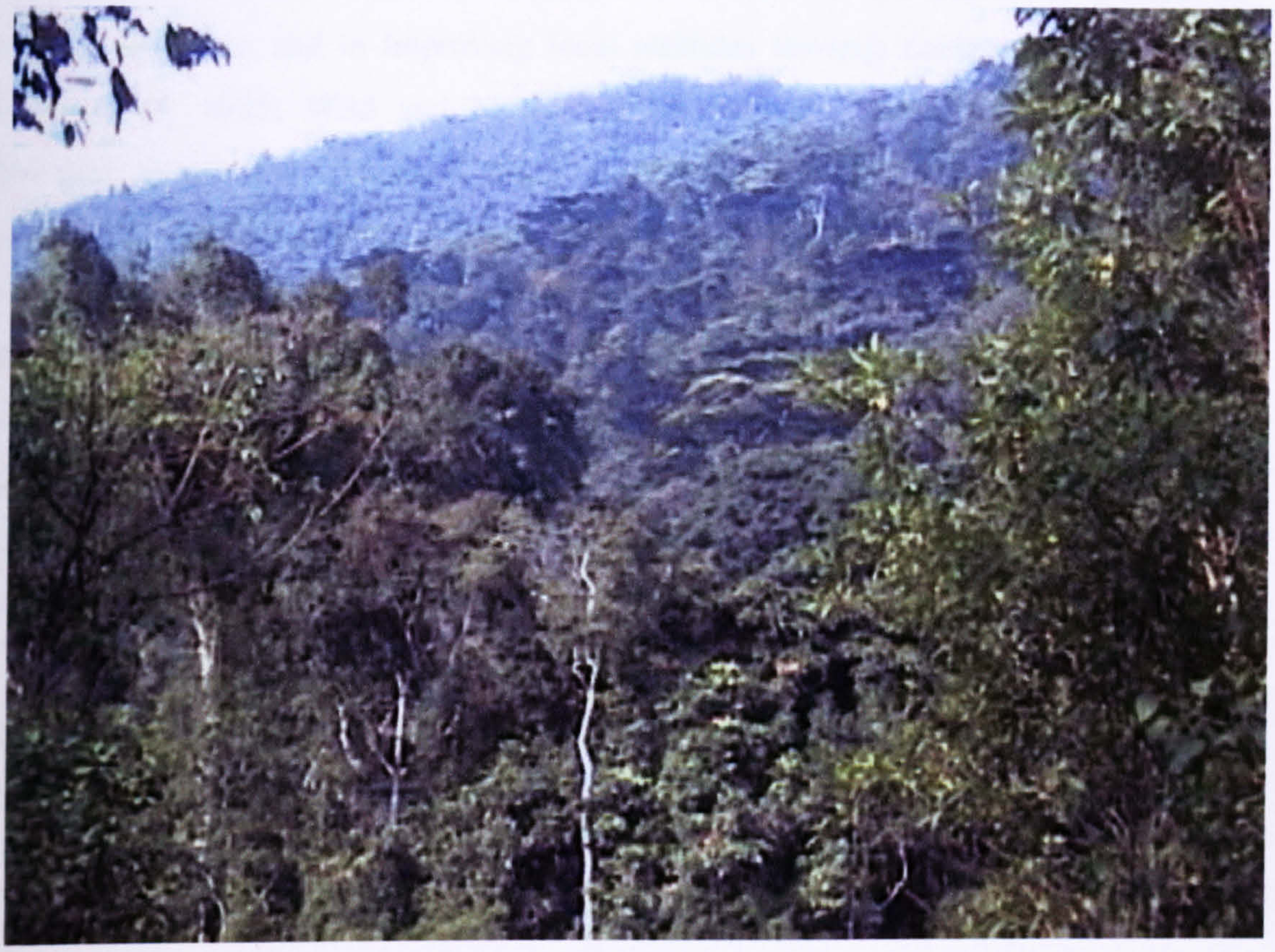
# Illegal Activity and the Harvest Zones



*Bwindi Impenetrable National Park*

*(J. Baker)*

# Chapter Five

# 5 Illegal activity and the harvest zones

## 5.1 Introduction

Integrated conservation and development is considered successful at Bwindi in conflict resolution and in improving local attitudes towards conservation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996; Blomely, 2003; Makombo, 2003). However, as noted in Chapter 4, there has been no assessment of impacts on illegal activity. In addition, the assumption underlying sanctioned resource harvesting that local communities who support conservation will refrain from collecting resources illegally, has rarely been tested (Wells and Brandon, 1993; Holmes, 2003; du Toit, Walker and Campbell, 2004). The previous chapter has examined the impact of harvest zones on subsistence bushmeat poaching by local communities. This chapter follows a similar approach in examining the impact on other illegal activities in Bwindi.

Ecological monitoring in protected areas is difficult within tropical forest ecosystems given the precision and sampling effort required for standard survey techniques (Plumptre, 2000). The recce method, whereby observers follow a path of least resistance through the forests, was developed with regard to difficulties of travel and observation in tropical forests (Walsh and White, 1999). Recce surveys enable a larger area to be surveyed than that possible with standard techniques, such as line transects. However, the surveys are limited to an assessment of relative values compared to those undertaken using a similar technique, and can be biased (section 2.2.3). For example, there is a possible bias when surveying human activity towards activities that mainly occur on or near forest trails, such as opportunistic collection of subsistence forest resources as the collector passes through the forest. Conversely, activities conducted away from trails, such as river mining, may be under-recorded. However, recce surveys have proven reliable for assessing abundance and distribution from encounter rates of indirect signs (Plumptre *et al*, 2002; Balcomb *et al*, 2000). In addition, the 1997 gorilla census established recce surveys as a reliable technique to examine abundance and distribution of wildlife and illegal activity in Bwindi, through comparisons with data collected from line transects (McNeilage *et al*, 1998). Therefore, given the limitations, recce walks were considered appropriate to examine distribution of human activity in Bwindi. Furthermore, using recce walks enabled a comparison of findings between this study of current human activity and the gorilla census of human activity in 1997.

The aim of this chapter is to determine the distribution of illegal activity in Bwindi. The main objectives are to examine the distribution of poaching, pit sawing, mining and subsistence resource collection in different areas, and in the harvest zones, of Bwindi. To address the objectives, I seek to determine the following research questions:

- In which forest areas does illegal activity occur?
- Are differences in the distribution of illegal activity related to north and south sectors?
- Are differences in the distribution of illegal activity related to harvest zones?
- What is the relative significance of area of Bwindi, the forest interior and boundary, and harvest zone to the distributions of illegal activity?

## 5.2 Materials and Methods

### 5.2.1 Field Data Collection

Recce walks were undertaken in the dry season of December 2000 to February 2001. The walks were conducted in the forest interior along an irregular network of existing human trails and animal paths (interior recce walks), and along the National Park boundary (boundary recce walks). For the survey, 64 recce walks were conducted that totalled 106.7 km. A total of 35 walks covered forest interior sectors, with a mean of 1.6 km (range 0.6 – 4.7 km) per walk, and 29 walks covered boundary sectors, with a mean of 1.5 km (range 0.5 – 5.2 km) per walk (section 2.2.3).

Recordings were made on incidents of illegal human activity that were observed by two field assistants walking at a pace of 1km/hour. Illegal activities, which included snares set for bushmeat, poacher's camps, pit sawing sites, and wood and bamboo cutting, were classified into five types: poaching for bushmeat; pit sawing for the commercial sale of timber; river mining for minerals; the collection of timber resources for subsistence use; and, the collection of non-timber resources for subsistence use. Subsistence timber resources included firewood, building poles and bean-stakes, and the non-timber resources included wild honey, fishing, medicinal resources and plant weaving materials.

The time elapsed since the activity took place was estimated by field assistants. These estimations were considered reliable because the field assistants, who were local villagers trained at ITFC, both had more than five years experience in ecological research at Bwindi and had participated in the 1997 gorilla census, which involved training in estimating age of human activities and wildlife signs. The estimations were assigned one of four categories to limit variation within the data. The categories were based on those of the 1997 gorilla census, as the census categories were developed from estimated decay rates based on environmental conditions of Bwindi (McNeilage *et al*, 1998) (section 2.2.3). The categories were of less than one year, between one and five years, between five and ten years, or over ten years. Estimations of over ten years indicated activity before Bwindi was gazetted a National Park. It was possible that older signs were less observable, as these signs were in the last stages of decay, and that decay rates varied between different human activities. However, the experience and training of the field assistants and use of broad age categories that had been developed for surveying human activities in Bwindi limited possible bias within the data.

## 5.2.2 Data analysis

Encounters with mining pits were excluded from the analysis, as most dated before gazettement and only one new mining site was encountered in the south of Bwindi, on the National Park boundary in the non-HZ sector K.

A total of 21 poaching signs, 11 poaching traps and two groups of poachers were encountered during the survey. Most poaching signs (78%), which comprised poachers' camps and trails, were estimated between five and ten years. Most poaching traps (46%), which comprised snares, bush-ropes and pitfall traps, were considered set between one and five years ago. However, as there were few poaching encounters during the survey, all were pooled for the analysis.

Pit saw sites estimated at over ten years were excluded, as previous studies have documented pit sawing in Bwindi prior to National Park gazettement (Hamilton, 1984; Howard, 1991). There were 38 pit saw sites and 210 pit-sawn trees encountered during the survey. Most (80%) were considered between five and ten years. Fewer encounters were considered between one and five years (12%) and less than one year (8%). Again, as few pit saw sites were encountered in Bwindi, all were pooled for analysis.

Certain types of timber were illegally collected from Bwindi for subsistence use including bean-stakes, firewood, building poles and hoe handles. Most (87%) encounters were considered less than one year and all were pooled for analysis. The types of non-timber resources illegally collected for subsistence use included plant weaving materials, medicinal forest products, wild honey and fish. Most (69%) encounters were also considered less than one year and these were also pooled for analysis

Incidents of illegal activity were converted into an encounter rate of the number of incidents per km of recce walk, for analysis using the non-parametric tests of Kruskal-Wallis and Mann Whitney U. Differences in distribution of each illegal activity in Bwindi were determined by comparing mean encounter rates per km firstly between north and south interior sectors, and secondly between south interior and south boundary sectors. Next, differences in distribution of each illegal activity in relation to harvest zones was determined by comparing mean encounter rates per km in south boundary harvest zone and south boundary non-harvest zone sectors. In addition, illegal activities in boundary sectors were examined by comparing encounter rates per km between interior recce walks and recce walks along the National Park boundary.

# 5.3 Results

## 5.3.1 Poaching and pit sawing

### 5.3.1.1 North and south sectors

Encounters with poaching and pit sawing on recce walks show that there were no differences between north and south sectors. However, encounter rates showed high variation around the mean, as a result of the low number of encounters (Table 5.1).

Six poaching traps were observed in north sectors. Three were old pitfall traps in the forest interior considered set over ten years ago, and three were fresh wire snares near the National Park boundary that were considered set less than one year ago. Snares on or near the National Park boundary are usually set for crop raiding animals (Bayenda oral communication). The recent snares were adjacent to the parish in which farmers are permitted to set snares around their crops for problem animal control, under the Memorandum of Understanding with the Uganda Wildlife Authority. However, farmers are not permitted to set snares in the National Park and so these snares were illegal. In addition, seven poaching signs were encountered in north sectors. These comprised a poacher's trail of less than one year in sector II, and six signs in sector LL, which were one killing site of less than one year, three dismantled bush-rope snares considered between one and five years ago, and two dismantled wire snares also considered between one and five years ago. Thus most poaching encounters in north sectors were considered less than one year or between one and five years, and there were fewer encounters over ten years. In contrast to north sectors, five poaching traps, 14 poaching signs and two groups of poachers were encountered in south sectors. All traps were considered set between one and five years ago. The estimated age of the poaching signs ranged from less than one year to over ten years (section 5.3.1.2).

Two pit saw sites and 25 pit-sawn trees were encountered in north sectors. Most encounters were in sectors KK and LL. These were considered between five and ten years old except for one site in sector KK that was considered less than one year. There were also five encounters in sector II considered less than one year, and one encounter in sector JJ and one encounter in sector MM both considered between five and ten years old. Thus most pit saw encounters in north sectors were considered between five and ten years and occurred in sectors KK and LL. Eight pit saw sites and 175 pit-sawn trees were encountered in south sectors. The estimated age of the encounters ranged from less than one year to over ten years (section 5.3.1.2).

Table 5.1 Mean±SE recce encounters with poaching and pit saw sites in north and south sectors of Bwindi

| Illegal activity | North sectors (n = 19) | South sectors (n = 29) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Poaching | 0.20±0.2 | 0.22±0.1 | -0.39 | NS |
| Pit sawing | 0.58±0.2 | 2.55±1.0 | -1.66 | NS |

### 5.3.1.2 South interior and boundary sectors

There were no differences in encounters with poaching and pit sawing between interior and boundary sectors of south Bwindi, although again encounter rates showed high variation around the means (Table 5.2).

No poaching traps were encountered in interior sectors. Five poaching signs were encountered in interior sectors and these were all poachers' camps. Four camps were considered over ten years and were encountered around Mubwindi swamp (sector G) and in the central sectors N and L. One camp encountered in the central sector Q was considered between one and five years. Most poaching encounters in interior sectors therefore dated to the time of gazettement. In contrast, five poaching traps and nine poaching signs ranging from less than one year to over ten years, and two groups of poachers, were encountered in boundary sectors (section 5.3.1.3).

No pit saw sites were encountered in interior sectors. A total of 37 pit-sawn trees were encountered in interior sectors that were all considered over ten years old. Most of these were encountered around Mubwindi swamp (sectors G and H). There were also encounters in the central sectors N, L, M and Q, and in the western sector DD.

Most pit saw encounters in interior sectors therefore dated to the time of gazettement. Eight pit saw sites were encountered in boundary sectors that were also considered over ten years old. However, most of the 138 pit-sawn trees encountered in boundary sectors were considered between five and ten years. Thus pit saw encounters in boundary sectors were more recent than in interior sectors.

Table 5.2 Mean±SE recce encounters with poaching and pit saw sites in south interior and boundary sectors of Bwindi

| **Illegal activity** | **Interior sectors (n = 13)** | **Boundary sectors (n = 16)** | **Mann Whitney U (z value)** | ***P*** |
|---|---|---|---|---|
| Poaching | 0.13±0.01 | 0.24±0.2 | -1.63 | NS |
| Pit sawing | 1.19±0.3 | 3.57±1.2 | -1.13 | NS |

### 5.3.1.3 South boundary harvest zone and non-harvest zone sectors

There were no differences in encounters with poaching and with pit saw sites between interior and boundary recce walks in boundary sectors, so encounters were pooled for the analysis. Encounters with poaching and pit sawing were similar between HZ and non-HZ sectors of south Bwindi, although encounter rates showed high variation around the means (Table 5.3).

Only one of the five poaching traps encountered in boundary sectors was in a HZ sector. This was a fresh wire snare near the National Park boundary in the medicinal plants and basket-making HZ sector T. The other four traps encountered were also recently set. These were all encountered near the National Park boundary in the non-HZ sector HH of the tourism zone, and comprised three wire snares and one bush-rope considered set less than a year ago. In contrast to traps, most poaching signs were encountered in harvest zones. Eight of the nine poaching signs encountered in boundary sectors were in the beekeeping HZ sector C. These comprised two signs considered less than one year, two signs between one and five years, and four signs over ten years. The two encounters with poachers also occurred in beekeeping zones. The first was a poacher carrying a bag of bushmeat in HZ sector B, and the second was poachers with hunting dogs in HZ sector C. The one poaching sign encountered in non-HZ sectors was a poacher's trail of less than one year in sector P. Thus old and recent poaching activity was encountered in beekeeping harvest zones, and recent activity was encountered in the tourism zone.

There were eight pit saw sites encountered in HZ sectors. All were considered over ten years old and were encountered in the beekeeping zones of sectors A, B and C. Most of the 46 pit-sawn trees encountered in HZ sectors were also considered over ten years old. These were encountered in the beekeeping zones of sectors C and D, and in the medicinal plants and basket-making HZ sector T. The encounters therefore indicate that areas now designated as harvest zones were high pit sawing areas before gazettement. The only HZ encounters with pit-sawn trees considered less than one year were in the beekeeping zone sector J. The only non-HZ encounters with pit-sawn trees considered less than one year were in sector K, which neighbours sector J. As in HZ sectors, most of the 90 pit-sawn trees encountered in non-HZ sectors were considered over ten years old. Most of these were in sector K. There were also encounters in sector P, which neighbours K, and in the central sector I and the west sector GG. Thus the only recent pit sawing encounters occurred in neighbouring HZ sector J and non-HZ sector K, and most old pit saw encounters occurred in sector K.

Table 5.3 Mean±SE recce encounters with poaching and pit saw sites in south boundary HZ and non-HZ sectors of Bwindi

| Illegal activity | HZ sectors (n = 8) | Non-HZ sectors (n = 10) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Poaching | 0.27±0.2 | 0.31±0.2 | -1.16 | NS |
| Pit sawing | 2.41±0.9 | 3.64±1.8 | -1.53 | NS |

## 5.3.2 Timber and non-timber subsistence collection

### 5.3.2.1 North and south sectors

There were two encounters of subsistence timber collection in south interior sectors. These were both firewood considered collected over ten years ago. The comparison between north and south sectors was therefore based on north sectors and only south boundary sectors. Encounters with timber collection were higher in south boundary sectors (n = 16) (Table 5.4). Recce encounters per type of timber collected were not sufficient for analysis, although on average bean-stakes and building poles were the most frequently collected timber in the south, while firewood and building poles were most frequently collected in the north (Figure 5.1). Most timber collection in both the north and south was considered less than one year old.

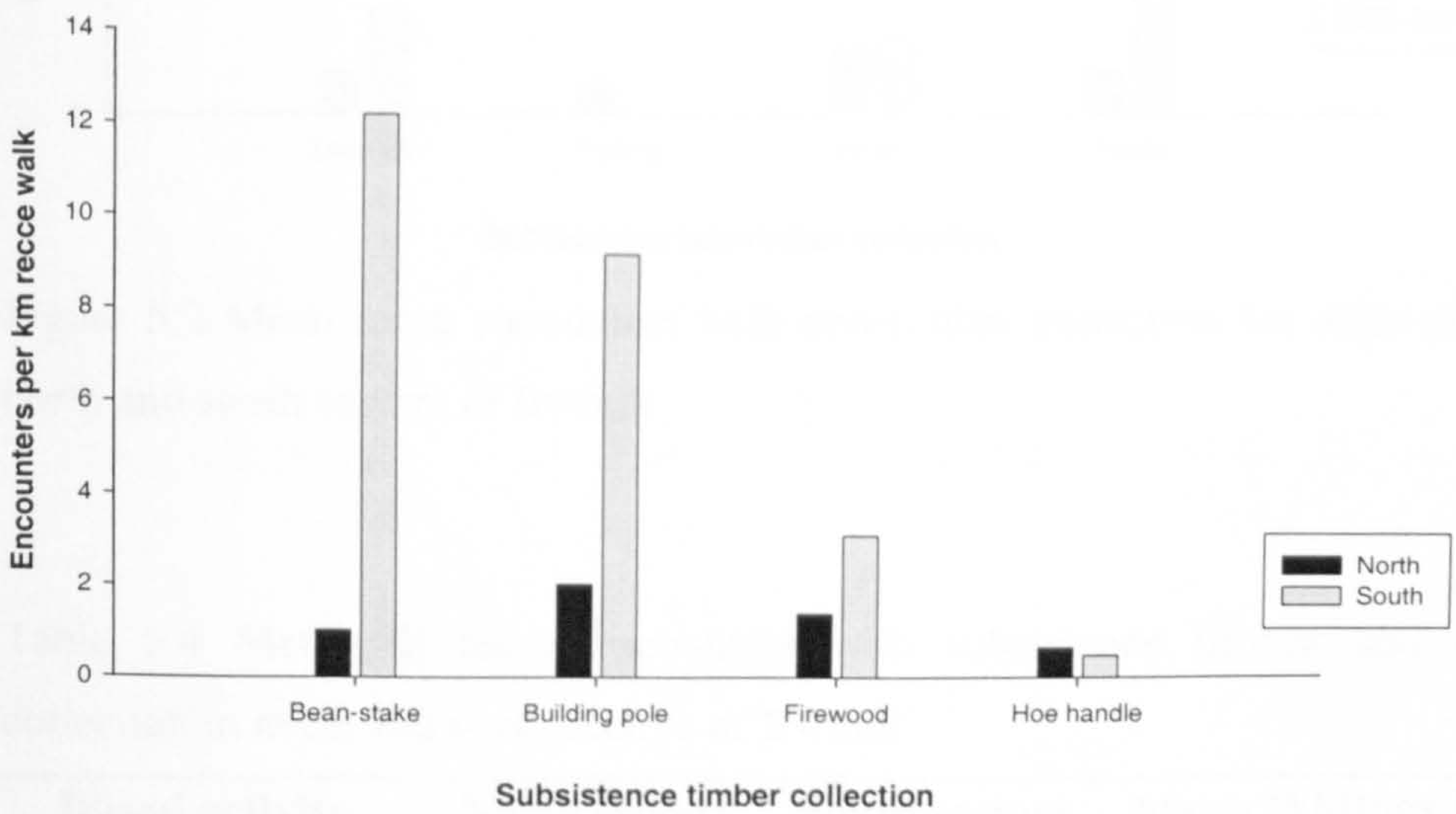



Figure 5.1 Mean recce encounters with timber collection for subsistence use in north and south sectors of Bwindi

Encounters with non-timber collection tended to be higher in south than in north sectors (p = 0.06) (Table 5.4). Recce encounters per type of non-timber collected were not sufficient for analysis, although on average wild honey, plant weaving material and medicinal resource collections were most frequently encountered in north sectors, whereas plant weaving material was most frequent in south sectors (Figure 5.2). Most non-timber collection in the north and south was considered over ten years old.

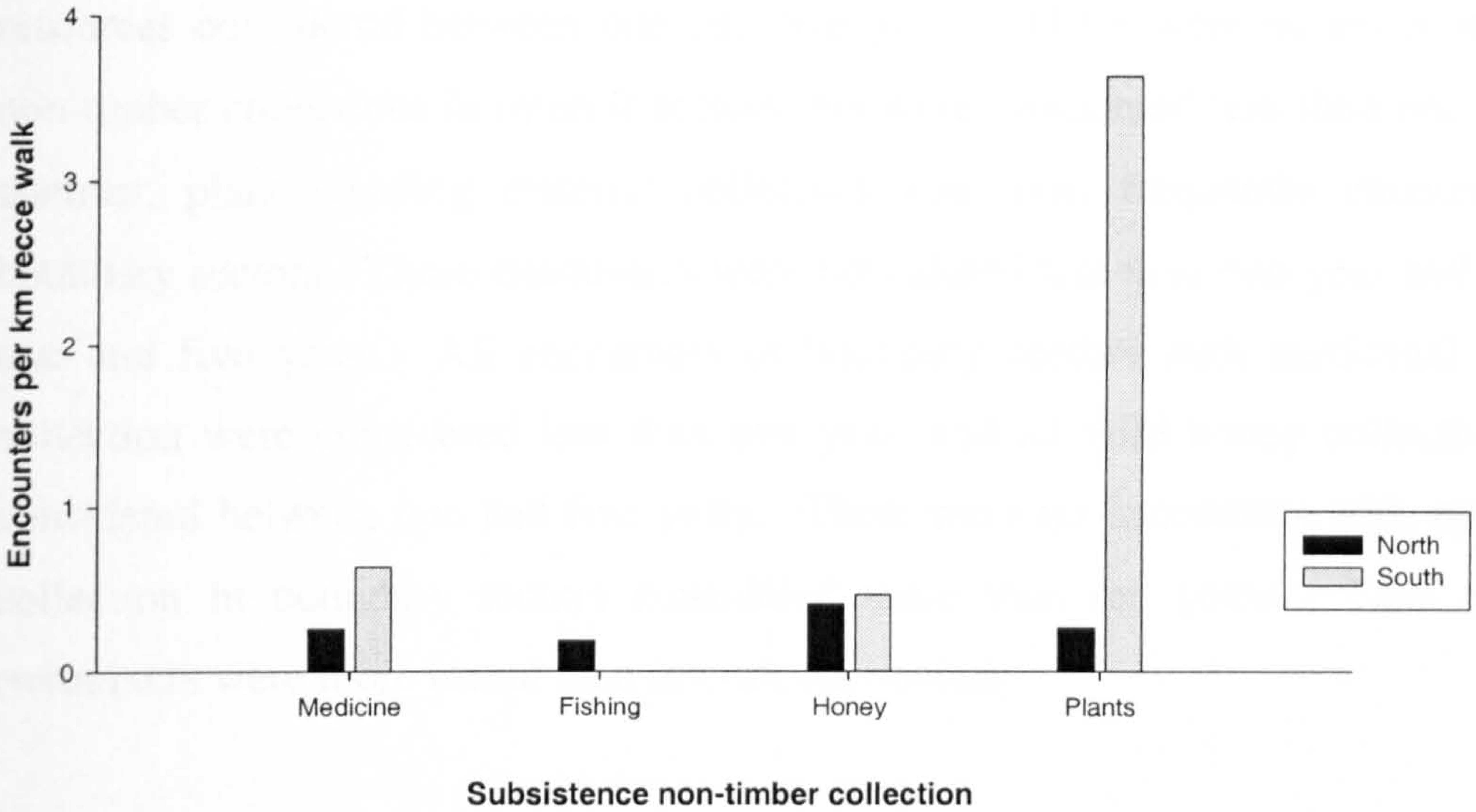



Figure 5.2 Mean recce encounters with non-timber collection for subsistence use in north and south sectors of Bwindi

Table 5.4 Mean±SE recce encounters with subsistence timber and non-timber collection in north and south sectors of Bwindi

| Illegal activity | North sectors (n = 19) | South sectors (n = 29) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Subsistence timber | 1.56±0.3 | 7.26±1.7 | -2.10 | < 0.01 |
| Subsistence non-timber | 0.77±0.1 | 0.47±0.3 | -1.66 | NS |

## 5.3.2.2 South interior and boundary sectors

The analysis for timber collection was not undertaken because of only two encounters in interior sectors. Thus most subsistence timber collection in the south of Bwindi was encountered in boundary sectors.

Encounters of non-timber collections were similar between interior and boundary sectors (Table 5.5). Wild honey collection was most frequently encountered in interior sectors. These encounters were considered more than ten years. Interior encounters also included collections of plant weaving materials and medicinal resources considered between one and five years. There were no encounters with non-timber collections in interior sectors that were considered less than one year. In contrast, plant weaving material collection was most frequently encountered in boundary sectors. These encounters were considered less than one year and between one and five years. All encounters in boundary sectors with medicinal resource collection were considered less than one year, and all wild honey collections were considered between one and five years. There were no encounters with non-timber collection in boundary sectors considered more than ten years. Thus boundary encounters were more recent than interior encounters.

Table 5.5 Mean±SE recce encounters with subsistence timber collection in south boundary and interior sectors of Bwindi

| Illegal activity | Boundary sectors (n = 16) | Interior sectors (n = 13) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Subsistence non-timber | 0.47±0.1 | 0.47±0.2 | -1.46 | NS |

### 5.3.2.3 South boundary harvest zone and non-harvest zone sectors

Subsistence timber collection in boundary sectors was encountered as frequently on interior as on boundary recce walks, and the encounters were pooled for analysis. Encounters of timber collection were higher in HZ than non-HZ sectors (Table 5.6). There were also differences in the type of timber collected. On average building pole and bean-stake collection was most frequent in HZ sectors, whereas bean-stake collection was most frequent in non-HZ sectors (Figure 5.3). Most encounters in HZ and non-HZ were considered between one and five years.

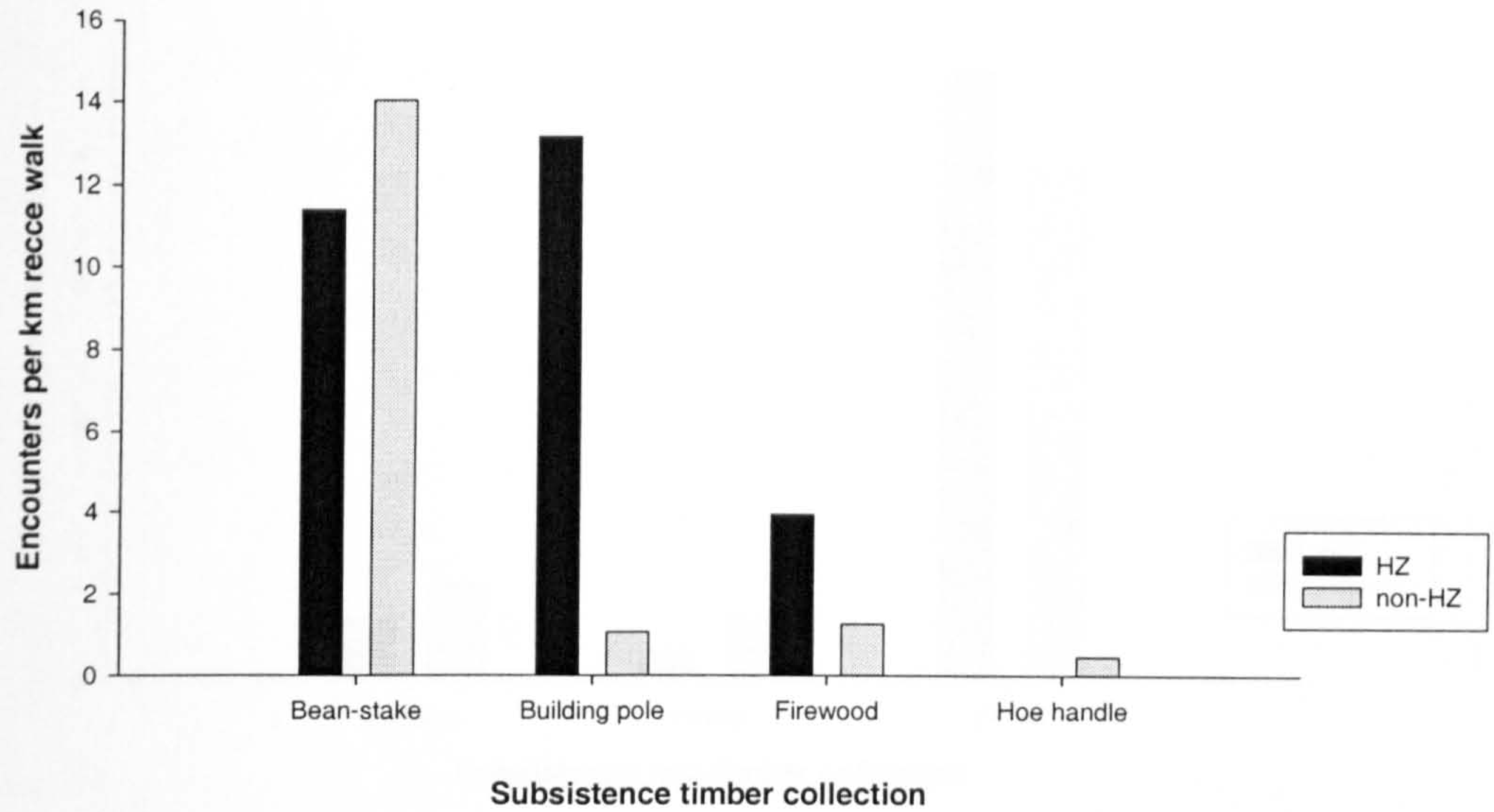



Figure 5.3 Mean recce encounters with timber collection for subsistence use in south boundary HZ and non-HZ sectors of Bwindi

Subsistence non-timber collection in boundary sectors was encountered as frequently on interior as on boundary recce walks, and the encounters were pooled for analysis. Non-timber collection tended to be encountered more frequently in HZ sectors ($p = 0.06$) (Table 5.6). The types of resources collected were similar, as on average plant weaving material collection was most frequently encountered in both HZ and non-HZ sectors (Figure 5.4). However, estimated ages of the collections differed. Plant collections in HZ sectors were considered over ten years old while in non-HZ were considered less than one year old. Encounters with recent collections in HZ sectors comprised wild honey and medicinal resources considered less than one year. Encounters with recent collections in non-HZ sectors comprised in addition to plant weaving materials, medicinal resources considered less than one year. Encounters in non-HZ considered over ten years old comprised wild honey collection.

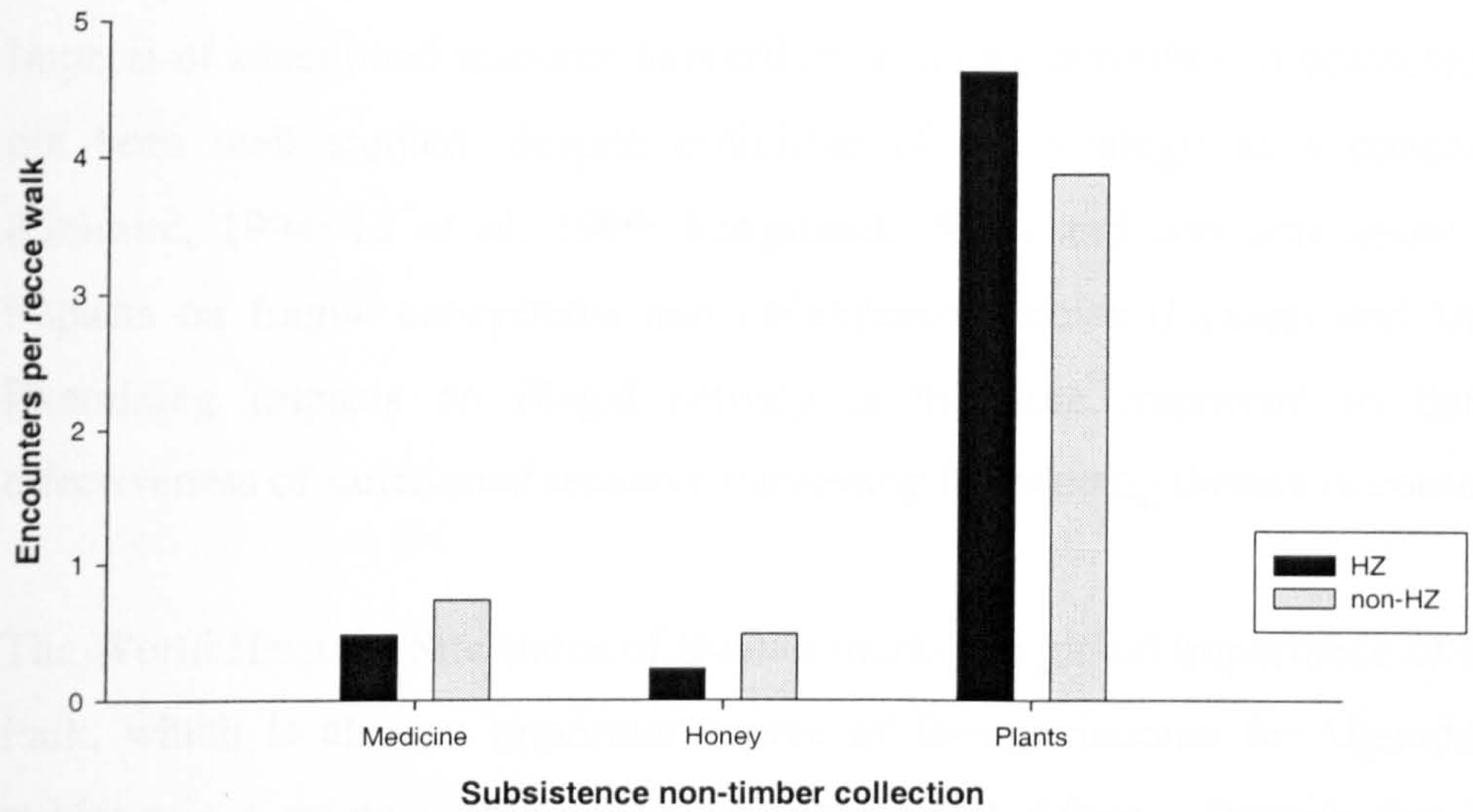



Figure 5.4 Mean recce encounters with non-timber collection for subsistence use in south boundary HZ and non-HZ sectors of Bwindi

Table 5.6 Mean±SE recce encounters with subsistence timber and non-timber collection in south boundary HZ and non-HZ sectors of Bwindi

| **Illegal activity** | **HZ sectors (n = 13)** | **Non-HZ sectors (n = 10)** | **Mann Whitney U (z value)** | ***P*** |
|---|---|---|---|---|
| Subsistence timber | 9.25±2.3 | 3.46±1.7 | -2.17 | < 0.05 |
| Subsistence non-timber | 4.15±0.5 | 1.89±0.8 | -1.82 | NS |

## 5.4 Discussion

Impacts of sanctioned resource harvesting on illegal activities in protected areas have not been well studied, despite criticisms of the strategy as a conservation tool (Ghimire, 1994; Li *et al*, 1999; Kingsland, 2002) and concerns about detrimental impacts on fragile ecosystems and endangered species (Lynagh and Urich, 2002). Examining impacts on illegal activity is therefore important to determine the effectiveness of sanctioned resource harvesting in reducing threats to conservation.

The World Heritage Site status of Bwindi marks the global importance of the National Park, which is also an important source of foreign income for Uganda, as gorilla trekking is a prime tourist attraction within East Africa. Despite this importance, there has been no assessment of the conservation impact of the harvest zones that cover 20% of the 321 km$^2$ of National Park. This study is the first to examine the distribution of bushmeat poaching, pit sawing and mining in Bwindi in relation to the harvest zones. In addition, although studies exist on subsistence use of forest resources by communities neighbouring Bwindi (Scott, 1992; Cunningham, 1996), this study is the first to examine the illegal collection of subsistence resources from the National Park.

### 5.4.1 Poaching, pit sawing and mining

Signs of poaching, pit sawing and mining activity from the last five years were rarely encountered during the survey. There was one recent mining pit of less than a year old, and eight poaching traps and nine pit saw sites estimated between one year and five years old. These findings indicate that poaching, pit sawing and mining in Bwindi are low in comparison with other tropical forests. For example, 414 snares were found during a gorilla census in the Virungas conducted in 1989, with methods similar to those used in the Bwindi census (McNeilage, 1995), and in Nyungwe forest in Rwanda, 317 snares were encountered during a recce walk survey of 346 km undertaken in 2002 (Plumptre *et al*, 2002). The findings also indicate that poaching, pit sawing and mining have remained at low levels in Bwindi following the decline that occurred after gazettement. Before Bwindi was declared a National Park, pit sawing was undertaken throughout the forest and mining was common in the forest boundary (Butynski, 1984). However after gazettement, six census teams found only three fresh pit saw sites and no mining pits during the 1997 mountain gorilla census (McNeilage *et al*, 2001). Similarly, Butynski (1984) found 89 snares from 200 km of survey trail before gazettement, whereas the gorilla census teams found 62 snares from over 500 km of recce walks during the 1997 census (McNeilage *et al*, 2001). This reduction was attributed to the high level of law enforcement during the gazettement period (McNeilage *et al*, 2001).

Most recent poaching and pit sawing encounters during this study were in south boundary sectors. Comparing these findings with the 1997 gorilla census indicates that more recent poaching and pit sawing activity was found during this study, where one small team covered 106.7 km of forest, than during the 1997 gorilla census where six teams covered a total of 548.4 km. Given the limitations of the study, it cannot be concluded that these activities have increased since 1997. However, the study showed that encounters with recent poaching and pit sawing activity occurred in the harvest zones. It is therefore important to consider the impact of harvest zones on illegal activity.

Bushmeat poaching in Bwindi is mainly undertaken by local villagers for domestic consumption (Namara, 2000). Hunters primarily target bushpigs and duikers and will sell bushmeat within their village, although income from bushmeat is low compared with other activities (Tukahirwa and Pomeroy, 1993). Hunting in Bwindi is also important as a cultural tradition (Namara, 2000). Thus the activities of poachers will be influenced by a variety of factors including traditional hunting areas, the deterrent of law enforcement patrols and harvest zones.

Recent poaching signs and the encounters with poachers occurred in the beekeeping harvest zones. These zones are on the periphery of Mubwindi swamp, which was traditionally favoured by hunters because of the high density of bushpigs and duikers in the area (Namara, 2000). Both Butynski (1984) and McNeilage (*et al*, 2001) found that snares in Bwindi were most common within eastern interior sectors, particularly around Mubwindi swamp. Poaching in the beekeeping zone could therefore reflect poaching in the areas that were historically used by hunters, or that are known among local communities to contain many ungulates.

Poachers will also be influenced by law enforcement and, at Bwindi, appear to react to patrols (Chapter 4). The fresh snares found in the west of Bwindi were less than 1 km from the National Park headquarters, which is also the centre for tourism. This area is not well patrolled, being close to the headquarters (Bayenda oral communication). The absence of law enforcement could therefore explain the snares. Poaching within beekeeping zones could also be explained by poachers' response to law enforcement levels. There was a decline in total law enforcement effort in Bwindi after harvest zones were established from ranger teams patrolling forest interior areas for a number of days to smaller teams covering periphery areas for a single day (Chapter 4). Thus, although ranger teams tended to target harvest zones, the overall decline in law enforcement may have influenced poachers' activities.

The results could indicate impacts of sanctioned resource harvesting on poaching. Conservationists face the risk that approved harvesters from rural communities will collect resources illegally when permitted to enter a protected area. There is also a possibility that non-harvesters, who see other community members enter the protected area, feel that they can also enter and collect forest resources. Both these factors could explain the results of this study. However, impacts of harvest zones on poaching, or of other factors including the historic use of forest areas for hunting and the deterrent of law enforcement, are difficult to determine. Nonetheless, this study indicates that poaching occurs in the beekeeping zone. Therefore, although currently at low levels, conservation managers at Bwindi must remain vigilant to the threat of poaching and review both law enforcement and integrated strategies aimed at reducing the activity.

Pit sawing differs from poaching in that it is primarily undertaken for income. Furthermore, it is not limited to a small, specialist resource user group, but involves the majority of working inhabitants in parishes neighbouring Bwindi (Tukahirwa and Pomeroy, 1993). The results of this study showed that pit saw encounters in harvest and non-harvest zone sectors were similar, although the analysis was limited by large variation within the data.

The fresh pit saw sites encountered during the survey could indicate that pit sawyers resumed their activities in Bwindi following the decline in law enforcement. The fresh sites were along the National Park boundary in neighbouring sectors, one a harvest zone for beekeeping and the other not a harvest zone. This area is adjacent to a large trading centre for sawn timber. The location indicates that pit sawyers chose sites with greater consideration to distance from the market and suitability for timber, than to the harvest zones. Therefore, pit sawing in the beekeeping zone was likely to be the consequence of a nearby timber market and a decline in law enforcement.

In summary, the results showed that recent poaching and pit sawing activities was encountered in the harvest zones, particularly beekeeping zones. Poaching could indicate the return of poachers to their traditional hunting areas that were designated as beekeeping zones after gazettement, or a consequence of allowing rural people into a protected area to harvest natural resources. In contrast, harvest zones appear less significant than either the motivation of income or deterrent of law enforcement to pit sawyers. Impacts of harvest zones are difficult to determine from this study. However, comparing two types of illegal activities, one for subsistence needs and the other for income, has revealed issues that are important for the debate as to whether sanctioned resource harvesting in protected areas lead to an increase in illegal activity.

### 5.4.2 Subsistence resource collection

In comparison with poaching and pit sawing, there is limited research on illegal subsistence resource collection in Bwindi. Previous work has documented the use of forest resources by communities neighbouring Bwindi (Cunningham, 1996) and the demand for each type of resource (Scott, 1992). Whilst both studies illustrated that the communities were dependent on the forest for their subsistence needs, and that most forest products were collected for domestic use, there has been no attempt to quantify this resource collection. The 1997 gorilla census provides the first assessment of illegal resource collection for subsistence use in Bwindi. A total of 28 woodcutting and four wild honey collections were encountered in south sectors, although the type of woodcutting was not recorded (McNeilage *et al*, 2001). In comparison, the findings of this study indicate an increase in subsistence timber and non-timber resource collection in Bwindi, as 88 woodcutting and 45 non-timber collections were encountered in south sectors during a smaller survey. However, collections might have been underestimated in the census because the census teams were primarily searching for gorilla trails and possibly missed small cuts of tree saplings for poles, or tree trunk hollows for honey collection.

#### 5.4.2.1 Timber

The high collection of subsistence timber resources in south sectors could be explained by population density. The districts of Kabale and Kisoro border these sectors and have population densities of 267 and 304 people per $km^2$, respectively, so have a greater demand for timber than the lower population density of Rukungiri district, which borders the north sector and contains a density of 151 people per $km^2$ (Population and Housing Census, 2002). The results showed that most timber collected from north sectors was for building poles and firewood, whereas most timber collected from south sectors was for bean-stakes. Before Bwindi was gazetted a National Park, Butynski (1984) commented on the widespread collection of building poles and firewood from boundary forest areas. He also noted that both were available outside Bwindi but these alternatives were not as easy or cheap to obtain. Following gazettement, Scott (1992) found that building poles and bean-stakes were the most highly demanded timber by communities neighbouring Bwindi. She suggested that the lesser demand for firewood was because of high wood-plot ownership and the tree-planting programme of the ICDP. This study, conducted ten years after Scott (1992), indicates that demand for subsistence timber, particularly building poles and bean-stakes, from Bwindi has continued. However, whether this reflects failure of the integrated approach to reduce subsistence timber demands on the forest, or that forest resources are easier and cheaper to obtain than alternatives, or demands from a growing rural population, requires further investigation.

There was a possibility of bias from the methodology, as poles cut legally by beekeepers could have been mistaken for illegally cut timber. However, it is unlikely that either building poles or firewood were mistaken because of the larger size of these resources than the smaller poles used for supporting beehives. Furthermore, beehive poles can only be legally cut within the immediate vicinity of the beehive and therefore, the chance of a mistake was low.

The proportion of recent to old collections was similar between south harvest and non-harvest zones. This indicates that subsistence timber has been, and continues to be, collected from all areas of south Bwindi. However, the level of collection was higher and there was a greater variety of timber collected in the harvest zones. Bean-stake, building pole and firewood cutting was observed in harvest zones, whereas most woodcutting in non-harvest zones were bean-stakes. The type of timber is important because of the tree size required. For example, the diameter of bean-stakes, which ranges from 1.5 – 5 cm dbh, is smaller than the diameter of building poles or firewood (5 – 15 cm dbh) (Cunningham, 1996). The results therefore indicate that larger trees were collected illegally from harvest zones than from non-harvest zones.

The high collection within harvest zones could have resulted from the harvest zone programme. It is possible that the harvesters illegally collect timber when entering the zones, or that non-harvesters feel that they can enter the forest areas that other members of their community are allowed to enter. However, demands for forest resources differ among communities neighbouring Bwindi (Scott, 1992). Thus communities adjacent to harvest zones might have a greater need for the timber, or be without accessible or affordable alternatives, than communities adjacent to non-harvest zone sectors. There are also socio-economic factors that could explain the findings. For example, a greater dependency of poorer communities on the forest for subsistence resources, as well as impacts of the tree-planting programme and law enforcement. It is difficult to assess the importance of each factor. Nevertheless, this study indicates that illegal subsistence timber collection was higher, and that the trees collected were larger, in the harvest zones.

#### 5.4.2.2 Non-timber

Prior to this study, only the 1997 gorilla census provided an estimate of non-timber resource collection in Bwindi. However, just four occurrences of honey gathering were recorded during the census (McNeilage *et al*, 2001) and, as previously discussed, comparisons with this study are limited.

There was an indication that non-timber resource collection was higher in north than in south sectors. Given the lower human population density around north areas of Bwindi, this could reflect a greater abundance of these resources in north sectors. For example, the absence of fishing encounters in the south of Bwindi was probably because the best fishing sites are in the north (Bayenda, oral communication). The difference between north and south sectors could also reveal differing household needs, which was indicated by the variety of resources collected. Encounters in north sectors were mainly for wild honey, whereas most in south sectors were for plant weaving materials. The traditional nomadic lifestyle of the Batwa has led to the assumption that the Batwa are primarily responsible for wild honey collection in Bwindi (personal observation). The high concentration of Batwa settlements around the north of Bwindi could account for the honey gathering in those sectors. However, Bakiga beekeepers neighbouring north sectors lost their beehives and the forest for placing hives after Bwindi was gazetted a National Park. Therefore, these beekeepers might be responsible for the illegal collection of wild honey.

Within south sectors, collection of non-timber resources was similar between interior and boundary sectors. However, the proportion of recent encounters was higher in boundary sectors. This result, and the result for timber resources, indicates that illegal collection of subsistence resources in Bwindi mainly occurs in the forest boundary. Most recent collections for non-timber resources in boundary sectors were for medicinal forest products. Medicine is a priority need for local communities of Bwindi. A recent study found a high prevalence of disease among the communities, and that the most commonly reported diseases were malaria, intestinal parasites and skin disease (Guerrera *et al*, 2003). Scott (1992) observed that the people living in close proximity to Bwindi were the most dependent on medicinal forest resources, and suggested that this was because of the small number of health clinics in the region. Six health clinics have been built in parishes surrounding Bwindi from funds of the revenue sharing programme and the Conservation Trust, as part of the ICDP. However, given the high collection of medicinal resources shown by this study, further construction of health clinics or implementation of community health programmes could provide conservation benefits by reducing this type of illegal activity in Bwindi. These initiatives would also benefit efforts for conserving the gorilla population. There is a high risk of disease transmission between the local human population and gorillas, as human-gorilla contact often occurs when gorillas forage within community land (Guerrera *et al*, 2003). Measures taken to improve the health of the local communities would reduce the risk of disease transmission between humans and primates, which is currently a significant threat to the great apes of Africa (Walsh *et al*, 2003).

Encounters with non-timber resource collection in harvest and non-harvest zone sectors were similar. There were also similar proportions of recent signs. It therefore appears that harvest zones have not affected this type of illegal activity. In addition, the type of resource collected was similar between harvest and non-harvest zones, with a high proportion of plants for weaving materials observed in both sectors. Few alternatives for weaving materials or for other non-timber forest products exist outside Bwindi (Scott, 1992). This study therefore illustrates the continuing dependence on these forest resources by local communities.

### 5.4.3 Summary

Impacts of harvest zones on illegal activity are difficult to determine from the findings of this chapter. Conclusions regarding the analyses were limited because of small sample sizes, particularly for recent activity. Interviewing local communities to determine their use of forest resources would have complemented the analyses and are thus a possibility to extend the research. Nonetheless, this chapter shows that recent poaching and pit sawing activities were encountered in harvest zones, illegal subsistence timber collection was higher in harvest than in non-harvest zones, and that harvest zones appear not significant to illegal subsistence non-timber collection.

The chapter provides insight for evaluating the integrated programme at Bwindi by showing the continuing dependence on forest resources by local communities. In addition, the chapter provides a basis for analysis of the impact of illegal activity on the distribution of gorillas (Chapter 9) and other key wildlife species (Chapter 10).

Having established the current distribution of illegal activity in Bwindi, which builds on the previous chapter of analysis of direct threats to biodiversity, I now seek to determine the indirect threats and first examine crop raiding activities by wild animals.

# Chapter Six

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# Crop Raiding Activities of Wild Animals

*Local resident of Bwindi watching a gorilla forage in vegetation near his homestead*

*(J. Baker)*

# Chapter Six

# 6 Crop raiding activities of wild animals

## 6.1 Introduction

Crop raiding by wild animals is a difficult problem for managers of protected areas (Osborn and Parker, 2003). The loss of agricultural produce, especially for communities living within subsistence economies, can cause negative attitudes towards conservation and even hostility between rural communities and conservation authorities (Infield, 1988; Newmark *et al*, 1993; Hill, 1999). This situation is particularly common in Africa because large mammals, such as elephants, whose conservation is a subject of concern, typically damage extensive agricultural areas during a single foray (Hill, Osborn and Plumptre, 2002). The impact of crop raiding on attitudes of local communities towards protected areas can undermine efforts to gain their support for conservation, even when these provide economic benefits. For example, in Uganda, conflict between local communities and National Park managers that arose because of crop raiding, continued despite local development projects receiving a proportion of the National Park's income from tourism (Archabald and Naughton-Treves, 2001). A further problem for conservation managers is the link between crop raiding and poaching. Hunting is a traditional method of mitigating crop loss that involves both trapping around fields and killing animals found raiding crops or livestock. The latter recently occurred in Uganda when farmers killed a chimpanzee after the animal entered a sugarcane plantation adjacent to the Budongo Forest Reserve (Kasanga, 2003). It is therefore important that managers of protected areas address issues of crop raiding to alleviate conflict with local communities and reduce conservation threats from poaching wild animals.

Crop raiding is important to local communities of Bwindi (Siriri, 2002). Previous studies have shown that the communities consider baboons and bushpigs responsible for most crop damage (Mwesigye, 1996; Musaasizi, 2000), and that these animals consume all major food crops including sorghum, millet and maize (Tukahirwa and Pomeroy, 1993). Fields adjacent to the National Park boundary are most affected, as the majority of baboon raids occur within 200 metres from the forest (Mwesigye, 1996), and the majority of bushpig raids, which mainly occur around the north sectors, are within 100 metres of the forest edge (Musaasizi, 2000). Elephants also forage within community land, particularly during the rainy season and around the bamboo forest in the east (Babassa, 2000). L'Hoesti monkeys, blue monkeys, chimpanzees, gorillas and species of small carnivores have all been observed crop raiding, but the level of crop raiding by these species is considered low in comparison with baboons and bushpigs (Mwesigye, 1996; Musaasizi, 2000). These studies on crop raiding at Bwindi have focused on either a single species or a specific site. Consequently, there is no comparative assessment on the patterns of crop raiding activities by wild animals around the forest. In particular, little is known about crop raiding by mountain gorillas, which are the flagship species for Bwindi.

Hence, the aim of this chapter is to determine patterns of crop raiding by wild animals around Bwindi. The main objectives are to assess human-wildlife conflict at Bwindi and to provide recommendations for problem animal control. To address the objective, I seek to determine the following research questions:

- In which area of Bwindi did rangers encounter crop raiding?
- Was the distribution of crop raiding related to species?
- Was the distribution of crop raiding related to crops?
- Were differences in crop raiding related to year or season?
- What is the relative significance of year, season, area of Bwindi and species to incidents of crop raiding?

## 6.2 Materials and Methods

### 6.2.1 Law enforcement patrol reports

#### 6.2.1.1 Data collection

The operations of law enforcement patrols in Bwindi, the rangers' patrol reports and the retrieval and means of verifying the patrol reports, were described in Chapter 2. From 1996, in addition to recording sightings of wildlife inside the National Park, rangers recorded sightings of wild animals raiding crops within fields adjacent to the National Park boundary when patrolling the boundary for illegal activities (section 2.2.1). Therefore, these data only represent incidents of crop raiding that were visible during the day and in fields immediately adjacent to the National Park boundary. Rangers also recorded year, month, number of rangers on patrol, number of effective patrol days, type of patrol whether long or day patrol, and area toponym(s), which were assigned to the corresponding sector or sectors within the different areas of Bwindi (north, centre, east, south and west) (section 2.2.1.3). An effective patrol day (hereafter referred to as 'patrol day') is a day spent in the active pursuit of illegal activities, thereby excluding days spent travelling to and from the patrol area (Bell, 1986).

Data were extracted from records of law enforcement patrols along the National Park boundary that comprised 1850 patrol days carried out from 1996 to 2000. The number of crop raiding incidents encountered per patrol day was summed for the north, centre, east, south and west of Bwindi, per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol in each area were included for analysis (1996-2000 monthly totals across all areas; n = 227).

A crop raiding incident was considered as wild animals encountered raiding crops or in community land. Encounters with wild animals on the National Park boundary were also considered crop raiding incidents because community land around Bwindi is cultivated to the National Park boundary (Figure 6.1). In addition, encounters with wild animals raiding beehives inside the National Park were considered crop raiding incidents, as such crop raiding is frequently reported by beekeepers of the sanctioned resource harvest programme (Wild and Mutebi, 1996; Blomely, 2003). The crop raiding species and type of crop consumed were also recorded. The patrol reports contained records of signs of crop raiding by bushpigs. However, the rangers did not consistently record bushpig signs and these records were omitted from the analysis.

The likelihood that recorder effort, with regard to vigilance of rangers to record crop raiding incidents, changed over time was low because the patrol report format included a section on crop raiding incidents. Thus from 1996 to 2000 rangers on patrol were required to record crop raiding incidents (section 2.2.1). Rangers did not consistently record all sightings of crop raiding along the National Park boundary before 1996. However, crop raiding incidents by elephants and gorillas were noted in archival records of Bwindi prior to 1996 (section 2.2.2). These records were employed to describe the historical context of crop raiding by elephants and gorillas in Bwindi before 1996. The number of elephant crop raiding incidents and gorilla crop raiding incidents per year was extracted from archival records from 1986 to 2000. An incident was considered either a sighting or a sign of crop raiding by rangers, National Park wardens or staff of conservation authorities. The variety of archival records with data on elephant and gorilla crop raiding enabled verification of the crop raiding incidents.

The archival records supplemented the patrol reports for the analysis of gorilla crop raiding because data from the patrol reports were limited. A Human-Gorilla Conflict Force team was established in the west area of Bwindi, where gorillas most frequently crop raid (Guerrera *et al*, 2003), by the International Gorilla Conservation Programme during the period from 1996 to 2000. The aim of the team was to mitigate gorilla crop raiding by chasing the gorillas back to the forest by ringing bells and beating drums (Makombo, 2003). Consequently, this team, rather than the rangers, encountered most gorilla crop raiding incidents in the west. Furthermore, patrol reports of crop raiding by gorilla groups habituated for tourism were omitted from the analysis because these records were inconsistent for two reasons. Firstly, rangers regularly accompanied tourists only after the attack on Bwindi by Rwandan rebels in 1999. Secondly, there is a possible bias from habituation, as it is currently debated whether habituated groups are more likely to raid crops than wild groups (McNeilage, oral communication).

Figure 6.1 The National Park boundary of Bwindi Impenetrable National Park

### 6.2.1.2 Data analysis

### 6.2.1.2.1 Law enforcement patrol reports

The first stage of the analysis was to adjust incidents of crop raiding by an appropriate variable of patrol effort into a "catch per unit effort" index (Bell, 1986) (see methods described in section 4.2). A Spearman's rank correlation showed a positive relationship between incidents of crop raiding and patrol days ($r_s = 0.64$; $p < 0.001$). Hence patrol encounters with crop raiding incidents were adjusted by the number of patrol days for consistency in analysis. This formed the dependent variable for the analysis, which were undertaken using non-parametric tests that included Kruskal-Wallis and Mann Whitney U.

The first analysis aimed to conduct univariate tests to examine possible differences in incidents of crop raiding between areas of Bwindi, years, seasons and crop raiding species. Comparisons were undertaken of the mean encounters with crop raiding incidents between areas of Bwindi, years from 1996 to 2000, months of the year, months of the rainy and dry seasons (Chapter 2) and months of the farming season (Table 6.1). Next, the species of wild animal encountered crop raiding and the crops that rangers observed being consumed in each area of Bwindi were determined. Comparisons were made of the proportions of encounters per species and per crop. In addition, spearman's rank correlations were undertaken between encounters per species and per crops to investigate associations between species and type of crop.

Table 6.1 Months of the annual farming season of southwest Uganda

| Farming season | Months |
|---|---|
| Harvesting | January; June; July, August; December |
| Planting | February; March; September; October |
| Weeding | April; May; November |

(Tukahirwa and Pomeroy, 1993)

The second analysis aimed to identify associations between crop raiding incidents and the factors of year, season, area and species, that best explained patterns of crop raiding around Bwindi. The number of crop raiding incidents per patrol were categorised by the factors of year, season, area and species in a four-way contingency table. The data were analysed by log linear analysis, under the assumption of a Poisson distribution, using the hierarchical approach and specifying a log link function (section 2.2.3.3). The number of patrol days was entered in the model as a covariate to account for the correlation between crop raiding incidents and effective patrol days. Two models were tested to examine associations first between area, rainy and dry season and crop raiding species, and second between area, farming season and crop raiding species.

Finally, patterns of elephant crop raiding were further examined. First, comparisons were undertaken of the mean encounters with elephant crop raiding incidents between areas of Bwindi, months of the year, months of the rainy and dry seasons (Chapter 2) and months of the farming season (Table 6.1). Second, multivariate analysis was undertaken to identify which of the factors of area and season best explained the likelihood of encountering elephant crop raiding on law enforcement patrol along the National Park boundary in Bwindi. The number of patrol encounters with crop raiding incidents involving elephants was converted into binary data comprising months with (1986-2000 monthly totals; n = 20), and months without (1986-2000 monthly totals; n = 207), an incident. This formed the dependent variable in a stepwise logistic regression analysis, using the forward stepwise procedure. The explanatory variables comprised: patrol days; rangers on patrol; area of Bwindi; and, season. Two models were tested, the first with months categorised as rainy or dry seasons and the second with months categorised as farming seasons. Areas and seasons were entered in the regression model as categorical variables (section 2.2.3.2).

#### 6.2.1.2.2 Archival records

Crop raiding activities of elephants recorded in the archival records were first described by non-quantitative analysis. The number of crop raiding incidents involving elephants per year and per area of Bwindi was determined. The number of incidents per month of the year, month of the rainy and dry seasons, and month of the farming season was also determined. Second, the type of raid, that is whether by a single elephant or by a group of elephants, and associations between type of raid and area of Bwindi, were examined by chi square.

Crop raiding activities of gorillas were described by non-quantitative analysis. First the number of crop raiding incidents involving gorillas per year and per area of Bwindi was determined. The west area was divided into the southwest (sectors V, X, Y, Z, CC, DD) and west (sectors HH, GG, EE) because this area is where gorillas most frequently crop raid (Guerrera *et al*, 2003). Limitations to the data did not permit analysis on the level of gorilla crop raiding from 1986 to 2000, although seasonal variation within gorilla crop raiding was examined by the number of crop raiding incidents per month of the year, month of the rainy and dry seasons, and month of the farming season. In addition, the type of raid, that is whether by a single gorilla or by a group of gorillas, was examined. Lastly, the type and quantity of crops consumed by gorillas were investigated.

### 6.2.2 Reconnaissance walks

### 6.2.2.1 Data collection

Recce walks were undertaken in the dry season of December 2000 to February 2001. The walks were undertaken during one dry season to limit bias from surveying different harvest seasons. The walks were undertaken along the National Park boundary. A total of 19 recce walks were conducted in north sectors that totalled 33.54 km (range 0.5 – 5.2 km), and 32 recce walks were conducted in south boundary sectors that totalled 44.91 km (range 0.3 – 2.8 km) (section 2.2.3).

Recordings were made on direct sightings and indirect recent signs (estimated at less than two weeks old) of crop raiding by wild animals observed by two field assistants walking at a pace of 1km/hour. Species, type of crop and area of Bwindi were recorded for direct sightings. Indirect recent signs comprised fields adjacent to the National Park boundary that had been raided by wild animals within the past two weeks. Species, type of crop and area of Bwindi were recorded. Species were identified from footprints and dung at the site where possible. Monkeys were grouped for the analysis because identifying individual species was difficult, with the exception of baboons that were easier to identify. Thus the data comprised crop raiding by baboons and by other species of monkey (l'Hoesti, red-tail, blue, black and white colobus). It was also recorded whether the incident occurred during the day or night, which was estimated from the crop raiding species using previous research on patterns of crop raiding for individual species in Bwindi. Thus the data represent actual and recent incidents of crop raiding within fields immediately adjacent to the National Park boundary.

Fresh dung (estimated at less than two weeks old) encountered during the recce walks were examined for signs of agricultural crops, which if present, was noted as a sign of crop raiding. Species, type of crop and area of Bwindi were recorded.

The estimations of age of sign were considered reliable because the field assistants both had more than five years experience in ecological research at Bwindi and had participated in the 1997 gorilla census, which involved training in estimating age of human activities and wildlife signs (section 2.2.3).

### 6.2.2.2 Data analysis

The aims of the analysis were to determine current patterns of crop raiding around Bwindi and to validate the patrol data. Sample sizes of direct sightings and of indirect signs of crop raiding, which included sites raided and dung containing agricultural crops both estimated at less than two weeks old, were small. All recce encounters were grouped for a total count of crop raiding incidents during recce walks. As observations of indirect signs were only made for those estimated at less than two weeks old, the data represent recent incidents of crop raiding in fields immediately adjacent to the National Park boundary. The data differed from the patrol data, as crop raiding incidents that occurred during the day and night were included. However, grouping recce encounters enabled a more robust analysis than would have been possible using separate encounters.

Recce encounters were converted into the number of encounters per km of recce walk, for analysis using the non-parametric tests of Kruskal-Wallis and Mann Whitney U. The first analysis aimed to determine the distribution of crop raiding around Bwindi. Mean recce encounters with each crop raiding encounter were compared north and south sectors, and between south harvest zone and south non-harvest zones sectors. Finally, the proportions of recce encounters per species and per crop were compared between north and south sectors.

## 6.3 Results

### 6.3.1 Area

Patrol encounters with crop raiding incidents varied around Bwindi (Kruskal-Wallis $\chi^2 = 25.49$; df = 4; $p < 0.001$) (Figure 6.2). Most crop raiding incidents occurred around the north and centre, with no difference between these two areas. Crop raiding around the north was higher than the east, south and west. Similarly, crop raiding around the centre was higher than the east, south and west. There was no difference in crop raiding between the south and east, south and west, and east and west (Table 6.2).

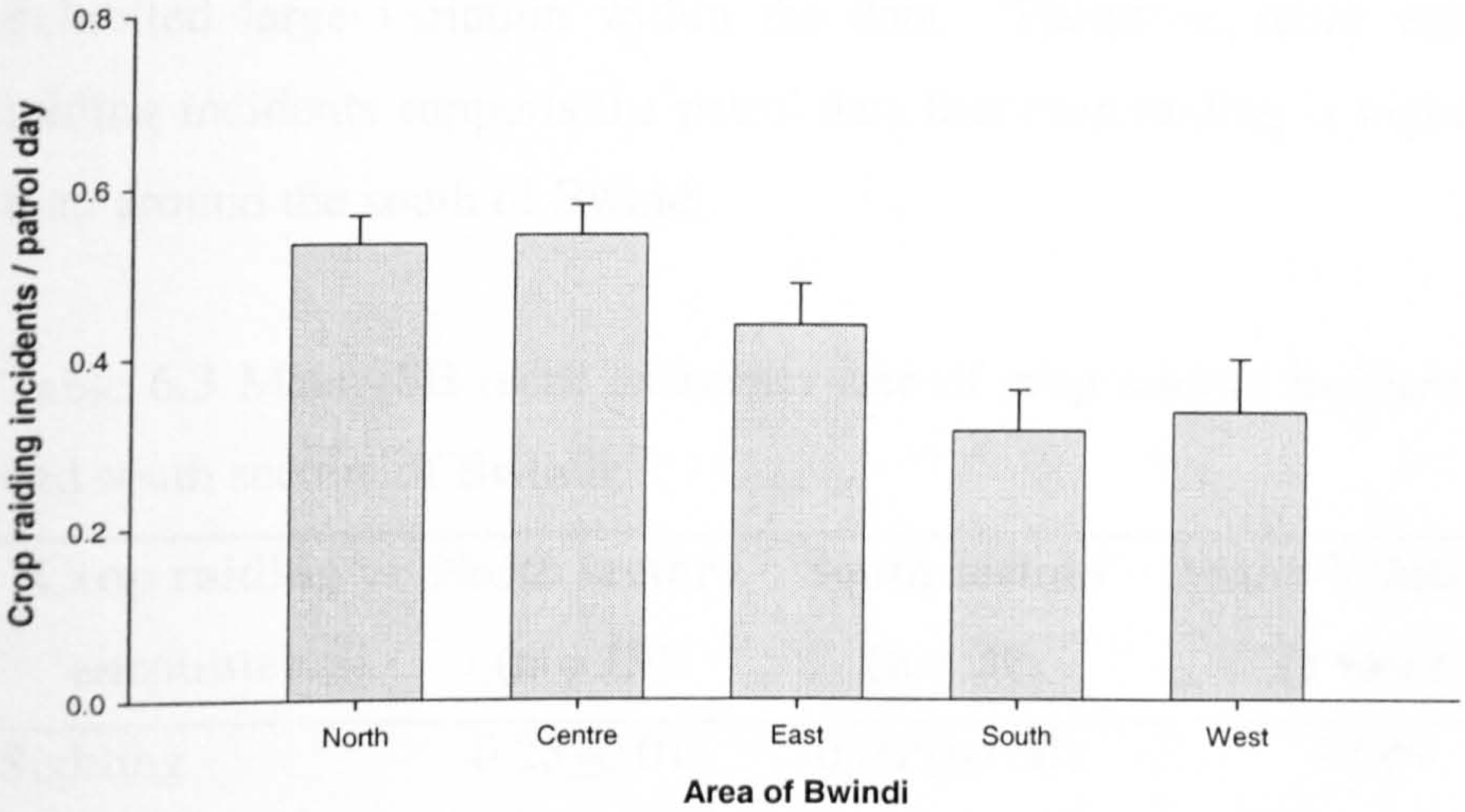


Figure 6.2 Mean±SE encounters with crop raiding incidents per month by patrols around areas of Bwindi from 1996 to 2000

Table 6.2 Significance of the Mann Whitney U Test (z value) of mean encounters with crop raiding incidents per month by patrols around areas of Bwindi from 1996 to 2000

| | Area of Bwindi (z value) | | | |
|---|---|---|---|---|
| | **North (n = 54)** | **Centre (n = 56)** | **East (n = 54)** | **South (n = 35)** |
| **Centre** | -0.27 | | | |
| **East** | -2.67** | -2.83* | | |
| **South** | -3.68*** | -3.68*** | -1.63 | |
| **West (n = 28)** | -3.00** | -2.96* | -1.33 | -0.02 |

* p < 0.05; **p < 0.01; *** p < 0.001

Results of the recce survey confirmed the patrol data. Sightings of crop raiding and signs of crop raiding around north sectors were higher than around south sectors (Table 6.3). The recce survey also provided further information on patterns of crop raiding around Bwindi. Sightings of crop raiding were widespread around north sectors with sectors KK and LL exhibiting the highest encounter rates. In contrast, crop raiding was only sighted in two south sectors (centre sector AA; south sector K). Signs of crop raiding exhibited a similar distribution being widespread around north sectors but only encountered in two south sectors. The south encounters were a sign of elephants raiding beans and Irish potatoes in south sector J, and a sign of baboons raiding millet in centre sector O. Encounters with dung containing agricultural crops were similar between north and south sectors, although the low number of encounters exhibited large variation within the data. Therefore, recce encounters with crop raiding incidents supports the patrol data that crop raiding is higher around the north than around the south of Bwindi.

Table 6.3 Mean±SE recce encounter rate of crop raiding incidents around the north and south sectors of Bwindi

| **Crop raiding encounter** | **North sectors (n = 19)** | **South sectors (n = 29)** | **Mann Whitney U (z value)** | ***P*** |
|---|---|---|---|---|
| Sighting | 0.23±0.01 | 0.005±0.001 | -2.99 | < 0.01 |
| Crop sign | 1.18±1.0 | 0.11±0.01 | -2.98 | < 0.01 |
| Dung sign | 0.93±2.0 | 0.52±1.2 | -1.33 | NS |

## 6.3.2 Year

There was no difference in encounters with crop raiding incidents between years from 1996 to 2000 (Kruskal-Wallis $\chi^2 = 8.15$; df = 4; $p > 0.05$). Around Bwindi, there was no difference between years in crop raiding around the north (Kruskal-Wallis $\chi^2 = 3.32$; df = 4; $p > 0.05$), east (Kruskal-Wallis $\chi^2 = 6.54$; df = 4; $p > 0.05$), south (Kruskal-Wallis $\chi^2 = 9.05$; df = 4; $p > 0.05$) or west (Kruskal-Wallis $\chi^2 = 8.72$; df = 4; $p > 0.05$). However, crop raiding around the centre varied between years (Kruskal-Wallis $\chi^2 = 25.38$; df = 4; $p < 0.001$). Low mean±SE encounters with crop raiding incidents occurred in 1998 ($0.33\pm0.01$) and 1999 ($0.32\pm0.01$). Higher encounters with crop raiding incidents occurred in 1996 ($0.66\pm0.01$), 1997 ($0.66\pm0.01$) and 2000 ($0.78\pm0.01$).

### 6.3.3 Season

Encounters with crop raiding incidents did not differ between months of the year (Kruskal-Wallis $\chi^2 = 8.36$; df = 11; $p > 0.05$), months of the rainy (n = 115) and dry season (n = 112) ($z = -0.10$; $p > 0.05$) or between months of the farming season (Kruskal-Wallis $\chi^2 = 0.48$; df = 2; $p > 0.05$). However, differences between seasons were evident in each area of Bwindi. Areas showing similar encounters with crop raiding incidents were pooled to determine seasonal patterns in crop raiding around Bwindi.

Around the north and centre (n = 110), most crop raiding occurred during April, June, August and September. However, there was no difference between months of the year (Kruskal-Wallis $\chi^2 = 11.80$; df = 11; $p > 0.05$), months of the rainy and dry seasons ($z = -0.24$; $p > 0.05$), or between months of the farming season (Kruskal-Wallis $\chi^2 = 0.86$; df = 2; $p > 0.05$). Thus, farmers adjacent to the north and centre of Bwindi experience similar levels of crop raiding throughout the year.

Crop raiding around the south and east (n = 88) revealed a different pattern. There was no difference in crop raiding incidents between months of the year (Kruskal-Wallis $\chi^2 = 12.03$; df = 11; $p > 0.05$). However, high crop raiding incidents occurred in March, October and November, which are months of the rainy season. Mean$\pm$SE encounters with crop raiding incidents were higher during months of the rainy season (n = 46; $0.19\pm0.01$) than during months of the dry season (n = 42; $0.11\pm0.01$) ($z = -2.01$; $p < 0.05$). Furthermore, the difference in crop raiding between months of the farming season (Kruskal-Wallis $\chi^2 = 5.98$; df = 2; $p > 0.05$) showed that mean$\pm$SE encounters with crop raiding incidents were higher during weeding months (n = 33; $0.21\pm0.01$), which are during the rainy season, than during harvesting months (n = 36; $0.12\pm0.01$) ($z = -2.23$; $p > 0.05$). Crop raiding around the south and east is therefore seasonal with high levels during the rainy and weeding season.

Crop raiding around the west (n = 23) varied throughout the year with peak levels during August, although the limited data did not permit statistical comparisons between months of the year. There was no difference in crop raiding incidents between months of the rainy and dry season ($z = -0.64$; $p > 0.05$), or between months of the farming season (Kruskal-Wallis $\chi^2 = 1.33$; df = 2; $p > 0.05$). Thus farmers around the west appear to experience crop raiding throughout the year, with peak levels during August.

### 6.3.4 Species

Rangers encountered ten species raiding crops in fields adjacent to the National Park boundary (Figure 6.3). These were two species of large ape, five of monkey, one of forest ungulate, as well as elephants and species of small carnivores.

Rangers most frequently encountered monkeys crop raiding around Bwindi (Table 6.4). Comparing crop raiding incidents between the five monkey species (Kruskal-Wallis $\chi^2 = 120.94$; df = 4; $p < 0.001$) showed that baboons were the species most frequently encountered crop raiding. Mean±SE encounters with crop raiding incidents involving baboons (0.19±0.02) were higher than black and white colobus monkeys (0.07±0.007), blue monkeys (0.06±0.008), l'Hoesti monkeys (0.04±0.005) and red-tail monkeys (0.02±0.004).

Table 6.4 Mean±SE encounters with crop raiding incidents per species per month by patrols around Bwindi from 1996 to 2000

| Crop raiding species | Encounters / patrol day (n = 227) | Kruskal-Wallis $\chi^2$ (df=5) | *P* |
|---|---|---|---|
| **Monkey** | 0.22±0.01 | 680.99 | < 0.001 |
| **Elephant** | 0.02±0.006 | | |
| **Gorilla** | 0.007±0.004 | | |
| **Duiker** | 0.006±0.002 | | |
| **Chimp** | 0.002±0.0 | | |
| **Carnivore** | 0.001±0.0 | | |

Crop raiding by monkeys varied around Bwindi (Figure 6.3). Crop raiding incidents involving baboons (Kruskal-Wallis $\chi^2 = 119.67$; df = 4; $p < 0.001$) were highest around the north, centre and west. Crop raiding incidents involving black and white colobus monkeys (Kruskal-Wallis $\chi^2 = 13.13$; df = 4; $p < 0.01$) were also highest around these areas, as well as incidents involving red-tail monkeys, although the low encounter rate for red-tail monkeys did not permit statistical analysis. In contrast, L'Hoesti monkeys (Kruskal-Wallis $\chi^2 = 26.41$; df = 4; $p < 0.001$) and blue monkeys (Kruskal-Wallis $\chi^2 = 31.97$; df = 4; $p < 0.001$) were most frequently encountered crop raiding around the south and east.

Crop raiding by other species also varied around Bwindi (Figure 6.3). Patrols only encountered crop raiding incidents involving elephants around the south and east (section 6.3.6). Patrols also only encountered crop raiding incidents involving duikers around the south and east. Most (93.7%) duiker encounters occurred around the east. Furthermore, most (56.0%) duiker encounters occurred during June, July and August, which are months of the dry season and of the harvest season.

Patrol encounters with crop raiding incidents involving gorillas mainly occurred around the west, but also occurred around the east, south and centre (section 6.3.7).

The six encounters with chimpanzees raiding crops comprised three encounters around the centre and three encounters around the east. The first encounter around the centre was during 1996 when rangers saw five chimpanzees outside the National Park adjacent to sector T. The rangers noted that this was the first time that they had seen crop-raiding chimpanzees clearly. The first encounter around the east was also during 1996 when rangers saw 12 chimpanzees raiding three beehives for honey, which were in the harvest zones of the National Park. All encounters of chimpanzee crop raiding around the east were on beehives in the harvest zone sectors D and B.

The two encounters with small carnivore species raiding crops both occurred around the east adjacent to sector D. The first encounter occurred in November 1996 and the second in July 2000.

Thus in summary, baboons account for most crop raiding incidents encountered by rangers on law enforcement patrol along the National Park boundary during the day. Most incidents involving baboons occurred around the north, centre and west. Black and white colobus monkeys and red-tail monkeys also most commonly crop raid around these areas, whereas L'Hoesti monkeys and blue monkeys most commonly crop raid around the south and east. Elephants only crop raid around the south and east and most gorilla crop raiding occurs around the west.

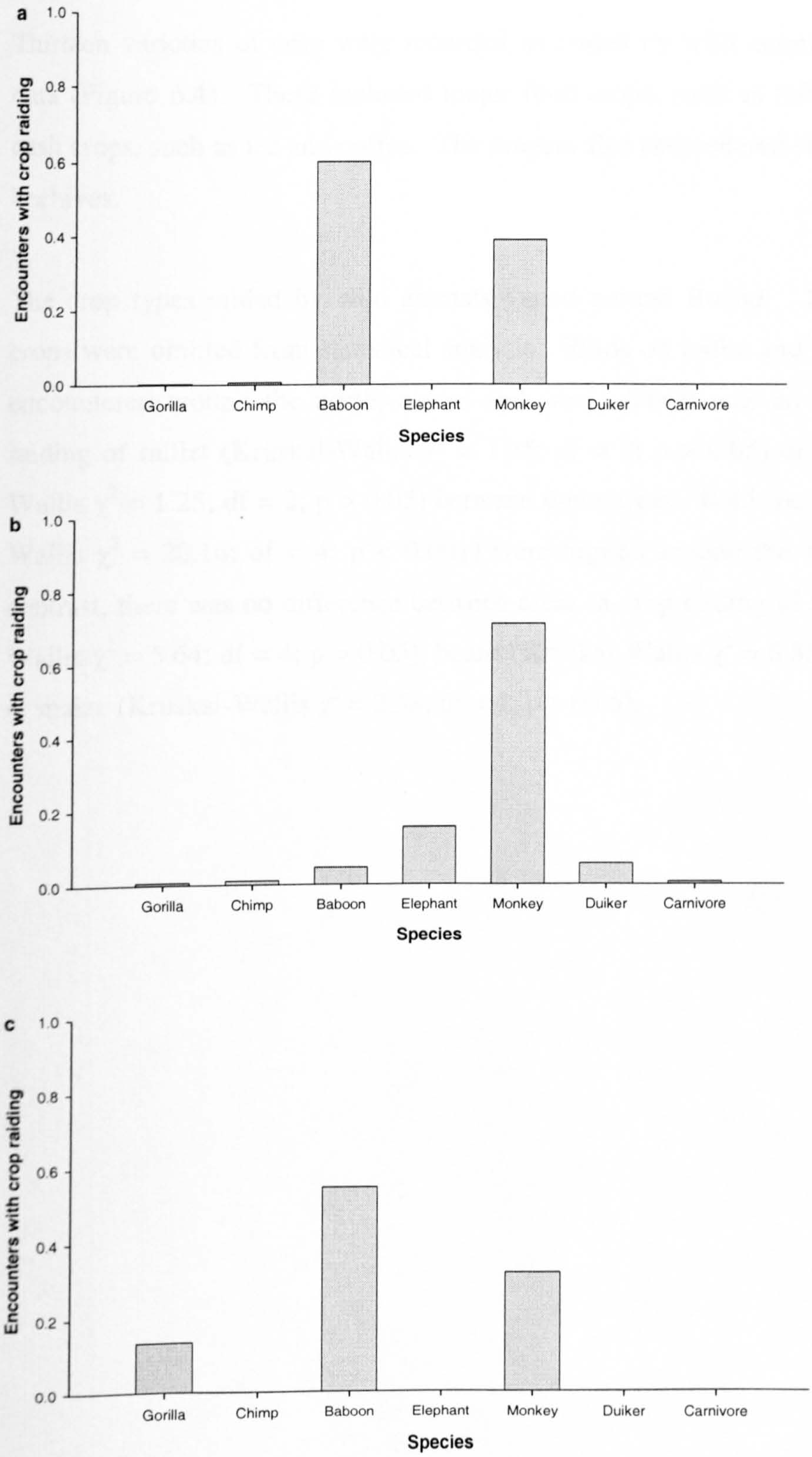


Figure 6.3 Mean proportions of encounters with crop raiding per species within each area of Bwindi per month by patrols around the north, south and west of Bwindi from 1996 to 2000

Key: a = north, b = south, c = west.

### 6.3.5 Crops

Thirteen varieties of crop were recorded as raided by wild animals from the patrol data (Figure 6.4). These included major food crops, such as millet and beans, and cash crops, such as tea and coffee. The rangers also encountered chimpanzees raiding beehives.

The crop types raided by wild animals varied around Bwindi. Infrequently raided crops were omitted from statistical analysis. Raids on millet and bananas were only encountered around the north, centre and west. There was no difference in crop raiding of millet (Kruskal-Wallis $\chi^2 = 1.45$; df = 2; $p > 0.05$) or bananas (Kruskal-Wallis $\chi^2 = 1.25$; df = 2; $p > 0.05$) between these areas. Raids on potatoes (Kruskal-Wallis $\chi^2 = 20.16$; df = 4; $p < 0.001$) were highest around the south and east. In contrast, there was no difference between areas in crop raiding of sorghum (Kruskal-Wallis $\chi^2 = 5.64$; df = 4; $p > 0.05$), beans (Kruskal-Wallis $\chi^2 = 6.88$; df = 4; $p > 0.05$) or maize (Kruskal-Wallis $\chi^2 = 2.58$; df = 4; $p > 0.05$).

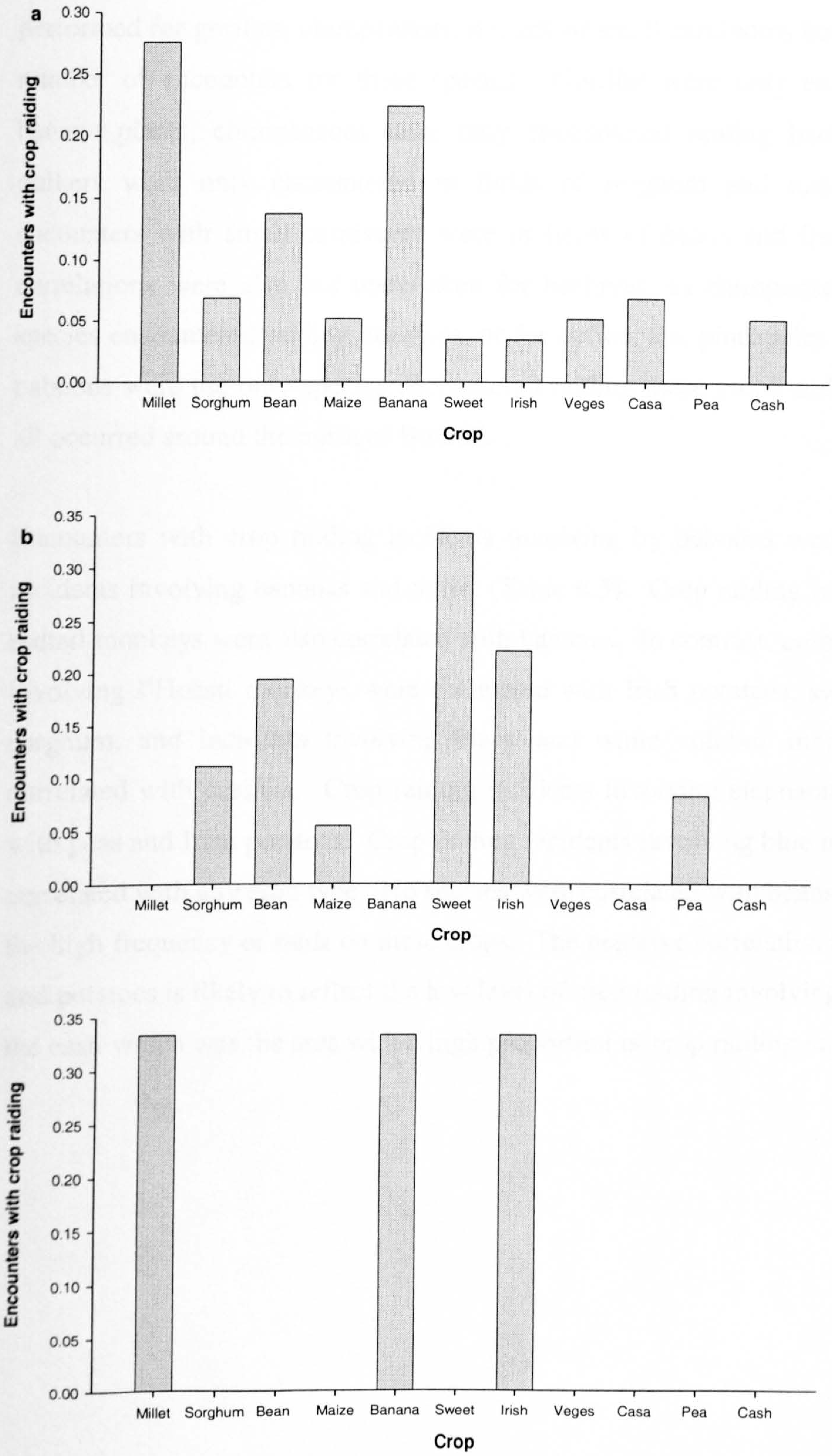


Figure 6.4 Mean proportions of encounters with crop raiding per crop within each area of Bwindi per month by patrols around the north, south and west of Bwindi from 1996 to 2000

Key: a = north, b = south, c = west.

Correlations undertaken to examine associations between species and crops were not performed for gorillas, chimpanzees, duikers or small carnivores because of the small number of encounters for these species. Gorillas were only encountered raiding banana plants, chimpanzees were only encountered raiding beehives and millet, duikers were only encountered in fields of sorghum and maize, and the two encounters with small carnivores were in fields of beans and Irish potatoes. The correlations were also not undertaken for beehives, as chimpanzees were the only species encountered raiding beehives, or for coffee, tea, pineapples and eggplants, as baboons were the only species encountered raiding these crops and these encounters all occurred around the north of Bwindi.

Encounters with crop raiding incidents involving by baboons were correlated with incidents involving bananas and millet (Table 6.5). Crop raiding incidents involving redtail monkeys were also correlated with bananas. In contrast, crop raiding incidents involving l'Hoesti monkeys were correlated with Irish potatoes, sweet potatoes and sorghum, and incidents involving black and white colobus monkeys were only correlated with cassava. Crop raiding incidents involving elephants were correlated with peas and Irish potatoes. Crop raiding incidents involving blue monkeys were not correlated with any crop type. No species were correlated with beans or maize despite the high frequency of raids on these crops. The negative correlation between baboons and potatoes is likely to reflect the low level of crop raiding involving baboons around the east, which was the area with a high proportion of crop raiding on potatoes.

Table 6.5 Spearman's rank correlations ($r_s$) between encounters with crop raiding incidents per species and per crop, per month by patrols around Bwindi from 1996 to 2000

| **Crop** | **Crop raiding species (n = 227)** | | | | | |
|---|---|---|---|---|---|---|
| | **Baboon** | **Black & White** | **Blue Monkey** | **L'Hoesti Monkey** | **Redtail Monkey** | **Elephant** |
| Banana | 0.31*** | 0.07 | -0.06 | -0.05 | 0.17* | -0.07 |
| Bean | 0.07 | 0.03 | 0.10 | -0.03 | -0.03 | 0.09 |
| Cassava | 0.16* | 0.13* | 0.03 | -0.01 | -0.06 | -0.04 |
| Irish potatoes | -0.15* | -0.08 | -0.07 | 0.13* | -0.08 | 0.20** |
| Maize | 0.06 | -0.05 | 0.04 | 0.09 | 0.10 | 0.06 |
| Millet | 0.26*** | 0.01 | -0.04 | -0.05 | 0.04 | -0.08 |
| Pea | -0.07 | 0.01 | 0.03 | 0.02 | -0.05 | 0.35*** |
| Sorghum | 0.05 | 0.02 | 0.06 | 0.19* | -0.01 | 0.03 |
| Sweet potatoes | -0.17* | 0.01 | 0.12 | 0.19* | 0.05 | 0.12 |

*$P < 0.05$, **$P < 0.01$, ***$P < 0.001$

The recce survey again confirms and supplements findings from the patrol data. Baboons, black and white colobus monkeys and l'Hoesti monkeys were sighted crop raiding around north sectors. Duikers were also sighted crop raiding around north sectors. Signs of crop raiding around north sectors were for chimpanzees and bushpigs, which were both of millet, and for monkeys, which were of sweet potatoes. In contrast, only l'Hoesti monkeys and baboons were sighted crop raiding around south sectors. Furthermore, the only signs of crop raiding around south sectors were of monkeys and elephants.

Dung containing crops around north sectors were of baboon, which were encountered in each north sector, and of other monkey species, which were encountered in sectors KK and LL. Dung containing crops around south sectors were of baboons, small carnivores and monkeys. Baboon dung was encountered around the centre (sectors AA and O) and west (sector GG), the dung of small carnivores was encountered around the centre (sector AA) and east (sectors D and B), and monkey dung was only encountered around the east (sector D). In both north and south sectors, baboon dung contained maize, millet and sorghum, whereas monkey dung only contained maize.

### 6.3.6 Patterns of crop raiding by wild animals

The three-way contingency table constructed for the log linear analysis with factors of area, season and crop raiding species comprised four categories for the crop raiding species. These were gorillas, elephants, baboons and other monkey species, which were black and white colobus monkeys, blue monkeys, l'Hoesti monkeys and red-tail monkeys. Crop raiding by chimpanzees, duikers and species of small carnivore were omitted because of the small number of encounters. Models of rainy and dry seasons and of farming seasons included the same significant terms in the final model. The results are presented for the model of rainy and dry seasons.

The final model exhibited a low deviance value ($G^2 = 22.73$; df = 13; $p > 0.05$) that did not significantly differ from the saturated model ($G^2 = 0.0$; df = 0) and was thus a more parsimonious model than the saturated model that explained the variance in the data. The final model contained the interaction term area*species, with the main effect of patrol days as a covariate. Interactions between patrol days, area and species on the number of crop raiding incidents were not significant. The chi square values for terms in the saturated model reveal the significance of the interaction and main effects of area and species (Table 6.6). The model therefore shows that the association between area of Bwindi and crop raiding species best explains encounters with crop raiding incidents around Bwindi. This indicates that patterns of crop raiding by wild animals are highly localised around Bwindi.

Table 6.6 Tests of partial associations for terms in the saturated model, by significance of the chi square value, of encounters with crop raiding incidents around Bwindi from 1996 to 2000

| Term | df | $\chi 2$ | Significance of $\chi 2$ |
|---|---|---|---|
| Area*season | 4 | 2.87 | NS |
| Area*species | 12 | 391.05 | < 0.001 |
| Season*species | 3 | 3.16 | NS |
| Area | 4 | 253.89 | < 0.001 |
| Season | 1 | 0.50 | NS |
| Species | 3 | 718.94 | < 0.001 |

### 6.3.7 Elephants

All encounters with crop raiding by elephants from 1996 to 2000 occurred around the south and east of Bwindi. There was no difference in mean encounters with crop raiding incidents involving elephant between these areas ($n = 89$; $z = -0.57$; $p > 0.05$). However, elephant raids were concentrated in certain locations. Around the south, most (86.7%) elephant raids were adjacent to sectors K and J. Around the east, elephant raids were only encountered adjacent to sectors A, B and C.

Most crop raiding incidents involving elephants occurred during October and November, and April and May, which are months of the rainy season (Figure 6.5). Mean$\pm$SE encounters with crop raiding incidents involving elephants were higher in the rainy season ($n = 46$; $0.09\pm0.03$SE) than in the dry season ($n = 43$; $0.02\pm0.001$) ($z = -2.48$; $p < 0.05$). Furthermore, elephant crop raiding encounters differed between months of the farming season ($\chi 2 = 6.02$; df = 2; $p < 0.05$). Most raids occurred during months of weeding ($n = 23$; $0.14\pm0.05$), which are in the rainy season, compared with a few raids during months of planting ($n = 30$; $0.04\pm0.01$) and harvesting ($n = 36$; $0.02\pm0.01$).

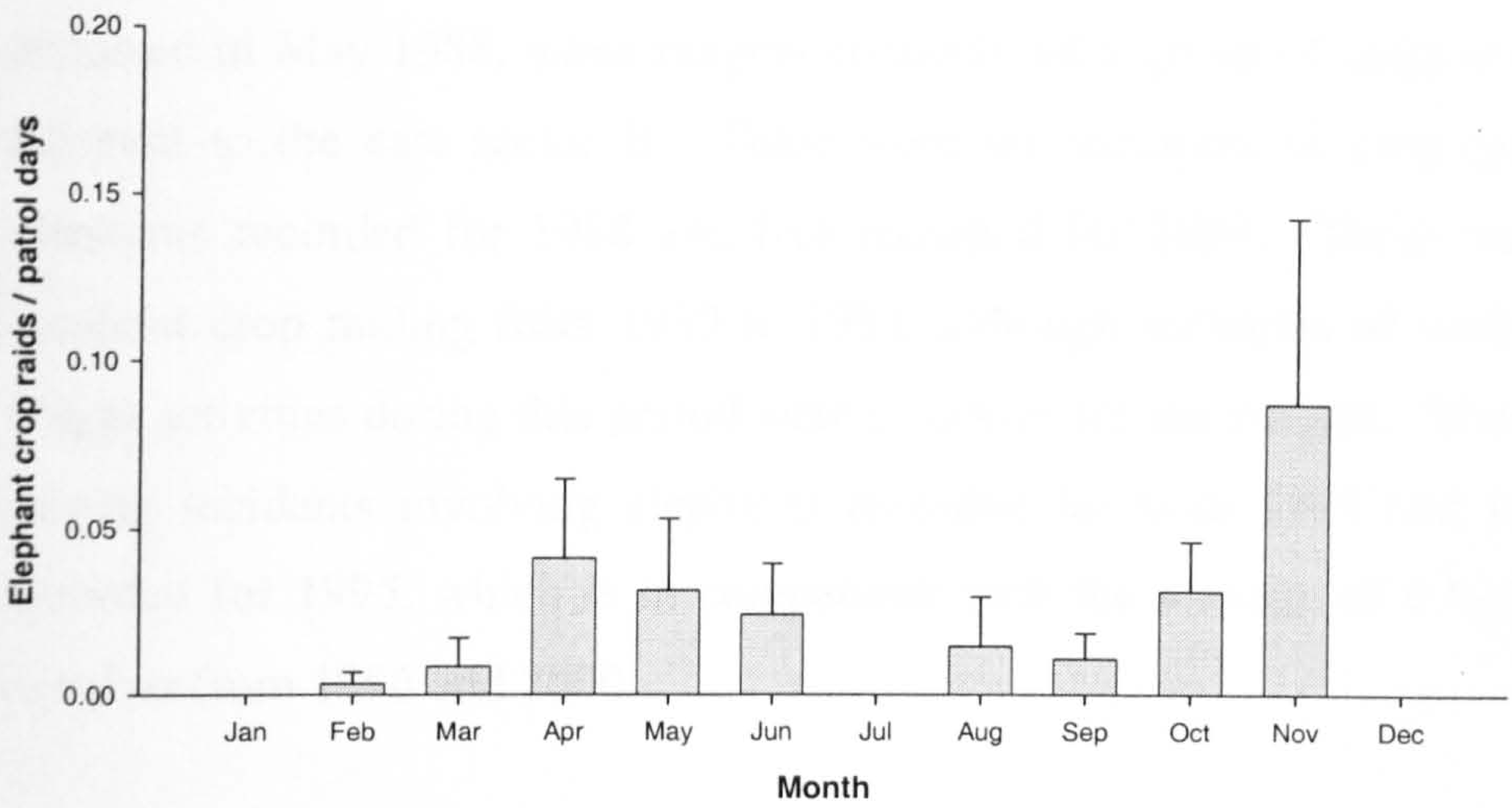


Figure 6.5 Mean±SE encounters with crop raiding incidents involving elephants around the south and east of Bwindi, per month by patrols from 1996 to 2000

The final regression model with months as farming seasons accepted patrol days and rejected area and farming season, and was a poor fit to the data (Nagelkerke R square = 0.10; AUC = 0.68). The final regression model with months as rainy and dry seasons included two variables that were, in order of entry, patrol days and season. The model was a good fit to the data (Nagelkerke R square = 0.18; AUC = 0.75) (Table 6.7). The model indicated that, accounting for the influence of the number of patrol days on encounters with crop raiding incidents involving elephants, months of the rainy and dry season was an important predictor of elephant crop raiding.

Table 6.7 Parameters of the stepwise multiple logistic regression model for the likelihood of encounters with crop raiding incidents involving elephants in south and east areas of Bwindi per month by patrols from 1996 to 2000

| Parameter | Coefficient (B) | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|
| Patrol days | 0.09 | 4.91 | 1 | < 0.05 |
| Rainy/dry season | 1.24 | 4.48 | 1 | < 0.05 |
| Constant | -2.90 | 19.56 | 1 | < 0.001 |

The first report from archival records of elephant crop raiding around Bwindi occurred in May 1988, when rangers encountered a group of elephants raiding fields adjacent to the east sector B. There were six incidents of crop raiding involving elephants recorded for 1988 and five recorded for 1989. There was no record of elephant crop raiding from 1989 to 1993, although incidents of violent conflict and illegal activities during this period were priorities for the rangers. There were 20 crop raiding incidents involving elephants recorded for both 1993 and for 1994, and 8 recorded for 1995, which is in comparison with the average of $6.8 \pm 2.2$SE incidents per year from 1996 and 2000.

The archival records confirm the patrol data. All crop raiding incidents involving elephants from 1988 to 1995 occurred around the south and east of Bwindi. Most (61.0%) elephant raids occurred around the east. Around the east, elephant raids were concentrated in the parishes of Kitojo (50.0%) and Nyamabare (30.6%), and also occurred within Kashasha (16.7%) and Mushanje parishes (2.8%). In contrast, around the south, most elephant raids occurred in the Rushaga area (69.6%), which covers sectors P, K and J. The archival records also showed that most (66.1%) elephant raids occurred during the rainy season.

Most (61.0%) crop raiding incidents were undertaken by a group of elephants. An association was evident between crop raiding by different social groups of elephants around Bwindi (Pearson's $\chi 2 = 30.16$; df = 1; $p < 0.001$). Single elephants were responsible for most (82.6%) raids around the south, whereas a group of elephants mostly (88.9%) undertook raids around the east (Table 6.8). Thus, the archival records confirms findings from the patrol data of highly localised elephant crop-raiding, and also show that farmers around the south mainly experience crop raiding by a single elephant, whereas farmers around the east, particularly farmers of Kitojo and Nyamabare parishes, experience crop raiding by a group of elephants.

Table 6.8 Encounters with crop raiding incidents involving a single and a group of elephants in the south and east areas of Bwindi, from archival records 1986 to 2000

| **Crop raiding by elephants** | **Area of Bwindi (%)** | |
|---|---|---|
| | **South** | **East** |
| **Single (n = 23)** | 82.6 | 17.4 |
| **Group (n = 36)** | 11.1 | 88.9 |

## 6.3.8 Gorillas

Archival records from 1986 to 2000 included 33 crop raiding incidents involving gorillas. The first incident was in 1989. The annual number of incidents ranged from a minimum of one to a maximum of six, with an average of 3.30+0.6SE incidents per year. Most (72.7%) incidents involved a group of gorillas. The longest incident was 19 days, over which a group of gorillas raided crops around the centre of Bwindi during September 1998. Other incidents lasted 3 days for a gorilla group around the centre during August 1997, 4 days for a gorilla group around the southwest during October 1999, 2 days for a single gorilla around the southwest during October 2000, and one day for both encounters of a group of gorillas on the south National Park boundary during May and June 1997.

Most gorilla crop raiding incidents occurred around the southwest and west of Bwindi (Figure 6.6). Gorilla raids also occurred around the south, centre and east. Most incidents within each area involved a group of gorillas, apart from the east where all incidents were undertaken by a single gorilla.

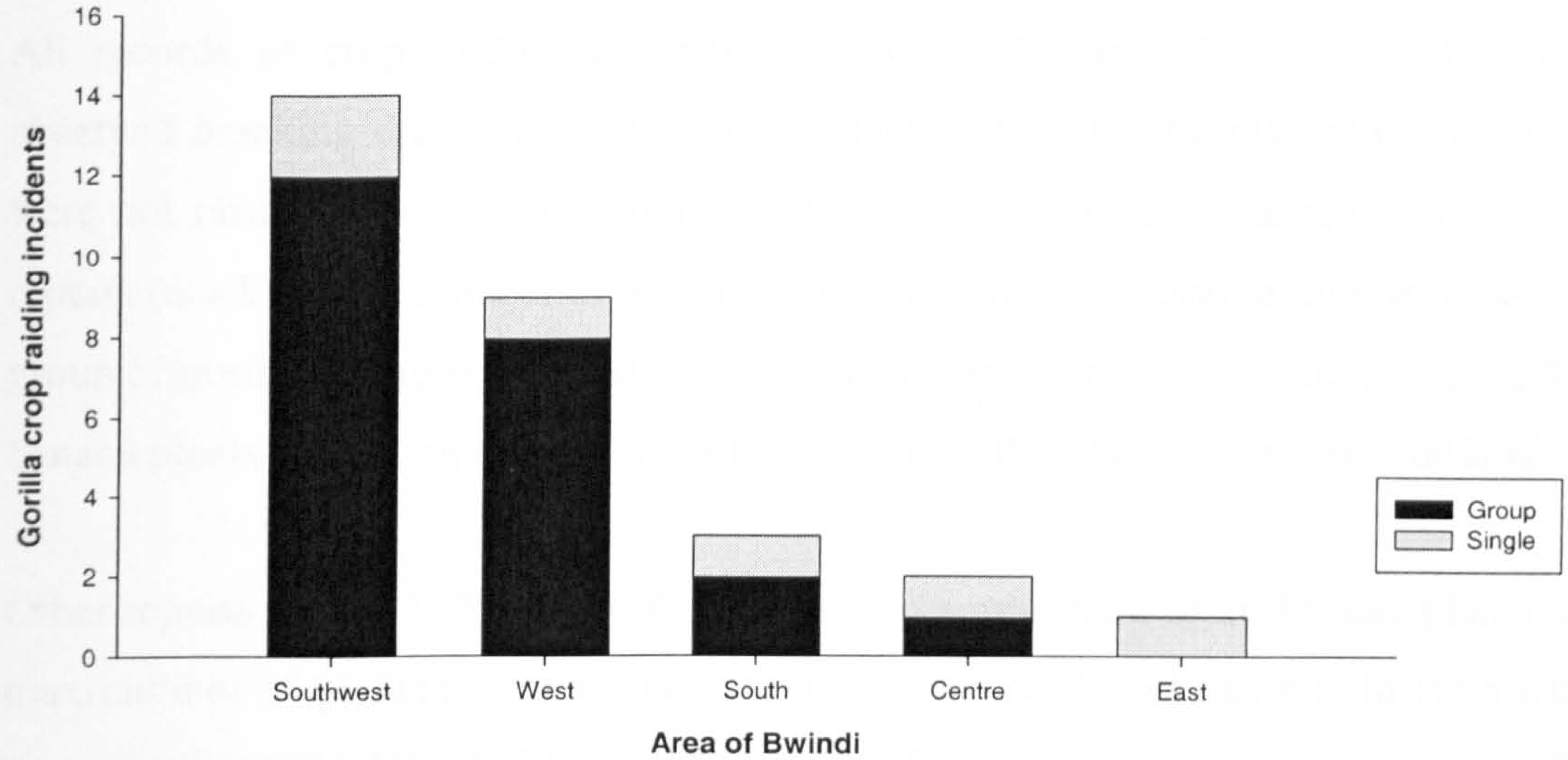


Figure 6.6 Gorilla crop raiding incidents by a group of gorillas and by a single gorilla around areas of Bwindi, from archival records 1986 to 2000

Gorilla crop raiding occurred throughout the year, with the exception of December, and with a peak during August and high levels during February and June (Figure 6.7). The level of gorilla raids was slightly higher in months of the dry season (54.5%) than months of the rainy season (45.5%). Crop raiding by a single gorilla only occurred in the latter months of the year, from May to November. Most (62.5%) raids by a single gorilla occurred during June, July and August, which are months or the dry and harvest season.

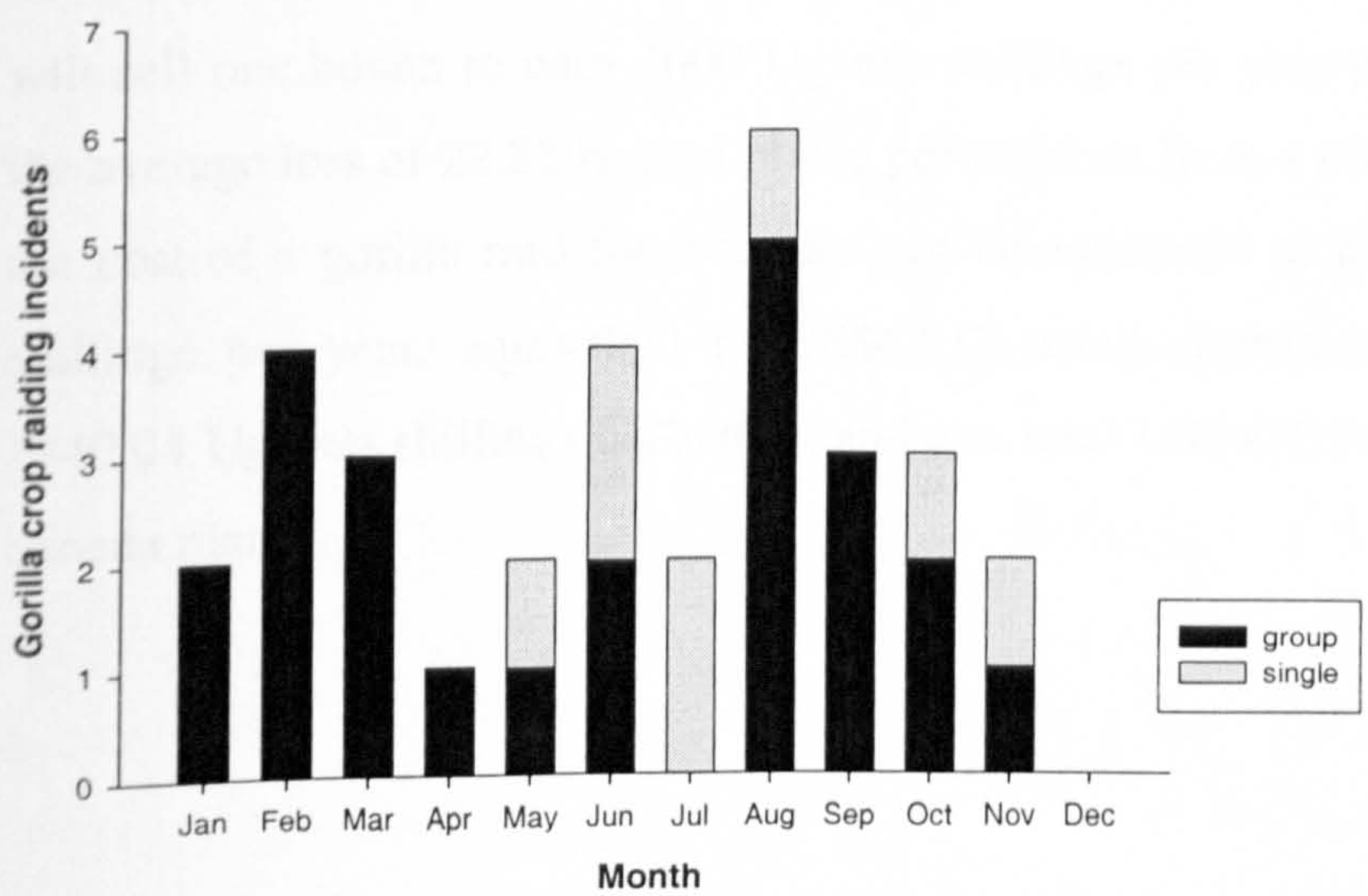


Figure 6.7 Gorilla crop raiding incidents by a group of gorillas and by a single gorilla per month at Bwindi, from law enforcement records 1986 to 2000

### 6.3.8.1 Crop damage

All records of crop raiding by gorillas involved banana plants. Gorillas were observed breaking the stem of the banana plant to feed on the pith of the stem and were not observed consuming the fruit of the plant. The archival records included reports (n = 8) on the number of banana plants destroyed per crop raiding incident of a group of gorillas. The first report, in 1992, documented that two gorillas damaged 17 banana plants belonging to one farmer in Kahurire village in the southwest of Bwindi.

Other reports during 1995 and 1996 ranged from a minimum of 16 banana plants to a maximum of 35 plants lost to one farmer, with the exception of one raid in 1995 when a group of gorillas damaged 106 banana plants of one farmer from the southwest. The mean+SE banana plants lost per farmer was 22.88+0.5. The maximum number of farmers affected per raid was three and between two and three farmers were affected for the majority of gorilla raids (72%). There was one report of an injury from an incident of gorilla crop raiding, which was in July 1997, when one man was injured by a single gorilla crop raiding around the west.

The banana plants (*Musa* spp.) of the Bwindi region produce an average of two bunches of green bananas per year, of which households will typically consume one bunch and sell the other, and can flower for up to ten years (Bagiri oral communication). In 2000, the market price for a medium-sized bunch of bananas was 4000 Uganda shillings (personal observation). Therefore, I assume that a household will sell one bunch to earn 4000 Uganda shillings per year per banana plant. Using the average loss of 22.88 banana plants per incident from a raid by a group of gorillas, the cost of a gorilla raid for a farmer can be estimated at a total of 91,520 Uganda shillings per year, equivalent to US$47.17 using current exchange rates (US$1 : 1940.04 Uganda shillings 01/01/04), and at a total US$471.74 for the ten years of the banana plant.

## 6.4 Discussion

Addressing human-wildlife conflict issues is a priority for managers of protected areas (Bridgewater, 2003). Conservation managers therefore require information on crop raiding activities of wild animals, yet undertaking the research necessary to gather this information places an extra burden on the resources available for conservation, which are particularly limited within tropical countries (Leader-Williams and Albon, 1988). This chapter demonstrates the use of data routinely collected by law enforcement rangers patrolling the boundary of a National Park to examine crop raiding. Law enforcement data have been shown to be a useful and sensitive measure of wildlife abundance (e.g. Bell, 1986; Leader-Williams, Albon and Berry, 1990; Jachmann and Billiouw, 1997). The principles employed for such an analysis, namely converting counts per patrol into an encounter rate that accounts for patrol effort, were adopted here to assess levels of crop raiding, with confidence permitted in the data from comparison with fieldwork surveys.

This chapter is the first comparative assessment of crop raiding by wild animals around Bwindi in fields adjacent to the National Park boundary. The analysis showed that crop raiding patterns are highly localised around Bwindi, as an association between area and crop raiding species best explained variation in the level of crop raiding. The crop raiding patterns were namely that farmers around north and centre experienced most crop raiding, which occurred throughout the year and mainly by baboons. Farmers around the south and east also experienced crop raiding by monkeys throughout the year, although most raids were by l'Hoesti and blue monkeys. Furthermore, crop raiding by elephants occurred during the rainy season in certain locations within the south and east areas. Monkeys, particularly baboons, raided crops around the west while crop raiding by gorillas mainly occurred around the southwest. This information is useful for the design of mitigation measures, and such differences in crop raiding between areas shows that managers of Bwindi must adopt specific mitigation measures for each species, in particular for monkeys, elephants and gorillas. This information is also useful to determine economic costs of crop raiding for different communities neighbouring Bwindi, which is an important area for research, particularly the implications of varying economic crop loss between different seasons.

### 6.4.1 Monkeys

Crop raiding by monkeys around Bwindi is documented in the archival records. A vermin guard was employed to mitigate crop raiding by monkeys when the forest was under management of the Game Department (Butynski, 1984). Furthermore, during the period of gazettement, in 1992, the Game Warden of the Bwindi region reported to the Chief Game Warden that all parishes surrounding Bwindi had complained about vermin monkeys.

From the patrol data from 1996 to 2000, patterns of crop raiding by monkeys showed that all monkeys raided crops throughout the year with limited seasonal variation in the level of crop raiding, as shown elsewhere (Naughton-Treves *et al*, 1998). However, there were differences between baboons and other species of monkeys in the level of crop raiding, and in the area and crops consumed. Most crop raiding incidents at Bwindi involved baboons. Rangers on patrol encountered baboons raiding crops around all areas, although most encounters occurred the north, centre and west. In the east, baboon crop raiding was concentrated around sector I, which borders the centre area where baboons were frequently encountered raiding crops. Other species of monkeys were also encountered raiding crops around Bwindi. Most raids by black and white colobus and red-tail monkeys occurred around the north, centre and west, while most raids by l'Hoesti and blue monkeys occurred around the south and east.

Such geographical patterns of wild animals foraging within community land have been associated with different crop preferences, which previous research on monkeys has demonstrated (Naughton-Treves *et al*, 1998; Siex and Struhsaker, 1999; Hill, 2000). Associations between monkey species and crops at Bwindi were evident from the analysis. Baboons were associated with millet and bananas, which are important food crops and as a source of locally derived income, l'Hoesti monkeys were associated with sorghum, which is a major food crop, and colobus monkeys were associated with the food crop cassava (Tukahirwa and Pomeroy, 1993). However, whether these associations reflect crop preference or differences in farming practices is difficult to determine, as a variety of crop types are planted around Bwindi (Tukahirwa and Pomeroy, 1993). Recording crop type during recce walks would have enabled analysis of raiding rate per km of crop to determine whether associations were stronger with area or crop type, and this remains a possibility for further research. Nonetheless, the patrol data and recce survey do show that baboons consume a greater variety of crops than other species that include the major food crops of sorghum, millet and maize, as well as cash crops of tea, coffee and pineapples. Furthermore, baboons were the only species observed raiding livestock both by rangers and during fieldwork. These results regarding baboons support previous findings on the association between baboons and banana plants, and on the variety of crops consumed by baboons (Naughton-Treves *et al*, 1998).

The patterns of crop raiding by monkeys at Bwindi have implications for the selection of mitigation measures. First, the measures need to be in place permanently throughout the year. Thus a structure, such as a fence or other type of barrier, would be appropriate. Second, planting of non-edible crops, such as tea or coffee, along the National Park boundary to protect food crops is unlikely to be effective against baboons, but could reduce the activities of other monkey species. Also in areas of baboon activity, it is important that farmers protect livestock, in particular hens and piglets. Appropriate mitigation could, for example, involve constructing pens that effectively safeguard domestic animals from baboons. Scare-shooting is currently employed at Bwindi to reduce crop damage by monkeys, although this measure is only temporarily effective and park wardens are considering an alternative measure for baboons of shooting (Mutebi, oral commuication). Shooting was employed by the Game Department for controlling monkeys around Bwindi, and is currently used in other regions of Uganda. From April to September 2003, the vermin control officer of the western Kamwenge district oversaw the killing of 103 baboons, which were shot with the permission of the Uganda Wildlife Authority (Kasanga, 2003). However, shooting wild animals classed as vermin is controversial and the effectiveness of this measure as a mitigation strategy has yet to be determined (Hill, Osborn and Plumptre, 2002). An alternative use of the conservation funds available for mitigation is to employ local villagers as vermin guards. This measure has several advantages for conservation managers. Firstly, communities receive immediate relief from the crop raiding activities of wild animals. Secondly, vermin guards relieve the local cost of crop raiding in the time spent guarding fields. This is significant for the local communities around Bwindi, as children commonly guard the fields and consequently miss schooling or assisting with other household activities, such as water collection, which places an extra burden on other members of the family (Mwesigye, 1996; Musaasizi, 2000).

A further advantage for conservation managers of employing vermin guards is the potential for improving their relations with local communities by mitigating crop raiding, and by providing a community benefit in the form of employment. Employment is a key benefit for securing good park-community relations (Alexander, 2000; Wunder, 2000) and is particularly important at Bwindi where the loss of employment because of gazettement was a significant cause of conflict when the forest was designated a National Park (Chapter 3).

### 6.4.2 Elephants

The distinct patterns of elephant crop raiding at Bwindi, as shown by this chapter, are similar to patterns observed elsewhere in Africa. The analysis revealed that months of the rainy and dry seasons were the most significant predictor of elephant crop raiding activities, and that elephants were most active during November, which is the end of the rainy season. Previous research on temporal patterns of elephant crop raiding has also shown that most crop damage occurs during the rainy season, with peak levels towards the end of the rains (Bell, 1984; Barnes *et al*, 1995; Hoare, 1995; Smith *el al*, 1995; Lahm, 1996). In addition to season, location was important, as crop raiding by elephants only occurred around the south and east of Bwindi. Localised elephant activity within community land has been previously demonstrated (Bell, 1984; Smith *et al*, 1995; Lahm, 1996; Sitati *et al*, 2003) and has been linked with migration routes and historic foraging areas (Bell, 1984; Hoare, 1995). In Bwindi, the elephants' preference for Mubwindi swamp in the south-east interior and for the bamboo forest in the east boundary area has been related to the seasonal production of their food plants (Babassa, 2000).

Crop raiding incidents involving elephants occurred directly south of Mubwindi swamp in the south and adjacent to the bamboo forest in the east, and thus the elephants could simply be extending their range into community land. Elephant movements could also be related to seasonal crop production, particularly of Irish potatoes and peas, which were significantly associated with crop raiding incidents involving elephants. Elephant foraging activities have been associated with the flowering and ripening of crops (Tchamba and Seme 1993), and with particular crop types including sweet potatoes and bananas (Bell, 1984; Smith *el al*, 1995; Nyhus *et al*, 2000; Ilukol, 2002). However, elephants consume a variety of crops (Parker and Graham, 1989) and the associations evident at Bwindi could reflect the produce that is cultivated around the south and east, rather than the preference of the elephants for particular plants.

The analysis provided insight into the spatial distribution patterns of elephants, as associations were identified between single elephants and south areas, and between elephant groups, which accounted for the majority of the crop raiding incidents, with east areas. However, investigation of the factors underlying these associations, including the area of cultivation (Sitati *et al*, 2003) and vegetation type along the National Park border (Nyhus *et al*, 2000), could not be undertaken from the patrol data. Nonetheless, the patrol data provide other information of interest. The majority of crop raiding incidents occurred either during late evening or early morning, and rangers sent to guard crops often spend the night chasing elephants back to the forest by scare-shooting. Furthermore, there were no records of human deaths or injuries caused by elephants from 1986 to 2000. This finding is similar to a study at Kibale Forest National Park, which is in western Uganda approximately 300km north of Bwindi, (Ilukol, 2002), although it differs from the results of other elephant studies, for example Indonesia (Nyhus *et al*, 2000) and Kenya (Sitati *et al*, 2003).

Scare-shooting is currently employed by rangers to control elephant crop raiding at Bwindi, although the measure is only temporarily effective (Osborn and Parker, 2003) and, at Bwindi, not conducted on a systematic basis (personal observation). The results of this chapter provide information for managers of Bwindi to target scare-shooting for a more efficient use of rangers and ammunition, and also to consider alternatives that could be more effective. Various measures have been proposed for reducing crop depredation by elephants, including non-lethal repellents, buffer zones of non-edible plants and fencing (Osborn, 2002; Osborn and Parker, 2003), and such measures would enable the issue of human-elephant conflict to be addressed without placing heavy demands on the National Park's law enforcement resources.

### 6.4.3 Gorillas

Understanding patterns of crop raiding is important for the conservation of gorillas. Crop raiding has increased contact between gorillas and the communities surrounding Bwindi and this has increased the risk of disease transmission between gorillas and the local human population (Guerrera *et al*, 2003). Disease is a major threat to the survival of the great apes (Walsh *et al*, 2003) and the situation at Bwindi is a particular concern because of the high level of disease within the densely populated rural communities that neighbour the forest (Guerrera *et al*, 2003), and because disease transmission between gorillas and humans has occurred. Two recent outbreaks of the *Sarcoptes scabiei* infection in the gorilla population were both attributed to contact between gorillas and villagers (Kalema-Zikusoka *et al*, 2002; Kalema-Zikusoka, oral communication). In addition to increasing the risk of disease, a further threat to the gorilla population is conflict between local communities and conservation managers, as conflict that arises from crop raiding can negatively impact upon local support for conservation (Infield, 1988; Newmark *et al*, 1993; Hill, 1999). Fear of gorillas by local communities is an important factor of human-gorilla conflict at Bwindi (Namara, 2000) in addition to loss of banana plants, as banana plants are an important food crop and source of local income (Tukahirwa and Pomeroy, 1993).

However, despite the importance for conservation, limited information is available on crop raiding patterns of gorillas. Since Bwindi was gazetted a National Park, gorilla raids have been noted to have occurred more often around Bwindi than the Virungas, where it seems to be incidental (Mudakikwa *et al*, 2001). At Bwindi, local communities claim that gorillas have only left the forest to forage within community land since the 1970s, and that crop raiding has increased since gazettement because gorillas habituated for tourism no longer fear human presence (Namara, 2000). An increase in gorilla raids at Bwindi has been noted, particularly around the southwest area (Guerrera *et al*, 2003), and this has led to the implementation of the Human-Gorilla Conflict Force to mitigate crop raiding by gorillas (Makombo, 2003). Thus, current perceptions at Bwindi are that the level of crop raiding by gorillas has increased in recent years.

Schaller (1964) observed mountain gorillas foraging in abandoned agricultural fields during his visit to Rwanda, the Congo and Uganda in 1959. He commented that the shifting cultivation practice of rural farmers created patterns of forest generation suitable for gorillas, as the secondary growth vegetation at these sites consists of several gorilla food plants. Schaller also observed gorillas feeding on banana plants, described how gorillas destroy the plant by feeding on the pith of the stem, and commented that although gorilla nests were seen close to human habituation, gorillas avoided contact with humans whenever they could do so. His observations indicate that crop raiding by gorillas is not a new phenomenon and this is confirmed by historical records of Bwindi.

The first evidence of gorilla crop raiding around Bwindi is a letter, written during the 1930s, by a prospector working in the Impenetrable Forest to the Chief Game Warden. The prospector described his encounters with gorillas and made the following observation *"the gorillas sometimes raid nearby shambas, but I have never heard of them attacking the natives, and the natives leave them alone except to chase them away from their property"* (Uganda Game Department Archives, 1923-1994:1933). Further evidence comes from a report by a game warden of his visit to Bwindi, in 1933, which was then the newly established reserve of Kayonsa *"the Kayonsa gorilla, apparently, is not guilty of frequent shamba-raiding, at least so the natives reassure me. It is true that the gorillas often feed in the vicinity of crops but the attraction is usually the occurrence of various nourishing weeds of exceptional growth which are found on the abandoned cultivated patches"* (Uganda Game Department Archives, 1923-1994:1933).

No further data on crop raiding by the Bwindi gorillas were found from historical records. My analysis based on law enforcement reports from 1986 to 2000 covered the period of gazettement. The first record of gorilla crop raiding during this period was in May 1989, and concerned a single gorilla raiding banana plantations in the west Buhoma area. The following month, the village chief of Buhoma wrote to the game warden to report that a single gorilla was found dead in a banana shamba. Only one other record exists prior to gazettement. In November 1989, rangers reported that a group of six gorillas stayed in community land around Murole village, in the southwest Nteko area, for a month yet did not consume any crops. There was no record of gorilla crop raiding in the law enforcement reports from November 1989 to January 1992, although during this time, incidents of violent conflict (Chapter 3) and illegal activity (Chapter 4) would have been a priority for rangers. Nonetheless, the records of 1989 and 1992-2000 revealed patterns of gorilla crop raiding in the type of raid, area of Bwindi and seasonal variation.

Most crop raiding incidents were undertaken by groups of gorillas, and the highest number of incidents occurred in the southwest and west. There are approximately 28 gorilla groups in Bwindi (McNeilage *et al*, 2001) and groups living within different areas of the forest eat different foods. A recent study found that gorillas at low elevation sites in west areas consume more plant species and a greater number of fruit species than the high altitude groups of the east. This dietary variation was largely attributed to differences in fruit availability and plant species between sites.

The study also found differences in the diet of groups with overlapping home ranges, which was considered partly a result of group traditions (Ganas *et al*, in press). Gorilla crop raiding around the southwest and west could therefore reflect dietary variation within the Bwindi gorilla population and differences between sites in food availability. The crop raiding could also indicate that gorilla groups exhibit different crop raiding tendencies, with groups around the southwest and west more prone to crop raid than groups around other areas. Understanding why these gorillas crop raid more frequently than other groups requires detailed investigation of the factors underlying gorilla crop raiding patterns. For example, there is a possibility that certain groups have become accustomed to foraging on banana plantations and that crop raiding is mainly undertaken by the same gorillas. Habitual problem animals have been noted among elephants (Hoare, 1995, Maisels *et al*, 2002) and this is an area of gorilla crop raiding that requires investigation.

Crop raiding by gorillas also occurred around other areas of Bwindi. Around the centre, three incidents of gorilla crop raiding were recorded in community land adjacent to sectors AA and FF, and were by a single gorilla in June 1996, by a group in August 1997 and by a group in September 1998. The one incident recorded around the east involved a single gorilla in community land adjacent to sectors D and I in July 1995. The first report of gorilla crop raiding around the south concerned a group of gorillas raiding banana plantations in January 1993. The other two reports from the south were from rangers patrolling sectors K, P and U, during May and June 1997, and both were encounters of a group of gorillas on the National Park boundary, which then returned to the forest.

The small number of incidents involving gorillas did not allow seasonal patterns to emerge, although crop raiding was recorded throughout the year except in December, and there were several incidents during August. The greatest number of gorilla crop raiding incidents during a single year, which was six, and the average of three incidents per year, indicate gorillas raid crops less frequently than baboons (maximum 115 crop raiding incidents during a single year, mean±SE 67.20±12.9, from 1996 to 2000) and elephants (maximum 14 crop raiding incidents during a single year, mean±SE 8.80±2.5, from 1996 to 2000). On average, only two to three farmers were affected during a gorilla raid. However, these farmers experience high crop and financial losses, as gorillas destroy the banana plant by feeding on the pith of the stem. Therefore, problems associated with crop depredation by gorillas appear similar to those identified for elephants (Hill, Osborn and Plumptre, 2002), which affect only a small number of farmers but with high costs for the affected farmers. Although bananas were the only crop that rangers recorded as consumed by gorillas, gorillas forage on other vegetation within community land including agricultural weeds and the bark of eucalyptus trees (personal observation).

Change in numbers of gorilla crop raiding incidents over the period of gazettement could not be determined from the patrol data. It has been suggested that there has been an increase in recent years (Mudakikwa *et al*, 2001; Guerrera *et al*, 2003), and there is debate as to whether this increase has been influenced by the process of habituation (McNeilage, oral communication). However, such an increase in gorilla crop raiding could reflect the effort invested in their conservation. The high level of illegal resource extraction within the forest periphery prior to the gazettement of Bwindi, is considered primarily responsible for the distribution of the gorillas in the forest interior (Harcourt, 1981; Butynski, 1984; McNeilage *et al*, 2001). Furthermore, gorilla poaching, involving the capture of infants for sale and the hunting of adults for trophies, occurred during this time (Butynski, 1984). Effective law enforcement since gazettement has reduced the level of illegal activity in the National Park and increased protection of the gorillas (McNeilage *et al*, 2001). An increase in crop raiding following protection from hunting has previously been noted for elephants (Walpole *et al*, 2003), and the reduction in both human disturbance and poaching pressure on the gorilla population may have contributed to the recent increase in crop raiding activity.

Therefore, this chapter is the first assessment of crop raiding by the Bwindi gorillas. The analysis reveals that, contrary to current perceptions, gorilla crop raiding around Bwindi is not a new phenomenon. Furthermore, the patterns of gorilla crop raiding identified by this chapter, although partly anecdotal, are important given the conservation status of mountain gorillas and the present lack of data on this aspect of human-wildlife conflict. Nevertheless, additional research is necessary to confirm these patterns, and to test hypotheses regarding the geographical distribution of gorilla crop raiding.

### 6.4.4 Summary

In summary, this chapter illustrates that patterns of crop raiding by wild animals observed during daylight hours and in fields adjacent to the National Park boundary, are highly localised around Bwindi. Thus managers of Bwindi must adopt specific mitigation measures that are appropriate for the different crop raiding species in each area. The primary goal for conservation managers addressing human-wildlife conflict is to secure long-term conservation by enlisting local support for protected areas. There are therefore two important factors for managers to consider, which are addressed in the following chapters. Firstly, impacts of problem animal control on the attitude of local communities regarding crop raiding (Chapter 7). Secondly, impacts of crop raiding on the response of local communities to rangers on law enforcement patrol (Chapter 8).

Having established patterns of crop raiding by wild animals around Bwindi, I now seek to determine problem animal control by law enforcement rangers, and interactions between rangers and local communities that regard crop raiding.

# Chapter Seven

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# Problem Animal Control and the Response of Local Communities

*Boundary between Bwindi and community land*

*(J. Baker)*

# Chapter Seven

# 7 Problem animal control and the response of local communities

## 7.1 Introduction

Managers of protected areas are increasingly adopting strategies to mitigate the crop raiding activities of wild animals, and so improve attitudes to conservation among rural communities neighbouring protected areas (Osborn and Parker, 2003). Various mitigation methods have been developed that include scaring animals away from crops, such as the scare-shooting tactics commonly employed for elephants, and establishing barriers, for example, by planting a field of non-edible crops. Compensation is also a possible means for managers to address human-wildlife conflict. The success or otherwise of compensation schemes to reduce local costs of crop raiding (Madhusudan, 2003) and the effectiveness of mitigation methods in preventing wild animals from raiding crops (Thouless and Sakwa, 1995; Osborn, 2002; Osborn and Parker, 2003) have been evaluated. In comparison, few studies have examined how mitigation efforts by conservation authorities influence their relations with local communities. One such study notes that local attitudes may change in favour of wildlife and protected areas if the communities are convinced that efforts are being made to deal with crop raiding animals (Infield and Namara, 2001). Therefore, although the influence of human-wildlife conflict on local attitudes towards conservation has been examined (Newmark *et al*, 1993; Infield, 1998), there are few assessments on the impact of mitigation strategies on relations between conservation managers and local communities.

Vermin control by government authorities began shortly after Uganda was declared a Protectorate of the British Empire. In 1926, the colonial government established a Game Department to control crop depredation by elephants (Uganda Game Department Archives, 1923-1994:1926). Elephant culls were undertaken throughout the country and vermin guards were stationed at game reserves to protect the crops of rural communities from elephants and other wildlife species (Uganda Game Department Archives, 1923-1994:1930). Rural farmers continued to receive assistance with vermin control until the 1980s, when the operations of the Game Department were restricted by the civil war (Uganda Game Department Archives, 1923-1994:1980).

One vermin guard was stationed at Bwindi when the forest was under joint management of the Game and Forest Departments (Butynski, 1984), although staff of both departments regularly assisted farmers by scare-shooting when wild animals foraged within agricultural land. Game guards, in particular, would respond when large animals, such as elephants, entered community land, and the guards would also kill smaller animals that frequently raided crop and livestock, including baboons and bushpigs (Namara, 2000). Vermin control remained a duty of the rangers after Bwindi was designated a National Park. Rangers employ scare shooting for elephants and monkeys, and chase gorillas and duikers into the forest by shouting and beating drums. Farmers often request assistance when rangers pass their fields while patrolling the National Park boundary, and some farmers will travel to the outpost to request assistance. However, problem animal control is a secondary duty for the rangers after law enforcement, and the ranger in charge of each outpost will decide on a day-to-day basis whether or not to assist the farmers.

The aims of this chapter are two-fold. The first is to examine problem animal control by law enforcement rangers at Bwindi, and the second is to examine interactions between local communities and rangers on law enforcement patrol that regarded crop raiding. The objectives are to determine the factors that best explain problem animal control, and the factors that best explain the ranger-community interactions. To address the objectives, I seek to determine the following research questions:

- In which area of Bwindi did rangers undertake problem animal control?
- Was the distribution of problem animal control related to species?
- Were differences in problem animal control related to year or season?
- What is the relative significance of year, season, area of Bwindi and species to problem animal control?
- What types of interactions regarding crop raiding occurred between rangers and local communities?
- In which areas did communities complain about crop raiding to rangers?

- Were there differences between complaints about crop raiding species and actual crop raiding?
- Were there differences between complaints about crop damage and actual crop damage?
- Were complaints about crop raiding related to incidents of crop raiding?
- Were complaints about crop raiding related to incidents of problem animal control?
- What is the relative significance of year, season, area of Bwindi, incidents of crop raiding and incidents of problem animal control to community complaints about crop raiding to rangers?

## 7.2 Materials and Methods

### 7.2.1 Problem animal control

#### 7.2.1.1 Data collection

The operations of law enforcement patrols in Bwindi, the rangers' patrol reports and the retrieval and means of verifying the patrol reports, were described in Chapter 2. From 1996, in addition to recording sightings of wild animals raiding crops in fields adjacent to the National Park boundary when patrolling the boundary for illegal activities, rangers recorded incidents of problem animal control. These incidents were undertaken by rangers and involved scare shooting and chasing animals back to the National Park. Rangers also recorded year, month, number of rangers on patrol, number of effective patrol days, type of patrol whether long or day patrol, and area toponym(s), which were assigned to the corresponding sector or sectors within the different areas of Bwindi (north, centre, east, south and west) (section 2.2.1.3).

Data were extracted from records of law enforcement patrols along the National Park boundary using only patrols where rangers encountered crop raiding incidents. These records comprised 1743 patrol days carried out from 1996 to 2000. The number of crop raiding incidents encountered and the number of incidents of problem animal control per patrol day was summed for the north, centre, east, south and west of

Bwindi, per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol in each area were included for analysis (1996-2000 monthly totals across all areas; n = 198). This chapter therefore employs a subset of the data presented in Chapter 6 and extends the analysis of Chapter 6 by including incidents of problem animal control.

To verify incidents of problem animal control and to check for missing data, a comparison was undertaken between patrol reports and ammunition records kept by the Head Ranger (section 2.2.1) of records of problem animal control. There were no extra records in the ammunition records although information regarding crop raiding species, which were missing from a few of the patrol reports (37% of the patrol reports), was gained from the ammunition records.

Farmers neighbouring Bwindi visit the rangers' outposts to request rangers for assistance with scaring crop raiding wild animals. Such visits tend to be when wild animals are crop raiding and, at times, rangers do respond by conducting a patrol to investigate (personal observation). Records of patrols conducted at the request of farmers for assistance with scaring crop raiding wild animals were not consistent and these patrols were omitted from any analysis. Patrols were also omitted when the objective of the patrol, for example law enforcement or mitigation, was not clear to avoid the possibility of including patrols that were specifically conducted for mitigation. Only patrols conducted for law enforcement were included and therefore, the analysis was based only on incidents when rangers encountered crop raiding while patrolling the National Park boundary.

Archival records (section 2.2.2) were employed to describe the historical context of problem animal control in Bwindi before 1996, by non-quantitative analysis because the records were not consistently recorded.

#### 7.2.1.2 Data analysis

The first stage of the analysis was to adjust incidents of problem animal control by an appropriate variable of patrol effort into a "catch per unit effort" index (Bell, 1986) (see methods described in section 4.2). A Spearman's rank correlation showed no relationship between incidents of problem animal control and patrol days ($r_2 = 0.14$; $p > 0.05$). Hence, the number of problem animal control incidents was expressed as a proportion of the total number of crop raiding incidents. This formed the dependent variable for the analysis, which were undertaken using non-parametric tests that included Kruskal-Wallis and Mann Whitney U.

The first analysis aimed to conduct univariate tests to examine possible differences in problem animal control between areas of Bwindi, years, seasons and crop raiding species. Comparisons were undertaken of the mean proportion of crop raiding incidents with problem animal control between areas of Bwindi, years from 1996 to 2000, months of the year, months of the rainy and dry seasons (Chapter 2) and months of the farming season (Chapter 6). Spearman's rank correlations were then undertaken between crop raiding incidents involving gorillas, elephants, duikers, baboons and other monkey species, and the proportion of incidents with problem animal control. Incidents of problem animal control for each crop raiding species in areas of Bwindi were also examined.

The second analysis aimed to identify which factors best explained the likelihood of rangers undertaking problem animal control on law enforcement patrol in Bwindi. The number of problem animal control incidents per month was converted into binary data comprising months with (1996-2000 monthly totals; $n = 33$) and months without (1996-2000 monthly totals; $n = 84$) an incident. This formed the dependent variable in a stepwise logistic regression analysis, using the forward stepwise procedure. The explanatory variables were area of Bwindi, year, season and crop raiding incidents involving gorillas, elephants, duikers, baboons and other monkey species. Areas and seasons were entered in the regression model as categorical variables (section 2.2.3.2).

## 7.2.2 Community response on crop raiding

### 7.2.2.1 Data collection

The operations of law enforcement patrols in Bwindi, the rangers' patrol reports and the retrieval and means of verifying the patrol reports, were described in Chapter 2. From 1996, rangers recorded interactions with, and observations of, members of local communities in their patrol reports. These records came under the heading of community response and consisted of descriptive notes detailing conversations with community members, and general observations made by the rangers on the attitude of local communities towards the National Park. Such interactions occurred when rangers patrolled the National Park boundary, or when the rangers returned to their outpost along the boundary after patrolling inside the National Park. Thus the interactions were between rangers and communities neighbouring Bwindi. The communities would either communicate directly with rangers, or would request the rangers to forward their comments to National Park officials.

Data were extracted from records of law enforcement patrols along the National Park boundary with descriptive notes on community responses. These records comprised 1288 patrol days carried out from 1996 to 2000. The number of community responses on crop raiding per patrol day was summed for the north, centre, east, south and west of Bwindi, per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol in each area were included for analysis (1996-2000 monthly totals across all areas; n = 95). Areas of Bwindi were grouped into three because of the limited dataset. These were the north, which were the north and centre (1996-2000 monthly totals; n = 50), the south, which were the south and east (1996-2000 monthly totals; n = 35), and the west (1996-2000 monthly totals; n = 10). The west was omitted from statistical tests because of the small sample size. For example, only requests for vermin guards to National Park officials were recorded in patrol reports from the west area, although communities in the west have been observed requesting compensation for damage to their banana plantations by gorillas (personal observation).

Rangers recorded 445 community responses from 1996 to 2000, of which 231 responses regarded crop raiding. The patrol reports contained varied descriptions regarding community responses on crop raiding. The most salient features of the descriptions were listed to develop a typology of crop raiding responses. Developing a typology enabled unification of the descriptions under general categories for analysis (McKinney, 1992). Community responses on crop raiding were categorized firstly by whether the response was made to rangers or to National Park officials, and secondly by the type of response. Eight types of community response on crop raiding were defined based on descriptions in the law enforcement records (Table 7.1). In addition, a record was made of whether or not community responses on crop raiding were made during a crop raiding incident or in the absence of a crop raiding incident, and whether or not rangers employed problem animal control for crop raiding incidents. Responses that were complaints about crop raiding or complaints about crop and livestock damage were also categorised by the crop raiding species and crop.

Table 7.1 Types of community response on crop raiding to law enforcement rangers, at Bwindi from 1996 to 2000

| **Type of response** | **Definition** |
|---|---|
| Complain crop raiding | Complain about crop raiding; crop and/or livestock damage |
| Complain migration | Complain about migrating to another area because of crop raiding |
| Complain unfair | Complain about being fined for entering the National Park, yet wild animals can enter fields |
| Appreciation | Appreciation for problem animal control |
| Request guard | Request employment of vermin guards |
| Request money | Request compensation for crop and/or livestock damage |
| Request land purchase | Request purchase of land because of crop raiding |
| Request visit | Request the park warden to visit and assess crop damage |

Archival records (section 2.2.2) were employed to describe the historical context of interactions between law enforcement rangers and local communities of Bwindi before 1996, by non-quantitative analysis because the records were not consistently recorded.

### 7.2.2.2 Data analysis

Community responses on crop raiding were expressed as a proportion of the total number of community responses per patrol. The first stage of the analysis was to adjust the proportion of community responses on crop raiding by an appropriate variable of patrol effort into a "catch per unit effort" index (Bell, 1986) (see methods described in section 4.2). Using monthly totals of responses (1996-2000 monthly totals; n = 95), a Spearman's rank correlation showed no relationship between the proportion of community responses on crop raiding and patrol days ($r^2 = -0.01$; $p > 0.05$). Hence, the proportion of community responses that regarded crop raiding formed the dependent variable in the analyses, which were undertaken using the non-parametric tests of Kruskal-Wallis and Mann Whitney U.

The first analysis aimed to conduct univariate tests to examine types of community response on crop raiding. Based on count data of the responses (n = 231), types of crop raiding response to rangers and to National Park officials were examined, and chi square tests were undertaken between area of Bwindi and response type to determine whether communities in a particular area responded directly to rangers or requested the rangers to forward their response to the officials.

The second analysis aimed to determine perceptions of local communities regarding crop raiding. Within each area of Bwindi, comparisons were undertaken of mean proportions of responses per month between crop raiding species, and between the crops raided. In addition, comparisons were undertaken between responses per species and patrol encounters with crop raiding incidents per species, and between responses per crop and patrol encounters with crop raiding per crop. However, the sample of responses on crop and livestock losses was too small to permit statistical analysis.

The third analysis aimed to determine impacts of crop raiding and of problem animal control on community response on crop raiding. Possible associations between numbers of responses made during a crop raiding incident and made in the absence of a crop raiding incident, with crop raiding involving gorillas, elephants, baboons and other species of monkey, were examined by Chi Square. Possible associations between numbers of responses made during a crop raiding incident with problem animal control and made during a crop raiding incident without problem animal control, with crop raiding involving gorillas, elephants, baboons and other species of monkey, were examined by Chi Square.

The final analysis aimed to identify associations between community response and the factors of area of Bwindi, year, season, crop raiding incidents, and incidents of problem animal control, that best explained patterns of community response to rangers on law enforcement patrol around Bwindi. Preliminary analyses were conducted to identify sources of variation in the data by examining possible differences in the proportion of community response on crop raiding per month between area of Bwindi, years from 1996 to 2000, months of the year, months of the rainy and dry season (Chapter 2) and months of the farming season (Chapter 6). A multi-way contingency table was then constructed with the significant factors from the analyses, with the number of community responses as the cell frequencies. The analysis was conducted by log linear under the assumption of a Poisson distribution, using the hierarchical approach and specifying a log link function (section 2.2.3.3).

## 7.3 Results

### 7.3.1 Historical context

#### 7.3.1.1 Before National Park gazettement

Before Bwindi was gazetted as a National Park, communities living adjacent to the forest protected their crops and livestock from wild animals by setting hunting traps. There were frequent notes in the patrol reports of wire snares and bush-ropes set along the forest boundary and around fields to prevent crop raiding by monkeys, bushpigs, carnivore species and other small animals, and occasional notes of steel traps set for elephants. Rangers also noted that individual animals that frequently foraged within community land were hunted, and that hunting was particularly important for controlling single, bull elephants, as these animals were not as easily scared by other mitigation methods, such as shouting and beating drums, that were effective on a family group of elephants. The last known elephant hunt in Bwindi occurred in September 1988 when farmers, from the southern village of Rushaga, killed a lone bull elephant that had been raiding fields around the village.

Community measures of vermin control before gazettement were supplemented by the efforts of the game guards. The law enforcement records indicate that the game staff recognised the importance of crop raiding as a local issue. The junior game assistant, in his monthly report for May 1989, described issues of the communities neighbouring the forest and commented "*most problems are now vermin problems*". The records also indicate that game guards primarily undertook vermin control for elephants and baboons, which involved scare-shooting for both species and the actual shooting of baboons.

##### 7.3.1.1.1 Elephant control

Evidence of vermin control on elephants was found in records of communications between game guards and farmers neighbouring the forest. In June 1987, the guards "*promised to help keep elephants away from their shambas*" after receiving complaints about elephant crop damage from farmers of Kiyebe village, which is in the east of Bwindi. The level of scare-shooting in proportion to the level of elephant crop raiding cannot be determined, although there is evidence that elephant control was mainly undertaken in response to demands from the community. For example, in May 1988, the chief of Nyakaranga village, which lies adjacent to the eastern sector B, wrote to the game warden concerning the crop raiding activities of elephants "*when visiting my parish, I found your animals had stopped a lot of crops in my area. A report was given to you by my people, yet you failed to act upon it. Your animals are still in Nyakaranga. These people depend on their crops, not your animals. You send your animals out or when they spoil property, you are the ones to answer.*" In response to this letter, the warden sent game guards to Nyakaranga village and the guards shot one round to scare a group of elephants back into the forest. There are several examples during 1988 illustrating the game warden's response to local demand for elephant control. In August, following a farmer's report, the warden sent guards to chase a single bull elephant foraging around Kanyamahene village in the southern area of Rushaga. In September, guards were again sent to Rushaga to control a lone bull elephant after a report by the parish chief of Rubuguli and, in December, following a report by the village chief, guards were sent to the eastern Ndego village and fired two bullets to chase a group of elephants away from shambas. The activities of the game guards regarding elephant control also involved protection for elephants, as, in February 1989, guards chased one adult and one juvenile elephant back into Bwindi after the elephants had crossed into neighbouring Congo.

#### 7.3.1.1.2 Baboon control

Records documenting vermin control on baboons before gazettement also indicate that the control was primarily undertaken in response to demand. The majority of scare-shooting for crop raiding baboons during 1988 was undertaken because of requests by farmers, particularly by farmers around the northern community area of Bino. Also that year, the monthly report for August by guards at the northern outpost of Bwindi revealed that the guards had written to the parish chief concerning their efforts with vermin control and "*since that day, we have not received complaints from anyone*". The guards noted that baboons were not active because the crops were still to be cultivated, but stated that vermin control "*shall begin again if we get complaints from the growers*".

Patrol reports of 1989 detail scare-shooting for baboons around the centre and east areas of Bwindi, and also the efforts made to improve community relations regarding crop raiding, which included visits by game guards to affected communities such as the visit during October to Mburameizi village, which is in the east of Bwindi, to "*attend complaints on baboon damage*".

Therefore, before gazettement, game staff of Bwindi actively undertook vermin control following complaints about elephants, which were often made by local chiefs, and about baboons, which were mainly from the farmers. However, this situation changed immediately prior to gazettement. The financial and logistical law enforcement support by IFCP to the Game Department was for effectively targeting the high number of illegal pit sawyers and miners within Bwindi by patrols. The resources available for law enforcement during this period were insufficient. For example, in 1988, there were 11 game guards and 13 game guard trainees with a total of eight guns and a limited supply of ammunition. Consequently, in May 1989, after chasing elephants that were crop raiding at Kiyebe back to the forest, the guards were "*seriously warned not to be extravagant with ammunitions in such cases*" by the junior game assistant of Bwindi, and then, later that year in June, again after an incident of elephant control, the guards were fined 1000 Uganda shillings, which was a large proportion of their monthly wage (1567 Uganda schillings), for "*using too many ammunitions on simple issues*".

#### 7.3.1.1.3 Gorilla control

Human-gorilla conflict is evident from when Bwindi was first gazetted as the Kayonsa reserve during the 1930s. A report by a game warden of his visit to Bwindi during 1933 describes his trip to see a gorilla group near the forest boundary "*when I had seen my fill and was about to retrace my steps, I found at least fifty unauthorised spearmen hanging* *in the rear, hoping for the opportunity of attacking the gorillas. In fact, I was warned that if I did not personally see this crowd out of the locality, the moment my back was turned they intended going in to spear the male before he could get away from the tree, after which the slaughter of the other four would have been simple. The presence of a European and a misunderstanding would have been their excuse. It shows how easily an unfortunate episode may develop, vide a recent incident in the Belgian Congo, unless all participants in gorilla investigations are absolutely under control*" (Uganda Game Department Archives, 1923-1994:1933).

There is also evidence from the report that, although gorillas often foraged within community land and were noted as favouring abandoned cultivated patches, the farmers generally left the gorillas alone except to drive the animals away "*the local natives, who can blame them, very naturally object to the proximity of these fearsome beasts, and usually try and drive them away. I am reliably informed that the gorillas are most contemptuous of their efforts, the females and young having been sent off to safety, males only move when it suits them to do so*" (Uganda Game Department Archives, 1923-1994:1933). Further evidence that contact between farmers and gorillas mainly occurred when farmers chased gorillas from community land comes from a letter written in 1933 by a prospector working in the Impenetrable Forest to the Chief Game Warden, in which the prospector describes shamba raiding by gorillas (section 6.4) (Uganda Game Department Archives, 1923-1994:1933).

Both the warden's report and the letter also indicate that complaints by farmers to the authorities of Bwindi mainly regarded "*the proximity of these fearsome beasts*", and this fear is further illustrated by complaints about gorillas that the warden received from miners working in Bwindi "*prospecting on a systematic scale has taken place in the extreme southerly portion of the forest, but when I was in that neighbourhood at the beginning of November, there were frequent complaints from isolated pairs of natives digging pits, that gorillas were too close to be pleasant*" (Uganda Game Department Archives, 1923-1994:1933).

Human-gorilla conflict at Bwindi during the period immediately prior to National Park gazettement, as documented in the law enforcement records, was also mainly driven by local communities' fear of gorillas. Patrol reports document complaints by community members that women could not collect water because of the gorillas, and that villagers feared to pass when gorillas were nearby. However, issues of compensation dominated the conflict. The one record before gazettement of local community responses regarding gorilla crop raiding details the compensation that was given to a farmer for crop damage by gorillas. In May 1989, a farmer of the western Buhoma area reported to rangers that a single gorilla was feeding on his banana plants and, later that month, the farmer received 1000 Uganda Shillings in compensation, which was a substantial sum in comparison with the monthly wage for a game guard (1567 Uganda shillings).

### 7.3.1.2 After National Park gazettement

#### 7.3.1.2.1 Elephant control

The first post-gazettement record of crop raiding by elephants dates from 1993. Records from early 1993 illustrate that requests by the community for National Park authorities to employ elephant control continued. In April, the chief of Kashasha parish, which borders the east areas of Bwindi, wrote to the Warden In Charge (WIC) of Bwindi "*I report to you that yesterday evening elephants invaded Ndego village and destroyed crops, mostly maize, peas, and up to now are still destroying more crops. Can you send us some guns to help chase them. Your help is of most urgency.*"

There are no records of elephant control by rangers during this period, although letters from local chiefs to National Park wardens document the attitude of community. For example, a letter written in June 1993 by the parish chief of Rubuguli, which is in the south of Bwindi, to the WIC illustrates the situation "*I inform you that elephants raided crops in Rushaga, all wheat, peas, beans and Irish are completely finished. This has caused a lot of problems between communities and the National Park rangers. The communities here want the park authorities to come here to their raided crops to discuss* *with them about compensation. I also request the park authority to send rangers with guns to keep the remaining crops. Your soon response will show much co-operation between National Park authorities and the community.*"

The attitude of the communities regarding the National Park's response to elephant control is also evident from the patrol reports. Rangers on patrol in the south of Bwindi reported "*all people whose crops raided by the elephant are very much annoyed to the rangers that they are not eager to enter the matter of securing their crops and their life*" and from east areas that farmers "*are very annoyed with the elephant and think the National Park staff don't mind much about their gardens.*"

The National Park authorities did respond after farmers reported the elephant raids to the police. In June 1993, the village chief of Rushaga requested farmers whose crops were damaged by a single bull elephant to each pay 1000 Uganda shillings to send one man to the Rubuguli police. Later that month, rangers were sent to the Rushaga area and spent three days chasing the bull elephant back to the forest by scare-shooting. Rangers were again employed to control a single elephant in Rushaga during July, and then visited the eastern Ndego area in December after farmers had gone to the rangers' home to report that four elephants had entered their field. However, despite the control efforts, the situation escalated and the District Administrator of Kabale became involved, which is evident from a letter written, in December, by the WIC to the District Administrator "*I received your letter about crop destruction by elephants in Nyamabare parish. I had already received a report from the rangers and then sent four rangers with two guns to scare the elephants. Now the men are stationed at Nyamabare for this purpose. I am surprised to learn from you that this office is ignoring people's appeal for help. We greatly sympathise with the people whose crops were damaged. The best we can do is to scare these animals away and not kill them as some people suggest. I intend to travel to the affected areas next week to discuss this issue with the people*".

The National Park's renewed activities with elephant control continued during 1994 and 1995. In addition, attempts were made to improve relations with the local community, which included the warden's visit to Ndego, in January 1994, to discuss the elephant problem with parish chiefs. Later that year, in May, rangers on patrol in the eastern area noted "*people were not happy because sorghum lost to elephant, but became somehow happy when the rangers chased the elephant away*".

### 7.3.1.2.2 Baboon control

Records on baboon control in Bwindi after gazettement date from 1993. The first records illustrate that National Park officials recognised the problem of crop damage by baboons. The WIC stated "*baboons are a nuisance in several areas of the park*" in his monthly report for January 1993, and during 1993 and 1994, rangers recorded crop raiding by baboons around the north, centre, west and east areas in their patrol reports. For example, in July 1994, the ranger in charge of Rubuguli outpost reported that, for west areas of Bwindi "*baboons have eaten more than 100 chickens this month and bite children guarding crops.*" The patrol reports also illustrate the response of the community regarding baboons. During 1993, rangers on patrol around the north noted "*people are very much complaining of the baboons*" and "*farmers living near the park boundary are complaining of the vermin baboons*", and reports from the east of Bwindi recorded that farmers "*complain of baboons and their delayed compensation*". Furthermore, in 1994, rangers on patrol around the north recorded farmers' complaints of "*having no time to go for money outside as they are scaring baboons*", and requests for National Park authorities to buy their land "*because crop raiding has gone to highest levels*". In addition, farmers in the west asked permission to set snares around their fields, to which the ranger responded "*I told them that the office will decide what to do*".

There are no records of scare-shooting for baboons during 1993 and 1994, and only one report exists for 1995, in November, when rangers shot four rounds to scare baboons raiding crops in fields adjacent to the east sectors D and I. Therefore, unlike the renewed efforts for elephant control, problem animal control for baboons after National Park gazettement appears to have remained at a low level.

### 7.3.1.2.3 Gorilla control

Issues of compensation dominated human-gorilla conflict during the period immediately prior to National Park gazettement. After National Park gazettement, compensation for gorilla damage was not consistently recorded, although patrol reports illustrate the farmers' complaints about the lack of compensation and their threats to rangers and gorillas. In August 1992, rangers on patrol in the west of Bwindi reported "*farmers are greatly complaining that they have not been compensated for their bananas destroyed by gorillas*". Also during August 1992, another patrol in the west reported "*people whose banana plantations were destroyed by gorillas have reached that extent of attacking us rangers, as maybe the warden gave the money to us and we have used it. The village chiefs are backing them saying that they were promised by high officials from this park that any farmer whose crops destroyed by gorillas automatically will be compensated for. From my observation, if these farmers do not get money for their bananas, as they were told publicly, they may harm the gorillas next time the animals come to banana plantations*".

Rangers on patrol in the west during the following month reported "*farmers were not happy because of not being paid in time and again they were saying that if they do not pay them, the next time they will kill the gorillas*". The National Park officials responded by sending rangers to count the number of banana plants destroyed by gorillas. During 1992, in September rangers visited farmers in western areas, in October the ranger in charge of Rubuguli sector went to assess gorilla damage around the western Nteko area, and in January 1993, the WIC of Bwindi visited Buhoma to assess "*damage to the banana plantations caused by the gorilla group that was living outside the park*". The warden's visit concerned the Katendgyere gorilla group, which was being habituated for tourism, and the warden commented on the conflict caused by the group's crop raiding activities in his monthly report for February 1993. Crop raiding by Katendgyere gorillas continued and, to alleviate the resulting conflict, the WIC and IGCP met Zaire chiefs during March 1993 and IGCP compensated farmers whose bananas had been destroyed by the Katendygere gorillas. Also during 1993, the expectation of farmers around Bwindi for compensation for gorilla crop damage continued. A letter written by the village chief of Kahurire village, which is in the west of Bwindi, to the WIC in November illustrates the situation *"I am receiving a lot of pressure from farmers of Kahurire village whose banana plantations were damaged by gorillas last and this year, yet they have not been compensated as it had been before. Should I assume this compensation has expired? If so, could you enlighten me on this issue. I am sure that the last of farmers whose bananas were destroyed by gorillas is in the Chief Warden's office at Ruhija. It was officially announced by former head ranger Didas Rutemba, and former Warden Alfred Otim, that farmers whose crops will be destroyed by gorillas will be compensated. I humbly beg you to save me from the pressure of farmers*".

The village chief of Kahurire village continued to write to the WIC about compensation for the farmers. In February and July 1995, the chief wrote to the warden detailing the number of banana plants that had been damaged by gorillas and the number of affected farmers. The warden sent rangers to assess the gorilla damage at Kahurire during July, and another patrol assessing gorilla damage in the west that month reported *"the owners of the banana trees are very annoyed and call on IGCP to come and see what is happening"*.

### 7.3.2 Problem animal control

#### 7.3.2.1 Area

The mean proportion of crop raiding incidents with problem animal control differed between areas of Bwindi (Kruskal-Wallis $\chi^2 = 10.31$; df = 4; $p < 0.05$) (Figure 7.1). Rangers mainly deployed problem animal control around the east, south and west. Furthermore, there was no difference in the fewer incidents between the north and centre (Table 7.2).

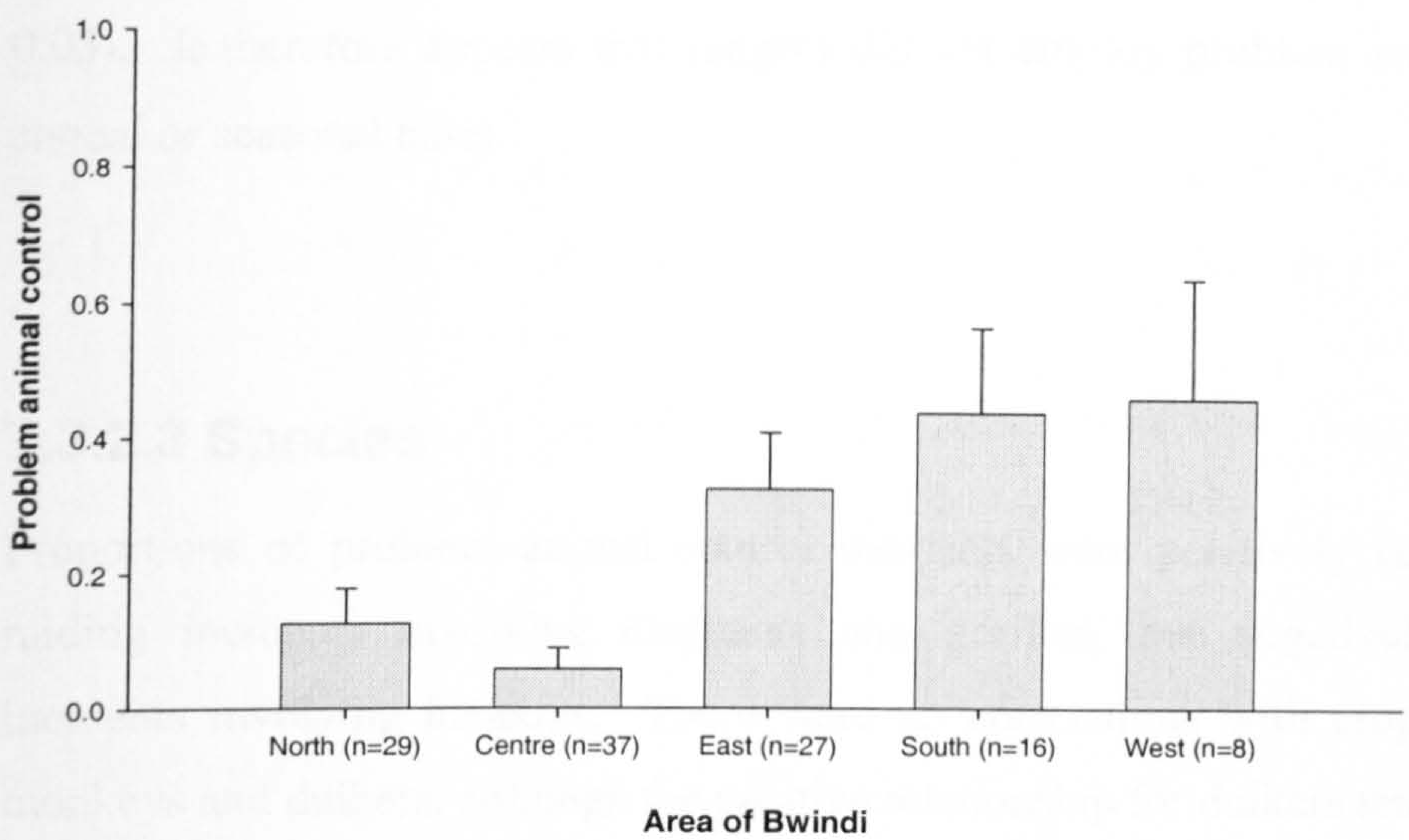



Figure 7.1 Mean±SE proportion of crop raiding incidents with problem animal control around areas of Bwindi from 1996 to 2000

Table 7.2 Significance of the comparisons of mean proportions of crop raiding incidents with problem animal control between areas of Bwindi from 1996 to 2000

| | Area of Bwindi (z value) | | | |
|---|---|---|---|---|
| | **North (n = 29)** | **Centre (n = 37)** | **East (n = 27)** | **South (n = 16)** |
| **Centre** | -0.72 | | | |
| **East** | -1.90* | -2.56* | | |
| **South** | -1.92* | -2.47* | -1.08 | |
| **West (n = 8)** | -1.92* | -2.56* | -0.79 | -0.54 |

* $p < 0.05$

#### 7.3.2.2 Year and season

The mean proportion of crop raiding incidents with problem animal control did not differ between years (Kruskal-Wallis $\chi^2 = 5.24$; df = 4; $p > 0.05$), months of the year (Kruskal-Wallis $\chi^2 = 9.4$; df = 11; $p > 0.05$), months of the rainy and dry season ($z = -0.09$; $p >$

0.05) or between months of the farming season (Kruskal-Wallis $\chi^2 = 0.42$; df = 2; p > 0.05). It therefore appears that rangers did not employ problem animal control on an annual or seasonal basis.

### 7.3.2.3 Species

Proportions of problem animal control incidents were positively correlated with crop raiding incidents involving elephants and gorillas, but negatively correlated with incidents involving baboons. There were no correlations with crop raiding involving monkeys and duikers, although the positive relationship for duikers tended to significance (p = 0.08) (Table 7.3).

Table 7.3 Spearman's rank correlations between crop raiding incidents per species and the proportion of incidents with problem animal control at Bwindi from 1996 to 2000

| Crop raiding species (n = 198) | Correlation coefficient ($r_s$) |
|---|---|
| Elephants | 0.58*** |
| Gorillas | 0.35*** |
| Baboons | -0.24** |
| Duikers | 0.17 |
| Other monkey species | 0.08 |

** $P < 0.01$; *** $P < 0.001$

The patrol data, although insufficient for analysis, show that rangers patrolling the north and centre of Bwindi mainly employed control for baboons (90.9%), and also for black and white colobus monkeys (9.0%). In contrast, rangers patrolling the south only employed control for elephants. Rangers patrolling the east mainly employed control for elephants (80.0%) and also for duikers (16.0%) and baboons (4.0%). Most problem animal control by rangers patrolling the west was for gorillas (75.0%) with some control for baboons (25.0%).

### 7.3.2.4 Factors explaining the likelihood of problem animal control

The final regression model correctly classified 84.6% of problem animal control incidents ($\chi 2 = 42.21$; df = 2; $p < 0.001$) and proved a good fit to the data (AUC = 0.74). The variables of the model accounted for 44% (Nagelkerke R square = 0.44) of the variation in the data. The model predicted that incidents of problem animal control were best explained by the variables, in order of entry, crop raiding involving elephants and crop raiding involving gorillas. Crop raiding incidents involving elephants and gorillas were not correlated ($r_s = 0.03$; $p > 0.05$), which indicated that there were no problems with multicollinearity in the final model. Elephant ($r_s = 0.35$; $p < 0.001$) and gorilla ($r_s = 0.20$; $p < 0.05$) crop raiding were more closely correlated with area of Bwindi. Elephant crop raiding was also correlated with months of the rainy and dry seasons ($r_s = -0.16$; $p < 0.05$) (Chapter 6).

Therefore, rangers on law enforcement patrol mainly employed problem animal control around the east, south and west of Bwindi. However, the driving factors were crop raiding incidents involving elephants, which occurs in the south and east, and crop raiding incidents involving gorillas, which mainly occurs in the west. The parameter coefficients of the regression model show that the probability of problem animal control was greater for elephant crop raiding than for gorilla crop raiding incidents (Table 7.4).

Table 7.4 Parameters of the stepwise multiple logistic regression model for the likelihood of problem animal control in Bwindi

| Parameter | Coefficient (B) | Standard error of B | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|---|
| Elephant crop raiding ($\log^{10+1}$) | 53.12 | 15.39 | 11.12 | 1 | < 0.01 |
| Gorilla crop raiding ($\log^{10+1}$) | 7.55 | 3.23 | 5.48 | 1 | < 0.05 |
| Constant | -1.68 | 0.28 | 36.69 | 1 | < 0.001 |

## 7.3.3 Community response on crop raiding

Most community responses that regarded crop raiding were to rangers rather than to National Park officials in north and south areas (Table 7.5). Most responses (72.7%) by communities around the west (n = 11) were also to rangers. There was no association between north and south areas and response to rangers or National Park officials (Pearson's $\chi^2 = 0.23$; df = 1; $p > 0.05$). Thus most communities around Bwindi made their responses on crop raiding to rangers rather than requesting the rangers to forward their comments to National Park officials.

Table 7.5 Community response on crop raiding to rangers and to National Park officials in north and south areas of Bwindi from 1996 to 2000

| Crop raiding response | Area of Bwindi (%) | |
|---|---|---|
| | North (n = 161) | South (n = 59) |
| **To rangers** | 82.5 | 83.3 |
| **To National Park officials** | 17.5 | 16.7 |

### 7.3.3.1 Response to National Park officials

All crop raiding responses to National Park officials were requests (Table 7.6). Communities around the north most frequently requested vermin guards, and also requested compensation, land purchase and for the National Park warden to visit. In contrast, communities around the south mainly requested vermin guards and compensation. They also requested land purchase but did not request the warden to visit. Communities around the west (n = 2) only requested vermin guards from National Park officials.

Table 7.6 Community response on crop raiding to National Park officials in north and south areas of Bwindi from 1996 to 2000

| Crop raiding response to National Park officials | Area of Bwindi (%) | |
|---|---|---|
| | North (n = 28) | South (n = 10) |
| **Request vermin guard** | 55.6 | 40.0 |
| **Request compensation** | 25.9 | 40.0 |
| **Request land purchase** | 11.1 | 20.0 |
| **Request visit** | 7.4 | 0.0 |

### 7.3.3.3 Response to rangers

Most crop raiding responses to rangers were complaints (Table 7.7). The complaints concerned the wild animals raiding crops (section 7.3.2.2.1) and losses of crops and livestock (section 7.3.2.2.2). As well as complaining about crop raiding, communities around the north also complained to rangers about migrating to other areas because of crop raiding and about being fined for entering the National Park even though wild animals can enter their fields. In contrast, the only other response to rangers by communities around the south was to express appreciation for problem animal control, which was elephant scare shooting. Communities around the west (n = 9) only complained to rangers about wild animals raiding crops and about losses of crops and livestock.

Table 7.7 Community response on crop raiding to rangers in north and south areas of Bwindi from 1996 to 2000

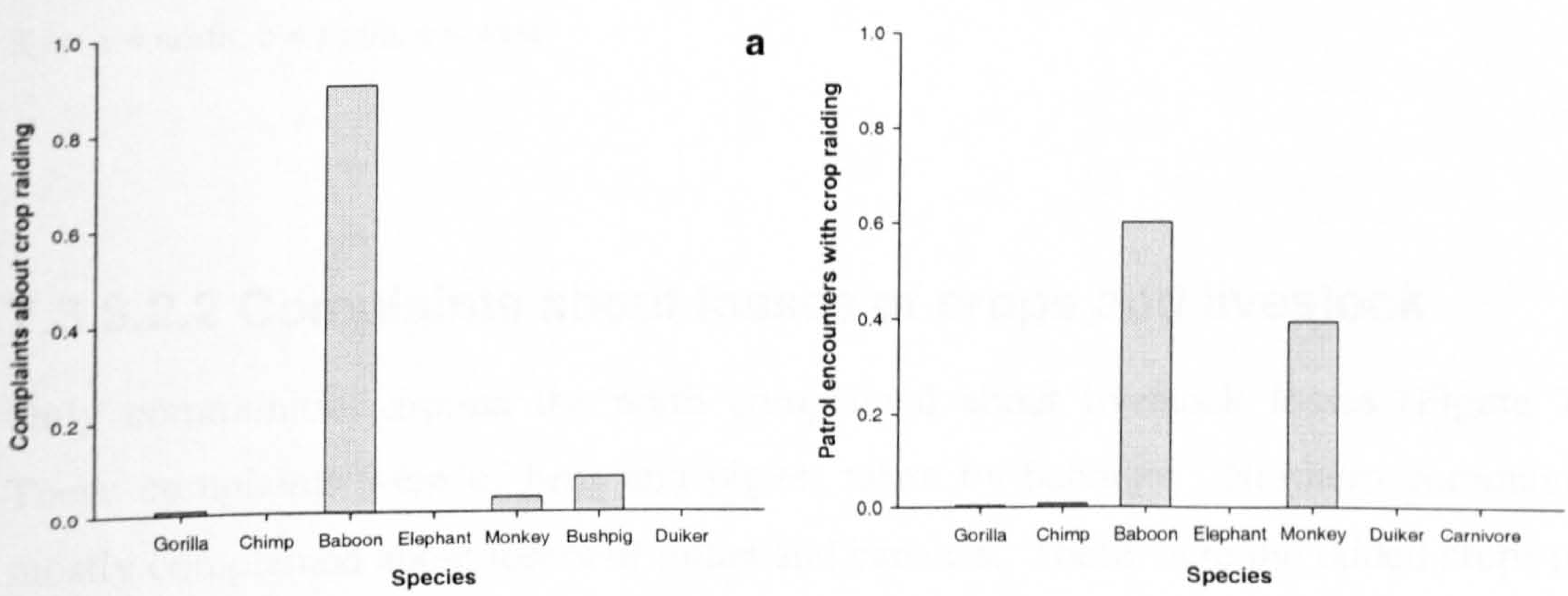
| Crop raiding response to rangers | Area of Bwindi (%) | |
|---|---|---|
| | North (n = 133) | South (n = 49) |
| **Complain crop raiding** | 97.2 | 90.0 |
| **Complain migration** | 2.0 | 0.0 |
| **Complain unfair** | 0.8 | 0.0 |
| **Appreciation** | 0.0 | 10.0 |

## 7.3.3.2.1 Complaints about crop raiding wild animals

Communities around the north mainly complained to rangers about baboons (Figure 7.2). Baboons were the most frequent crop raider that rangers patrolling the north encountered. However, rangers also encountered crop raiding by other species of monkey, although communities rarely complained about these or other crop raiding wild animals. Communities around the centre area of the north made the complaints about gorillas.

Complaints about crop raiding animals by communities around the south differed from the north and west (Figure 7.2). Firstly, communities around the south complained about a greater variety of crop raiding species. Secondly, south communities mainly complained about crop raiding by elephants, baboons and other species of monkeys, although monkey species were the most frequent crop raiders encountered by rangers on patrol. Rangers also encountered small carnivores crop raiding although there were no complaints about small carnivores. Complaints about chimpanzees were made by beekeepers and concerned the raiding of beehives.

Communities around the west most frequently complained about baboons, gorillas and bushpigs (Figure 7.2). In comparison, rangers mainly encountered crop raiding involving baboons and other monkey species.



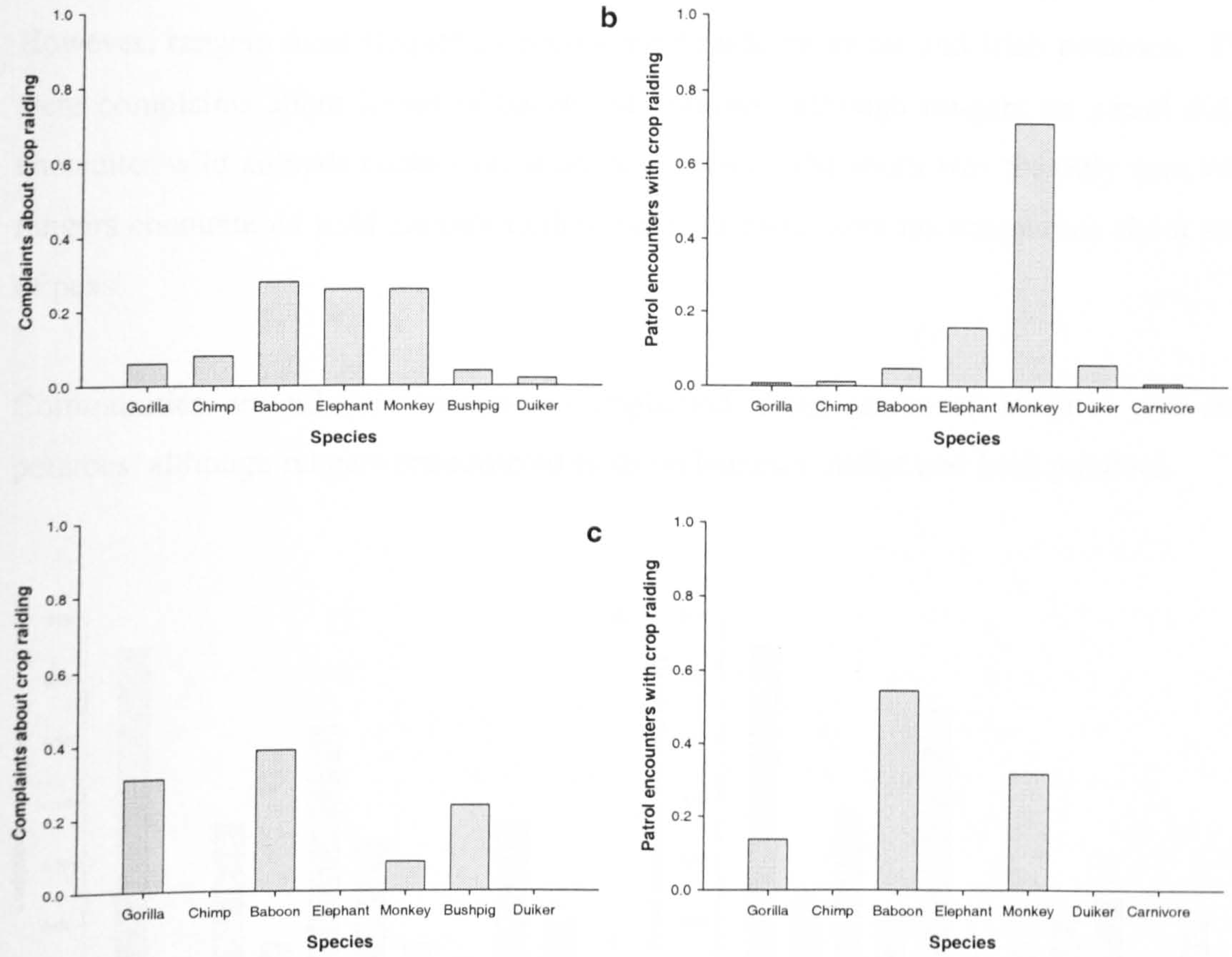



Figure 7.2 Mean proportion of community complaints to rangers about crop raiding wild animals, and mean proportion of law enforcement patrol encounters with crop raiding incidents, around the north, south and west of Bwindi from 1996 to 2000

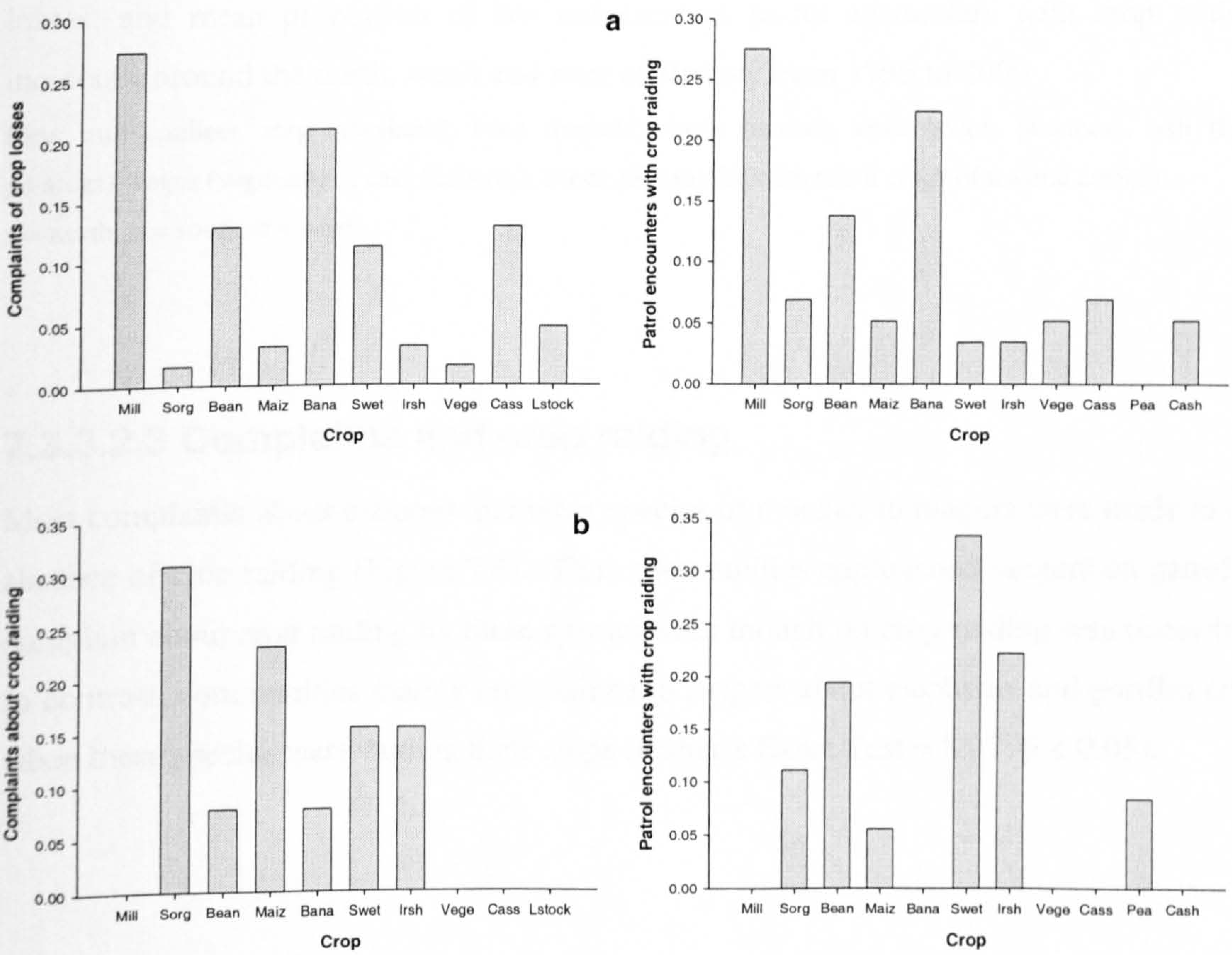
Key: a = north, b = south, c = west

### 7.3.3.2.2 Complaints about losses of crops and livestock

Only communities around the north complained about livestock losses (Figure 7.3). These complaints were of hens and piglets taken by baboons. Northern communities mostly complained about losses of millet and bananas. These were the raided crops most frequently encountered by rangers. Furthermore, complaints by north communities comprised a variety of crops, and raids on several crop types were evident from the patrol encounters.

Communities around the south mostly complained about losses of sorghum and maize. However, rangers most frequently encountered raids on sweet and Irish potatoes. There were complaints about losses of banana plantations, although rangers on patrol did not encounter wild animals raiding bananas. Conversely, the south was the only area where rangers encountered wild animals raiding peas yet there were no complaints about losses of peas.

Communities around the west only complained about losses of bananas and sweet potatoes, although rangers encountered raids on bananas, millet and Irish potatoes.



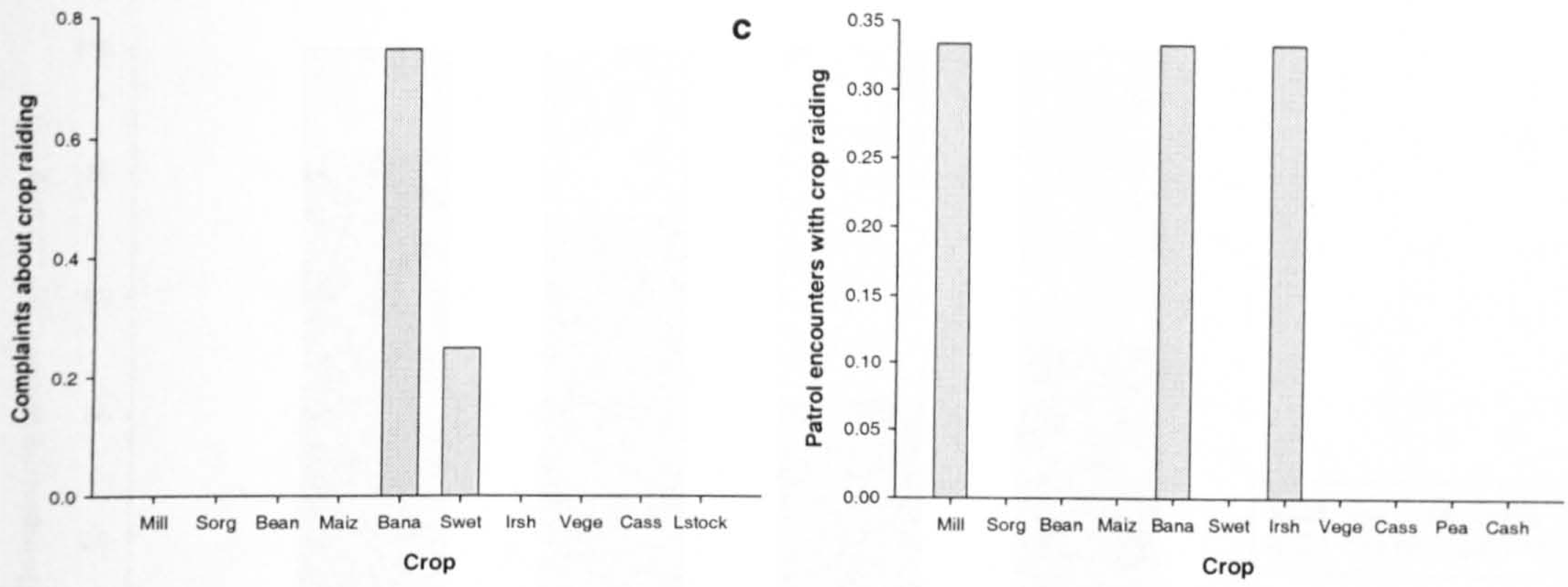



Figure 7.3 Mean proportion of community complaints to rangers about crop and livestock losses, and mean proportion of law enforcement patrol encounters with crop raiding incidents, around the north, south and west of Bwindi from 1996 to 2000

Key: mill (millet), sorg (sorghum), bana (banana), maiz (maize), swet (sweet potatoes), irsh (Irish potatoes), veges (vegetables), cass (cassava), lstock (livestock), cash (cash crops of tea and coffee)

a = north, b = south, c = west

### 7.3.3.2.3 Complaints and crop raiding

Most complaints about baboons and other species of monkey to rangers were made in the absence of crop raiding (Figure 7.4). Thus communities approached rangers on patrol to complain about crop raiding by these species even though no crop raiding was occurring. In contrast, communities mainly complained to rangers about elephants and gorillas only when these species were raiding their crops (Fisher's Exact Test = 8.02; $p < 0.05$).

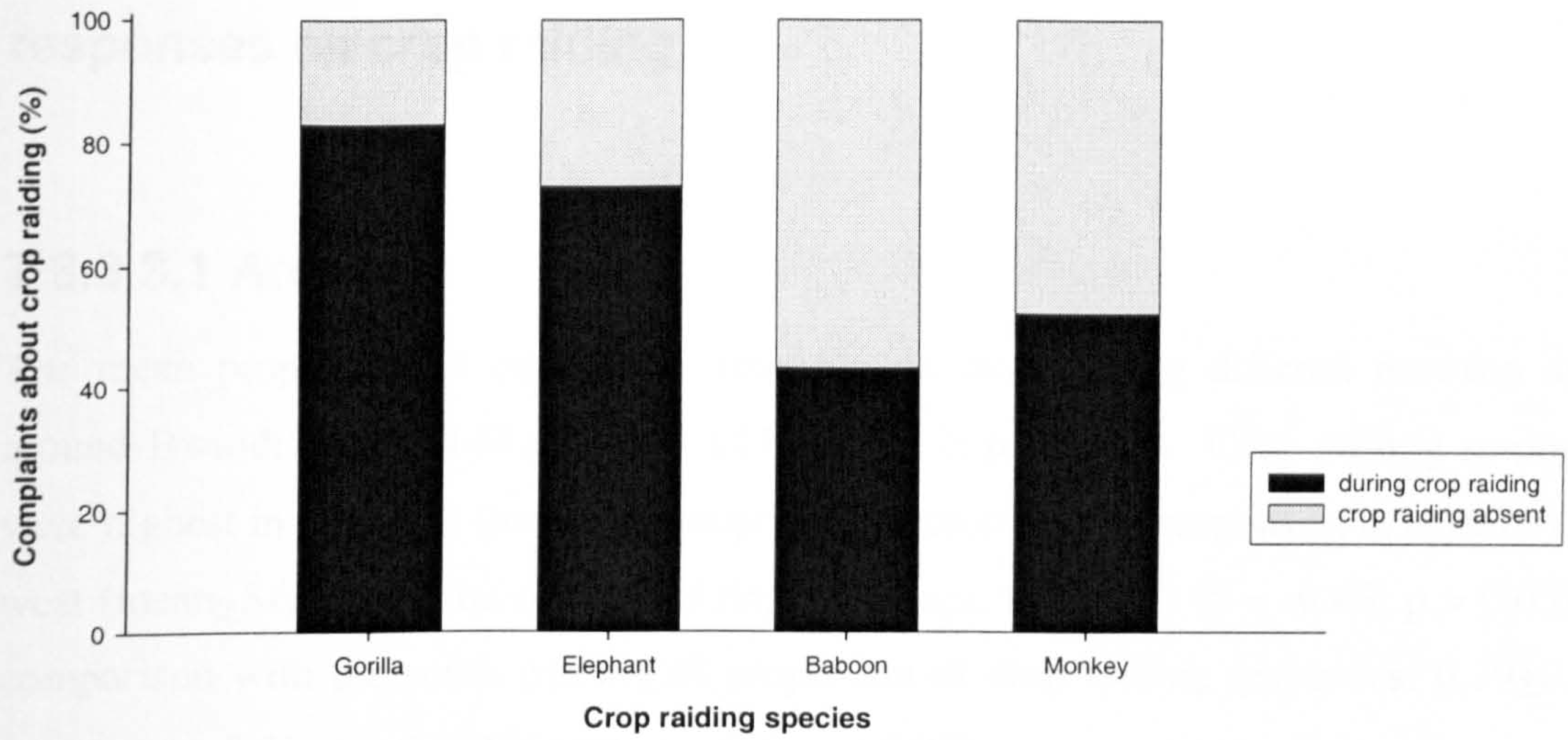



Figure 7.4 Complaints about crop raiding species to rangers made during crop raiding incidents and in the absence of crop raiding incidents, by communities neighbouring Bwindi from 1996 to 2000 (n = 231)

#### 7.3.3.2.4 Complaints and problem animal control

Most communities complaining to rangers about baboons while baboons were raiding their crops did not receive assistance from rangers with problem animal control (90.5%). In contrast, most communities complaining about elephants during an elephant raid (90.0%), and about gorillas during a gorilla raid (66.7%), did receive assistance from rangers with scaring these animals back into the National Park (Fisher's Exact Test = 35.23; $p < 0.001$) (n = 231).

### 7.3.3.3 Factors explaining the likelihood of community responses on crop raiding

#### 7.3.3.3.1 Area

The mean proportion of community response on crop raiding differed between areas around Bwindi (Kruskal-Wallis $\chi^2 = 14.80$; df = 2; $p < 0.01$). Crop raiding responses were highest in the north (mean±SE proportion of crop raiding responses: 0.71±0.04) and west (mean±SE proportion of crop raiding responses: 0.68±0.2) ($z = -0.43$; $p > 0.05$), in comparison with the south (mean±SE proportion of crop raiding responses: 0.39±0.07) (north: $z = -3.41$; $p < 0.001$) (west: $z = -2.0$; $p < 0.05$).

#### 7.3.3.3.2 Year and season

The mean proportion of community response on crop raiding did not differ between years from 1996 to 2000 (Kruskal-Wallis $\chi^2 = 9.05$; df = 4; $p > 0.05$), months of the year (Kruskal-Wallis $\chi^2 = 11.07$; df = 11; $p > 0.05$) or months of the farming season (Kruskal-Wallis $\chi^2 = 3.40$; df = 2; $p > 0.05$). However, crop raiding responses were higher during months of the rainy season (1996-2000 monthly totals n = 48) (mean±SE proportion of crop raiding responses: 0.64±0.05) than months of the dry season (1996-2000 monthly totals n = 47 (mean±SE proportion of crop raiding responses: 0.48±0.05) ($z = -2.38$; $p < 0.05$).

#### 7.3.3.3.3 Log linear model

The analysis has shown that most community responses on crop raiding were complaints to rangers about crop raiding animals. A four-way contingency table was constructed for the log linear analysis with factors categorising complaints to rangers about crop raiding animals. These factors were area of Bwindi (north, south), season (rainy, dry), crop raiding species of the complaint (gorillas, elephants, baboons and other monkey species) and whether the complaint was made during a crop raiding incident or in the absence of crop raiding.

The final model consisted of the two-way interaction term between area and crop raiding species, and the main effects from both factors (Table 7.8). The model exhibited a low deviance value that did not significantly differ from the saturated model ($G^2 = 18.40$, df = 16, $p > 0.05$) and was thus a more parsimonious model than the saturated model ($G^2 = 0.0$; df = 0) that explained the variance in the data. The interaction term between complaints and whether complaints were made during a crop raiding incident or in the absence of crop raiding tended to significance ($p = 0.060$.

Table 7.8 Tests of partial associations for terms in the saturated model, by significance of the chi square value

| Term | Chi square | df | Significance of $\chi^2$ |
|---|---|---|---|
| Area*season*species | 2.94 | 3 | NS |
| Area*season*crop-raid | 0.01 | 1 | NS |
| Area*species*crop-raid | 0.76 | 3 | NS |
| Area*season | 0.19 | 1 | NS |
| Area*species | 96.17 | 3 | < 0.001 |
| Season*species | 4.82 | 3 | NS |
| Area*crop-raid | 1.53 | 1 | NS |
| Season*crop-raid | 0.05 | 1 | NS |
| Species*crop-raid | 7.02 | 3 | NS |
| Area | 52.33 | 1 | < 0.001 |
| Season | 2.89 | 1 | NS |
| Species | 263.98 | 3 | < 0.001 |
| Crop-raid | 0.02 | 1 | NS |

The ratio of the standardised lambda values of the parameters in the final model show that the north*baboon-complaint interaction was most significant (Table 7.9). Thus complaints about baboons by communities around the north of Bwindi best explained the community response on crop raiding to rangers. The interaction term between area and species (Fisher's Exact Test = 91.18; $p < 0.001$) showed that complaints about baboons were predominant among communities around the north (95.3%), yet rare among communities around the south (30.0%).

Table 7.9 Parameter estimates and the ratio of the standardised lambda values of the significant terms included in the final model for community response on crop raiding to rangers

| Parameter | Parameter estimate | Standardised lambda |
|---|---|---|
| Constant | 1.25 | 4.69 |
| North | -0.69 | -0.64 |
| Baboon complaint | 0.07 | 0.19 |
| Monkey complaint | 0.07 | 0.19 |
| Gorilla complaint | -0.56 | -1.15 |
| North*baboon-complaint | 2.95 | 2.65 |
| North*monkey-complaint | 0.06 | 0.05 |

## 7.4 Discussion

Improved relations with local communities are a primary motive for managers of protected areas to mitigate crop raiding activities by wild animals. However, our understanding of the impact of such mitigation efforts on local attitudes towards conservation is limited. Conservation-orientated research has largely focused on patterns of crop raiding by wild animals, particularly of elephants (Dey, 1991; Nyhus *et al*, 2000; Williams *et al*, 2001; Sitati *et al*, 2003) and primates (Strum, 1994; Naughton-Treves *et al*, 1998; Siex and Struhsaker; 1999;), and the subsequent impact on the food and economic security of farmers bordering a protected area (Hill, 2000; Hill, Osborn and Plumptre, 2002; Osborn and Parker, 2003). In contrast, the untested assumption that mitigation efforts by conservation authorities will improve their relations with local farmers, and gain the support of these farmers for conservation, has rarely been examined.

This study, which is the first in Bwindi to examine problem animal control by rangers on law enforcement patrol, assesses the mitigation of crop raiding by wild animals around a relatively small National Park in a rural area of high human population density. In addition, the study, which is also the first in Bwindi to examine interactions between local communities and rangers regarding crop raiding, contributes to debate on the impact of mitigation on local community support for conservation. However, in contrast to previous studies on local community attitudes based on questionnaires (Newmark *et al*, 1994; Infield and Namara, 2001), this study based on a five year dataset of day to day interactions between local communities and law enforcement rangers, is more indicative of behavioural aspects and of the situation on the ground.

The study demonstrates the use of data routinely collected by rangers on law enforcement patrol for monitoring purposes. Limitations are associated with such data. It was possible that rangers did not record incidents of problem animal control. However, the likelihood of such missing data was low because rangers are required to account for all use of ammunition, which includes scare shooting of crop raiding animals. It was also possible that, although the patrol report form contains a section entitled "community response" (section 2.2.1), rangers did not record complaints by local communities about crop raiding, particularly if such complaints commonly occurred. However, verification of rangers' recording undertaken during fieldwork permits confidence in the patrol data (section 2.2.1.2). Furthermore, the typologies developed for the study enabled analysis of types of community response on crop raiding. It is important to note that the analysis is based on rangers' perceptions with no assessment of ranger-community interactions as perceived by local communities. Community-based surveys would have strengthened the study in this regard and remain a possibility for further research.

### 7.4.1 Elephant and baboon control before gazettement

Communities living adjacent to Bwindi before Bwindi was gazetted as a National Park could protect their crops and livestock from wild animals by setting hunting traps in the forest boundary. Communities could also hunt individual animals, particularly single bull elephants, that frequently foraged within community land. However, the situation changed after gazettement. The prohibitions on hunting wild animals in the National Park also prevented farmers from using hunting to mitigate crop raiding by the animals. Consequently, farmers felt incapacitated in dealing with vermin, as they could only guard their crops and deter animals with shouting and drumming (Namara, 2000).

Communities neighbouring Bwindi believe that crop raiding has increased since the forest was gazetted because they are no longer allowed to hunt animals. Furthermore, the communities state that the response from National Park authorities to their reports about crop raiding has declined since gazettement, and that the response now only concerns crop raiding by elephants and gorillas (Namara, 2000). The analyses presented here, which cover the period from 1996 to 2000, support the latter claim and are thus important to understand within a historical context. The law enforcement records of Bwindi prior to 1996 were not suitable for analysis, although these records, which comprised ranger patrol reports, monthly reports by National Park wardens and letters written between National Park officials and members of the local community, documented events during the period of gazettement and are therefore useful for understanding the results of this study.

Law enforcement records before gazettement showed that community measures of vermin control before gazettement were supplemented by the efforts of the game guards. The records indicated that game guards of Bwindi actively undertook vermin control following complaints about elephants, which were often made by local chiefs, and about baboons, which were mainly from the farmers. Furthermore, records after gazettement showed that National Park authorities continued activities with elephant control and made attempts to improve relations with the local community. In contrast, problem animal control for baboons after National Park gazettement appeared to remained at a low level.

### 7.4.2 After gazettement

#### 7.4.2.1 Elephant control

This study focused on the period in Bwindi from 1996 to 2000. The analysis showed that the level of problem animal control by rangers did not change over time and that crop raiding by elephants was a significant determinant to the employment of problem animal control, which has consequently resulted in farmers in the south and east of Bwindi receiving more assistance from rangers with mitigating crop raiding than farmers in other areas of Bwindi.

Patterns of elephant crop raiding activities in Bwindi (Chapter 6) are similar to patterns revealed by previous studies, namely highly seasonal movements that are restricted to certain locations (Williams *et al*, 2001; Sitati *et al*, 2003). However, the response of farmers in Bwindi to elephant crop raiding differs from the response of farmers found at other sites in Africa. Most farmers tend to exaggerate crop damage caused by larger animals such as elephants, even when smaller species account for a higher proportion of the damage (Hill, Osborn and Plumptre, 2002). In Bwindi however, the level of farmers' complaints about elephants was similar to the level of elephant crop raiding, as the majority of farmers complaining to rangers about elephants only did so when elephants were raiding their crops. This difference is partly explained by the data. This study was based on day-to-day interactions between communities neighbouring a National Park and law enforcement rangers, which gives a different insight in to the relations between local communities and staff of a protected area, and local attitudes towards conservation, than that gained from attitudinal research, in particular research based on questionnaire surveys (for example De Boer and Baquete, 1998; Hill, 1998; Infield and Namara, 2001; Weladji and Tchamba, 2003). Another explanation is the assistance that farmers received from rangers with mitigating crop damage by elephants. Rangers felt that farmers complain to them about crop raiding in the hope that the rangers would assist them by employing scare-shooting. Farmers whose fields were raided by elephants tended to receive assistance and therefore had no reason to complain to rangers when elephants were not crop raiding. The impact of problem animal control on community response regarding crop raiding can be further investigated by examining control and response in relation to baboons.

### 7.4.2.2 Baboon control

The results of this study indicate that the low level of baboon control continued from 1996 to 2000. The study also revealed that baboon complaints, particularly from farmers around the north and centre, accounted for the majority of the community response regarding crop raiding, and that farmers complained more about baboons to rangers than about other species, even though other species accounted for higher proportions of crop damage. For example, bushpigs are common raiders around north areas of Bwindi (Musaasizi, 2000), yet farmers from the north rarely complained to rangers about bushpigs. Also, there were no complaints about small carnivores, despite their frequent raids on crops and livestock in all areas around Bwindi (Andama, 2000). The high level of baboon complaints could indicate that local perceptions of crop raiding are greater for baboons than for other species. Factors contributing to this perception could be the crops consumed, as baboons consumed a greater variety of crops in comparison with other monkey species, including cash crops of tea, coffee and pineapples as well as the major food crops of sorghum, millet and maize.

Furthermore, although carnivore species take livestock from farms adjacent to Bwindi, these raids are nocturnal and baboons were the only species observed raiding hens and piglets during the day (Chapter 6). In addition, baboons are larger than other species of monkey that crop raid and are therefore more visible. Fear could also explain the high level of baboon complaints, as fear of a wild animal can led to greater concerns about its crop raiding activities than about other species (Hill, 1998). Communities around Bwindi fear baboons because the baboons attack people guarding crops, as noted in the patrol reports, and also the dogs sent to chase the animals away from fields (personal observation). Baboon complaints could have also resulted from the level of problem animal control by rangers. The results showed that, regardless of area around Bwindi, the majority of farmers complaining to rangers about baboons while baboons were crop raiding did not receive assistance from the rangers with problem animal control. This is understandable, as the high number of baboon complaints placed great demand on the rangers. However, the lack of baboon control may have led to farmers to complain more and even to complain when baboons were not raiding their crops.

Such an influence of problem animal control on communications regarding crop raiding between farmers and rangers has implications for conservation managers seeking to improve their relations with local communities. Studies on protected area management have concluded that crop damage by wild animals is a significant cause of negative attitudes of local communities towards conservation (De Boer and Baquete, 1998; Bauer, 2003; Weladji and Tchamba, 2003), and has implications for community-based programmes and integrated initiatives aiming to secure local support for protected area conservation (Hill, 2000; Nyhus, Tilson and Sumianto, 2000; Archabald and Naughton-Treves, 2001). However, this analysis indicates that the main issue regarding park-community relations over crop raiding is not damage by wild animals, but rather the assistance with mitigation given by conservation authorities to local farmers.

### 7.4.3 Gorilla control

Hunting is a traditional method of rural communities of Africa to mitigate crop raiding by gorillas. From his visit to Rwanda, the Congo and Uganda in 1959, Schaller (1964) observed gorillas feeding on banana plants and described how, to protect their crop, farmers would surround and kill a gorilla group. Furthermore, in

January 2003, after the Rugendo gorilla group consumed 235 corn stalks of one farmer in community land neighbouring the Virunga National Park, an infant of the group died from injuries when farmers threw stones to chase the gorillas away (Kiyengo and Binyeri, 2003).

In Bwindi, the law enforcement records showed that human-gorilla conflict was evident during the 1930s when Bwindi was first gazetted as the Kayonsa reserve. Furthermore, during the period before National Park gazettement, human-gorilla conflict was caused by fear, although issues of compensation have dominated the conflict. Farmers have continued to request National Park officials to compensate their losses from crop raiding by gorillas (personal observation), although the analysis on the type of community response regarding crop raiding by gorillas, from 1996 to 2000, was limited. However, the analysis revealed that the level of gorilla crop raiding was a significant determinant on problem animal control employed by rangers, and that community response on gorilla crop raiding appeared to be similar to crop raiding responses about elephants, as the majority of farmers complaining about gorillas only did so when gorillas were raiding their crops. A high level of complaints about gorillas could be expected because of the local fear of these animals (Namara, 2000), because a single foray by gorillas typically causes more crop damage than a foray by monkeys, and because gorillas favour banana plants that are an important household source of food and income (Chapter 6). However, the majority of farmers complaining about gorillas received assistance from the rangers with chasing gorillas away from their crops, and thus problem animal control appears to have been of key importance to the relations between National Park staff and the local community that regard crop raiding.

Regarding all species, positive correlations between elephant and gorilla crop raiding and problem animal control indicate that links existed between patrols and these high profile species, and that no such links existed for other less high profile species. There is a possible bias in the data, as rangers may have conducted law enforcement patrols in areas and during seasons of elephant and gorilla crop raiding (Chapter 6) with the intention of undertaking problem animal control if crop raiding was encountered. However, the occurrence of such patrols, which was not possible to determine from the data, would strengthen the conclusion that rangers primarily assist communities who experience elephant and gorilla crop raiding.

### 7.4.4 Community response on crop raiding

In addition to examining data per species, conclusions can be drawn about responses of communities neighbouring Bwindi regarding crop raiding. The majority of responses, regardless of area around Bwindi, were complaints made by farmers hoping to secure immediate relief from crop raiding. This is perhaps not surprising given the fact that farmers were communicating with law enforcement rangers who decide whether or not to employ scare-shooting, and given the historical reliance by rural communities in Uganda on authorities for assistance with vermin control. Nonetheless, few requests were made for longer-term solutions, such as vermin guards or land purchase, which would take more time for National Park officials to implement in comparison with scare-shooting by rangers.

The findings of this study reveal a mismatch between community complaints of crop raiding species and actual damage. This was particularly evident for baboons and indicated that local perceptions of crop raiding are greater for baboons than for other species. As discussed, exaggerated perceptions likely resulted from the high variety of crops consumed by baboons, the visibility of this large mammal in comparison with smaller monkeys that crop raid, local peoples' fear of baboons and the low level of problem animal control by rangers. Exaggerated perceptions of crop raiding resulting from perceived damage and species dangerousness have been previously documented (Hill, Osborn and Plumptre, 2002). Therefore, the findings of this study, which were based on day-to-day interactions between communities and rangers, appear similar to studies based on questionnaire surveys. This illustrates that understanding mismatches between complaints and actual damage is vital for conservation managers to resolve conflict and improve relations with local communities.

There have been recent changes in vermin control at Bwindi. IGCP initiated the Human-Gorilla Conflict Force (HUGO) to reduce and mitigate crop raiding by gorillas and, in 1999, employed a HUGO team in western areas of Bwindi to chase gorillas back to the forest by ringing bells and beating drums. Members of the team are from the community and work as volunteers, and IGCP supports the team by providing field equipment (Makombo, 2003). Also, in 2000, the Uganda Wildlife Authority, in collaboration with CARE-DTC, introduced a pilot programme of problem animal control. The programme permits farmers to construct live traps in their fields for baboons and bushpigs, and was introduced in three parishes bordering the north and two parishes bordering the south of Bwindi. The programme was implemented under the collaborative management approach for protected area conservation that has been adopted at Bwindi, and involved a Memorandum of Understanding signed between National Park authorities and local communities (Makombo, 2003). However, despite these changes and the recognition that crop raiding has a strong negative impact on community attitude towards Bwindi (Makombo, 2003), donor investment in mitigation is lower than the investments in other community-based conservation initiatives. The Mgahinga and Bwindi Impenetrable Forest Conservation Trust, which was established in 1995 to conserve the Mgahinga Gorilla and Bwindi Impenetrable National Parks region, is a major donor at Bwindi operating with an annual budget of US$400,000 (Dutki, 2002). Based on the premise that communities benefiting from a protected area are more likely to support its conservation than communities not receiving such benefits, the Trust, following other ICDPs in Africa, has primarily implemented these benefits as funding for community projects, such as schools and health clinics, and has devoted the majority (60%) of its net revenue to these projects. Projects supported for the mitigation of crop damage by wild animals have been research, and research projects in total receive 20% of the Trust's net revenue.

Mitigating crop raiding requires a level of manpower and resources that is often unavailable to managers of protected areas. Thus donor investment in problem animal control, which could be perceived as a community benefit from the National Park, is vital for managers of Bwindi to effectively address issues of human-wildlife conflict.

### 7.4.5 Summary

In summary, this chapter illustrates that communities of the south, east and west receive most problem animal control, as rangers mainly control crop raiding by elephants and gorillas. In addition, communities around the north and centre account for most complaints to rangers about crop raiding, and that problem animal control appears of key importance to community complaints about crop raiding. This chapter established the historical context and current situation of problem animal control at Bwindi, and interactions between local communities and rangers that regarded crop raiding. This provides a basis for analysis of the impacts of problem animal control on the response of local communities to rangers on law enforcement patrol (Chapter 8).

Having established problem animal control at Bwindi and interactions between communities and rangers regarding crop raiding, I now seek to determine the response of local communities to rangers on law enforcement patrol.

# Chapter Eight

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# Responses by Local Communities to Rangers on Law Enforcement Patrol

*Local resident of Buhoma, the village neighbouring the headquarters of Bwindi*

*(J. Baker)*

# Chapter Eight

# 8 Responses by local communities to rangers on law enforcement patrol

## 8.1 Introduction

Relations between conservation authorities and local communities are important for the sustainable management of protected areas. This premise underlies community-based and integrated conservation and development initiatives, and is based on the assumption that improving local attitudes towards conservation, and gaining local support for protected areas, will reduce threats to biodiversity (Wells and Brandon, 1992). Following the shift in conservation policy from strict law enforcement measures to community-based approaches that resulted from the recognition that enforcement policies had failed to conserve biodiversity (e.g. Bell and McShane-Caluzi, 1986; Leader-Williams and Albon, 1988), the international community prioritised the issues of local conservation attitudes and relations between communities and conservation authorities (IUCN, 1980).

There has since been much attention in the literature on factors that determine attitudes of rural communities towards conservation (e.g. Newmark *et al*, 1993). Such research enables an evaluation of the relative success of different strategies to secure good relations with local communities, and there is evidence that community-based and integrated approaches improve local attitudes to conservation. For example, a buffer zone community forestry programme in Nepal led to the acceptance of the National Park by local people (Straede and Helles, 2000), and a community-based conservation project in the Yunnan province of China, which aimed to support rural economic development, played an important role in resolving human-elephant conflict (Zhang and Wang, 2003). However, the link between improved local attitudes towards conservation and a reduction in threats to biodiversity has yet to be established, as studies have shown that positive attitudes towards protected areas do not necessarily benefit conservation. An evaluation of the community forestry programme in Nepal concluded that the park-people conflict had not been fully resolved because, despite improved local attitudes towards the National Park, illegal firewood collection had continued (Straede and Helles, 2000). Also, in northern India, people living in and around a forest corridor linking two National Parks were supportive of the concept of conservation, yet they continued to collect forest resources because of a lack of alternative resources and negative attitudes towards conservation authorities (Badola, 1998). Furthermore, an assessment of a seven-year community conservation programme in Lake Mburo in Uganda revealed that, although the conservation attitude of communities benefiting from the programme was more positive than that of communities that did not, high levels of poaching and illegal grazing continued in the National Park (Infield and Namara, 2001).

An additional factor contributing to the success of integrated approaches is the difference between individuals and communities in the incentives that they face from conservation projects. Projects aiming to provide benefits from protected areas to communities rather than to individuals by, for example schools and health clinics (Larson *et al*, 1997), have been criticised. Local conservation costs differ between individuals according to dependency on natural resources and consequently, community benefits may not outweigh individual costs or may not extend to all individuals that bear costs of conservation (Wells *et al*, 1992). There is therefore a need for conservation managers to consider the difference between individual and community incentives when implementing benefit schemes to improve attitudes towards conservation. Thus although strategies aiming to provide local benefits from protected areas reduce conflict between rural communities and conservation authorities and gain local support for protected areas, there is debate as to whether these community-benefit strategies reduce threats to biodiversity, particularly the level of illegal activity within protected areas (Infield and Namara, 2001; Makombo, 2003). Nonetheless, a priority for integrated conservation and development initiatives is to gain local community support for conservation (Larson *et al*, 1997).

The approach for protected area conservation in Uganda that was adopted after the country gained political stability in 1986, involves the participation of local communities in the management of natural resources, and the distribution of economic benefits from protected areas to local communities. The government's conservation policy emphasises the importance of gaining local support for protected areas, and of securing good relations between the communities and conservation authorities (UWA, 1999). Integrated conservation and development initiatives have been established in many of the country's protected areas, including Bwindi. The Development Through Conservation (DTC) project of CARE-Uganda has monitored attitudes of local communities towards Bwindi with the aim to assess impacts of the integrated programme on local communities. Attitudinal surveys were conducted in 1998, 1999 and 2001. Respondents in each survey most frequently cited development projects of schools and health centres as the benefit that they received from the National Park. Furthermore, there was an increase in the number of people who felt that the benefits of the National Park were greater than the costs, as the number rose from 32% in 1998 to 54% in 1999, although declined to 43% in 2001. Respondents stating that there were no benefits from the National Park were from areas with high crop raiding. Also, crop raiding by wild animals was identified as the biggest problem for communities because of the National Park in each survey (Siriri, 2002).

The aim of this chapter is to examine responses by local communities to rangers on law enforcement patrol in Bwindi. The objectives are to determine types of positive and types of negative responses, and the factors that best explain the type of response. To address the objectives, I seek to determine the following research questions:

- Were most responses positive or negative?
- In which areas of Bwindi did positive and negative responses occur?
- Were differences in responses related to community member?
- Were differences in responses related to year and season?
- Were differences in responses related to crop raiding by wild animals or problem animal control?
- Were differences in responses related to law enforcement or the illegal activities of bushmeat poachers?
- Were differences in responses related to community benefit schemes of the integrated programme?
- What is the relative significance of year, season, area of Bwindi, crop raiding by wild animals, problem animal control, law enforcement, illegal activity and community benefit schemes to positive responses by communities to law enforcement rangers

## 8.2 Materials and Methods

### 8.2.1 Data collection

The operations of law enforcement patrols in Bwindi, the rangers' patrol reports and the retrieval and means of verifying the patrol reports, were described in Chapter 2. From 1996, in addition to recording wild animals raiding crops and problem animal control, rangers recorded interactions with, and observations of, members of local communities. These records came under the heading of community response and consisted of descriptive notes detailing conversations with community members, and general observations made by the rangers on the attitude of local communities towards the National Park. All community responses were made outside the National Park when rangers patrolled the National Park boundary or when rangers returned to their outpost after a patrol through community land (sections 2.2.1 and 7.2.2). Rangers also recorded year, month, number of rangers on patrol, number of effective patrol days, type of patrol whether long or day patrol, and area toponym(s), which were assigned to the corresponding sector or sectors within the different areas of Bwindi (north, centre, east, south and west) (section 2.2.1.3).

Data were extracted from records of law enforcement patrols along the National Park boundary with descriptive notes on community responses that comprised 1288 patrol days carried out from 1996 to 2000. The number of community responses per patrol day was summed for the north, centre, east, south and west of Bwindi, per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol in each area were included for analysis (1996-2000 monthly totals across all areas; n = 141).

Community responses were categorized according to the type of response, which were ranked from very negative to very positive using a five-point Likert scale (Table 8.1). The scale was constructed from discussions with law enforcement rangers, community conservation rangers, National Park wardens and staff of conservation authorities at Bwindi during fieldwork, on the type of positive and negative response by communities to law enforcement rangers. The community member responsible for the response was also recorded. Four types of community members were identified:

villagers; councillors of local authorities which were village and parish chiefs; resource users of the harvest zone programme and the Batwa.

Rangers noted whether their interaction was with a villager or resource user, even though resource users are members of the local community and therefore also villagers. Thus a distinction could be made between villagers and resource users, which enabled comparison of type of community response by individuals benefiting and not benefiting from the harvest zone programme. However, it was possible that rangers only recorded villagers if rangers did not know whether an individual was a resource user, or if rangers missed this detail while noting the interaction. This was considered of low likelihood because rangers are themselves local community members and know most of the small number of resource users, and because villagers are often referred to as resource users because of the status gained within the community (personal observation). The categorisation of each area of Bwindi by proportion of forest designated as harvest zone (section 2.2.1.3) was noted to account for the proportion of resource users in the community per area.

Validation of rangers' recording of community response showed that most (89%) recording by rangers were assigned the same categories that were assigned from my recording made while accompanying the patrols (section 2.2.1.2). A difference was evident between the rangers' and my recording, namely that I tended to include more detail about the community member of the interaction such as parish of residence, parish of origin, sex and age. This information would have enabled analysis of community response with regard to type of community member and benefits per parish that they have received from the National Park. Nonetheless, rangers' recordings were sufficient to assign each interaction to the appropriate category and the validation permits confidence in the accuracy of rangers' recording of community response.

Table 8.1 The Likert scale for the type of response by communities to law enforcement rangers in Bwindi from 1996 to 2000

| Type of Response | Definition |
|---|---|
| Very negative | Refuse to assist rangers investigating illegal activities<br>Refuse to assist rangers with the trial of arrested offenders<br>Alert offenders inside the National Park to rangers on patrol<br>Request compensation, vermin guards or land purchase because of crop raiding by wild animals |
| Negative | Complain to rangers about crop raiding animals<br>Complain to rangers about living adjacent to the National Park<br>Complain to rangers about community projects of the integrated program |
| Neutral | Report problems in the forest to rangers, e.g. dead animals<br>Enquire about National Park related issues |
| Positive | Positive comments about National Park and/or conservation<br>Appreciation for rangers' assistance with problem animal control |
| Very positive | Report fire in the National Park to rangers<br>Assist rangers with fire control<br>Assist rangers investigating illegal activities<br>Report illegal activities to rangers on patrol<br>Report illegal activities to rangers at the outpost |

## 8.2.2 Data analysis

The first analysis aimed to determine the area and community member associated with positive and with negative responses by examining possible associations between response type, area of Bwindi and community member. Types of positive and negative response were first examined. Possible associations between positive and negative response and area of Bwindi, and between positive and negative response and community member, were then examined by Chi Square. In addition, responses by resources users were examined. The low number of responses did not permit statistical analysis, and responses by resource users were grouped into three categories of negative (negative and very negative), neutral and positive (positive and very positive).

The second analysis aimed to identify the relative significance of area of Bwindi and community member to the type of response. The data, which comprised the number of community responses per month, were analysed by log linear analysis, under the assumption of a Poisson distribution, using the hierarchical approach and specifying a log link function (section 2.2.3.3). A three-way contingency table was constructed with the factors of area, community member and the five-point Likert scale of community response.

The third analysis aimed to conduct univariate tests to examine possible differences in positive community response between areas of Bwindi, years and seasons, and possible associations with crop raiding by wild animals, problem animal control, law enforcement, illegal activity and community benefit schemes of the integrated programmes of Bwindi. The number of positive responses per month was expressed as a proportion of the total number of community responses. This formed the dependent variable for the analyses, which were undertaken using the non-parametric tests of Kruskal-Wallis, Mann Whitney U and Spearman's rank correlation. First, comparisons were undertaken of the mean proportion of positive community response between areas of Bwindi, years from 1996 to 2000, months of the year, months of the rainy and dry seasons (Chapter 2) and months of the farming season (Chapter 6).

Possible associations between positive community response and crop raiding by wild animals (Chapter 6) and problem animal control (Chapter 7) were then examined. Spearman's rank correlations were undertaken between the proportion of positive community response and patrol encounters with crop raiding incidents involving gorillas, elephants, baboons and other monkey species. Spearman's rank correlations were also undertaken between the proportion of positive community response and the proportion of crop raiding incidents encountered by patrols with problem animal control.

Possible differences in positive community response between areas receiving community benefit schemes from the integrated programme of Bwindi were investigated. First, comparisons were undertaken of the mean proportion of positive response between communities adjacent to areas of Bwindi with high and low proportions of harvest zone (Chapter 2). Second, areas of Bwindi were categorised by the proportion of community benefit schemes that were implemented by the revenue sharing scheme and the conservation trust fund from 1991 to 2000 (Table 8.1). Comparisons were then undertaken of the mean proportion of positive response between communities in low, medium and high benefit areas.

Possible associations between positive community response and law enforcement and illegal bushmeat poaching activities were examined. Spearman's rank correlations were undertaken between the proportion of positive response and the average number of rangers on patrol, and between the proportion of positive response and the number of effective patrol days (Chapter 4). Spearman's rank correlations were also undertaken between the proportion of positive response and patrol encounters with snares, signs of poaching and poachers, and with the number of snares per snare encounter (Chapter 4).

The final analysis aimed to identify which factors best explained the likelihood of positive responses by communities to rangers on law enforcement patrol in Bwindi. The number of positive responses per month was converted into binary data comprising months with (1996-2000 monthly totals; $n = 81$) and months without (1996-2000 monthly totals; $n = 60$) a positive interaction. This formed the dependent variable in a stepwise logistic regression analysis, using the forward stepwise procedure. The explanatory variables were significant factors identified from the univariate analyses. Area of Bwindi and the categories of harvest zone and community benefit schemes were entered as categorical variables (section 2.2.3.2).

Table 8.2 Area of Bwindi by the proportion of community benefit schemes implemented by the revenue sharing scheme and the conservation trust fund from 1991 to 2000

| **Community project** | **Area of Bwindi** | | | | |
|---|---|---|---|---|---|
| | **North** | **Centre** | **East** | **South** | **West** |
| Income generating | 1 | 0 | 1 | 0 | 0 |
| School construction | 7 | 2 | 6 | 1 | 2 |
| Medical facilities | 4 | 0 | 2 | 2 | 1 |
| Road construction | 3 | 0 | 0 | 1 | 1 |
| Problem animal control | 0 | 2 | 0 | 0 | 0 |
| Specialist group | 1 | 1 | 0 | 1 | 1 |
| Total | 16 | 5 | 9 | 5 | 5 |
| Proportion of total projects (n = 40) | 0.40 | 0.12 | 0.24 | 0.12 | 0.12 |
| **Benefit area** | **High** | **Low** | **Medium** | **Low** | **Low** |

## 8.3 Results

Rangers on law enforcement patrol recorded 445 responses by members of the local community from 1996 to 2000. There were two records when communities reported fire to the outpost, both in 1999 by villagers around the centre, and there were 23 records when communities assisted with fire control, in 1999 (n = 13) and 2000 (n = 10), by villagers around the centre (n = 4), and by both villagers and beekeepers around the south (n = 8) and east (n = 11). Reporting fire and assistance with fire control were initially categorised as positive responses. However, fieldwork undertaken with community conservation rangers showed that some forest fires were deliberately started by villagers who then assisted rangers with fire control to receive a reward. Therefore, the true nature of responses concerning fire, that is whether positive or negative, was difficult to determine and so fire responses were omitted from the analysis.

Most responses to rangers by communities neighbouring Bwindi were negative (Figure 8.1). Most negative responses were complaints about crop raiding by wild animals (84.3%). There were fewer complaints about the National Park (5.7%) or about community benefits from the integrated program (10.0%).

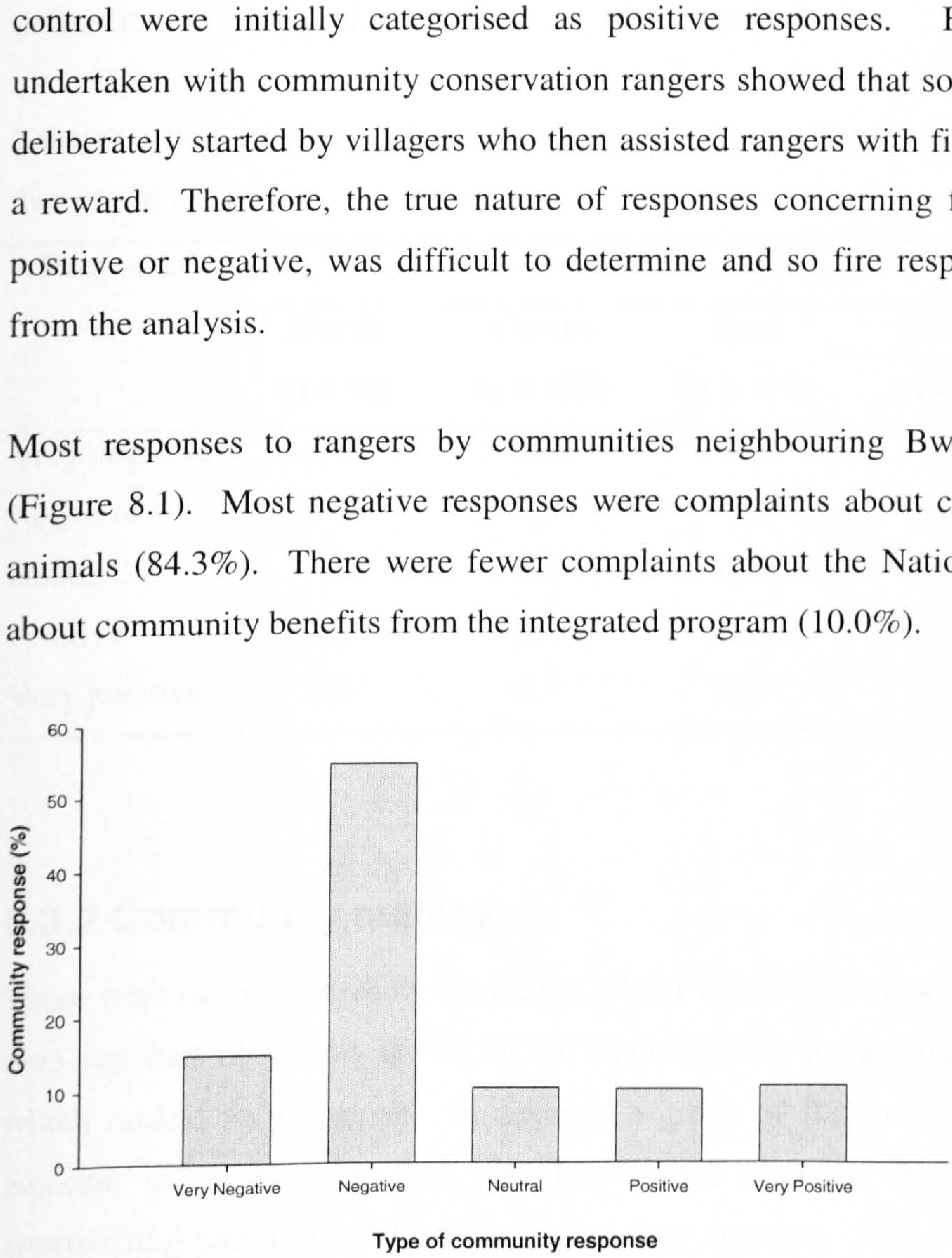


Figure 8.1 Community responses to law enforcement rangers at Bwindi from 1996 to 2000

### 8.3.1 Area

The west area was omitted from analysis because of low cell frequencies, as there were no very positive responses by communities in the west. Most responses by communities in each area were negative (Pearson's $\chi 2 = 60.83$; df = 12; $p < 0.001$) (Table 8.3). However, the north and centre comprised high proportions of negative and very negative responses. In contrast, the east comprised high proportions of positive and very positive responses. Furthermore, the south comprised high proportions of very positive and very negative responses.

Table 8.3 Type of community response to law enforcement rangers by area of Bwindi from 1996 to 2000

| Response | Area (%) | | | | |
|---|---|---|---|---|---|
| | North (n = 96) | Centre (n = 153) | East (n = 110) | South (n = 39) | West (n = 22) |
| Very negative | 14.6 | 21.6 | 4.6 | 20.5 | 9.1 |
| Negative | 64.6 | 60.8 | 40.0 | 46.2 | 54.6 |
| Neutral | 7.3 | 7.8 | 12.7 | 10.3 | 27.3 |
| Positive | 7.3 | 3.9 | 21.8 | 7.7 | 9.1 |
| Very positive | 6.3 | 5.9 | 20.9 | 15.4 | 0.0 |

### 8.3.2 Community member

There were two responses by the Batwa, which were both around the south. A Batwa man reported illegal pit sawing in the National Park to rangers on patrol in 1996, which ranked very positive. In contrast, a group of Batwa men working in fields adjacent to the National Park boundary alerted offenders inside the forest to an approaching patrol in 1998, which ranked very negative. The Batwa were excluded from the analysis because of the small number of responses.

Most community responses to rangers were by villagers (89.3%). There were fewer by local authorities (5.0%) and resource users of the harvest zone programme (5.7%). The association between type of response and community member (Fisher's Exact

Test = 69.84; $p < 0.001$) (Table 8.4) showed that most responses by villagers and local authorities were negative, whereas responses by resources users were mainly positive or very positive. In addition, proportions of very negative responses by villagers and local authorities were similar, whereas there were no very negative responses by resource users.

Table 8.4 Type of community response to law enforcement rangers by community member of Bwindi from 1996 to 2000

| Response | Community member (%) | | |
|---|---|---|---|
| | Villager (n = 374) | Local authority (n = 21) | Resource user (n = 24) |
| Very negative | 16.1 | 15.1 | 0.0 |
| Negative | 60.6 | 55.4 | 12.5 |
| Neutral | 9.3 | 9.3 | 12.5 |
| Positive | 6.2 | 9.3 | 37.5 |
| Very positive | 7.6 | 10.8 | 37.5 |

The east and north are high harvest zone areas and therefore contain a higher proportion of resource users per community than other areas of Bwindi. However, although most responses by resource users (87.5%) were by beekeepers of the east, there were fewer responses from herbalists and basket makers of the north (8.4%) (Figure 8.2). In addition, most responses by beekeepers of the east were positive (66.7%). There were few responses by herbalists and basket makers of the centre (4.2%) and no responses from beekeepers of the south.

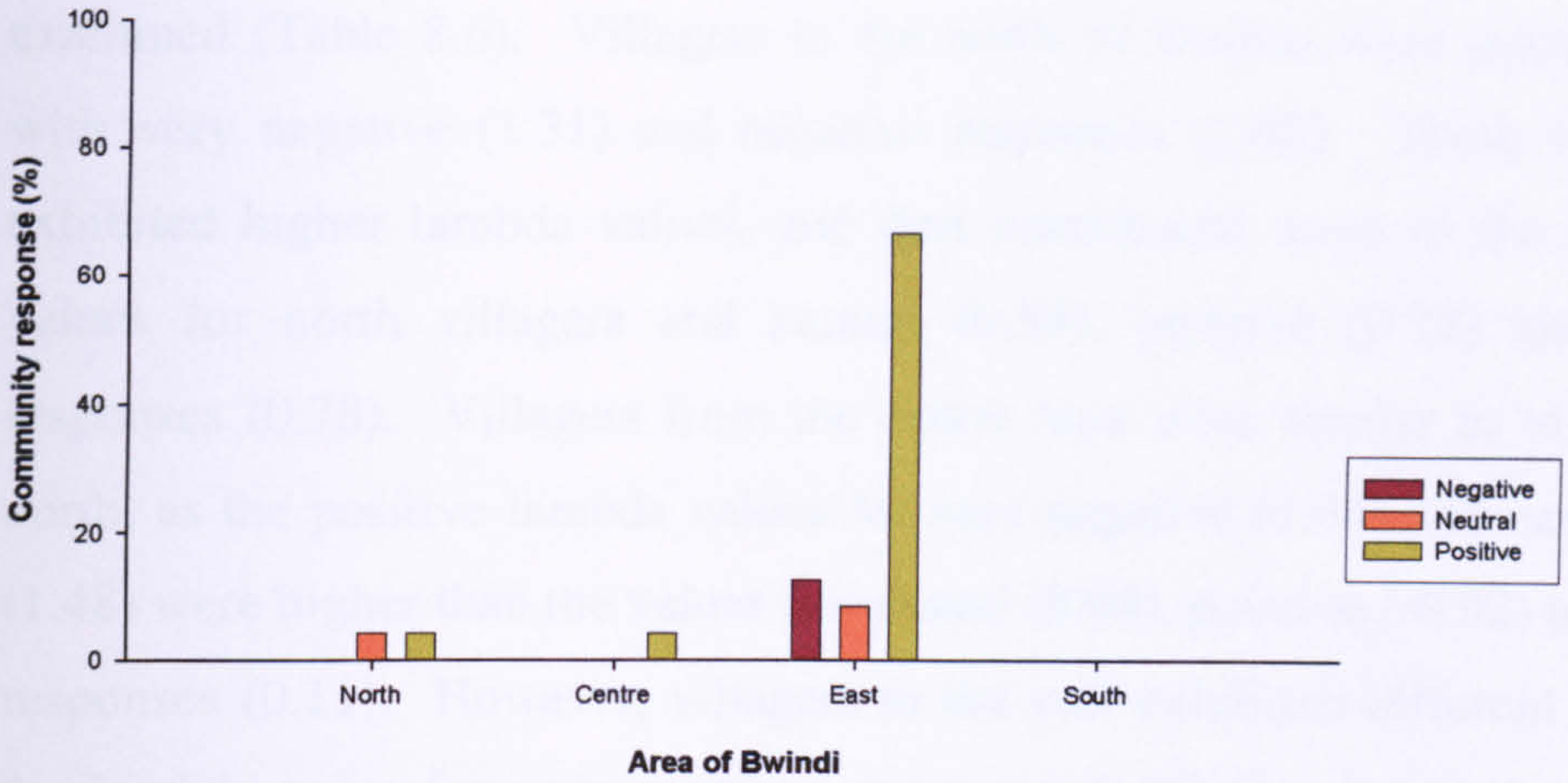


Figure 8.2 Responses to law enforcement rangers by resource users of the harvest zone programme in areas of Bwindi from 1996 to 2000

### 8.3.3 Patterns of community response

The west area and the Batwa were omitted from the log linear analysis because of the small numbers of responses. A three-way (4x3x5) contingency table was constructed with the factors of area (north, centre, south, east), community member (villager, local authority, resource user) and the type of response from very negative to very positive. The three way interaction of area*member*type was significant (Table 8.5). Thus the final model that best explained the data was the saturated model, with a likelihood value of zero (G2 = 0.0; df = 0). The model therefore perfectly predicts the expected cell frequencies.

Table 8.5 Tests of partial association, using the chi square statistic, for interaction terms and main effects of factors in the final model of community response to law enforcement rangers at Bwindi from 1996 to 2000

| Term | df | Partial $\chi^2$ | Significance of $\chi^2$ |
|---|---|---|---|
| Area*member | 6 | 23.65 | < 0.001 |
| Area*type | 12 | 34.42 | < 0.001 |
| Member*type | 8 | 51.78 | < 0.001 |
| Area | 3 | 75.70 | < 0.001 |
| Member | 2 | 535.16 | < 0.001 |
| Type | 4 | 249.05 | < 0.001 |

The standardised lambda values for interaction terms involving villagers were examined (Table 8.6). Villagers in the north of Bwindi were positively associated with very negative (1.31) and negative responses (1.62). These interaction terms exhibited higher lambda values, and thus contributed more to the model, than the values for north villagers and neutral (0.59), positive (0.78) and very positive responses (0.78). Villagers from the centre area were similar to villagers from the north, as the positive lambda values for very negative (1.44) and negative responses (1.48) were higher than the values for neutral (0.69), positive (-0.92) and very positive responses (0.11). However, villagers in the east exhibited different associations, as the lambda value for very negative responses (0.69) was lower than the values for neutral (1.23) and negative (1.31) responses. Furthermore, the values for these responses were lower than for positive (1.56) and very positive (1.62) responses. Thus villagers in the east were associated with positive and very positive responses, whereas villagers in the north and centre were associated with negative and very negative responses. Parameters for terms of the south area were references in the model. Thus only the estimate for very negative responses by villagers (1.04) was calculated.

Table 8.6 Parameter estimates and the ratio of the standardised lambda values for interaction terms that included villagers, in the final model of community response to law enforcement rangers at Bwindi from 1996 to 2000

| Parameter | Parameter estimate | Standardised lambda |
|---|---|---|
| Constant | 0.92 | 1.45 |
| North*villager*very-negative | 2.37 | 1.31 |
| North*villager*negative | 1.73 | 1.62 |
| North*villager*neutral | 0.71 | 0.59 |
| North*villager*positive | 0.96 | 0.78 |
| North*villager*very-positive | 0.96 | 0.78 |
| Centre*villager*very-negative | 2.43 | 1.44 |
| Centre*villager*negative | 1.28 | 1.48 |
| Centre*villager*neutral | 0.69 | 0.69 |
| Centre*villager*positive | -1.18 | -0.92 |
| Centre*villager*very-positive | 0.12 | 0.11 |

| | | |
|---|---|---|
| East*villager*very-negative | 1.27 | 0.69 |
| East*villager*negative | 1.32 | 1.23 |
| East*villager*neutral | 1.53 | 1.31 |
| East*villager*positive | 1.86 | 1.56 |
| East*villager*very-positive | 1.93 | 1.62 |
| South*villager*very-negative | 1.27 | 1.04 |

### 8.3.4 Positive responses

Types of positive community response differed between areas (Table 8.7). Communities around the north and centre made no reports of illegal activities to rangers on patrol or at their outpost. The only assistance with law enforcement given by these communities occurred when rangers investigated illegal activities during a patrol by making enquiries among neighbouring communities. Most of this assistance around the north was by villagers (83.3%) with some by councillors of village courts (16.7%). In contrast, although most of the assistance around the centre was by villagers (55.6%), there was a higher proportion by councillors of village courts (33.3%) and also assistance by herbalists and basket makers of the harvest zone programme (11.1%). Proportions of positive comments about the National Park were similar between the north and centre. However, around the north villagers (66.7%) made most of the positive comments with fewer by resource users (16.7%) and councillors of parish courts (16.7%). In contrast, around the centre councillors of village courts (83.3%) made most of the positive comments with fewer by villagers (16.7%).

Community members around the east and south reported illegal activities both to rangers on patrol and at their outpost. Villagers (66.7%) made most of the reports around the east, with some also by beekeepers of the harvest zone programme (33.3%). Both villagers (50.0%) and beekeepers (42.9%) around the east assisted rangers investigating illegal activities during a patrol. In addition, the beekeepers (57.1%) made most of the positive comments about the National Park, with fewer by villagers (21.4%) and councillors of village courts (21.4%). In contrast, around the south there were no responses by resource users. Only villagers reported illegal activities to rangers on patrol and at their outpost. Both villagers (66.7%) and councillors of village courts (33.3%) of the south assisted rangers investigating illegal activities during a patrol.

Most responses around the west were reports to rangers concerning problems in the National Park, which were by villagers (88.3%) and councillors of village courts (11.7%), and enquiries about National Park issues, which were by villagers. The few positive community responses were all positive comments about the National Park by villagers.

Table 8.7 Positive responses to law enforcement rangers by communities in areas of Bwindi from 1996 to 2000

| | **Response** | **Area (%)** | | | | |
|---|---|---|---|---|---|---|
| | | **North (n = 20)** | **Centre (n = 27)** | **East (n = 61)** | **South (n = 13)** | **West (n = 7)** |
| Very positive | Report IA to outpost | 0.0 | 0.0 | 5.1 | 5.5 | 0.0 |
| | Report IA to patrol | 0.0 | 0.0 | 2.7 | 2.7 | 0.0 |
| | Assist investigation | 6.3 | 5.9 | 7.7 | 12.7 | 0.0 |
| Positive | Positive comment | 13.5 | 9.8 | 7.7 | 21.8 | 9.0 |
| | Appreciation | 0.0 | 0.0 | 2.6 | 2.7 | 0.0 |
| Neutral | Report problems | 1.0 | 2.0 | 5.1 | 10.0 | 22.7 |
| | Enquiry | 0.0 | 0.0 | 2.4 | 0.0 | 4.5 |

Key: report IA to outpost (report illegal activities to rangers at the outpost); report IA to patrol (report illegal activities to rangers on patrol); assist investigation (assist rangers investigating illegal activities); positive comment (positive comments about the National Park and/or conservation); appreciation (appreciation for rangers assistance with problem animal control); enquiry (enquire about National Park issues)

## 8.3.5 Negative responses

Villagers made all very negative responses in each area, except for one very negative response in the north by councillors of village courts who refused the trial of offenders (Table 8.8). Most very negative responses around the north, centre and south were requests concerning crop raiding, which were particularly high around the centre. In contrast, there were few very negative responses from communities around the east. Furthermore, the only very negative responses around the west were villagers refusing to assist rangers investigating illegal activities.

Most negative responses in each area were complaints about crop raiding by villagers. Only villagers made complaints around the north, centre and south, whereas villagers (92.1%) and beekeepers (7.9%) made complaints around the east. There were few complaints by communities about the National Park or about benefits from the integrated programme.

Table 8.8 Negative responses to law enforcement rangers by communities in areas of Bwindi from 1996 to 2000

| Response | | Area (%) | | | | |
|---|---|---|---|---|---|---|
| | | North (n = 76) | Centre (n = 126) | East (n = 49) | South (n = 26) | West (n = 14) |
| Very negative | Refuse assist IAs | 5.2 | 5.9 | 0.9 | 5.1 | 9.1 |
| | Refuse trial | 1.0 | 0.0 | 0.0 | 2.3 | 0.0 |
| | Alert offenders | 0.0 | 0.7 | 0.9 | 2.3 | 0.0 |
| | Request CR | 8.3 | 15.0 | 2.7 | 10.3 | 0.0 |
| Negative | Complain CR | 54.2 | 51.0 | 34.6 | 35.9 | 50.0 |
| | Complain NP | 6.3 | 6.5 | 4.6 | 7.7 | 4.6 |
| | Complain ICDP | 4.2 | 3.3 | 0.9 | 2.6 | 0.0 |

Key: refuse assist IAs (refuse to assist rangers investigating illegal activities); refuse trial (refuse to assist rangers with the trial of offenders); alert offenders (alert offenders inside the National Park to rangers on patrol); request CR (request compensation, vermin guards, or land purchase from National Park officials because of crop raiding); complain CR (complain to rangers about crop raiding by wild animals); complain NP (complain to rangers about living adjacent to the National Park); complain ICDP (complain to rangers about community benefit schemes of the ICDP)

## 8.3.6 Factors explaining the likelihood of positive responses

### 8.3.6.1 Area

The difference in the mean proportion of positive community responses between areas of Bwindi (Kruskal-Wallis $\chi^2 = 18.25$; df = 4; $p < 0.01$) (Figure 8.3) confirmed the log linear analysis. The east comprised the highest proportion and the north and centre comprised the lowest proportions of positive responses by communities to rangers on law enforcement patrol.

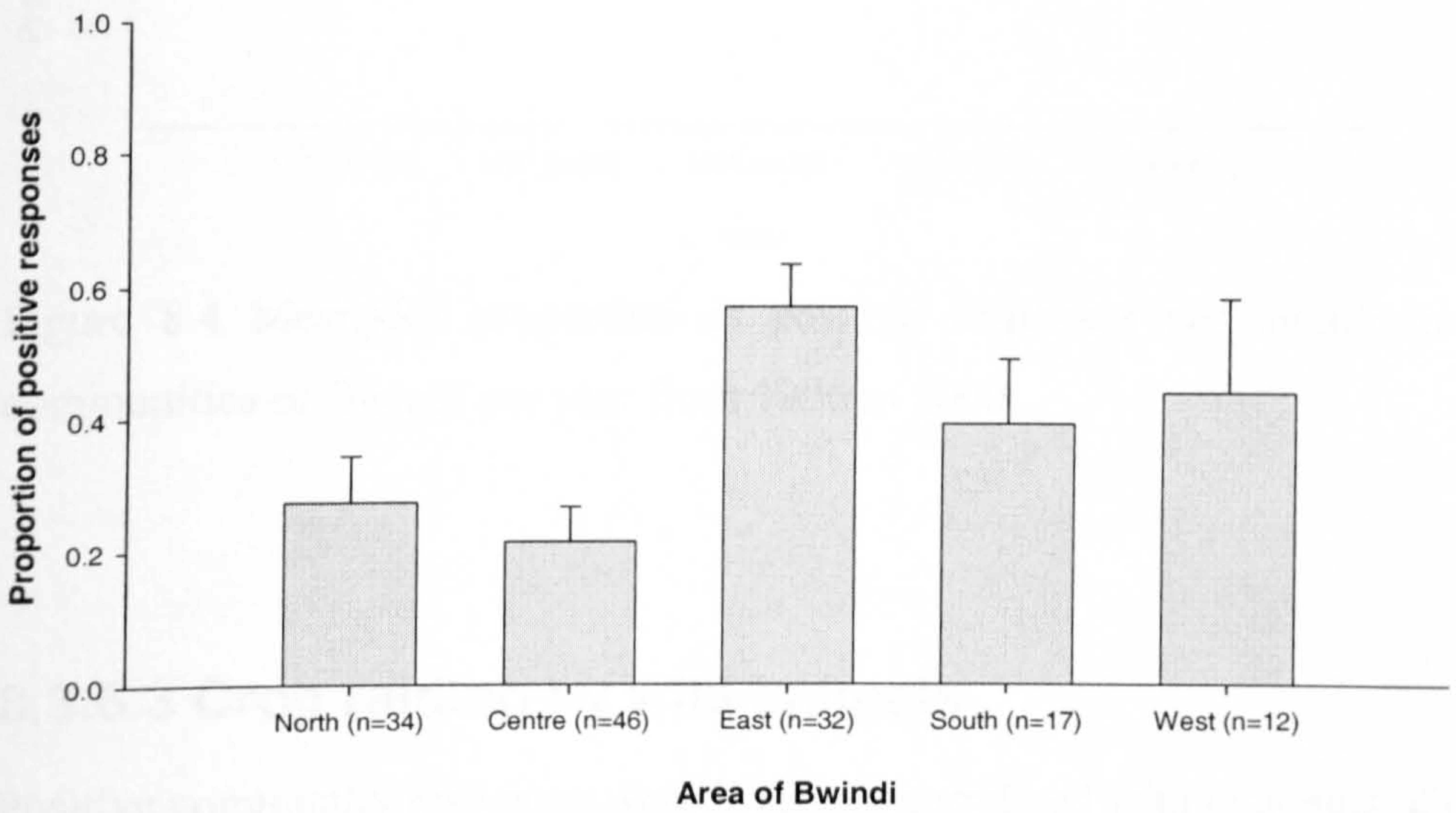


Figure 8.3 Mean±SE proportion of positive responses per month to rangers by communities in areas of Bwindi from 1996 to 2000

### 8.3.6.2 Year and season

There was no difference in the mean proportions of positive community response between the years from 1996 and 2000 (Kruskal-Wallis $\chi^2 = 4.02$; df = 4; $p > 0.05$) (Figure 8.4). The slight rise during 1999 may reflect the attack on the National Park headquarters by the Rwanda based Interahamwe rebels, which resulted in much local support for the National Park (Bayenda oral communication). In addition, there was no difference in the proportion of positive community responses between months of the year (Kruskal-Wallis $\chi^2 = 10.63$; df = 11; $p > 0.05$), months of the rainy or dry seasons ($z = -1.14$; $p > 0.05$), or months of the farming season (Kruskal-Wallis $\chi^2 = 1.24$; df = 2; $p > 0.05$).

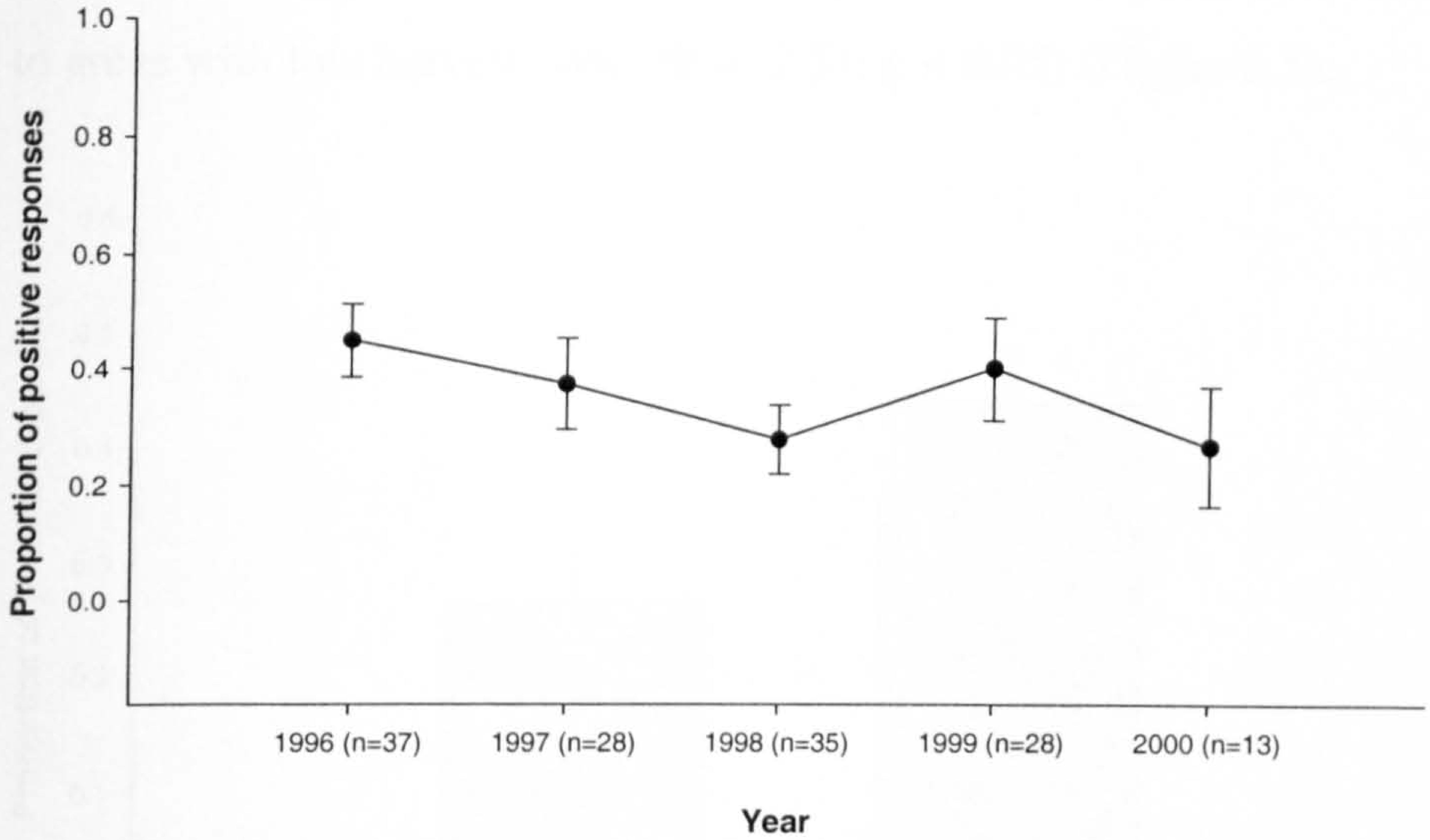


Figure 8.4 Mean±SE proportion of positive responses per month to rangers by communities of Bwindi per year from 1996 to 2000

### 8.3.6.3 Crop raiding by wild animals

Positive community responses were inversely correlated with incidents of crop raiding by wild animals ($r_s = -0.18$, $p < 0.05$). Incidents of crop raiding by gorillas ($r_s = -0.06$, $p > 0.05$) and monkeys ($r_s = 0.04$, $p > 0.05$) were not related to proportions of positive response. However, proportions of positive responses were negatively correlated with incidents of crop raiding by baboons ($r_s = -0.26$, $p < 0.01$) and positively correlated incidents of crop raiding by elephants ($r_s = 0.18$, $p < 0.05$).

### 8.3.6.4 Problem animal control

The correlation between positive response and elephant crop raiding may reflect villagers' appreciation for problem animal control by rangers, as rangers primarily target elephant crop raiding (Chapter 7). However, there was no relationship between the proportion of positive responses and incidents of problem animal control ($r_s = 0.07$, $p > 0.05$).

### 8.3.6.5 Harvest zones

The mean proportion of positive responses by communities adjacent to areas of Bwindi with high harvest zones was higher than responses by communities adjacent to areas with low harvest zones ($z = -2.51$; $p < 0.05$) (Figure 8.5).

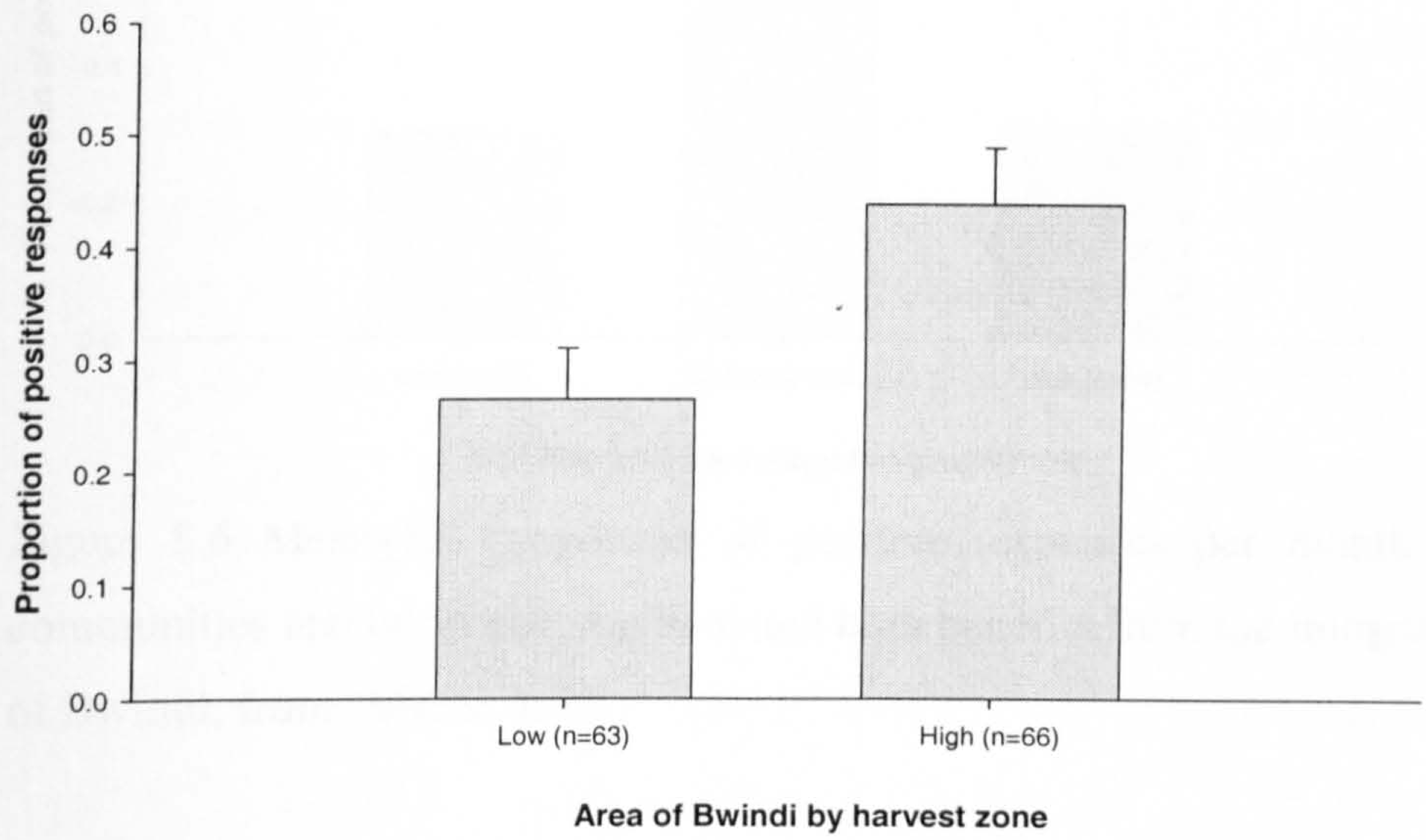


Figure 8.5 Mean±SE proportion of positive responses per month to rangers by communities adjacent to low and high harvest zone areas of Bwindi from 1996 to 2000

### 8.3.6.6 Community benefit schemes

Mean proportions of positive responses differed between communities receiving low, medium and high benefits from the integrated programme of Bwindi (Kruskal-Wallis $\chi^2 = 13.42$; df = 2; $p < 0.01$) (Figure 8.6). Positive responses were highest by communities receiving medium benefits, which were communities in the east. Furthermore, the proportions of positive responses were similar between communities receiving low and high benefits.

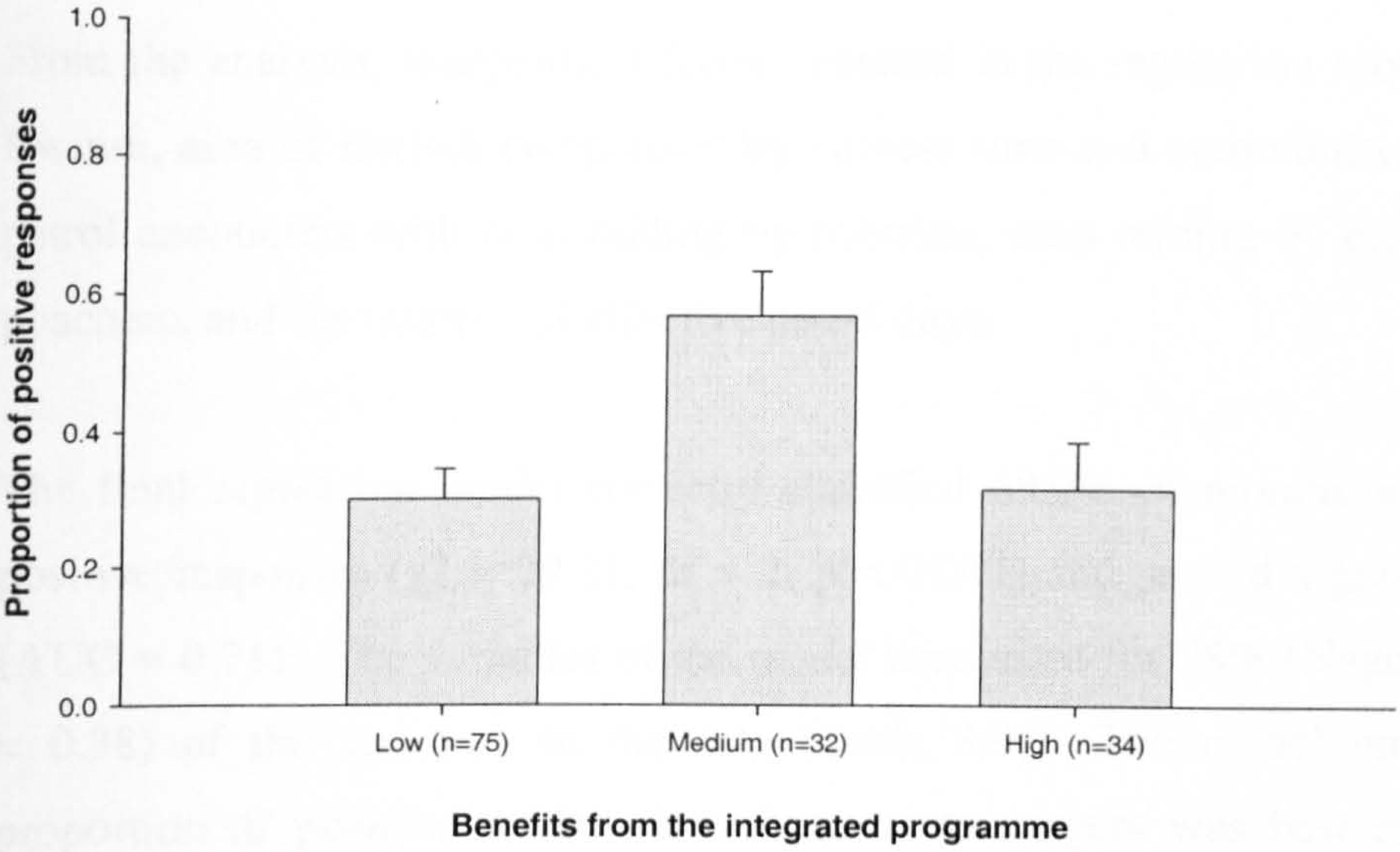


Figure 8.6 Mean±SE proportion of positive responses per month to rangers by communities receiving low, medium and high benefits from the integrated programme of Bwindi, from 1996 to 2000

### 8.3.6.7 Law enforcement

There was no relationship between the proportion of positive community responses and the average number of rangers on patrol ($r_s = 0.75$, $p > 0.05$). However, the proportion of positive community responses to rangers increased with an increasing number of effective patrol days ($r_s = 0.17$, $p < 0.05$).

### 8.3.6.8 Illegal bushmeat poaching

There was no relationship between the proportion of positive community responses and the patrol encounter rate with snares ($r_s = 0.13$; $p > 0.05$) and signs of poaching ($r_s = -0.04$; $p > 0.05$), or with the number of snares that rangers collected per snare encounter ($r_s = 0.12$; $p > 0.05$). However, the proportion of positive community responses increased with increasing patrol encounters with poachers ($r_s = 0.18$; $p < 0.05$).

### 8.3.6.9 Logistic regression model

From the analysis, independent factors entered in the regression model were area of Bwindi, area of Bwindi categorised by harvest zone and community benefit scheme, patrol encounters with crop raiding by baboons, crop raiding by elephants and with poachers, and the number of effective patrol days.

The final regression model correctly classified 69.0% of months with and without positive responses ($\chi 2 = 29.21$; df = 2; $p < 0.001$) and proved a good fit to the data (AUC = 0.71). The variables of the model accounted for 38% (Nagelkerke R square = 0.38) of the variation in the data (Table 8.9). The model predicted that the proportion of positive community responses to rangers was best explained by the variables, in order of entry, patrol encounters with crop raiding by baboons and number of effective patrol days. Patrol encounters with baboon crop raiding were not correlated with effective patrol days ($r_s = -0.06$; $p > 0.05$), which indicated that there were no problems with multicollinearity in the model. The negative association confirmed between positive community response and crop raiding by baboons (section 8.3.6.3) further emphasizes the importance of crop raiding by baboons to the type of response by local communities to rangers on law enforcement patrol.

Table 8.9 Parameters in the stepwise multiple logistic regression model for the likelihood of positive community responses to law enforcement rangers at Bwindi from 1996 to 2000

| Parameter | Coefficient (B) | Standard error of B | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|---|
| Baboon crop raiding ($log^{10+1}$) | -13.52 | 4.11 | 10.84 | 1 | < 0.01 |
| Patrol days ($log^{10}$) | 0.18 | 0.06 | 8.37 | 1 | < 0.05 |
| Constant | -0.47 | 0.76 | 0.38 | 1 | > 0.05 |

## 8.4 Discussion

Monitoring projects in multi-disciplinary terms of ecological and socio-economic impacts is vital to determine whether the integration of conservation and development objectives can protect wildlife (Larson and Svendsen, 1996). However, choosing indicators and methods to monitor socio-economic impacts is difficult because of the complex social components involved (Kleiman *et al*, 2000). Attitudes are commonly used to indicate local support for conservation and thus social impacts of conservation policy (Straede and Helles, 2000; Mehta and Heinen, 2001; Zhang and Wang, 2003) because of the advantages of attitudinal surveys. Attitudinal surveys are relatively simple and quick in comparison with other methods of social analysis (Philip, 1975), which is an advantage for conservation managers who are restricted in their activities by time and funding. Consequently there has been much research on factors that influence community attitudes towards conservation, such as the socio-economic characteristics of the community, particularly wealth and education (Fiallo and Jacobson, 1995; Sah and Heinen, 2001; Holmes, 2003), and external factors, for example crop raiding by wild animals (Hill, 1998; Mehta and Heinen, 2001). However, the recognition that positive community attitudes towards a protected area do not necessarily benefit conservation (Badola, 1998; Straede and Helles, 2000; Infield and Namara, 2001), raises the question as to how well these attitudes represent the support of local communities for conservation. Furthermore, there are limitations to the use of attitudinal surveys within conservation research, as the surveys, particularly fixed-response questionnaires, are primarily useful as exploratory tools to direct further investigation (Philip, 1975). Therefore, their use for evaluating conservation policy is limited, particularly for evaluations that relate policy to behavioural change in resource use (Holmes, 2003). Thus there is a need for alternative measures of community support for conservation, such as behavioural measures, in order to improve the evaluation of conservation policy.

This study examined relations between local communities and law enforcement rangers. The analyses were based on day-to-day interactions between community members and rangers over a five year period. This enabled behavioural measures for gauging both conflict and the level of community support for conservation. The refusal of individuals to assist rangers with law enforcement illustrated resentment of the National Park and thus conflict between community members and conservation authorities. Conversely, the assistance of individuals with law enforcement, particularly a willingness to report illegal activities, indicated a voluntary participation in conservation and thus local support for the National Park.

The difference between individuals and communities in the incentives that they face from community-based conservation programmes is an important consideration when monitoring local attitudes towards a protected area (Berkes, 2004). This analysis concerned the response of individual community members and the distinction between villagers and resource users enabled comparison of response from individuals directly benefiting and not directly benefiting from the harvest zone programme.

The study is the first in Bwindi to examine relations between local communities and law enforcement rangers. Fire has been used to indicate relations between local communities and National Park officials at Bwindi, as the reduction in deliberately started fires and the increase in community assistance with fire control, particularly from beekeepers of the harvest zone programme, is considered evidence that relations improved (Hamilton *et al*, 1999; Blomely, 2001; Makombo, 2003). Reports by the community about forest fires and their assistance with fire control were omitted from this study because the true nature of these reports was uncertain. This had implications for the analysis, as there were no interactions recorded between resources users of the south and rangers, although these beekeepers did assist rangers with fire control. Further study is needed to investigate the relationship between community conservation attitudes and forest fires at Bwindi, although the fire incidents illustrate the complexities of relations between local communities and conservation authorities.

### 8.4.1 Conflict

Indicators of conflict from the community response to law enforcement rangers were categorised as either negative or very negative. Negative responses included complaints about the loss of forest resources, such as the response to rangers patrolling the east (sectors A and C) in 1996 "*the community were very annoyed and discontent, they were saying that since we had taken their bamboos and their* *firewood, now and then we should co-operate with them*". There were also complaints about community benefit schemes of the ICDP and complaints about crop raiding by wild animals (Chapter 7). Requests to National Park officials regarding crop raiding (Chapter 7) were classified as very negative because of the difference in the level of conflict between complaints and requests. Villagers complaining to rangers would typically just complain, whereas those making requests would often become aggressive, particularly when their requests were not met by the National Park (Bayenda oral communication; personal observation). Incidents when community members alerted offenders to an approaching patrol or refused to assist rangers investigating illegal activities were also categorised as very negative responses. For example, in 1998, villagers neighbouring the centre (sectors AA and T) would not give rangers information about hunters following an incident of bushmeat poaching in the National Park and, also in 1998, around the west (sectors HH and GG), rangers found illegal pole cutting in the National Park and noted "*we rangers asked people who cut the poles but they refused to tell us*".

Most responses to rangers by community members around the National Park were negative. These responses were mainly complaints about crop raiding and thus crop raiding accounted for most of the interactions between individuals and rangers at Bwindi. The log linear model revealed that villagers around the north and centre were associated with negative and very negative responses. Previous studies have demonstrated the influence of crop raiding on relations between local communities and conservation authorities, namely that crop raiding results in hostility between the communities and authorities (Newmark *et al*, 1993; Hill, 1999; Nyhus, Tilson and Sumianto, 2000) and can undermine efforts to gain local support for conservation (Infield, 1988; Archabald and Naughton-Treves, 2001). The findings of this study were similar, as the analyses revealed the significance of the negative association between baboon crop raiding and local support for the National Park. In addition, the findings indicate an influence from individual versus community benefits from conservation programmes on local attitudes towards a protected area. Crop raiding impinges on an individual's livelihood whereas benefits from the ICDP schemes at Bwindi were at the community level. Complaints about ICDP schemes, which included the response recorded by rangers patrolling the north (sector LL) in 1996 "*people around the northern sector are not happy because the money of the Bwindi*

*Trust is given to those who never had problems of the forest*", indicates that the difference between individuals and communities in the incentives that they face was key to the issue.

Thus the association between the north and centre communities and conflict seems likely to be explained by the high level of crop raiding, particularly the high level of baboon crop raiding, in these areas (Chapter 6). In addition, this result suggests that crop raiding negatively affects the willingness of individuals to report illegal activities. Such a conservation impact of crop raiding was evident from the patrol reports. For example, in 2000, rangers patrolling the centre (sectors AA and T) recorded "*we could not get any response on illegal activities, only people complaining about baboon damage*". However, this is a complex issue because rangers received assistance with law enforcement from women and children who were guarding their crops from wild animals. In 1998, rangers patrolling the centre (sector II) recorded "*a woman guarding from vermin told us that children were fishing inside the National Park*", and, in 1996, rangers patrolling the east (sectors C and F) recorded "*we were told by a young boy who was chasing monkeys from his garden that firewood collection always occurs on Sunday evenings*".

This further highlights the importance of considering the difference between individuals and communities when assessing community attitude towards a protected area. Nonetheless, the analysis reveals that crop raiding is primarily significant to the response of individual community members to law enforcement rangers. It is also important to consider the influence of other factors, namely problem animal control by rangers, harvest zones and community benefit schemes from the integrated programme.

Villagers around the north and centre receive little problem animal control in comparison with other areas around Bwindi (Chapter 7). The lack of the rangers' control efforts is associated with conflict between communities and rangers (Chapter 7) and thus it is possible that these efforts influence local support for conservation. However, there was no relationship between positive response and problem animal control. Nonetheless, the findings of this study are that the villagers associated with conflict experienced high crop raiding and received little problem animal control from rangers. The potential influence of problem animal control on conflict has important implications for the integrated programme at Bwindi, particularly for the investment of funds for community benefit schemes, as reducing crop raiding is a benefit that managers of protected areas can provide to local communities. The recommendation from the previous analysis, namely to invest funds for community benefit schemes in problem animal control (Chapter 7), is strengthened here in light of the positive conservation impact to be gained from addressing the conflict issues that hinder the willingness of individuals to participate in conservation.

### 8.4.2 Community support for conservation

Positive responses by community members to law enforcement rangers indicated individual support for the National Park. Responses placed in this category were positive comments about the National Park, such as the response by a resource user to rangers patrolling the east of Bwindi (sectors C and F) in 1996 "*one man who was also a beekeeper member told us that people are ready to look after the park as they promised themselves as beekeepers, we thanked the beekeepers bordering the area and encouraged them to continue with the same spirit*". Also categorised as positive was the appreciation for problem animal control (Chapter 7). Communities reporting illegal activities to rangers or assisting rangers investigate illegal activities were incidents categorised as very positive responses. For example, in 1998, beekeepers of the harvest zone programme in the east (sectors A and B) reported snares in their harvest zone to rangers, and the rangers recorded "*the beekeepers were not happy with this activity, which is carried out in their zone. They gave us two porters of their society to lead us to those snares. All snares we found were new and we talked with these porters to organise another patrol so they can lead us to other suspected places in the same area.*"

The log linear model revealed that the individual resource users and villagers of the east were associated with positive and very positive responses. Thus from 1996 to 2000 individuals of eastern communities demonstrated a voluntary participation in conservation by assisting rangers with law enforcement, and this behaviour indicated their support for the National Park. The analysis also reveals an increase in support since gazettement, as eastern communities were associated with incidents of unprovoked attacks on rangers during the period of gazettement from 1989 to 1992 (Chapter 3). Understanding why resource users, who are beekeepers, and villagers of the east were associated with positive responses is important for conclusions regarding the conservation impact of sanctioned resource use, particularly the impact on conflict between local communities and conservation managers.

Beekeepers' support for conservation indicates a positive impact of sanctioned resource use on the conservation attitudes of individuals involved with the harvest zone programme. This support, particularly the reports of illegal activities, was expected because the role of resource users in protecting the forest was emphasised during the programme's implementation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). However, resource users around other areas of Bwindi did not assist rangers with law enforcement. Thus type of resource does not appear a major influence on support for conservation, as eastern beekeepers were more willing to report illegal activities than southern beekeepers and harvesters of medicinal plants and basketry materials of the north and centre. The proportion of resource users within a community does also not appear a major influence, as both east and north communities are in areas of high harvest zones yet eastern beekeepers accounted for most of the responses by resource users.

The difference in conservation support between resource users could reflect the implementation of the harvest zone programme. Eastern beekeepers were the first communities neighbouring Bwindi to be granted access to the forest and this access was granted in the year following gazettement (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). In comparison, the implementation process for resource users in other areas began three years after gazettement and the process was delayed by organisational failure (Bensted-Smith *et al*, 1995), which created frustration with conservation authorities among resource users (Blomely, 2003). Thus, perhaps the quick implementation process for eastern beekeepers and the sense of forest ownership that was re-established soon after gazettement, led them to adopt the role of forest guardians more eagerly than other resource users.

Impacts of sanctioned resource use on local conservation attitudes could explain the support for conservation by individual villagers around the east. Such an impact could result from indirect benefits of sanctioned resource use that are gained locally, which for the east was the local trade in honey. However, villagers around the north and centre also gained indirectly from sanctioned resource use yet were associated with conflict. Given the influence of crop raiding by baboons on the conflict of the north and centre, it appears that direct and indirect benefits from sanctioned resource use were outweighed by individual costs of crop raiding.

It is difficult to determine whether impacts of sanctioned resource use on conservation attitudes of eastern villagers contributed to the decline in conflict between eastern communities and conservation authorities over the period of gazettement. Nonetheless, the results reveal that eastern beekeepers and villagers were associated with support for conservation and that these individuals experience less crop raiding and receive more problem animal control than villagers around the north and centre who were associated with conflict. Therefore, this combination of factors, with crop raiding by baboons as a primary determinant, may have resulted in the difference between the communities of Bwindi in conflict and in support for conservation.

Community benefit schemes from the integrated programme may also influence local support for conservation. The east community of Bwindi has received a medium proportion of the schemes implemented. Eastern community members were more positive than communities that have received low and high proportions of the schemes. However, differences between areas in terms of community benefit schemes were not significant in the regression model. This reveals firstly that other factors characterising the east, particularly harvest zones, were more significant than community benefit schemes to individual support for conservation. Secondly, it appears that crop raiding has a greater influence on individual support for conservation than community benefits from the integrated programme, particularly benefits of school and health clinic construction. Further insight is gained from a recent review of the integrated approach at Bwindi, which found that efforts of the conservation authorities to provide benefits for communities surrounding the National Park have failed (Makombo, 2003). Thus, it is perhaps not failure of community benefit schemes but rather the fact that individuals bordering the National Park have not benefited from the schemes, which is an important factor determining local support for conservation.

A limitation of the analyses was use of descriptive reports by law enforcement rangers. The results are presented under the assumption that rangers' recordings were an accurate representation of their interactions with communities. This assumption was verified by fieldwork surveys and, in addition, attempts were made in the analysis to address limitations of the data by assigning categories to the ranger-community interactions. However, there was no validation of rangers recording by independent attitude surveys of community members regarding the community-ranger interactions and subsequently, the results reflect rangers' perceptions of their interactions with individual community members.

A previous study demonstrated that a lack of community visits by protected area staff were associated with increased local interest in seeing the protected area degazetted (Holmes, 2003). Therefore the number and type of community response may have been affected by rangers' time within community land. It is possible that community members who regularly saw rangers felt more able to approach rangers. Furthermore, rangers themselves are members of the local community and may know communities when stationed near their home. Increasing familiarity between rangers and communities may therefore result in an increase in positive responses, which could explain why the proportion of positive responses increased with an increasing number of effective patrol days and patrol encounters with poachers. It is policy of UWA to regularly move rangers between outposts to avoid familiarly between rangers and local communities, as this may lead to local communities bribing rangers to conduct illegal activities (Bayenda, oral communication). However, this is a possible bias in the data.

### 8.4.3 Summary

In summary, providing benefits for local communities neighbouring a protected area is a strategy currently adopted within many tropical countries for conserving biodiversity. The findings of this chapter contribute to the debate on the effectiveness of this strategy by examining the conservation impact of community relations with law enforcement rangers. Furthermore, this chapter provides an assessment of the social impact of conservation policy based on behavioural measures of the support of rural communities for conservation.

Having established the social impact of conservation policy, I now seek to determine the impact on the flagship species of Bwindi by determining the distribution of the gorillas within Bwindi over the period of establishment of harvest zones for sanctioned resource use.

# Chapter Nine

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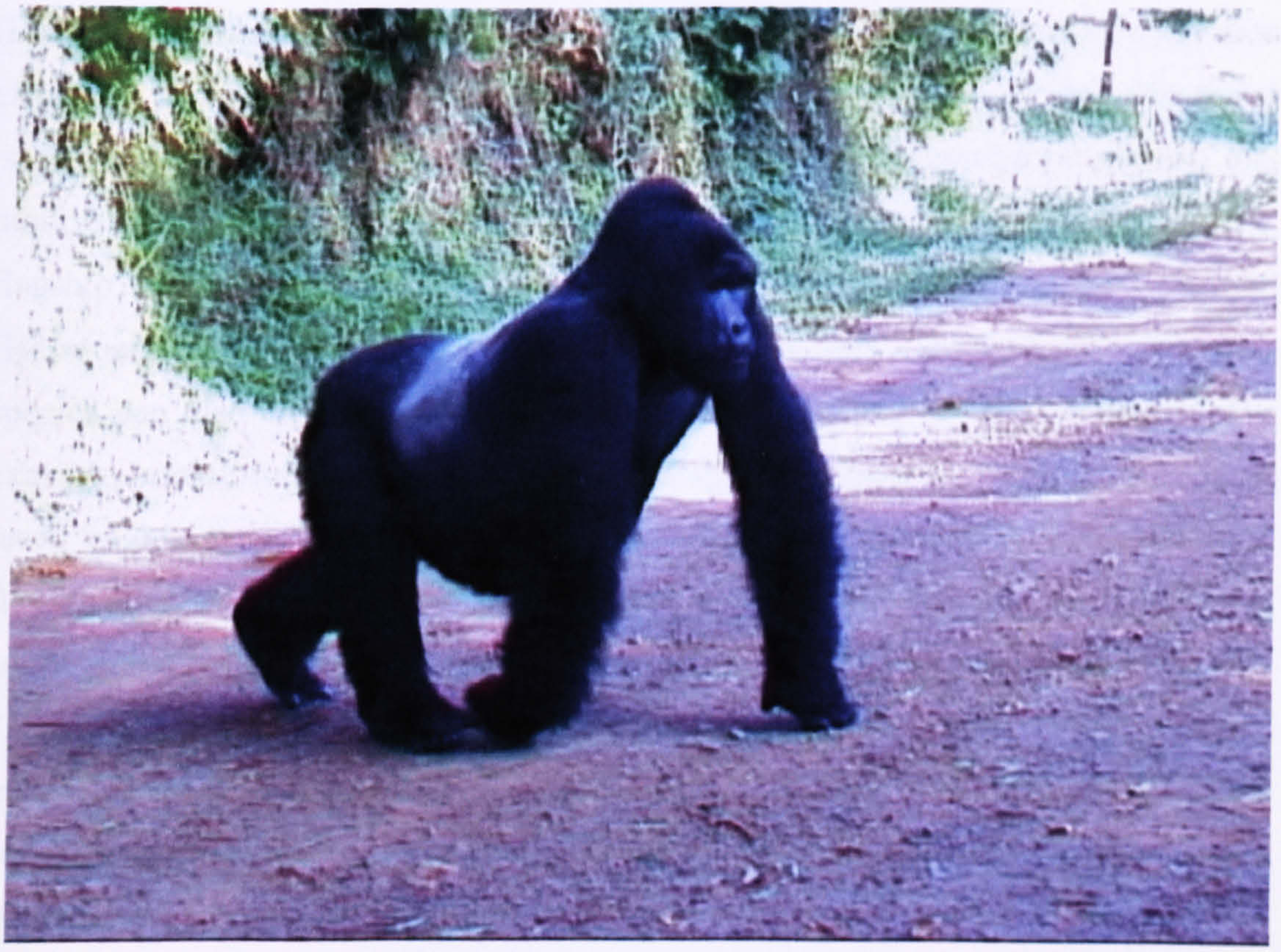
## Gorilla Distribution over the Harvest Zone Period



*Ruhondeza, the silverback of Mubale gorilla group, crossing a road within Bwindi*

*(J. Baker)*

# Chapter Nine

# 9 Gorilla distribution over the harvest zone period

## 9.1 Introduction

The single-species approach to conservation involves several different concepts (Leader-Williams and Dublin, 2000). In many instances, focussing conservation efforts on charismatic mammals can attract popular support, while also addressing issues of broader conservation relevance, including the integration of species- and biodiversity-approaches to conservation (Entwistle and Dunstone, 2000). Hence, flagship species can stimulate conservation awareness and action, and funding (Heywood, 1995; Simberloff, 1998; Leader-Williams and Dublin, 2000). Flagship species can also have a strategic role as indicators of conservation success. For example, monitoring an African rhino population indicated a change in the threat faced by this species from hunting by man (Walpole *et al*, 2001). In addition, using flagships as population indicators can indicate the performance of a particular conservation policy (Western, 1987; Leader-Williams and Dublin, 2000).

Integrated conservation and development is currently favoured by some international donor agencies as the optimal approach for protected area management in the tropics (Hughes and Flintan, 2001). Sanctioned resource harvesting is a core strategy of the integrated approach and has been shown successful in resolving conflict between local communities and conservation managers, and in improving local attitudes towards conservation (Lebonetse, 1996; Slavin, 1996; Scott, 1998; Hinchely *et al*, 2000). However, despite the success stories, concerns about the risks of harvest schemes have been raised and, in particular, the risk of destructive resource exploitation (Barrett and Arcese, 1995; du Toit, 2002). Another concern is the possible increase in illegal activities from allowing people entry to a protected area, and the associated increase in human disturbance (Butynski and Kalina, 1998).

Human disturbance is a particular concern for protected areas with endangered species or species targeted by poachers, yet the reviews on resource use mainly focus on the prominent issues of conflict resolution (Wells and Brandon, 1993; Ghimire, 1994; Neumann, 1997; Lynagh and Urich, 2002) and the risks of harvesting (Barrett and Arcese, 1995; Hackel, 1999; du Toit, 2002). There has been little assessment of the impact on non-harvested species. Subsequently, whether these programmes can achieve the overall goal of protected area conservation is a matter open to debate. Therefore, Bwindi provides an ideal opportunity to evaluate the effectiveness of sanctioned resource harvesting in conserving biodiversity in an integrated approach. The harvesting programme has been considered a success in improving in local attitudes towards conservation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). However, no assessment has been made on impacts of harvest zones on wildlife, particularly on the gorillas, which are the flagship species for efforts to conserve Bwindi.

Mountain gorillas remain threatened directly from poaching, and indirectly from snares set for bushmeat (Plumptre and Williamson, 2001). The populations in the Virungas and in Bwindi are subject to intensive conservation efforts, yet the gorilla population of Bwindi is not well known in comparison with the Virunga gorilla population. Schaller (1964) conducted a short survey of 20 days in Bwindi in 1959, and estimated that the reserve contained between 120 and 180 individuals. Counts in 1981 and 1983, based on similarly limited survey, estimated 116 and 146 gorillas (Harcourt, 1981; Butynski, 1984). Repeated and more extensive population censuses were undertaken over a seven-year period up to mid-1993, which suggested a population of around 300 individuals (Butynski and Kalina, 1993). Although the numbers estimated appear to have increased, the earlier surveys mainly encompassed the forest boundary and probably missed gorillas in the more inaccessible interior parts, so underestimating population size (Harcourt, 1981; Butynski, 1984; McNeilage *et al*, 2001).

The first comprehensive census of the gorilla population in Bwindi was undertaken in 1997, as a collaborative effort between UWA, WCS, IGCP and ITFC. The census involved six teams that traversed the forest systematically recording sites of gorilla nests. Subsequent surveys were planned to take place every five years, and the second survey took place in 2002. The 1997 census estimated the population to be 292 individuals (McNeilage *et al*, 2001), while initial findings of the 2002 census indicated an increase in the population, although this will be confirmed by DNA tests (McNeilage, oral communication). Therefore, based on the best knowledge available, the gorilla population of Bwindi appears to have remained stable at around 300 individuals from the early 1980s to the early 2000s.

The distribution of the gorillas also appears to have remained fairly constant since the 1980s. Harcourt (1981), Butynski (1984) and McNeilage (*et al*, 2001) all found that gorillas predominantly inhabited interior areas of the forest. These surveys all concluded that high levels of human disturbance in boundary areas were primary factors restricting gorillas to the forest interior. Although population data on other mammals in Bwindi are also incomplete, the greater abundance of many species in the forest interior, including the ungulate species targeted by poachers, was also explained by high human activity in boundary areas (Butynski, 1984; McNeilage *et al*, 2001). However, the lack of systematic ecological monitoring has limited efforts to examine the relationship between gorilla distribution and human activity, or to investigate how gorillas use boundary areas following changes in human disturbance.

The aim of this chapter is to determine impacts of sanctioned resource harvesting, and of bushmeat poaching, on the distribution of gorillas. The objectives are to examine gorilla distribution in Bwindi over the period of the establishment of harvest zones, to examine current gorilla distribution in relation to harvest zones, and to examine associations between gorillas and bushmeat poaching activities. To address the objectives, I seek to determine the following research questions:

- Which forest areas were utilised by gorillas before harvest zones were established?
- Was there a change in the forest areas utilised by gorillas after harvest zones were established?
- Are differences in the distribution of gorillas within Bwindi related to activities of poachers hunting bushmeat?
- What is the relative significance of area of Bwindi, the forest interior and boundary, harvest zones and bushmeat poaching activity to gorilla distribution?

## 9.2 Materials and Methods

### 9.2.1 Law enforcement patrol reports

#### 9.2.1.1 Data collection

The operations of law enforcement patrols in Bwindi, the rangers' patrol reports and the retrieval and means of verifying the patrol reports, were described in Chapter 2. Rangers recorded their observations of gorillas inside the boundaries of Bwindi in addition to recording encounters with illegal activities. The gorilla records comprised: direct sightings of an individual or of a group of gorillas; indirect signs of gorillas, which included nests and dung (Figure 9.1). Gorillas and their signs were considered reliably recorded by rangers because of their importance for conservation (Bayenda, oral communication). Rangers also recorded year, month, number of rangers on patrol, number of effective patrol days, type of patrol whether long or day patrol, and area toponym(s), which were assigned to the corresponding sector or sectors within the different areas of Bwindi (centre, east, south and west) (section 2.2.1.3).

Figure 9.1 Nest and dung of mountain gorillas in Bwindi

Data were extracted from records of law enforcement patrols of encounters with wild gorillas inside Bwindi from 765 days on long patrol and 2071 days on day patrol carried out from 1986 to 2000, except for the lack of patrol reports for 1990 and 1991. The analysis excluded patrols covering the north of Bwindi, as gorillas are absent from these areas, and only included patrols covering the centre, east, south and west (Butynski, 1984; McNeilage *et al*, 2001). The analysis also excluded patrol encounters with habituated gorilla groups to avoid bias in the analyses from possible impacts of habituation on gorilla distribution.

Patrols made 43 direct sightings of gorillas and encountered 71 indirect signs of gorillas. The latter comprised 51.5% of nests and 48.5% of dung. Direct sightings were pooled with indirect signs because of the low number of encounters. For the centre, east, south and west, gorilla encounters per patrol day were summed per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol were included for analysis (1986-2000 monthly totals across all areas; n = 441). The few encounters with gorillas did not permit analysis by the three periods of gazettement and harvest zones used for poaching incidents in Chapter 4. The monthly totals were instead grouped into the same two periods of before (1986-1994 monthly total: n = 226) and after (1995-2000 monthly total: n = 215) harvest zones were established that were used for encounters with poachers (see methods described in section 4.2). Consequently, the before harvest zone period covered National Park gazettement of Bwindi and change in gorilla distribution between policies of protected area designation and sanctioned resource harvesting could not be compared, as for poaching incidents (Chapter 4). The analysis instead focuses on gorilla distribution over the harvest zone period.

### 9.2.1.2 Data analysis

Rangers on day patrol covered a higher proportion ($z = -20.50$; $p < 0.001$) of boundary sectors (1986-2000 monthly total: n = 428; mean±SE 0.99±0.001) than rangers on long patrol (1986-2000 monthly total: n = 130; mean±SE 0.68±0.02). Gorillas are concentrated in interior areas of Bwindi (Harcourt, 1981; Butynski 1984; McNeilage *et al*, 2001). Thus the first stage of the analysis was to determine whether there was a difference in gorilla encounters between the types of patrol. Rangers on long and day patrols covering the same forest area recorded similar rates of encountering gorillas (Appendix D). Long and day patrols were therefore pooled for the analysis.

The second stage of the analysis was to adjust gorilla encounters by an appropriate variable of patrol effort into a "catch per unit effort" index (Bell, 1986), from which to examine an encounter rate of gorillas (see methods described in section 4.2). Patrol encounters with gorillas were adjusted by the number of patrol days ($r_s = 0.13$; $p < 0.01$) for consistency in analysis and to examine possible associations between patrol encounters with gorillas and with poaching. Gorilla encounters divided by patrol days formed the dependent variable for the univariate analyses. This gorilla encounter rate was log transformed, but the distribution (Kolmogorov-Smirnov $Z = 9.80$; $p < 0.001$) still remained significantly different from normal. Therefore, analyses were conducted using the non-parametric tests of Kruskal-Wallis and Mann Whitney U.

The first analysis aimed to conduct univariate tests to examine possible differences in patrol encounters with gorillas between areas of Bwindi before and after harvest zones were established. In each period, comparisons were undertaken of mean gorilla encounters between interior and boundary areas, between areas of Bwindi and between low, medium and high harvest zones. Possible differences in encounters with gorillas before and after harvest zones were also examined by comparisons of mean gorilla encounters between periods.

The second analysis aimed to examine associations between patrol encounters with gorillas and with illegal bushmeat poaching per month (Chapter 4). Spearman's rank correlations were conducted between gorilla encounters and each type of poaching encounter of snares, poaching signs and directly with poachers, and these encounters pooled into one encounter rate (1986-2000 monthly total; $n = 441$). A correlation was also conducted between gorilla encounters and the number of snares per snare encounter (1986-2000 monthly total; $n = 211$).

The final analysis aimed to identify which factors best explained the likelihood of encountering gorillas on law enforcement patrols in Bwindi. The number of encounters with gorillas per month was converted into binary data comprising months with (1986-2000 monthly total: $n = 72$), and months without (1986-2000 monthly total: $n = 369$), an encounter. This formed the dependent variable in a stepwise logistic regression analysis, using the forward stepwise procedure. The explanatory variables comprised: patrol days; rangers on patrol; harvest zone period; interior and boundary area; low, medium and high harvest zone; and area (centre, east, south and west) of Bwindi. Periods and areas were entered in the regression model as categorical variables (section 2.2.3.2).

## 9.2.2 Reconnaissance walks

### 9.2.2.1 Data collection

Recce walks were undertaken in the dry season of December 2000 to February 2001. The walks were conducted in the forest interior along an irregular network of existing human trails and animal paths (interior recce walks), and along the National Park boundary (boundary recce walks). For the survey, 64 recce walks were conducted that totalled 106.7 km. A total of 35 walks covered forest interior sectors, with a mean of 1.6 km (range 0.6 – 4.7 km) per walk, and 29 walks covered boundary sectors, with a mean of 1.5 km (range 0.5 – 5.2 km) per walk (section 2.2.3).

Recordings were made on direct sightings and indirect signs of gorillas comprising nests and dung observed by two field assistants walking at a pace of 1km/hour. Only indirect signs estimated at less than three months old were recorded. During each recce walk, different signs of the same group of gorillas were examined to avoid double recording. For example, in the event that nests of one gorilla group were found, only the nests rather than the dung were recorded.

The illegal activities recorded comprised sites of poaching and pitsawing, and sites of subsistence resource collection. Most poaching and pitsawing sites encountered during recce walks were considered between five and ten years old. Most poaching sites were camps in forest clearings and were thus similar in habitat type to pitsawing sites, as both were open sites with secondary vegetation species dominant. There were few encounters of poaching and of pitsawing sites and, as the sites were similar in habitat, recce encounters with poaching were grouped with the encounters of pit sawing. Thus the data represents old sites of illegal poaching and pit sawing activity within Bwindi. In contrast to poaching and pit sawing, most sites of subsistence resource collection were considered less than one year old. Recce encounters with subsistence timber collection were grouped with subsistence non-timber collection because of the low number of encounters. Only encounters of subsistence resource collection that were considered less than one year old were included in the analysis for the data to represent recent activity (section 5.2).

The analysis excluded sectors in the north of Bwindi, as gorillas are absent from these areas, and only included sectors in the south (Butynski, 1984; McNeilage *et al*, 2001). Furthermore, no evidence of gorillas in north sectors was observed during this study. There was only one direct sighting of a gorilla group during recce walks in south sectors. There were also few observations of indirect signs of gorillas, which resulted in large variation within the data. The analysis was therefore based on the pooled indirect signs of nests and dung.

#### 9.2.2.2 Data analysis

Recce encounters with gorilla signs were converted into the number of encounters per km of recce walk, for analysis using the non-parametric tests of Kruskal-Wallis and Mann Whitney U. The first analysis aimed to determine the distribution of gorillas in Bwindi. Mean recce encounters with gorilla signs from interior recce walks were compared firstly between interior and boundary sectors, and secondly between boundary harvest zone and boundary non-harvest zone. Gorilla nest and dung encounters were pooled for the analysis of boundary sectors because of few encounters in these sectors.

Associations between recce encounters with gorilla signs and recce encounters with illegal activities were then examined by Spearman's rank correlation. Gorilla nest and dung were pooled for the analysis to reduce the possibility of spurious correlation results from the limited dataset. The correlations indicated associations between gorillas and old sites of poaching and pitsawing, and associations between gorillas and recent sites of subsistence resource collection.

The final analysis aimed to identify which factors best explained the likelihood of encountering gorilla signs on recce walks in Bwindi. Numbers of gorilla signs on recce walks were converted into binary data of walks with (n = 22) and without (n = 31) gorilla signs. This formed the dependent variable in a stepwise logistic regression analysis, using the forward stepwise procedure. The explanatory variables were interior, boundary harvest zone and boundary non-harvest zone sectors, area (centre, east, south and west) of Bwindi, which were entered as categorical variables, and recce encounters with old poaching and pit sawing sites, and recce encounters with recent signs of subsistence resource collection, which were entered as continuous variables. Interaction terms were specified between interior, boundary harvest zone and boundary non-harvest zone sectors and recce encounters with illegal activities, and between area of Bwindi and recce encounters with illegal activities (section 2.2.3.2).

# 9.3 Results

## 9.3.1 Law enforcement encounters

### 9.3.1.1 Before harvest zones

Law enforcement patrols encountered sightings and signs of gorillas 79 times on 1111 patrol days from 1986 to 1994, before harvest zones were established in Bwindi. More encounters occurred in the interior areas than in the boundary areas covered by patrols (Table 9.1). The encounters differed between areas of Bwindi and most occurred in the east (Table 9.2). With regard to the future harvest zones, more encounters occurred in the future high harvest zone than in future low or medium harvest zones (Table 9.3). Therefore, before harvest zones were established, when patrols spent similar time covering interior and boundary areas, patrols encountered gorillas most frequently in the forest interior. Gorilla encounters were particularly high in the east in comparison with other areas of Bwindi, and were particularly high in this future high harvest zone in comparison with future low and medium harvest zones.

### 9.3.1.2 Before and after harvest zones

Law enforcement patrols encountered gorillas less often after harvest zones were established (Table 9.4), particularly in interior areas, although gorillas were still infrequently encountered in boundary areas (Table 9.1). Gorillas were also encountered less frequently in the east, but the low number of encounters in the centre, south and west remained constant after harvest zones were established (Table 9.2). Furthermore, encounters with gorillas declined in the high harvest zone, while encounters in low and medium harvest zones did not change after harvest zones were established (Table 9.3).

### 9.3.1.3 After harvest zones

Gorillas or their signs were encountered 35 times on 1725 patrol days from 1995 to 2000, after harvest zones were established. Gorillas were infrequently encountered in both interior and boundary areas covered by patrols (Table 9.1). There were no differences in encounters with gorillas between the centre, east, south and west areas

(Table 9.2). Furthermore, there were no differences between low, medium and high harvest zones (Table 9.3). Therefore, after harvest zones were established when law enforcement patrols spent more time in boundary than in interior areas, encounters with gorillas declined. Gorillas were encountered as frequently in the interior and boundary areas, the areas of Bwindi, and the low, medium and high harvest zones, that were covered by patrols.

Table 9.1 Mean±SE encounters with gorillas per month by patrols in interior and boundary areas of Bwindi before (1986-1994) and after (1995-2000) harvest zones were established

| **Harvest period** | **Area** | | **Mann Whitney U (z value)** | ***P*** |
|---|---|---|---|---|
| | **Interior** | **Boundary** | | |
| **Before zones** | (n = 97) | (n = 129) | | |
| | 0.16±0.03 | 0.02±0.01 | -5.99 | < 0.001 |
| **After zones** | (n = 33) | (n = 182) | | |
| | 0.04±0.02 | 0.03±0.01 | -0.75 | NS |
| **Mann Whitney U (z value)** | -2.67 | -1.16 | | |
| ***P*** | < 0.01 | NS | | |

Table 9.2 Mean±SE encounters with gorillas per month by patrols in areas of Bwindi before (1986-1994) and after (1995-2000) harvest zones were established

| **Harvest period** | **Area of Bwindi** | | | | **Kruskal-Wallis $\chi^2$ (df=3)** | ***P*** |
|---|---|---|---|---|---|---|
| | **Centre** | **East** | **South** | **West** | | |
| **Before zones** | (n = 55) | (n = 69) | (n = 61) | (n = 41) | | |
| | 0.03±0.02 | 0.13±0.02 | 0.08±0.03 | 0.07±0.1 | 25.34 | < 0.001 |
| **After zones** | (n = 65) | (n = 65) | (n = 50) | (n = 35) | | |
| | 0.03±0.01 | 0.02±0.01 | 0.01±0.01 | 0.08±0.1 | 0.55 | NS |
| **Mann Whitney U (z value)** | -1.26 | -4.14 | -1.36 | -0.25 | | |
| ***P*** | NS | < 0.001 | NS | NS | | |

Table 9.3 Mean±SE encounters with gorillas per month by patrols in harvest zones before (1986-1994) and after (1995-2000) harvest zones were established

| **Harvest period** | **Harvest zone** | | | **Kruskal-Wallis** | ***P*** |
|---|---|---|---|---|---|
| | **Low** | **Medium** | **High** | **$\chi^2$ (df=2)** | |
| **Before zones** | (n = 116) | (n = 41) | (n = 69) | | |
| | 0.06±0.02 | 0.07±0.1 | 0.13±0.02 | 22.47 | < 0.001 |
| **After zones** | (n = 115) | (n = 41) | (n = 66) | | |
| | 0.02±0.01 | 0.08±0.1 | 0.02±0.01 | 0.37 | NS |
| **Mann Whitney U (z value)** | -0.16 | -0.25 | -4.14 | | |
| ***P*** | NS | NS | < 0.001 | | |

Table 9.4 Mean±SE encounters with gorillas per month by patrols before (1986-1994) and after (1995-2000) harvest zones were established

| | **Harvest period** | | **Mann Whitney U** | ***P*** |
|---|---|---|---|---|
| | **Before zones** | **After zones** | **(z value)** | |
| | **(n = 226)** | **(n = 215)** | | |
| **Gorillas / patrol day** | 0.08±0.02 | 0.03±0.01 | -2.87 | < 0.01 |

### 9.3.1.4 Gorillas and bushmeat poaching

Patrols encountered gorillas most frequently in areas with most snares (Table 9.5). In contrast, there were no relationships between areas where patrols encountered gorillas and poaching signs or poachers. There was also no relationship between gorillas and numbers of snares per snare encounter.

Table 9.5 Spearman's rank correlations ($r_s$) between law enforcement patrol encounters with gorillas and with bushmeat poaching per month in Bwindi from 1986 to 2000

| **Poaching / patrol day (n = 411)** | **Gorillas / patrol day ($r_s$)** |
|---|---|
| All poaching encounters | 0.11* |
| Snares | 0.18** |
| Poaching signs | 0.003 |
| Poachers | -0.002 |
| | |
| **n. snares / snare encounter (n = 211)** | **0.02** |

* $P < 0.05$; ** $P < 0.01$

### 9.3.1.5 Factors explaining the likelihood of encountering gorillas

The final regression model correctly classified 83.9% of the gorillas encounters ($\chi 2$ = 44.32; df = 2; p < 0.001) and proved a good fit to the data (AUC = 0.74). The variables of the model accounted for 16% (Nagelkerke R square = 0.16) of the variation in the data. The model that best predicted patrol encounters with gorillas comprised the variables, in order of entry, interior and boundary areas and patrol days (Table 9.6). The positive association between patrol coverage of interior areas and gorilla encounters shows the importance of interior areas to the likelihood of patrols encountering gorillas (Figure 9.2). Therefore, the results suggest that the interior of the forest is more important in determining the distribution of gorillas than harvest zones or poaching activity.

Table 9.6 Parameters of the stepwise multiple logistic regression model for the likelihood of encounters with gorillas by patrols in Bwindi from 1986 to 2000

| **Parameter** | **Coefficient (B)** | **Standard error of B** | **Wald statistic** | **df** | **Significance of Wald** |
|---|---|---|---|---|---|
| Interior areas | 1.69 | 0.28 | 36.55 | 1 | < 0.001 |
| Patrol days | 0.09 | 0.03 | 9.82 | 1 | < 0.01 |
| Constant | -2.91 | 0.30 | 93.57 | 1 | < 0.001 |

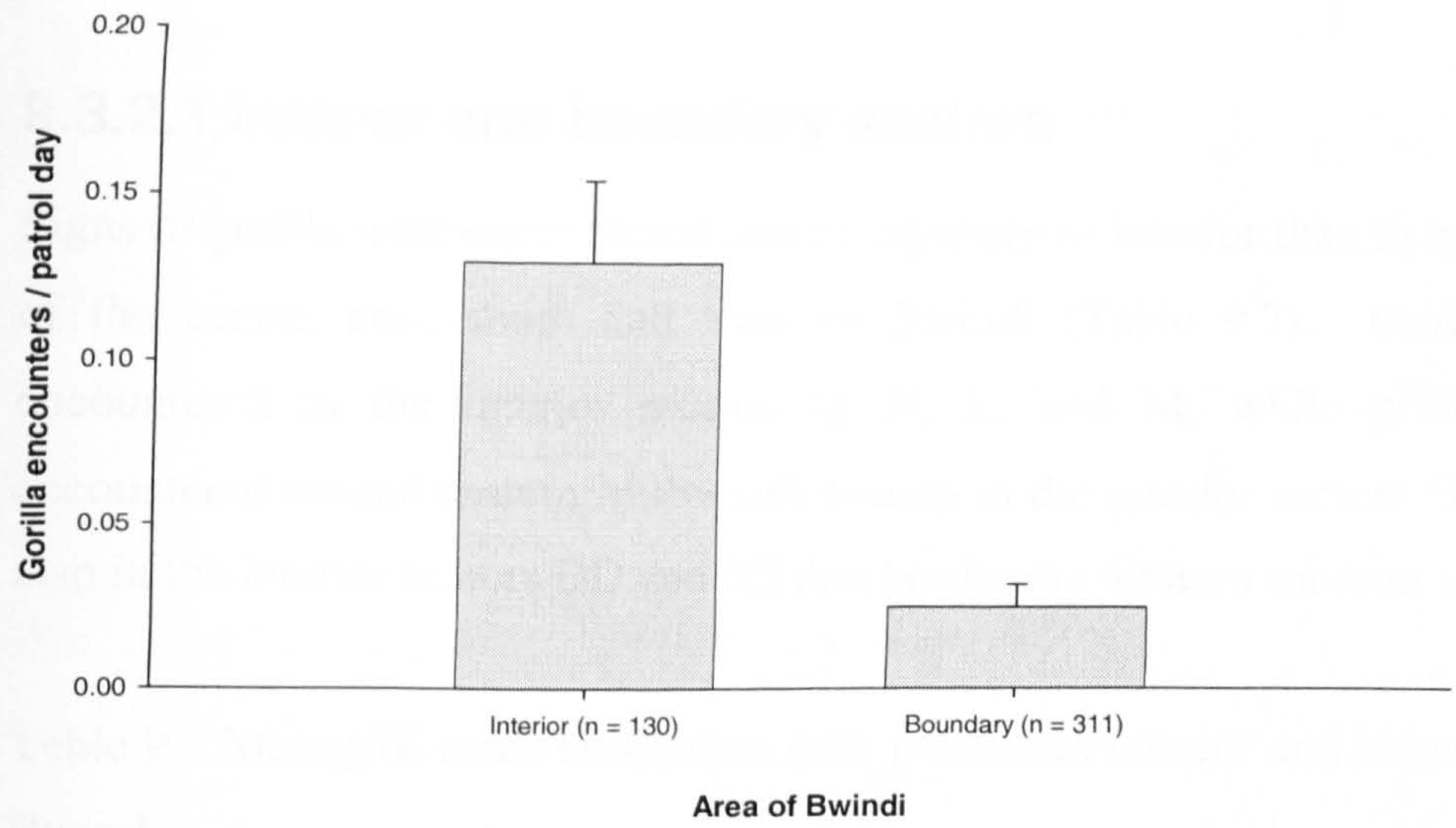


Figure 9.2 Mean±SE encounters with gorillas per month by patrols in interior and boundary areas of Bwindi from 1986 to 2000

### 9.3.1.6 Interior and boundary gorilla encounters

Patrol encounters with gorillas in the forest interior and boundary from 1986 to 2000 were further explored (Figure 9.3). Gorilla encounters in the forest interior fluctuated between years with two peaks of before National Park gazettement and after harvest zones were established. In comparison, patrol encounters with gorillas in the forest boundary peaked following gazettement and following harvest zone establishment.

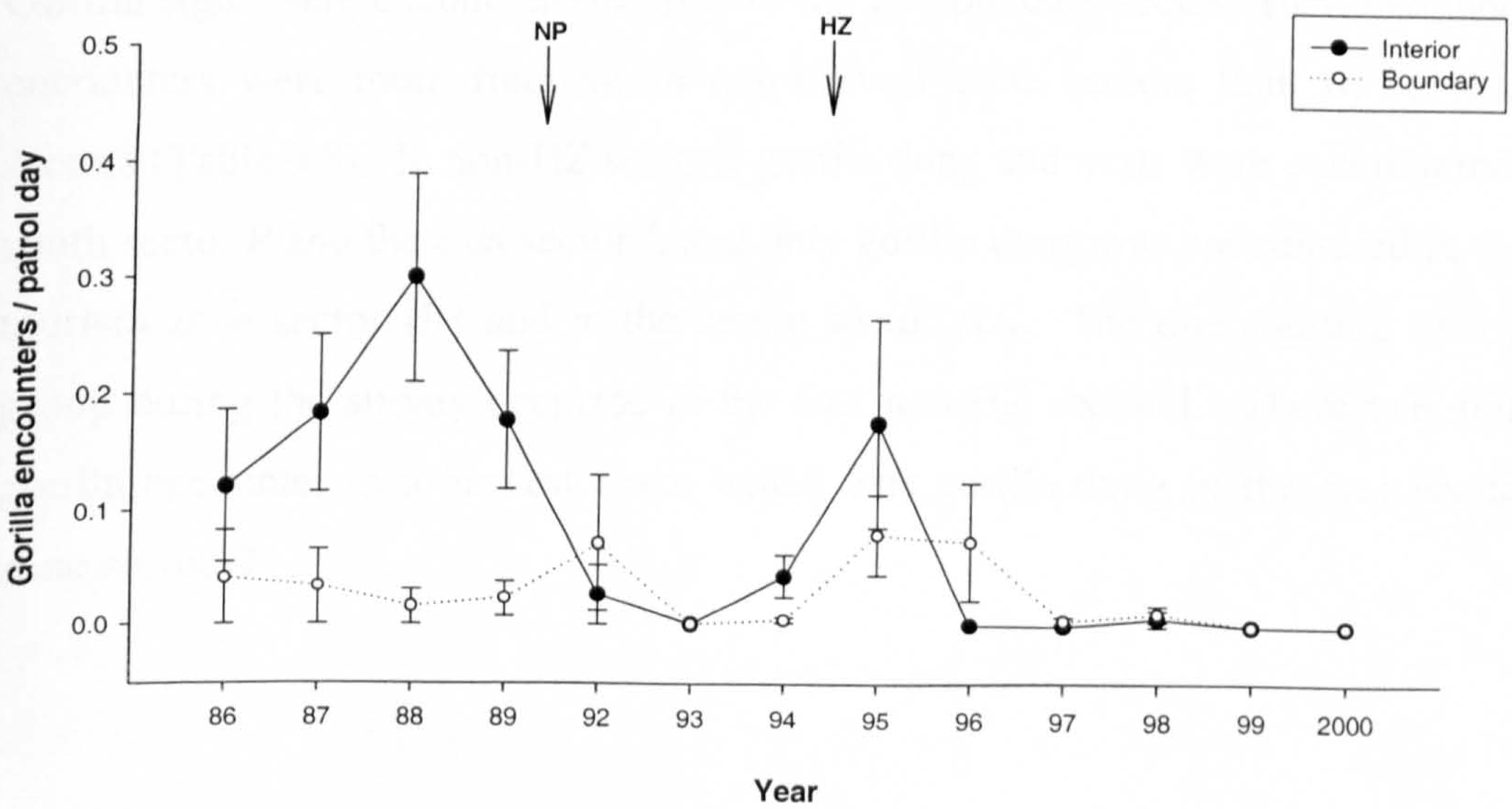


Figure 9.3 Mean±SE encounters with gorillas per month by patrols in interior and boundary areas of Bwindi per year from 1986 to 2000

Key: NP – National Park gazettement; HZ – harvest zone establishment

### 9.3.2 Reconnaissance walks

#### 9.3.2.1 Interior and boundary sectors

Signs of gorilla were encountered more frequently in interior than in boundary sectors of the centre, east, south and west of Bwindi (Table 9.7). Gorilla nests were encountered in the interior sectors Q, N, L, and M, while gorilla dung were encountered around eastern Mubwindi swamp in the interior sectors G, H and E, and also in the interior sectors DD and EE that border the western tourism zone.

Table 9.7 Mean±SE recce encounters with gorillas in interior and boundary sectors of Bwindi

| Recce encounters | Interior sectors (n = 13) | Boundary sectors (n = 18) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Gorilla nest | 0.69±0.1 | 0.21±0.1 | -3.25 | < 0.05 |
| Gorilla dung | 0.44±0.1 | 0.14±0.1 | -2.82 | < 0.05 |

#### 9.3.2.2 Boundary harvest zone and non-harvest zone sectors

Gorilla signs were encountered in five of the 20 boundary sectors surveyed, and these encounters were more frequent in non-harvest zone sectors than in harvest zone sectors (Table 9.8). In non-HZ sectors, gorilla dung and nests were encountered in the south sector P and the east sector I, and only gorilla dung was encountered in the west tourism zone sector HH and in the centre sector AA. The one sighting of a gorilla group during the survey occurred in the east non-HZ sector I. There was only one gorilla encounter in a harvest zone, which was gorilla dung in the east beekeeping zone sector O.

Table 9.8 Mean±SE recce encounters with gorilla signs in boundary harvest zone (HZ) and non-harvest zone (non-HZ) sectors of Bwindi

| Recce encounters | HZ sectors (n = 8) | Non-HZ sectors (n = 10) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Gorilla signs | 0.06±0.1 | 0.53±0.2 | -2.45 | < 0.05 |

### 9.3.2.3 Gorillas and illegal activity

In interior sectors, most encounters with gorillas occurred in sites where most old poaching and pit sawing sites occurred. In boundary sectors, most encounters with gorillas tended to occur where few old poaching and pit sawing sites occurred, and did occur in areas where few recent subsistence resource collection sites occurred (Table 9.9).

Table 9.9 Spearman's rank correlation ($r_s$) between recce encounters with gorillas and illegal activities in south interior and boundary sectors of Bwindi

| Illegal activity / recce walk (km) | Gorilla signs / recce walk (km) ($r_s$) |
|---|---|
| Interior old poaching & pit sawing | 0.47* |
| Boundary old poaching & pit sawing | -0.29 |
| Boundary recent subsistence collection | -0.61* |

* $P < 0.05$

### 9.3.2.4 Factors explaining the likelihood of encountering gorillas

The final regression model correctly classified 71.7% of the gorilla encounters ($\chi2$ = 16.67; df = 2; p < 0.001) and proved a good fit to the data (AUC = 0.78). The model accounted for almost 40% (Nagelkerke R square = 0.36) of the variation in the data. The model that best predicted recce encounters with gorilla signs comprised interior, boundary harvest zone and boundary non-harvest zone sectors (Table 9.10). The coefficients show that recce encounters with gorilla signs were positively associated with interior sectors and negatively associated with boundary harvest zone (HZ) sectors, while the negative association of boundary non-harvest zone was not significant. Therefore, the results suggest that the forest interior and boundary harvest zones are more important in determining the distribution of gorillas than boundary non-harvest zones or poaching activity (Figure 9.4).

Table 9.10 Parameters of the stepwise multiple logistic regression model for the likelihood of recce encounters with gorillas in Bwindi

| Parameters | Coefficient (B) | Standard error of B | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|---|
| Interior | - | - | 9.37 | 2 | < 0.001 |
| Boundary HZ | -3.40 | 1.10 | 9.23 | 1 | < 0.01 |
| Constant | 0.63 | 0.44 | 2.06 | 1 | NS |

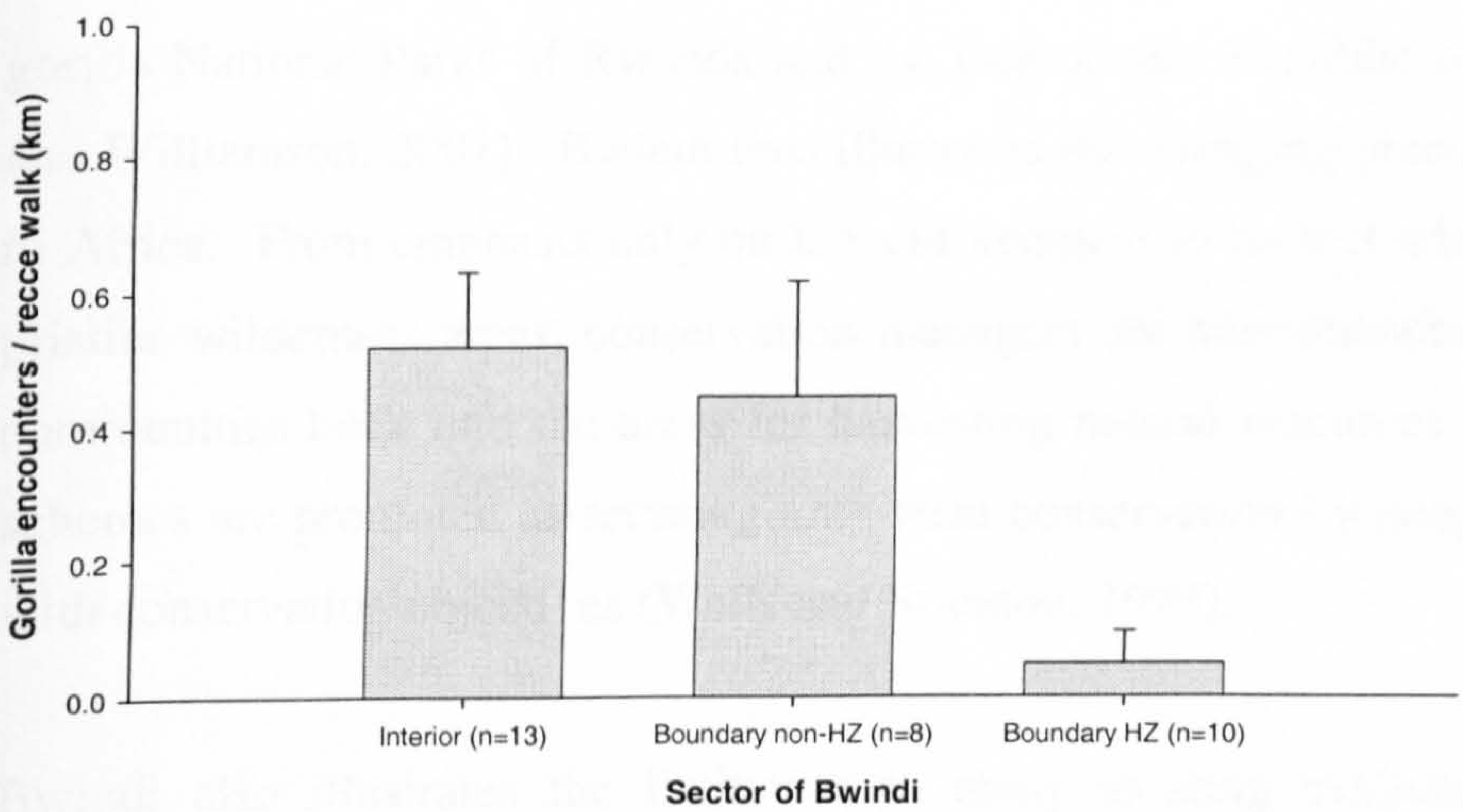



Figure 9.4 Mean±SE recce encounters with gorilla signs in forest interior, boundary harvest zone and boundary non-harvest zone sectors in Bwindi

## 9.4 Discussion

Mountain gorillas are a powerful flagship species (Leader-Williams and Dublin, 2000). Their high public profile from popular articles, books and films has enhanced their own intrinsic appeal and gorillas are now one of the most widely known flagship species for conservation in Africa (Weber and Vedder, 2001). In particular, mountain gorillas have been the focus for the conservation of the afro-montane forest region in Rwanda, the DRC and Uganda, and for increasing cooperation between protected area authorities in these three countries where the gorillas occur (Muruthi *et al*, 2000). The gorillas have also been the flagship species for efforts to conserve Bwindi (McNeilage *et al*, 2001).

The integrated approach adopted to address the issue of conflict with local communities around Bwindi, particularly the harvest zone programme, has contrasted with the more conventional methods of law enforcement employed for the mountain gorilla National Parks of Rwanda and the Democratic Republic of Congo (Plumptre and Williamson, 2001). Bwindi thus illustrates the changing practice of conservation in Africa. From emphasis only on law enforcement to protect what were considered pristine wilderness areas, conservation managers are now encouraged to allow local communities back into the areas for harvesting natural resources. These harvesting schemes are promoted as securing long-term conservation by integrating local needs with conservation objectives (Wells and Brandon, 1993).

Bwindi also illustrates the limitation to many existing evaluations of integrated conservation and development, which have focussed only on impacts at the community level. Without examining impacts at species level, a comprehensive assessment of the effectiveness of the integrated approach for conserving protected areas is not possible. Sanctioned resource harvesting at Bwindi is considered successful in conflict resolution, and conservation managers are now under pressure to extend harvest zones to other parishes bordering the National Park (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). However, the managers must weigh up the advantage of improved relations with local communities against the potential threats to gorillas and other wildlife species.

However, impacts of harvest zones on the success of conservation efforts are little understood, and there has been no assessment of the impact of harvesters on gorillas in Bwindi. This is particularly important because the gorillas in Bwindi comprise half of the world's population of mountain gorillas, and because it is assumed that a major threat to the gorillas is snares set for bushmeat (McNeilage *et al*, 2001).

This study, which is the first in Bwindi to examine how the establishment of harvest zones may have affected the distribution of gorillas, contributes to debate on the effectiveness of integrated conservation for flagship species. The study assessed gorilla distribution in relation to forest areas designated for local resource harvesting, and also the possible differential impacts of sanctioned resource harvesting and of bushmeat poaching on the gorillas. In addition, the law enforcement data provides a historical context of gorilla distribution in Bwindi to further understand current distribution patterns and harvest zones.

### 9.4.1 Gorilla distribution

Direct and indirect encounters with gorillas by rangers on law enforcement patrol indicated the distribution of the gorilla population of Bwindi which has remained stable at approximately 300 individuals during the study (Butynski and Kalina, 1993; McNeilage *et al*, 2001). A limitation of the patrol data was that the data only represented areas covered by the patrols. Thus, the decline in gorilla encounters after harvest zones were established probably reflected the decline in patrol coverage of interior areas. Law enforcement after harvest zone establishment was mainly by small ranger teams patrolling forest boundary areas for a single day. In addition, patrols of interior areas during this period tended to cover interior sectors bordering boundary sectors, rather than interior sectors deep within Bwindi (Chapter 4). Thus findings after harvest zone establishment that rangers continued to infrequently encounter gorillas in boundary areas, and encountered fewer gorillas in interior areas, indicate that gorillas remained deep within the forest during this period. This confirms findings from independent surveys that gorillas remained within the forest interior after gazettement (Harcourt, 1981; Butynski, 1984; McNeilage *et al*, 2001).

The patrol data also confirmed that gorillas were concentrated in interior forest areas before harvest zones were established (see also Harcourt, 1981; Butynski, 1984), and showed that rangers patrolling boundary areas after harvest zones were established rarely encountered gorillas, and that interior and boundary areas were significant to the likelihood of gorilla encounters in comparison with bushmeat poaching activities, harvest zones and area of Bwindi. The significance of interior and boundary areas to gorilla distribution was confirmed by the recce survey, and is likely to explain the positive correlation between gorillas and bushmeat poaching shown by the patrol data, as poaching in Bwindi is concentrated in the forest interior (Chapter 4). Gorillas therefore remained concentrated in interior areas from before Bwindi was declared a National Park to almost ten years later.

The recce survey gave further insight by showing that gorillas were negatively associated with harvest zones. The decline in patrol encounters with gorillas was most evident in the high harvest zone of the east area. Law enforcement remained high in east areas after harvest zones were established (Chapter 4), although during this period rangers tended not to patrol where gorilla monitoring teams were present in east interior areas (Bayenda, oral communication). As discussed reduced patrol coverage of interior areas may account for the decline in gorilla encounters in the east. However, previous surveys also confirm the distribution patterns shown in this study. Both Butynski's (1984) survey and the 1997 gorilla census (McNeilage *et al*, 2001) showed that gorillas did not occur in east boundary areas. This contrasts to the use of boundary areas by gorillas elsewhere in Bwindi, particularly by gorillas that crop raid around the southwest (Chapter 6) and the gorillas habituated for tourism that regularly forage within western boundary areas (personal observation). Furthermore, a recent study of the Kyagurilo gorilla group shows that the group's annual home range, which covers the east, does not extend into beekeeping harvest zones (Robbins and McNeilage, 2003). Therefore, this and other studies indicate that gorillas may not utilise the east boundary areas of Bwindi. This study therefore raises two questions: firstly why have gorillas remained only in the forest interior, and secondly why do gorillas not utilise the beekeeping east boundary areas?

## 9.4.2 Ecological and demographic factors

A range of ecological factors could explain the continued use of particular core areas by gorillas. Food availability might underlie gorilla movement patterns, even though the terrestrial herbaceous vegetation that forms the main component of the gorilla diet, is abundant and widely distributed, and there is little competition for food within or between groups (Doran and McNeilage, 2001). Yet despite the wide distribution of gorilla food, groups foraging in habitats with low food availability travel further per day than groups utilising areas rich in food resources (Vedder, 1984; Watts, 1991). Therefore, the importance of food availability to gorilla distribution could restrict the Bwindi gorillas to the forest interior. However, groups in Bwindi exhibit wide dietary variation. Gorillas in the lower altitudes of western areas feed on different plant species to gorillas in the higher eastern areas, even though the groups are only separated by 25 to 30 km (Ganas, oral communication). Furthermore, boundary areas of Bwindi are potential gorilla habitats because the secondary vegetation species of these areas comprise gorilla food plants (McNeilage *et al*, 2001).

The Bwindi gorillas do sometimes utilise boundary areas. The 28 gorilla groups found during the 1997 census were located in 18 forest sectors, of which seven were boundary sectors (McNeilage *et al*, 2001). In addition, the Bwindi gorillas utilise areas outside the forest, particularly around the west, and have been foraging in fields neighbouring Bwindi since the 1920s (Chapter 6).

In addition to ecological factors, demographic factors could explain why gorillas have remained concentrated in the forest interior. The gorilla population has remained stable at approximately 300 individuals since the mid-1980s (McNeilage *et al*, 2001) and may not need to expand their home range. However, preliminary results of the 2002 gorilla census reveal an increase in the Bwindi population, which would suggest that the population might expand into other forest areas (McNeilage, oral communication). Furthermore, the Bwindi gorillas exhibit large home ranges in comparison with the Virunga gorillas and thus could be expected to increase their distribution within the forest (Robbins and McNeilage, 2003).

Previous studies provide further discussion of gorilla distribution in the context of Bwindi. These note that complex relationships between ecological factors, and between ecological and social factors such as male mating tactics, influence gorilla home range and habitat utilisation (McNeilage *et al*, 2001; Robbins and McNeilage 2003). However, the gorilla census conducted after National Park gazettement showed that human activities in boundary areas, which were a primary factor restricting gorillas to interior areas, had declined. This led to the expectation that gorillas would expand their range into boundary areas. Whilst acknowledging that habitat variation could explain why gorillas avoid boundary areas, McNeilage *et al* (2001) suggest that the gorillas have remained in the interior because that is where the gorillas ranged historically. He concludes that past impacts of human activity on gorilla distribution may continue to bear influence on the current areas favoured by gorillas.

### 9.4.3 Human disturbance

Human disturbance associated with eastern boundary areas could be influencing gorilla movement patterns in these areas, as the east is potential gorilla habitat because of the mix of bamboo and herbaceous vegetation (McNeilage *et al*, 2001).

An impact on gorilla distribution from beekeeping activities has previously been indicated at Bwindi. Gorilla nest encounters during the 1997 census were negatively correlated with numbers of beehives, although this was considered the result of the interior location of gorilla nests and the boundary location of beehives (McNeilage *et al*, 2001). It is possible that in addition to current beekeeping activity, as McNeilage *et al* (2001) suggested, the historical influence of human disturbance on gorilla distribution may be important. There is a tradition of beekeeping in the east (Butynski, 1984; Scott, 1992), which was designated the beekeeping harvest zone because the area contained the highest density of beehives in Bwindi at the time of gazettement (Scott, 1992). Thus, past and present activities of beekeepers could influence the distribution of gorillas in eastern areas.

Illegal resource collection could also influence gorilla distribution. The recce survey showed gorilla encounters were negatively correlated with recent collections of subsistence forest resources, which were high in the east compared with other areas of Bwindi (Chapter 5). In addition, other forms of human disturbance in the east could be influencing gorilla distribution. A road separates the east boundary from interior areas. This road was regularly used by pit sawyers transporting timber to town markets before Bwindi gained National Park status, and has been used following National Park status by National Park staff, the ITFC research station, and by tourists, although the road is not the main tourist route to Bwindi. Thus the use of the road and the open habitat of the road in comparison with the forest, may be a barrier preventing gorillas from utilising boundary areas. Edge effects from the four parishes bordering the east could also have been a factor, as these are among the parishes with the highest population densities that surround Bwindi (Population and Housing Census, 2002).

It is also important to consider the relationship between human disturbance and the occurrence of gorillas within the forest interior. As discussed the positive correlation between poachers and gorillas from the patrol data could reflect the fact that both occur within the forest interior. The correlation could also indicate that both are responding to lack of disturbance. Poachers appear to respond to levels of law enforcement within Bwindi and therefore, after harvest zone establishment, may have concentrated their activities within the less frequently patrolled interior areas. Poachers may also be responding to high prey numbers, as duikers and bushpigs mainly occur in the forest interior (Chapter 4). Gorillas appear to respond to levels of human disturbance (McNeilage, 1988) and therefore may have remained concentrated within interior areas following the decline of human activity in the interior after National Park gazettement. However, the correlation was based on a broad classification of forest area that did not account for the specific location of poachers and of gorillas. It is possible that encounters between poachers and gorillas were rare because of the hills, valleys and dense vegetation of Bwindi. Thus the broad classification of forest area employed by this study may have masked differences between use of the forest interior by poachers and gorillas.

There is therefore a complex mix of ecological factors and various forms of human disturbance that could explain why gorillas may not utilise east boundary areas and continue to occupy the forest interior. To identify the most important factor is difficult. Firstly, data available for this study are limited. Secondly, most knowledge on gorilla ecology derives from three decades of research at the Karisoke Research Centre in Rwanda on gorilla groups that occupy the highest altitudes within the geographical range of the population (Robbins *et al*, 2001). In contrast, little is known about the ecology or distribution patterns of gorillas in the lower altitudes of Bwindi (McNeilage *et al*, 2001).

### 9.4.4 Summary

In summary, resource harvesting is a risky strategy for protected area managers aiming to integrate conservation aims with local development goals. In the dense forest and steep terrain of Bwindi, the risks appear to have been worthwhile, as harvest zones for beekeepers, medicinal practioners and basket makers were important to improving community relations with National Park staff. However, the loss of potential gorilla habitat was a concern when the harvesting strategy was implemented (Bensted-Smith *et al*, 1995). The data presented here indicate that gorillas did not and still do not utilise areas now making up the beekeeping harvest zones. Various factors influence gorilla movement patterns. Historical use of the forest by beekeepers may have caused the original disturbance, although evidence from ITFC's gorilla monitoring does suggest that gorillas and beekeepers can coexist. The home range of the Kyagurilo gorilla group, which was habituated for research purposes during the 1980s, centres around interior eastern areas of Bwindi. In 2000, for the first time since the group was habituated, the gorillas crossed the east road into the beekeeping harvest zone. Possible reasons for this are unknown (Robbins, oral communication), but the incident illustrates the potential use of beekeeping areas by gorillas, and the need for a greater understanding of the relationship between gorillas and traditional use of the forest by local communities.

Having established the distribution of the gorilla population over the period of establishment of harvest zones, I now seek to determine the current distribution of other key wildlife species in Bwindi.

# Chapter Ten

# -

# Wildlife Distribution and the Harvest Zones

*A meeting for beekeepers of the Mpungu harvest zone in Bwindi*

*(J. Baker)*

# Chapter Ten

# 10 Wildlife distribution and the harvest zones

## 10.1 Introduction

Strategies that aim to integrate biodiversity conservation with rural development have been shown successful in improving attitudes of local communities towards conservation (Slavin, 1996; Scott, 1998; Hinchely *et al*, 2000). However, impacts of integrated strategies on biodiversity have rarely been examined. This is particularly important for the sanctioned use of resources within protected areas because of the possible negative impacts from destructive resource exploitation and human disturbance (Barrett and Arcese, 1995; Butynski and Kalina, 1998; du Toit, 2002).

As noted in Chapter 9, previous evaluations of sanctioned resource harvesting in Bwindi have focused on the success in improving local attitudes towards conservation (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). The previous chapter has examined the impact of harvest zones on mountain gorillas. This chapter follows a similar approach in examining the impact on other species of wildlife.

The aim of this chapter is to determine the distribution of key wildlife species in Bwindi. The main objectives are to examine the distribution of chimpanzees, elephants, bushpigs, duikers, carnivore species and monkeys, in different areas, and in the harvest zones, of Bwindi. To address the objectives, I seek to determine the following research questions:

- In which forest areas are species distributed?
- Are differences in species distribution related to north and south sectors?
- Are differences in species distribution related to harvest zones?
- Are differences in species distribution related to levels of illegal activity?
- What is the relative significance of area of Bwindi, the forest interior and boundary, and harvest zone, and illegal activity to the distributions of key wildlife species?

## 10.2 Materials and Methods

### 10.2.1 Field Data Collection

Recce walks were undertaken in the dry season of December 2000 to February 2001. The walks were conducted in the forest interior along an irregular network of existing human trails and animal paths (interior recce walks), and along the National Park boundary (boundary recce walks). For the survey, 64 recce walks were conducted that totalled 106.7 km. A total of 35 walks covered forest interior sectors, with a mean of 1.6 km (range 0.6 – 4.7 km) per walk, and 29 walks covered boundary sectors, with a mean of 1.5 km (range 0.5 – 5.2 km) per walk (section 2.2.3).

Recordings were made on the observations of two field assistants walking at a pace of 1km/hour of direct sightings and indirect signs (nests, trails and dung) of chimpanzees, and sightings and dung of elephants, bushpigs, duikers, carnivore species, baboons and other monkey species. Encounters with baboons were separated from other species of primate because identification of baboon dung could be made with a good level of confidence, whereas identifying other species of primate from dung was more difficult.

### 10.2.2 Data analysis

Direct sightings of wildlife were few during the reconnaissance walks, with the exception of baboons and other species of monkey. I made no direct sightings of chimpanzees, elephants, bushpigs or carnivore species, and only four sightings of duikers. The analysis was therefore based on the indirect signs of wildlife to permit comparisons between species. In addition, dung and nest encounters of chimpanzees were pooled because of the low number of observations.

Encounters with wildlife signs on recce walks were converted into an encounter rate of the number of encounters per km of recce walk, for analysis using the non-parametric tests of Kruskal-Wallis and Mann Whitney U. Differences in distribution of each species in Bwindi were determined by comparing mean encounter rates per km firstly between north and south interior sectors, and secondly between south interior and south boundary sectors. The north sectors were excluded from the analysis of elephant signs because the species is known to only occur in the south sectors of Bwindi. Furthermore, no evidence was observed of elephants in the north sectors during this study. Bushpig and duiker were excluded from north-south analyses because there were only two observations of bushpig dung, one observation of duiker dung and one duiker sighting in north sectors.

Next, differences in distribution of each species in relation to harvest zones were determined by comparing mean encounter rates per km in south boundary harvest zone and south boundary non-harvest zone sectors.

Differences in distribution of wildlife in relation to sites of illegal activity (section 5.2) were then examined by Spearman's rank correlation. The illegal activities were sites of poaching and pitsawing considered between five and ten years, and sites of subsistence resource collection considered less than one year. North sectors were excluded from the correlations because of the low encounter rates of both wildlife and illegal activity. In addition, signs of baboons and of other monkey species were pooled into one encounter rate, and signs of bushpigs and of duikers were also pooled into one encounter rate, to reduce possibilities of spurious correlation results from the limited dataset. Correlations were not undertaken for encounters with monkey signs or sites of subsistence resource collection in south interior sectors because of the low numbers of encounters.

Encounters with chimpanzee signs were excluded from all analysis comprising south boundary sectors because of only three observations in boundary sectors, which comprised two observations of nests and one of dung.

The final analysis aimed to identify which factors best explained the likelihood of encountering wildlife on recce walks in Bwindi. For ungulates, chimpanzees and other primates, the number of recce encounters was converted into binary data of walks with and without an encounter. This formed the dependent variable in a stepwise logistic regression analysis, using the forward stepwise procedure. The explanatory variables were the categorical factors of area of Bwindi (north, centre, east, south, west) and forest interior, boundary harvest zone, boundary non-harvest zone, and the continuous variables of levels of illegal activity, which were recce encounters with old poaching and pit sawing sites, and recce encounters with recent signs of subsistence resource collection (section 2.2.3.2).

## 10.3 Results

### 10.3.1 Wildlife distribution

The dung of carnivore species that were observed during the recce walks were of the golden cat, jackal and the African wild cat. The dung of monkey species were of the l'Hoesti monkey, blue monkey, redtail monkey and black and white colobus monkey. There were few observations of indirect signs for all species and this resulted in large variation within the data.

#### 10.3.1.1 North and south sectors

Encounters with wildlife signs on recce walks show that only baboons occurred more frequently in north sectors, whereas monkeys and carnivores occurred more often in south sectors (Table 10.1). There was no difference in chimpanzee encounters between north and south sectors.

Table 10.1 Mean±SE recce encounters with wildlife in north and south sectors of Bwindi

| Indirect signs of species | North sectors (n = 19) | South sectors (n = 29) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Baboon dung | 1.11±0.5 | 0.31±0.1 | -3.13 | < 0.01 |
| Carnivore dung | 0.21±0.1 | 1.14±0.2 | -2.77 | < 0.01 |
| Chimpanzee dung & nest | 0.15±0.1 | 0.16±0.1 | -0.39 | NS |
| Monkey dung | 0.17±0.1 | 1.26±0.4 | -2.15 | < 0.05 |

#### 10.3.1.2 South interior and boundary sectors

Chimpanzee, bushpig and duiker signs were encountered more frequently in interior than in boundary sectors (Table 10.2). These species were thus similarly distributed to gorillas (section 9.3). In contrast, signs of carnivore species and of monkeys were encountered more frequently in boundary sectors. There were no observations of baboon dung in the interior sectors. There was no difference between interior and boundary sectors in encounters with elephant signs.

Table 10.2 Mean±SE recce encounters with wildlife signs in south interior and boundary sectors of Bwindi

| Indirect signs of species | Interior sectors (n = 13) | Boundary sectors (n = 16) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Bushpig dung | 1.07±0.2 | 0.07±0.04 | -4.86 | < 0.001 |
| Carnivore dung | 0.75±0.1 | 3.31±0.3 | -1.82 | < 0.05 |
| Chimp nest & dung | 0.31±0.1 | 0.08±0.05 | -2.10 | < 0.05 |
| Duiker dung | 1.21±0.4 | 0.11±0.1 | -4.20 | < 0.001 |
| Elephant dung | 0.72±0.2 | 0.71±0.1 | -1.66 | NS |
| Monkey dung | 0.25±0.01 | 3.46±0.5 | -2.17 | < 0.05 |

### 10.3.1.3 South boundary harvest zone and non-harvest zone sectors

Encounter rates on interior and boundary recce walks for each species did not significantly differ and were pooled for the analysis (Table 10.3). Signs of bushpigs and duikers tended to be encountered more frequently in non-HZ sectors, although unlike gorillas (section 9.3), the difference was not significant. As with gorillas, the only bushpig and duiker sign in harvest zones was in the east beekeeping zone sector O. In contrast, the dung of carnivore species was widely distributed across 12 boundary sectors, and there was no difference in carnivore signs between HZ and non-HZ sectors. Similarly, monkey dung was widely distributed across boundary sectors and there was no difference between HZ and non-HZ sectors. There was also no difference in baboon dung between HZ and non-HZ sectors. However, baboons appeared less widely distributed as baboon signs were only observed in west and centre sectors. Elephants also appeared less widely distributed, as, with the exception of one encounter in centre sectors, elephant dung was only observed in east and south sectors.

Table 10.3 Mean±SE recce encounters with widlife signs in south boundary HZ and non-HZ sectors of Bwindi

| Indirect signs of species | HZ sectors (n = 7) | Non-HZ sectors (n = 9) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Baboon dung | 0.24±0.2 | 0.66±0.3 | -1.63 | NS |
| Bushpig dung | 0.03±0.01 | 0.14±0.1 | -1.13 | NS |
| Duiker dung | 0.04±0.01 | 0.22±0.1 | -1.53 | NS |
| Carnivore dung | 1.70±0.4 | 0.68±0.1 | -1.35 | NS |
| Elephant dung | 0.97±0.4 | 0.28±0.2 | -1.16 | NS |
| Monkey dung | 2.03±0.8 | 0.67±0.2 | -0.88 | NS |

### 10.3.2 Wildlife and illegal activities

#### 10.3.2.1 South interior sectors

Signs of carnivore species, chimpanzees and elephants all tended to a negative correlation with old poaching and pit sawing sites (Table 10.4). In contrast, signs of bushpigs and duikers tended to a positive correlation, which were similar to gorillas (section 9.3.1.4). However, none of the correlations of carnivore species, chimpanzees, elephants and bushpigs and duikers were significant, which is in contrast to the significant correlation of gorillas (section 9.3.1.4).

Table 10.4 Spearman's rank correlation ($r_s$) between recce encounters with wildlife signs and with illegal activities in south interior sectors of Bwindi

| Illegal activity | Indirect signs of species (n = 13) | | | |
|---|---|---|---|---|
| | Bushpig & duiker | Carnivore | Chimpanzee | Elephant |
| Old poaching & pit sawing | 0.18 | -0.26 | -0.58 | -0.49 |

* $P < 0.05$

#### 10.3.2.2 South boundary sectors

Elephant signs were positively correlated with old poaching and pit sawing sites (Table 10.5). In contrast, carnivore species and monkeys tended to a negative correlation with the sites and were thus similar to gorillas (section 9.3). No relationship was evident for signs of bushpigs and duikers. Signs of carnivore species were positively correlated with recent subsistence resource collection. Signs of all other species tended to a negative correlation with the recent sites, and were therefore similar to gorillas (section 9.3).

Table 10.5 Spearman's rank correlation ($r_s$) between recce encounters with wildlife signs and illegal activities in south boundary sectors of Bwindi

| Illegal activity | Indirect signs of species (n = 16) | | | |
|---|---|---|---|---|
| | **Bushpig & duiker** | **Carnivore** | **Elephant** | **Monkey** |
| Old poaching & pit sawing | 0.06 | -0.24 | 0.48** | -0.18 |
| Recent subsistence collection | -0.39 | 0.38** | -0.35 | -0.17 |

**$P < 0.01$

### 10.3.3 Factors explaining the likelihood of encountering wildlife

#### 10.3.3.1 Bushpigs and duikers

The final regression model correctly classified 84.9% of the bushpig and duiker encounters ($\chi 2 = 31.50$; df = 2; $p < 0.001$) and proved a good fit to the data (AUC = 0.88). The model predicted that recce walks with (n = 23) and without (n = 25) bushpig and duiker signs were best explained by forest interior, boundary harvest zone and boundary non-harvest zone sectors. Interior and boundary areas accounted for more variation in the data (Nagelkerke R square = 0.60) in comparison with gorillas, but otherwise associations between forest areas and bushpig and duiker, and gorillas were similar (section 9.3). The coefficients show that boundary harvest zone sectors were negatively associated with bushpig and duiker signs (Table 10.6). Therefore, most bushpig and duiker signs on recce walks were encountered in interior sectors (Figure 10.1).

Table 10.6 Parameters of the stepwise multiple logistic regression model for the likelihood of recce encounters with bushpig and duiker signs in Bwindi

| Parameter | Coefficient (B) | Standard error of B | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|---|
| Forest interior | - | - | 18.73 | 2 | < 0.001 |
| Boundary HZ | -4.37 | 1.06 | 17.11 | 1 | < 0.001 |
| Boundary non-HZ | -3.16 | 0.95 | 11.01 | 1 | < 0.01 |
| Constant | 2.35 | 0.74 | 10.10 | 1 | < 0.01 |

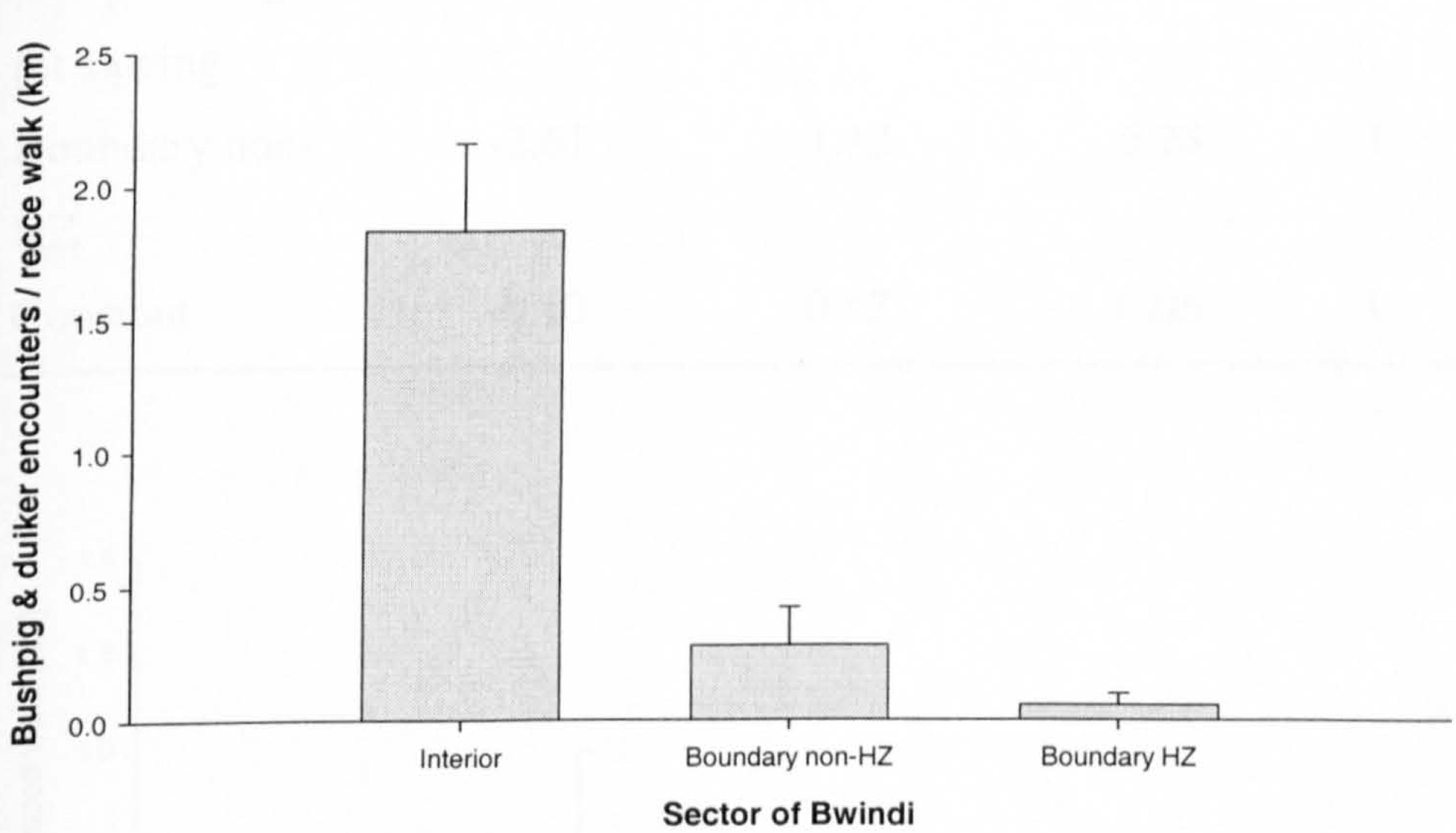



Figure 10.1 Mean±SE recce encounters with bushpig and duiker signs in forest interior, boundary harvest zone and boundary non-harvest zone sectors in Bwindi

### 10.3.3.2 Elephants

The final regression model correctly classified 69.1% of the elephant encounters ($\chi2$ = 13.91; df = 3; $p < 0.01$) and proved a good fit to the data (AUC = 0.75). The model predicted that recce walks with (n = 21) and without (n = 27) elephant signs were best explained by two variables, which were, in order of entry, old poaching and pit sawing sites and forest interior, boundary harvest zone and boundary non-harvest zone sectors. The variables accounted for 30% of the variation in the data (Nagelkerke R square = 0.30). The coefficients show that old poaching and pit sawing sites were positively associated with elephant signs, and boundary non-harvest zone sectors were negatively associated, whereas the negative association with boundary harvest zone sectors was not significant and interior areas were also not significant (Table 10.7). Therefore, most elephant signs on recce walks were encountered in old poaching and pit sawing sites (Figure 10.2).

Table 10.7 Parameters of the stepwise multiple logistic regression model for the likelihood of recce encounters with elephant signs in Bwindi

| Parameters | Coefficient (B) | Standard error of B | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|---|
| Old poaching & pit sawing | 0.18 | 0.08 | 4.90 | 1 | < 0.05 |
| Boundary non-HZ | -2.61 | 1.13 | 5.28 | 1 | < 0.05 |
| Constant | -0.10 | 0.43 | 0.05 | 1 | NS |

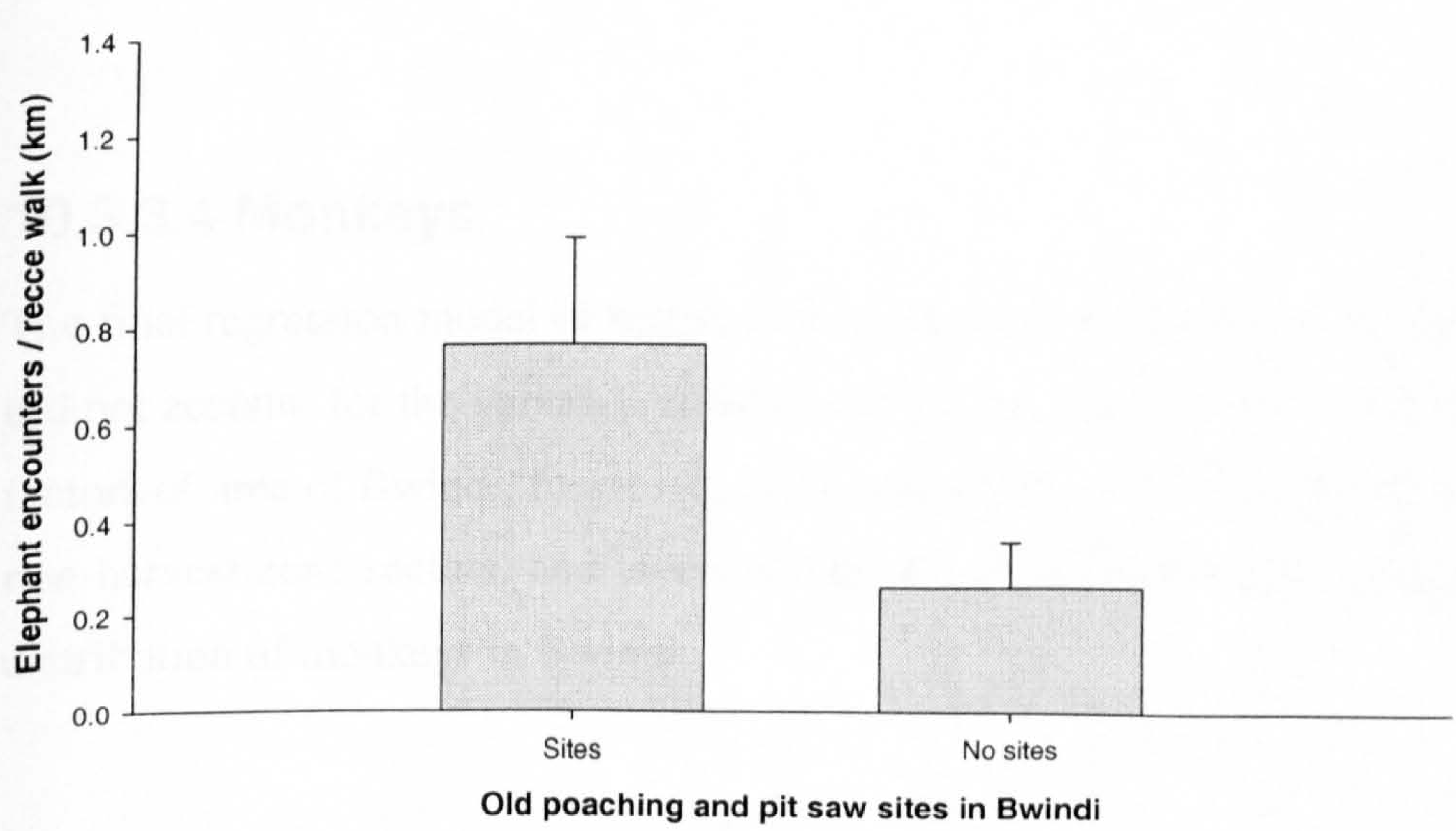



Figure 10.2 Mean±SE recce encounters with elephant signs with and without old poaching and pit saw sites in Bwindi

### 10.3.3.3 Carnivores

The final regression model correctly classified 72.6% of the carnivore encounters ($\chi 2 = 17.92$; df = 2; $p < 0.001$), and proved a good fit to the data (AUC = 0.73). The model predicted that recce walks with (n = 20) and without (n = 28) signs of carnivore species were best explained by interaction terms between forest interior, boundary harvest zone sectors and boundary non-harvest zone sectors, and recent signs of illegal subsistence resource collection. Forest area and recent illegal activity accounted for over 30% of the variation in the data (Nagelkerke R square = 0.34). Only the parameter of recent illegal activity in harvest zone sectors was significant. This parameter exhibited a positive association with carnivore signs (Table 10.8). Therefore, most carnivore signs on recce walks were encountered in boundary harvest zone sectors of high recent illegal subsistence resource collection.

Table 10.8 Parameters of the stepwise multiple logistic regression model for the likelihood of recce encounters with carnivore signs in Bwindi

| Parameters | Coefficient (B) | Standard error of B | Wald statistic | df | Significance of Wald |
|---|---|---|---|---|---|
| Boundary HZ * recent activity | 0.42 | 0.22 | 3.63 | 1 | < 0.05 |
| Constant | -0.80 | 0.33 | 5.87 | 1 | NS |

### 10.3.3.4 Monkeys

The final regression model of the likelihood of recce encounters with monkey species did not account for the variation within the data and was rejected. This indicated that factors of area of Bwindi, forest interior, boundary harvest zone sectors and boundary non-harvest zone sectors, and levels of illegal activity do not adequately explain the distribution of monkeys in Bwindi.

## 10.4 Discussion

Previous studies in Bwindi have documented the distribution of wildlife in the forest (Butynski, 1984: McNeilage *et al*, 1998; McNeilage *et al*, 2001) and have examined impacts of poaching, pit sawing and mining activity on the gorillas and other species of conservation concern (McNeilage *et al*, 1998; McNeilage *et al*, 2001). This study is the first to examine wildlife distribution in relation to harvest zones. The results are therefore the first assessment of the conservation impact of sanctioned resource harvesting in Bwindi, and complements the previous chapter on flagship species conservation (Chapter 9).

Monitoring wildlife in tropical forests requires a high level of sampling effort, which is difficult in the dense vegetation and steep terrain of these forests (Plumptre, 2000; Walsh *et al*, 2001). Recce sampling was employed for this study because the method has proven reliable for rapidly assessing wildlife distribution (McNeilage *et al*, 1998; Plumptre *et al*, 2002), and because a greater area could be surveyed than would have been possible with line transects (section 5.2). However, there were limitations to the methodology. Wildlife signs were difficult to observe in the dense vegetation of Bwindi, particularly chimpanzee nests that were high in the forest canopy, and it is likely that some wildlife signs were missed. Furthermore, few encounters with bushpig dung were recorded in north sectors, although many bushpig trails were evident in these areas during the survey and bushpigs have been observed foraging in community land adjacent to north sectors (Musaasizi, 2000). There were also limitations to the statistical analysis possible from the few encounters recorded, although similar studies examining wildlife distribution in relation to human activity also produce many non-significance results. From over 300 km of recce walks in the Nyungwe forest in Rwanda, only nine of the 105 correlations between wildlife encounter rates and illegal activities were significant (Plumptre *et al*, 2002), which is few given that five significant correlations would be expected by chance at 5%. A primate census in Kenya found that the non-significant correlations between group densities and forest patch size probably arose because interacting impacts of habitat destruction on primates require a more detailed analysis to investigate (Muoria *et al*, 2003). Despite the limitations, confidence was permitted in the data, and in the relatively crude sampling technique employed, through comparisons with previous studies. The trends in wildlife distribution between north and south sectors, and between south interior and boundary sectors, that were shown by this study were similar to the findings of the 1984 survey of Bwindi (Butynski, 1984) and the 1997 gorilla census (McNeilage *et al*, 1998; McNeilage *et al*, 2001).

### 10.4.1 Bushpigs and duikers

Comparisons between this study and previous research also show that the ungulate species primarily targeted by poachers in Bwindi have remained concentrated in the forest interior over the ten-year period since the National Park was established. In addition, this study showed that bushpigs and duikers were negatively associated with harvest zones and were thus similar in this regard to the gorillas. A primary concern of conservationists when the harvest zones were established in Bwindi was the loss of potential habitat for wildlife, and disturbance from human activity (Bensted-Smith *et al*, 1995; Wild and Mutebi, 1996). The gorillas were of particular concern, as research in the Parc National des Volcans had demonstrated that gorilla distribution is negatively correlated with levels of human activity (McNeilage, 1995). This study appears to give strength to the concerns. The results indicate that harvest zones and recent illegal activity in the harvest zones are significant to the use of forest boundary areas by gorillas and ungulates. However, there are other factors to consider.

Wildlife distribution is influenced by complex interactions between ecological and environmental factors. Habitat preference is an important factor influencing the coexistence and distribution of species (Pimm, 1991), and the occurrence of species can be explained by the availability of resources and habitat utilisation (Schoener, 1983). In Bwindi, the positive association between ungulates and the forest interior could reflect the fact that boundary areas are unsuitable for these species in terms of food availability and habitat type. The suitability of boundary areas for ungulates has not been assessed, although these areas are considered potential gorilla habitats (McNeilage *et al*, 2001) (Chapter 9). It is therefore possible that associations between ungulates and forest areas evident in this study reflect underlying ecological factors.

Pit sawing and mining in boundary areas were considered primary factors restricting gorillas and other species sensitive to human disturbance to the forest interior before gazettement (Harcourt, 1981; Butynski, 1984). Disturbance from human activities is therefore a possible influence on wildlife distribution in Bwindi. Currently, human disturbance in Bwindi results from illegal activities and from harvest zones.

Illegal activities in Bwindi have declined since the forest was designated a National Park (McNeilage *et al*, 1998; 2001) (Chapter 4). Findings of the 1997 gorilla census showed that the gorilla population had remained concentrated in interior sectors. Therefore, McNeilage *et al* (2001) concluded that, despite a decline in human activity, gorillas were still using the forest interior because this area is where the gorillas ranged historically. Historical distribution patterns could also explain the current interior range of gorillas and ungulates. However, this study indicates an impact of past human usage of the forest on ungulate distribution. The positive correlation between ungulate signs and old poaching and pit saw sites in interior areas, which was similar to the gorillas, could reflect the attraction of plant species in disturbed habitats to these species.

Historical use of the forest by humans could also explain the negative association between ungulates and harvest zones. The zones were established in resource-rich areas of Bwindi to minimise impacts on biodiversity from harvesting (Scott, 1992). It is therefore possible that communities neighbouring Bwindi entered these areas for forest resources before Bwindi was gazetted a National Park, and historically have been areas of high human activity that animals avoided. For example, as discussed for gorillas (Chapter 9), the beekeeping zone was established in the east of Bwindi because of the tradition of beekeeping in the surrounding communities (Butynski, 1984; Scott, 1992) and because the area contained the highest density of beehives at the time of gazettement (Scott, 1992). Wild animals may have avoided these areas in the past because of the concentration of beekeepers and now, under the harvest zone programme, have continued to do so. There are also other sources of human disturbance associated with harvest zones, including the road through the east of Bwindi and edge effects from neighbouring parishes, which might influence wildlife distribution (Chapter 9).

Therefore, various ecological factors and forms of human disturbance could explain the negative association between ungulates and harvest zones, and determining impacts of harvest zones is difficult. Nonetheless, this study demonstrates that impacts of sanctioned resource harvesting on wildlife, in particular on species of conservation concern, is an important consideration for managers of protected areas.

### 10.4.2 Monkeys and carnivores

The distribution of monkeys, including baboons, and species of small carnivore provide an interesting comparison with those of gorillas and ungulates, as monkeys and carnivores are considered to differ in their sensitivity to human disturbance. Monkeys have been associated with disturbed forest areas and have been shown to shift dietary patterns in response to human disturbance (Fairgrieve and Muhumuza, 2003). In Bwindi, previous research has shown that monkeys are most abundant in boundary forest areas (Butynski, 1984; McNeilage *et al*, 1998) and are frequently sighted within adjacent community land (Butynski, 1984; Mwesigye, 1996). The findings of this study also demonstrate that monkeys in Bwindi are widely distributed in boundary areas and occur across a variety of habitat types. This wide ranging distribution may explain why forest area and level of illegal activity did not adequately explain the likelihood of a recce encounter with monkey signs. However, the results may have been a consequence of grouping different species for the analysis, as the species of Bwindi differ in altitudinal range. Black and white colobus monkeys and redtail monkeys are most common in the lower altitudes of Bwindi and baboons only occur in forest areas below 2000 metres, whereas blue monkeys and l'Hoesti monkeys are most abundant in the higher altitudes (Butynski, 1984). Nonetheless, the results do show that harvest zones appear not to be significant to the overall distribution of monkeys in Bwindi.

Harvest zones were nevertheless significant to the distribution of small carnivores. Species of small carnivores in Bwindi have been classified into two groups of those that mainly occur in the forest interior, which feed on forest ungulates and include, for example, the golden cat, and those that are most abundant within boundary areas, such as the side-stripped jackal and the African civet, which feed on small rodents and on livestock and agricultural crops in adjacent community land (Andama, 2000). All species were hunted before gazettement of Bwindi by local communities for various domestic uses including medicinal products and ornaments, and for commercial sale within Rwanda and the DRC. The communities also hunted carnivores to try to prevent the animals feeding on their agricultural produce (Anadama, 2000). This hunting pressure is considered to have reduced carnivore populations in Bwindi (Butynski, 1984). However, little is known about the impact of human disturbance on small carnivore distribution in tropical forests. This study showed a positive association between small carnivores and harvest zones and therefore indicates that, with prohibitions on wildlife hunting, these species tolerate disturbed environments and environments with frequent human activity. This tolerance could be related to food availability. Bwindi supports a diverse community of rodents and shrews, and this diversity is higher in the disturbed boundary habitats than in the primary forest of interior areas (Kasangaki *et al*, 2003). The positive association between small carnivore species and the high level of recent illegal resource collection in harvest zones could therefore reflect the distribution of these species in relation to rodent diversity.

### 10.4.3 Elephants

The elephant population of Bwindi is thought to have remained stable over the last 15 years, at approximately 22 individuals. The elephants, except for a few lone males, move in one group and are known to favour the east interior areas around Mubwindi swamp and east boundary areas of the bamboo forest (Babassa, 2000). The ranging patterns of forest elephants have been linked to their feeding ecology (Tchamba and Seme, 1993). In Bwindi, the preference for certain habitats by the elephants has been related to the seasonal production of their food plants (Babassa, 2000).

The negative association between elephant signs and boundary non-harvest zones could indicate impacts of human activity on elephant distribution, as previous research has demonstrated that the distribution of forest elephants is determined by human activity (Barnes *et al*, 1991). However, the association is more likely to reflect the concentration of elephant signs around the bamboo forest, part of which is the beekeeping harvest zone. In comparison, the highly significant association between elephant signs and old poaching and pit saw sites in boundary sectors is likely to indicate that elephants favoured these open, disturbed areas. Barnes (*et al*, 1991) used dropping counts to examine elephant abundance in forests of equatorial Africa, and found that the elephants preferred the secondary forest of abandoned villages and plantations and avoided occupied human settlements. The results of this study support such findings, and also show that in Bwindi, in comparison with the seasonal production of food plants and preference for secondary forest areas, the harvest zones appear not significant to elephant distribution.

## 10.4.4 Summary

This chapter illustrates the potential of recce walks for monitoring wildlife and human activities in tropical forests. Although quantitative long-term studies are necessary to investigate the effect of human disturbance on mammal populations (Plumptre *et al*, 2002), the analysis demonstrates that recce walks are a suitable methodology for conservation managers who are unable to devote the time and manpower required for detailed monitoring surveys within tropical forests.

In summary, harvesting strategies for the conservation of protected areas are controversial, in part because of possible disturbance from human activity on biodiversity. Conservation managers at Bwindi are currently under pressure from local communities to expand the harvest zones in the forest, so that all parishes neighbouring the National Park can benefit from the programme. The findings of this chapter show that managers of Bwindi must weigh up the benefits from gaining local support for the National Park against the possible negative impact on species of conservation concern.

Having established the current distribution of gorillas and other key wildlife species in Bwindi, I now present a summary of the findings of the thesis and recommendations for managers of protected areas.

# Chapter Eleven

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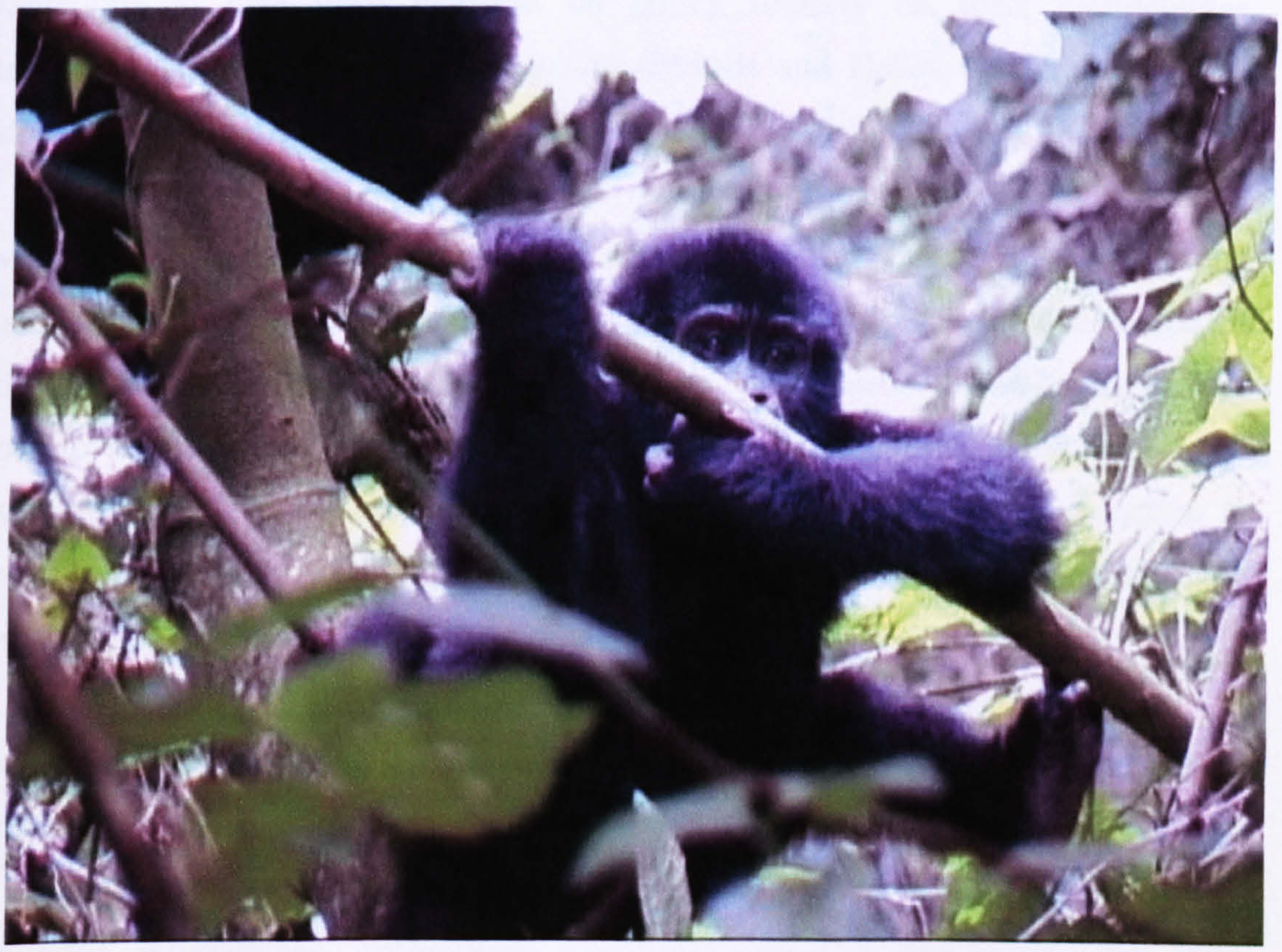
# Research Findings and Conclusions



*Gorilla of Mubale gorilla group, Bwindi*

*(J. Baker)*

# Chapter Eleven

# 11 Research findings and conclusions

Integrated conservation and development has been adopted for the management of protected areas throughout the tropics. Evaluating this policy is therefore critical, and a priority for the international conservation community (IUCN, 2003). Most evaluations to date have focussed on policy impacts on local communities, particularly their support for conservation (Straede and Helles, 2000) and conflict with conservation managers (Zhang and Wang, 2003). The conclusion from a variety of sites is that integrated conservation and development can improve local attitudes towards conservation, which are vital for sustainable management of protected areas (Larson *et al*, 1997; Hughes and Flintan, 2001). However, evaluations based on attitude surveys are limited, as attitudinal surveys are primarily useful as exploratory tools to direct further investigation (Philip, 1975). A further limitation is the assumption that gaining local support for conservation will lead to a reduction in threats to biodiversity, as attitudes of local communities do not necessarily determine how they use natural resources (Holmes, 2003).

Bwindi provides a well-known example of the approach that seeks to integrate conservation and development for a protected area supporting an important population of a well-known flagship species. Bwindi is also an example of how the success of integrated programmes, particularly sanctioned resource harvesting, has been examined in terms of its social impacts on the local community (Blomley, 2003; Makombo, 2003) without any parallel assessment of its impacts on biodiversity or on reducing threats to biodiversity. Therefore, this study aimed to evaluate the integrated approach for protected area conservation.

The study had three main objectives:

- to determine bushmeat poaching over the periods of National Park gazettement and establishment of harvest zones
- to determine interactions between local communities and law enforcement rangers and factors that best explained the type of interaction

- to determine the distribution of gorillas in relation to harvest zones and illegal activities

Law enforcement patrol reports were employed for the analysis, which involved verifying the rangers' recordings and their encounters with illegal activities and wild animals, and mapping forest toponyms. The use of law enforcement data has limitations, so the study gathered additional and secondary evidence including reconnaissance surveys of illegal activity and wildlife distribution and archival material in order to address each objective. The study arrived at one primary conclusion: maintaining a dual strategy of law enforcement and integrated conservation and development appears most beneficial for future conservation efforts in Bwindi. The following sections discuss each objective separately and comment on the implications of the findings for conservation.

## 11.1 Bushmeat poaching

Snares set for bushmeat are a major threat to gorillas in Bwindi. Snares are the most common form of bushmeat hunting in Bwindi and poachers concentrate their activities in forest interior areas where gorillas are most abundant (Butynski, 1984; McNeilage *et al*, 2001). Thus a primary aim of the integrated programme was to reduce bushmeat poaching, particularly the number of snares, in the National Park (UNP, 1995).

This study documented poaching activities of communities neighbouring Bwindi from 1986 to 2000 (Chapter 4). In addition, the current distribution of illegal activity in Bwindi was examined by reconnaissance survey, which enabled comparison with the patrol data (Chapter 5). The analyses showed that, after National Park gazettement, poachers entered Bwindi less frequently but set larger snare clusters while inside Bwindi. Furthermore, poaching remained constant in the less well-patrolled interior areas, and in the low and medium harvest zones, after harvest zones were established when local attitudes towards the National Park improved. Effort of law enforcement was a significant factor affecting patrol encounters with poaching. Therefore, law enforcement appears central to the conservation strategy of Bwindi. Furthermore, conservation managers should ensure even patrol coverage of Bwindi and maintain the necessary law enforcement effort required for encountering prevailing levels of poaching.

The patrol data showed that most poachers in Bwindi are Bakiga agriculturalists hunting bushmeat with snares, mainly for domestic consumption. The data also indicated that beekeepers of the harvest zone programme refrained from poaching after harvest zones were established. There are several factors including law enforcement and impacts of sanctioned resource harvesting that could have reduced (or influenced) poaching by beekeepers. Further study of the benefits that individual poachers received from Bwindi's integrated programmes is therefore necessary to determine the effectiveness of integrated programmes in protected area conservation. The findings do indicate that the integrated programme failed to reduce threats to gorillas from snares, despite gaining local support for conservation. However, establishing this conclusion requires knowledge of the socio-economic characteristics of individual poachers and of impacts of different types of sanctioned resource harvesting on poaching.

## 11.2 Local communities and staff of Bwindi

Gaining local community support for protected areas is a primary objective of integrated conservation and development programmes. The integrated approach at Bwindi was adopted to alleviate conflict between local communities and conservation managers that arose during the establishment of the National Park. This study documented incidents of conflict recorded by staff of government and conservation authorities of Bwindi during the gazettement period (Chapter 3). The findings showed that the loss of income to local communities from gazettement was a major cause of conflict. Violent attacks on law enforcement rangers primarily occurred because of the arrest of miners, which were largely instigated by villagers, and the arrest of pit sawyers, which involved local chiefs and members of the army. Income-generation schemes to improve the economic status of local communities are therefore important for the integrated programme of Bwindi.

Assessing conflict incidents provided a historical context to interactions between local communities and law enforcement rangers at Bwindi that occurred from 1996 to 2000 (Chapter 8). The interactions comprised positive interactions, which included community members reporting illegal activity, and negative interactions, which included members refusing to assist rangers with law enforcement activities. The results showed that most interactions were negative and that crop raiding by wild animals largely explained negative interactions. Also, most complaints about crop raiding by local communities to rangers regarded baboons, and were by communities who received little assistance from rangers with problem animal control. Impacts of problem animal control on local attitudes towards protected areas are little studied in comparison with other community benefits, such as revenue sharing schemes or ecotourism, that conservation managers provide (Archabald and Naughton-Treves, 2001; Walpole and Goodwin, 2001). The findings of this study indicate that problem animal control, particularly for baboons around the centre and north of Bwindi, is an important component of the integrated programmes.

The study also showed that beekeepers of the high harvest zone of the east area, and communities adjacent to the east harvest zone, interacted positively with rangers. Therefore, the findings suggest that expanding harvest zones would encourage the voluntary participation of local communities in law enforcement. Beekeepers accounted for a larger proportion of positive interactions than other resource users, which was possibly because their harvest zones were established relatively quickly in comparison with harvest zones for medicinal plants and basket-making materials. The study therefore indicates that an efficient implementation process is important for establishing harvest zones.

## 11.3 Gorillas

Mountain gorillas have been the flagship species for conservation efforts of the afro-montane forest of Uganda, Rwanda and the DRC (Muruthi *et al*, 2000). However, the integrated approach used for conserving Bwindi contrasted to the more traditional law enforcement methods employed for the mountain gorilla National Parks in the Virungas. Furthermore, harvest zones are controversial because human disturbance was thought to be a primary factor restricting gorilla distribution to the forest interior before Bwindi gained National Park status (Harcourt, *1981*; Butynski, *1984*; McNeilage *et al*, 2001).

This study documented law enforcement encounters with gorillas in Bwindi from 1986 to 2000 (Chapter 9), and assessed impacts from sanctioned resource harvesting and bushmeat poaching on the distribution of gorillas and other wildlife species (Chapter 10). The main findings were that gorillas were not utilising boundary areas of the high harvest zones of the east area, and that other species sensitive to human disturbance were negatively associated with harvest zones. Conclusions regarding impacts from sanctioned resource harvesting were difficult because of the variety of factors that could determine wildlife distribution. These factors include historical human use of the forest, other forms of human disturbance in the National Park and ecological factors. Conclusions regarding gorillas were particularly limited because most research on mountain gorillas has been conducted on the gorillas that occupy high altitude ranges within the Virungas. Nonetheless, the study showed that disturbance from sanctioned resource harvesting on species of conservation concern is an important consideration for managers of protected areas.

## 11.4 Further research

There are possibilities for further research from this study to address limitations of the methodology and to investigate questions raised by the findings.

Surveys to determine the perspective of local communities neighbouring Bwindi on issues presented in the thesis, particularly conflict (Chapter 3), crop raiding (Chapter 6) and community-ranger interaction (Chapter 8), would address limitations of the methodology by testing assumptions regarding the rangers' recording. Such surveys would also further the study by complementing the analyses on behavioural aspects of community support for conservation. In addition, although use of attitudinal questionnaires as a primary tool for evaluating conservation policy is limited (Chapter 8), community surveys are an important component within multi-disciplinary research and would provide a comprehensive evaluation of social impacts of the integrated programme at Bwindi. Attitude surveys of protected area staff are also important to evaluate integrated programmes, as understanding rangers' attitude would provide insight on factors affecting success of the programmes. This is particularly relevant for protected areas such as Bwindi where law enforcement rangers regularly interact with local communities.

The findings of this study indicate that motivation of rangers is important to the success of law enforcement (Chapter 4). Thus examining factors that motivate rangers and monitoring their level of empowerment would assist protected area managers in maintaining a motivated workforce, which would increase the effectiveness of law enforcement. Questionnaire surveys are often used within social research to examine individuals' motivation for work, which is a function of a desire to see the work completed, financial gain, job satisfaction and status associated with employment. Effective personnel management is also important to motivate staff (Cooper, 1974; Robertson *et al*, 1992), and this type of research would highlight needs for management skill training.

Unsustainable use of natural resources by local communities is a threat to protected areas in the tropics (IUCN, 1980). Thus determining relationships between type of resource use and socio-economic characteristics of resource users, particularly regarding illegal activities, is important for identifying threats to protected areas and for evaluating conservation policy. For example, as discussed socio-economic data on poachers including area of origin and/or residence, sex, age, education and wealth, would enable conclusions regarding effectiveness of integrated initiatives to reduce numbers of snares. Such research would also identify development needs of local communities and their dependency on natural resources, which would aid selection of community-based initiatives for improving rural development. An additional study would be to determine whether illegal resource users have received benefits from the protected area, and the type of benefit received, in order to distinguish between the effectiveness of individual incentives and community-level benefits for reducing threats to biodiversity.

This study demonstrated use of law enforcement patrol records to examine effectiveness of conservation policy. The study also illustrated how historical materials can provide insight on factors underlying current patterns, and highlighted areas where examining the historical perspective would be important, such as forest use by resource users selected for the harvest zone programme. For example, establishing the history of beekeeping in Bwindi would contribute to debate regarding use of forest boundary areas by gorillas and other wildlife species sensitive to human disturbance (Chapter 9).

The focus on bushmeat poaching in this study enabled evaluation of integrated initiatives regarding a primary threat to mountain gorillas. Determining distribution and density of all illegal activity in Bwindi particularly pit sawing and mining, and numbers of offenders associated with each activity, over National Park and harvest zone periods would provide a more comprehensive evaluation of integrated programmes. The findings could then be compared with a similar evaluation based on law enforcement records and field surveys of mountain gorilla National Parks in the Virungas. A comparison of the success of conservation efforts between Bwindi and the Virungas would be fundamental to current debate on the effectiveness of integrated programmes for flagship species conservation.

## 11.5 Conclusions

In conclusion, a dual strategy of law enforcement and sanctioned resource harvesting is recommended for the conservation of Bwindi. Law enforcement was most significant to activities of local poachers and thus vital for conserving the gorilla population. Sanctioned resource harvesting promoted positive interactions between local communities and law enforcement rangers. However, conservation managers should consider the possible negative impacts from harvesting on wildlife for the establishment of harvest zones. Furthermore, mitigating the crop raiding activities of wild animals is important for managers of Bwindi because crop raiding mainly accounted for negative interactions between communities and rangers.

# References

**Abbot, J.I.O and I. Guijt** (1998) *Changing views on change: participatory approaches to monitoring the environment.* IIED SARL Discussion Paper No.2, IIED, UK.

**Abbot, J.I.O. and R. Mace** (1999) Managing protected woodlands: Fuelwood collection and law enforcement in Lake Malawi National Park, *Conservation Biology,* 13, 2: 418-421.

**Abbot, J.I.O., D.H.L. Thomas, A.A. Gardner, S.E. Neba and M.W. Khen** (2001) Understanding the links between conservation and development in the Bamenda Highlands, Cameroon, *World Development,* 29, 7: 1115-1136.

**Agrawal, A. and C.G. Gibson** (1999) Enchantment and disenchantment: the role of community in natural resource conservation, *World Development,* 27, 4: 629-649.

**Alexander, S.E.** (2000) Resident attitudes towards conservation and black howler monkeys in Belize: the Community Baboon Sanctuary, *Environmental Conservation,* 27, 4: 341-350.

**Alpert, P.** (1995) Applying ecological research at integrated conservation and development projects, *Ecological Applications,* 5, 4: 857-860.

**Andama, E.** (2000) *The status and distribution of carnivores in Bwindi Impenetrable National Park, south-western Uganda.* MSc thesis, Makerere University, Kampala, Uganda.

**Apaza L, D. Wilkie, E. Byron, T. Huanca, W. Leonard, E. Perez, V. Reyes-Garcia, V. Vadez and R. Godoy** (2002) Meat prices influence the consumption of wildlife by the Tsimane Amerindians of Bolivia, *Oryx,* 36, 4: 382-388.

**Arcese, P., J. Hando and K. Campbell** (1995) Historical and present-day anti-poaching efforts in Serengeti. *In* Sinclair, A.R.E. and P. Arcese (eds) *Serengeti II: Dynamics, management and conservation of an ecosystem.* University of Chicago Press, Chicago, USA.

**Archabald, K., and L. Naughton-Treves** (2001) Tourism revenue-sharing around national parks in Western Uganda: early efforts to identify and reward local communities, *Environmental Conservation*, 28, 2: 135-149.

**Babaasa, D.** (2000) Habitat selection by elephants in Bwindi Impenetrable National Park, south-western Uganda. *African Journal of Ecology*, 38, 2:116-122.

**Babaasa, D., G. Eilu, A. Kasangaki and R. Bitariho** (2001) *Gap Characteristics and Regeneration in a Logged Albertine Rift Afromontane Forest Island.* Unpublished report for the Institute of Tropical Forest Conservation, Bwindi Impenetrable National Park, Uganda.

**Badola, R.** (1998) Attitudes of local people towards conservation and alternatives to forest resources: a case study from the lower Himalayas. *Biodiversity and Conservation*, 7: 1245-1259.

**Balcomb, S.R., C.A. Chapman and R.W. Wrangham** (2000) Relationship between Chimpanzee (*Pan troglodytes*) density and large, fleshy-fruit tree density: conservation implications, *American Journal of Primatology*, 51, 3: 197-203.

**Balmford, A., J.L. Moore, T. Brooks, N. Burgess, L.A. Hansen, P. Williams and C. Rahbek** (2001) Conservation conflicts across Africa, *Science*, 291, 5513:2616-2619.

**Balmford, A., K.J. Gaston, S. Blyth, A. James and V. Kapos** (2003) Global variation in terrestrial conservation costs, conservation benefits, and unmet conservation needs, *Proceedings of the National Academy of Sciences of the United States of America*, 100, 3: 1046-1050.

**Balmford, A., and T. Whitten** (2003) Who should pay for tropical conservation, and how could the costs be met? *Oryx*, 37, 2: 238-250.

**Barnes, R.F.W.** (1993) Indirect methods for counting elephants in forests, *Pachyderm*, 16, 24-30.

**Barnes, R.F.W.** (2001) How reliable are dung counts for estimating elephant numbers? *African Journal of Ecology*, 39, 1: 1-9.

**Barnes, R.F.W.** (2002) The problem of precision and trend detection posed by small elephant populations in West Africa, *African Journal of Ecology*, 40, 179-185.

**Barnes, R.F.W., S. Asika and B. Asamoah-Boateng** (1995) Timber, cocoa and crop raiding elephants: a preliminary study from southern Ghana. *Pachyderm*, 19: 33-38.

**Barret, C.B. and P. Arcese** (1995) Are integrated conservation-development projects (ICDPs) sustainable – on the conservation of large mammals in sub-Saharan Africa. *World Development*, 23, 7: 1073-1084.

**Barrow, E., H. Gichohi and M. Infield** (2000) *Rhetoric or reality? A review of community conservation policy and practice in East Africa.* Evaluating Eden Series Number 5. International Institute for Environment and Development, London, UK.

**Bauer, H.** (2003) Local perceptions of Waza National Park, northern Cameroon, *Environmental Conservation*, 30, 2:175-181.

**Beale, C. and P. Monaghan** (2004) Human disturbance: people as predation-free predators? *Journal of Applied Ecology*, 41: 335-343.

**Becker, C.D.** (2003) Grassroots to grassroots: why forest preservation was rapid at Loma Alta, Ecuador. *World Development*, 31, 1: 163-176.

**Bell, R.H.V.** (1984) The effect of soil nutrient availability on community structure in African ecosystems. *In* Huntley, B.J. and B.H. Walker (eds) *Ecology of tropical savannahs.* CSIR Pretoria, 193-216.

**Bell, R.H.V.** (1986) Monitoring of illegal activity and law enforcement in African conservation areas. *In* Bell, R.H.V. and E. McShane-Caluzi (eds) *Conservation and Wildlife Management in Africa.* The proceedings of a workshop organised by the US Peace Corps at Kasungu National Park, Malawi, October 1984, US Peace Corps.

**Bell, R.H.V. and E. McShane-Caluzi** (eds) (1986) *Conservation and Wildlife Management in Africa.* The proceedings of a workshop organised by the US Peace Corps at Kasungu National Park, Malawi, October 1984, US Peace Corps.

**Bennett, E., A. Neiland, E. Anang, P. Bannerman, A.A. Rahman, S. Huq, S. Bhuiya, M. Day, M. Fulford-Gardiner and W. Clerveaux** (2001) Towards a better understansding of conflict management in tropical fisheries: evidence from Ghana, Bangladesh and the Caribbean, *Marine Policy,* 25: 365-376.

**Bensted-Smith, R., M. Infield, J. Otekat and N. Thomson-Handler** (1995) *Review of the multiple use (resource sharing) programme on Bwindi Impenetrable National Park.* Unpublished report for CARE-DTC, CARE-International, Kampala, Uganda.

**Berkes, F.** (2004) Rethinking community-based conservation, *Conservation Biology,* 18, 3: 621-630.

**Bhima, R.** (1998) Elephant status and conflict with humans on the western bank of Liwonde National Park, Malawi. *Pachyderm,* 25: 74-80.

**Bitariho, R., D. Babaasa and A. Kasangaki** (2000) *Weather patterns at Ruhija, Bwindi Impenetrable National Park.* Unpublished report for the Institute of Tropical Forest Conservation, Bwindi Impenetrable National Park, Uganda.

**Blomley, T.** (2003) *Natural resource conflict management: the case of Bwindi Impenetrable and Mgahinga Gorilla National Parks, south-western Uganda.* Unpublished report for CARE-International, Kampala, Uganda.

**Bodmer, R. E.** (1995) Managing Amazonian wildlife: biological correlates of game choice by detribalised hunters. *Ecological Applications*, 5, 4: 872-877.

**Boot, R.G.A. and R.E. Gullison** (1995) Approaches to developing sustainable extraction systems for tropical forest products, *Ecological Applications*, 5, 4: 896-903.

**Borrini-Feyerabend, G.** (ed) (1997) *Beyond fences: seeking social sustainability in conservation.* IUCN, Gland, Switzerland.

**Browder, J.O.** (2002) Conservation and development projects in the Brazilian Amazon: Lessons from the community initiative program in Rondonia, *Environmental Management*, 29, 6: 750-762.

**Brown, M. and B. Wyckoff-Baird** (1994) *Designing Integrated Conservation and Development Projects.* The Biodiversity Support Program. USAID. Washington, DC, USA.

**Bruner A.G., R.E. Gullison, R.E. Rice and G.A.B. da Fonseca** (2001) Effectiveness of parks in protecting tropical biodiversity, *Science*, 291, 5501:125-128.

**Butynski, T.M.** (1989) Afromontane forest conservation and rural development in southwestern Uganda. *In Proceedings of the First International Workshop for the Conservation and Management of Afromontane Forests.* Wildlife Conservation Society, U.S.A.

**Butynski, T.M.** (1984) *Ecological survey of the Impenetrable (Bwindi) forest, Uganda, and recommendations for its conservation and management.* Unpublished report for New York Zoological Society Report, New York, U.S.A.

**Butynski, T.M. and J. Kalina** (1993) Three new mountain national parks for Uganda. *Oryx*, 27, 4: 214-224.

**Butynski, T.M. and J. Kalina** (1998) Gorilla tourism: a critical look. *In* Milner-Gulland, E. J. and R. Mace (eds) *Conservation of Biological Resources*. Blackwell Science, Oxford.

**Camilli, G.** (1990) The test of homogeneity for 2 x 2 contingency tables: a review of and some personal opinions on the controversy, *Psychological Bulletin*, 180, 135-145.

**Caro, T.M.** (1999) Demography and behaviour of African mammals subject to exploitation. *Biological Conservation*, 91: 91-97.

**Caro, T.M., M. Rejmanek and N. Pelkey** (2000) Which mammals benefit from protection in East Africa? *In* Entwistle, A. and N. Dunstone (eds) *Priorities for the conservation of mammalian diversity: has the panda had its day*, Conservation Biology 3, Cambridge, Cambridge University Press, UK.

**Caughley, G.** (1994) Directions in Conservation Biology, *Journal of Animal Ecology*, 63, 2: 215-244.

**Charles, A.T.** (1992) Fishery conflicts; a unified framework. *Marine Policy*, 16 (5), 379-393.

**Cohen, J.** (1988) *Statistical power analysis for the behavioural sciences*. Second Edition. Hillsdale and Associates, London, UK.

**Cohen, J. and P. Cohen** (1983) *Applied Multiple Regression/Correlation Analysis for the Behavioral Sciences*. Second Edition. Lawrence Erlbaum Association, USA.

**Colfer, P., R.L. Wadley, and P. Venkateswarlu** (1999) Understanding local people's use of time: a pre-condition for good co-management. *Environmental Conservation*, 26, 1: 41-52.

**Conelly, W. T.** (1985) Copal and rattan collecting in the Philippines, *Economics Botany*, 39: 39-46.

**Cooper, R.** (1974) *Job motivation and job design*. Institute of Personnel Management, London, UK.

**Cunningham, A.B.** (1996) *People, park and plant use. Recommendations for multiple-use zones and development alternatives around Bwindi Impenetrable National Park, Uganda*. People and Plants Working Paper 4. UNESCO, Paris.

**Davenport, T., P. Howard and R. Matthews** (1996) *Uganda biodiversity report*. Unpublished report for Uganda Forest Department, Kampala, Uganda.

**Davey, A.G.** (1998) (ed) *National system planning for protected areas; Best practice protected area guidelines series n.001*. IUCN World Commission on Protected Areas. IUCN, Gland, Switzerland.

**De Boer, W. and D. Baquete** (1998) Natural resource use, crop damage and attutides of rural people in the vicinity of the Maputo Elephant Reserve, Mozambique, *Environmental Conservation*, 25, 3, 208-218.

**Delucchi, K. L.** (1983) The use and misuse of chi-square: Lewis and Burke revisited, *Psychological Bulletin*, 94, 166-176.

**Dey, S.C.** (1991) Depredation by wildlife in the fringe areas of North Bengal forests with special reference to elephant damage. *Indian Forester*, 117, 10: 901-908.

**Docherty, M.T.** (1993) *Survey of attitudes towards natural resource conservation and development, and tourism in southwest Uganda*. MSc Thesis, Duke University.

**Doran, D.M. and A. McNeilage** (2001) Subspecific variation in gorilla behaviour: the influence of ecological and social factors. *In* Robbins, M.M., P. Sicotte and K.J. Stewart (eds) *Mountain gorillas: three decades of research at Karisoke*, Cambridge University Press, UK.

**Drewes, R.C., J.V. Vindum and J.P. O'Brien** (1992) *Amphibians for the Impenetrable Forest.* Unpublished report for CARE-International, Kampala, Uganda.

**Dutki, G.Z.** (2002) *Paper on the Activities of Mgahinga and Bwindi Impenetrable Forest Conservation Trust.* Unpublished report for the Mgahinga and Bwindi Impenetrable Forest Conservation Trust, Uganda.

**du Toit, J.T.** (2002) Wildlife harvesting guidelines for community-based wildlife management: a southern African perspective, *Biodiversity and Conservation,* 11, 8: 1403-1416.

**du Toit, J.T., B.H. Walker and B.M. Campbell** (2004) Conserving tropical nature: current challenges for ecologists, *Trends in Ecology and Evolution,* 19, 1: 12-17.

**Dytham, C.** (1999) *Choosing and using statistics – a biologists guide.* Blackwell Science, Oxford.

**Entwistle, A. and N. Dunstone** (2000) *Priorities for the conservation of mammalian diversity: has the panda had its day.* Conservation Biology 3, Cambridge, Cambridge University Press, UK.

**Ervin J.** (2003) Protected area assessments in perspective, *Bioscience,* 53, 9: 819-822.

**Everitt, B.S.** (1977) *The analysis of contingency tables.* London, Chapman and Hall.

**Fairgrieve, C. and G. Muhumuza** (2003) Feeding ecology and dietary differences between blue monkey (Cercopithecus mitis stuhlmanni Matschie) groups in logged and unlogged forest, Budongo Forest Reserve, Uganda, *African Journal of Ecology,* 41, 2: 141-149.

**FAO** (1967) *Timber trends and prospects in Africa.* Food and Agricultural Organisation, Rome, Italy.

**FAO** (1998) Integrated coastal area management, agriculture, forestry and fisheries. Food and Agricultural Organisation Forestry Paper, FAO, Rome, Italy.

**FAO** (2000) *Global forest resources assessment.* Food and Agricultural Organisation Forestry Paper 140, FAO, Rome, Italy.

**Ferraro, P.J.** (2001) Global habitat protection: limitations of development interventions and a role for conservation performance payments. *Conservation Biology*, 15, 4: 990-1000.

**Ferraro, P.J. and Simpson, R.D.** (2002) The cost-effectiveness of conservation performance payments. *Land Economics*, 78, 3: 339-353.

**Fiallo, E.A. and S.K. Jacobson** (1995) Local communities and protected areas: Attitudes of rural residents towards conservation and Machalilla National Park, Ecuador. *Environmental Conservation*, 22, 3: 241-249.

**Forest Department** (1955) *A history of the Uganda Forest Department 1930-1950.* Unpublished report, Uganda Government Printer, Entebbe, Uganda.

**Forest Department** (1964) *Annual report for 1963-1964*, Unpublished report, Uganda Government Printer, Entebbe, Uganda.

**Forest Department** (1967) *Report of the vegetation of the Impenetrable.* Unpublished report, Uganda Government Printer, Entebbe, Uganda.

**Forest Department** (1968) *Annual report for 1964-1968*, Unpublished report, Uganda Government Printer, Entebbe, Uganda.

**Forest Department** (1974) *Annual report for 1973-1974*, Unpublished report, Uganda Government Printer, Entebbe, Uganda.

**Forsyth C.J.** (1993) Chasing and catching bad guys - the game wardens prey, *Deviant Behaviour*, 14, 3: 209-226.

**Fuller, D.O.** (2000) The fallacy of popular wisdom in African wildlife management. *Conservation Management*, 14, 2: 586-587.

**Garner, K.J. and O.A. Ryder** (1996) Mitochondrial DNA diversity in gorillas. *Molecular Phylogenetics and Evolution*, 6: 39-48.

**Ghimire, K.B.** (1994) Parks and people: livelihood issues in national parks management in Thailand and Madagascar. *Developmental Change*, 25: 195-229.

**Gibson, C.C. and S.A. Marks** (1995) Transforming rural hunters into conservationists: an assessment of community-based wildlife management programs in Africa. *World Development*, 23, 6: 941-957.

**Glowka, L., F.B. Burhenne-Guilmin, H. Synge, J.A. McNeely and L. Gundling** (1994) *A Guide to the Convention on Biological Diversity*. IUCN, Gland, Switzerland.

**Greene, H.W.** (1992) *Reptiles of the Bwindi forest*. Unpublished report for CARE-International, Kampala, Uganda.

**Goldsmith, M.L. and H. Moles** (2003) Does topography affect the foraging effort of mountain gorillas in Bwindi Impenetrable National Park, Uganda? *American Journal of Physical Anthropology*, 36: 102-102.

**Gombya-Ssembajjwe, D.** (1995) *Forest Conservation for Sustainable Development in Uganda: Considering Local Users*. Unpublished report for the Forestry Department, Kampala, Uganda.

**Gottret, M.V. and D. White** (2002) Assessing the impact of integrated natural resource management: Challenges and experiences, *Conservation Ecology*, 5, 2 (17).

**Guerrera, W., J.M. Sleeman, S.B. Jasper, L.B. Pace, T.Y. Ichinose and J.S. Reif** (2003) Medical survey of the local human population to determine possible health risks to the mountain gorillas of Bwindi Impenetrable Forest National Park, Uganda. *International Journal of Primatology*, 24, 1: 197-207.

**Hackel, J.D.** (1999) Community conservation and the future of Africa's wildlife. *Conservation Biology*, 13, 4: 726-734.

**Hamilton, A.C.** (1984) *Deforestation in Uganda.* Oxford University Press, Nairobi East Africa.

**Hamilton, A., A. Cunningham, D. Byarugaba and F. Kayanja** (2000) Conservation in a region of political instability: Bwindi Impenetrable Forest, Uganda, *Conservation Biology*, 14, 6: 1722-1725.

**Hanks, J.** (2001) Conservation strategies for Africa's large mammals. *Reproduction Fertility and Development*, 13, 7-8: 459-468.

**Harcourt, A.H.** (1981) Can Uganda gorillas survive – a survey of the Bwindi Forest Reserve, *Biological Conservation,* 19, 4: 269-282.

**Harrop, J.R.** (1960) *The soils of the western province of Uganda.* Series 1, No. 6. Mem. Res. Div. Dept. Agric. Uganda.

**Heywood, V.H.** (ed) (1995) *Global Biodiversity Assessment.* Cambridge, Cambridge University Press, UK.

**Hinchely, D., L. Turyomurugyendo and K. Stonewall** (2000) *Review of collaborative management arrangements for Mt. Elgon National Park.* IUCN, Gland, Switzerland and Cambridge, UK.

**Hill, C.M.** (1997) Crop-raiding by Wild Vertebrates: the Farmer's Perspective in an Agricultural Community in Western Uganda. *International Journal of Pest Management*, 43, 1: 77-84.

**Hill, C.M.** (1998) Conflicting attitudes towards elephants around the Budongo Forest Reserve, Uganda. *Environmental Conservation*, 25, 3: 244-250.

**Hill, C.M.** (1999) Conflict of Interest Between People and Baboons: Crop Raiding in Uganda. *International Journal of Primatology*, 21, 2: 299-315.

**Hill, C.M.** (2000) Conflict of interest between people and baboons: crop raiding in Uganda. *International Journal of Primatology*, 21, 2: 299-315.

**Hoare, R.** (1995) Options for the control of elephant conflict with people. *Pachyderm*, 19: 74-80.

**Holmes C.M.** (2003) The influence of protected area outreach on conservation attitudes and resource use patterns: a case study from western Tanzania, *Oryx*, 37, 3: 305-315.

**Hough J.L.** (1994) Improving the effectiveness of conservation area personnel - lessons from social-research in northern Benin, West-Africa, *Environmental Conservation*, 21, 3: 231-235.

**Howard, P.C.** (1991) *Nature conservation in Uganda's tropical forest reserves.* IUCN, Gland, Switzerland and Cambridge, UK.

**Howell, D. C** (1997) *Statistical methods for psychology.* Fourth Edition. Belmont, CA: Duxbury.

**Hughes, R. and F. Flintan** (2001) *Integrating Conservation and Development Experience: A review and bibliography of the ICDP literature.* International Institute for Environment and Development, London, UK.

**Ilukol, P.** (2002) Elephant crop raiding patterns in areas around Kibale National Park, Uganda. *In* Hill, C., F. Osborn and A.J. Plumptre (eds) *Human-wildlife conflict: identifying the problem and possible solution.* Albertine Rift Technical Report Series, Vol 1. Wildlife Conservation Society, New York, USA.

**Infield, M.** (1995) Community aspects of multiple use. *In* Bensted-Smith, R., M. Infield, J. Otekat and N. Thomson-Handler (eds) *Review of the multiple use (resource sharing) programme on Bwindi Impenetrable National Park.* Unpublished report for CARE-International, Kampala, Uganda.

**Infield, M.** (1988) Attitudes of a Rural Community towards Conservation and a local Conservation Area in Natal, South Africa. *Biological Conservation,* 45: 21-46.

**Infield, M.** (2001) Cultural values: a forgotten strategy for building community support for protected areas in Africa. *Conservation Biology,* 15, 3: 800-802.

**Infield, M. and A. Namara** (2001) Community attitudes and behaviour towards conservation: an assessment of a community conservation programme around Lake Mburo National Park, Uganda. *Orxy,* 35, 1: 48-60.

**IUCN** (1980) *World Conservation Strategy.* IUCN, Gland, Switzerland.

**Jachmann, H. and M. Billiouw** (1997) Elephant poaching and law enforcement in the central Luangwa Valley, Zambia. *Journal of Applied Ecology,* 34, 1: 233-244.

**Jacobs, M.** (1988) *The tropical rainforest: a first encounter.* Springer-Verlag, Berlin.

**Jagannathan, V.** (1990) *Applications of Geographical Information Systems in Economic Analysis: a case study of Uganda.* World Bank, Washington, D.C.

**Jorgensen, J.J.** (1981) *Uganda: a modern history.* Croom Helm, London.

**Kabanukye, K. and L. Wily** (1996) *A report on a study of the Abayanda pygmies of south-west Uganda.* Unpublished report for the Maghinga and Bwindi Impenetrable Forest Conservation Trust, Uganda.

**Kalema-Zikusoka, G.R., D. Kock and E. Macfie** (2002) Scabies in free-ranging mountain gorillas (Gorilla beringei beringei) in Bwindi Impenetrable National Park, Uganda. *The Veterinary Record,* 150, 1: 12-15.

**Kamugisha, J.R.** (1993) *Management of natural resources and environment in Uganda: policy & legislation landmarks 1890 – 1990.* Report 11 for the Regional Soil Conservation Unit/Swedish International Development Agency. Nairobi, Kenya.

**Kanabahita, C.** (2001) *Forestry Outlook Studies in Africa – Uganda.* Unpublished report for Uganda Forest Department, Kampala, Uganda.

**Kasanga, D.** (2003) Farmers kill chimpanzee. *New Vision Newspaper*, Kampala, Uganda.

**Kasangaki, A., D. Babaasa, R. Bitariho and G. Mugiri** (2001) *A survey of recently burnt areas in Bwindi Impenetrable and Mgahinga Gorilla National Parks, SW Uganda.* Unpublished report for the Institute of Tropical Forest Conservation, Bwindi Impenetrable National Park, Uganda.

**Kasangaki A., R. Kityo and J. Kerbis** (2003) Diversity of rodents and shrews along an elevational gradient in Bwindi Impenetrable National Park, south-western Uganda, *African Journal of Ecology*, 41, 2: 115-123.

**Kingdom, J.** (1997) *The Kingdom field guide to African mammals.* Academic Press, USA.

**Kingsland, S.** (2002) Designing nature reserves: adapting ecology to real-world problems, *Endeavour*, 26, 1: 9-14.

**Kiyengo, D. and G. Binyeri** (2003) Mountain gorillas eat farmer's crop, *New Vision Newspaper*, Kampala, Uganda.

**Kleiman, D.G., P.R Reading, B.J. Miller, T.W. Clark, J.M. Scott, J. Robinson, R.L. Wallace, R.J. Cabin and F. Felleman** (2000) Improving the evaluation of conservation programs, *Conservation Biology*, 14, 2: 356-365.

**Kremen, C., I. Raymond and K. Lace** (1998) An interdisciplinary tool for monitoring conservation impacts in Madagascar, *Conservation Biology*, 12, 3: 549-563.

**Kremen, C., V. Razafimahatratra, R.P. Guillery, J. Rakotomalala, A. Weiss and J-S Ratsisompatrarivo** (1999) Designing the Masoala National Park in Madagascar Based on Biological and Socioeconomic Data, *Conservation Biology*, 13, 5: 1523-1739.

**Lahm, S.A.** (1996) A nationwide survey of crop raiding by elephants and other wildlife species in Gabon. *Pachyderm*, 21: 69-77.

**Langdale-Brown, I., H.A Osmaton and J.G. Wilson** (1964) *The vegetation of Uganda and its bearing on land-use.* Unpublished report for the Uganda Forest Department, Entebbe, Uganda.

**Larson, P. and D.S. Svendsen** (1996) *Participatory Monitoring and Evaluation: A practical guide to successful ICDPs.* WWF, USA.

**Larson, P., M. Freudenberger and B. Wyckoff-Baird** (1997) *Lessons learnt from the field: a review of World Wildlife Fund's experience with integrated conservation and development projects 1985-1996.* World Wildlife Fund, Washington D.C., USA.

**Leader-Williams, N. and S.D. Albon** (1988) Allocation of resources for conservation. *Nature*, 336:533-535.

**Leader-Williams, N., S.D. Albon and P.S.M. Berry** (1990) Illegal exploitation of Black Rhinoceros and elephant populations: patterns of decline, law enforcement and patrol effort in Luangwa Valley, Zambia. *Journal of Applied Ecology*, 27: 1055-1087.

**Leader-Williams, N. and H.T. Dublin** (2000) Charismatic megafauna as flagship species. *In* Entwistle, A. and N. Dunstone (eds) *Priorities for the conservation of mammalian diversity: has the panda had its day*, Conservation Biology 3, Cambridge, Cambridge University Press, UK.

**Lebonetse, G.** (1996) Resolving conflicts around protected areas: the case for Botswana. *In* Lewis, C. (ed) *Managing conflicts in protected areas.* IUCN Gland, Switzerland and Cambridge, UK.

**Leggat, G.J. and H.A. Osmaston** (1961) *Working plan for the Impenetrable Central Forest Reserve, Kigezi District, Western Province, Uganda. Period 1961-1971.* Unpublished report for Uganda Forest Department, Kampala, Uganda.

**Lewis, D.M.** (1995) Importance of GIS to community-based management of wildlife: lessons from Zambia. *Ecological Applications*, 5, 4: 861-871.

**Lewis, C.** (1996) *Managing conflicts in protected areas.* IUCN, Gland, Switzerland and Cambridge, UK.

**Li, W.J., Z.J. Wang and H.X. Tang** (1999) Designing the buffer zone of a nature reserve: a case study in Yancheng Biosphere Reserve, China, *Biological Conservation*, 90, 3: 159-165.

**Linkie, M., D.J. Martyr, J. Holden, A. Yanuar, A.T Hartana, J. Sugardjito, J. and N. Leader-Williams** (2003) Habitat destruction and poaching threaten the Sumatran tiger in Kerinci Seblat National Park, Sumatra. *Oryx*, **37**, 1: 41:48.

**Lynagh, F.M. and P.B. Urich** (2002) A critical review of buffer zone theory and practice: a Philippine case study. *Society and Natural Resources*, 15: 129-145.

**Macfie, L.** (1996) Case report on scabies infection in Bwindi gorillas. *Gorilla Journal*, 13: 19-20.

**Mackinnon, J.R., K. MacKinnon, G. Child and J. Thorsell** (1986) *Managing protected areas in the tropics.* IUCN, Gland, Switzerland.

**Madhusudan, M.D.** (2003) Living amidst large wildlife: Livestock and crop depredation by large mammals in the interior villages of Bhadra Tiger Reserve, South India, *Environmental Management*, 31, 4: 466-475.

**Maikhuri, R., K.S. Nautiyal, K.S. Rao, K. Chandrasekhar, R. Gavali and K.G. Saxena** (2000) Analysis and resolution of protected area–people conflicts in Nanda Devi Biosphere Reserve, India. *Environmental Conservation*, 27, 1: 43–53.

**Maisels, F., D. Ekoutouba, M. Mboulafini, R. Abeguo, M. Mahmadu, and G. Mobolombi** (2002) A forest lake in northern Republic of Congo: a window on forest. *Society for Conservation Biology 16th Annual Meeting 2002 Abstracts*, SCB, New York, USA.

**Makombo, J.** (2003) *Responding to the challenge – how protected areas can best provide benefits beyond boundaries. A case study of Bwindi Impenetrable National Park in western Uganda.* Unpublished report for Uganda Wildlife Authority, Kampala, Uganda.

**Malleson, R.** (2002) Changing perspectives on forests, people and 'development': Reflections on the case of the Korup Forest, *IDS Bulletin: Institute of Development Studies*, 33, 1: 94-95.

**Malpas, R., G. Ishiriza, D. Johnson, S. Masayanyika and G. Tumushabe** (2002) *Development through Conservation Phase Three: Report of the final evaluation 15 April to 4 May 2002.* Unpublished Report to CARE-International, Kampala, Uganda.

**Marchant, R., D. Taylor and A. Hamilton** (1997) Late Pleistocene and Holocene History at Mubwindi Swamp, Southwest Uganda. *Quaternary Research,* 47: 316-328.

**Margoluis, R. and N. Salafsky** (1998) *Measures of success: designing, managing and monitoring conservation and development projects.* Island Press, USA.

**McCallum, H. and A. Dobson** (1995) Detecting disease and parasite threats to endangered species and ecosystems. *Trends in Ecology and Evolution*, 10, 5: 190-194.

**McKinney J.C.** (1966) *Constructive typology and social theory.* Meredith Publishing Company, USA.

**McNeely, J.A. and K.R Miller** (eds) (1984) *National Parks, Conservation and Development: The role of protected areas in sustaining society.* Smithsonian Institution Press, Washington, D.C., USA.

**McNeely, J.A.** (1988) *Economics and Biological Diversity: Developing and using economic incentives to conserve biological diversity.* IUCN, Gland, Switzerland.

**McNeely, J.A.** (1994) Protected areas for the 21st-Century - working to provide benefits to society, *Biodiversity and Conservation*, 3, 5: 390-405.

**McNeilage, A.** (1995) *Mountain gorillas in the Virunga Volcanoes: ecology and carrying capacity.* PhD Thesis, University of Bristol, Bristol, UK.

**McNeilage, A., A.J. Plumptre, A. Brock-Doyle and A. Vedder** (1998) *Bwindi Impenetrable National Park, Uganda Gorilla and large mammal census 1997.* Working Paper Number 14. Unpublished report for the Wildlife Conservation Society, U.S.A.

**McNeilage, A., A.J. Plumptre, A. Brock-Doyle and A. Vedder** (2001) Bwindi Impenetrable National Park, Uganda: gorilla census 1997, *Oryx*, 35, 1: 39-47.

**Mehta, J.N. and S.R. Kellert** (1998) Local attitudes toward community-based conservation policy and programmes in Nepal: a case study in the Makalu-Barun Conservation Area. *Environmental Conservation*, 25, 4: 320-333.

**Mehta, J.N. and J.T. Heinen** (2001) Does community-based conservation shape favorable attitudes among locals? An empirical study from Nepal. *Environmental Management*, 28, 2: 165-177.

**Menard, S.** (1995) *Applied logistic regression analysis.* Quantitative Applications in the Social Sciences, Series No. 106, Sage Publications, USA.

**Ministry of Finance and Economic Planning** (1991) *The 1991 Population and Housing Census Analytical Report.* Statistics Department, Entebbe, Uganda.

**Ministry of Finance and Economic Planning** (2002) *The 2002 Population and Housing Census Analytical Report.* Statistics Department, Entebbe, Uganda.

**Mudakikwa, A.B., M.R. Cranfield, J.M. Sleeman and U. Eilenberger** (2001) Clinical medicine, preventive health care and research on mountain gorillas in the Virunga Volcanoes region. *In* Robbins, M.M., P. Sicotte and K.J. Stewart (eds) *Mountain gorillas: three decades of research at Karisoke,* Cambridge University Press, UK.

**Muller, J. and Albers, H.J.** (2004) Enforcement, payments, and development projects near protected areas: how the market setting determines what works where. *Resource and Energy Economics,* 26: 185-204.

**Muoria, P.K., G.M. Karere, N.N. Moinde and M.A. Suleman** (2003) Primate census and habitat evaluation in the Tana delta region, Kenya, *African Journal of Ecology,* 41, 2:157-163.

**Muruthi, P., M. Stanley-Price, P. Soorae, C. Moss and A. Lanjouw** (2000) Conservation of large mammals in Africa. What lessons and challenges for the future? *In* Entwistle, A. and N. Dunstone (eds) *Priorities for the conservation of mammalian diversity. Has the Panda had its day?* Conservation Biology 3. Cambridge University Press, UK.

**Musaasizi, J.M.** (2000) *Bushpig density, distribution and crop raiding trends in the northern sector of Bwindi Impenetrable National Park, southwest Uganda.* Unpublished report for the Institute of Tropical Forest Conservation, Bwindi Impenetrable National Park, Uganda.

**Mwesigye, L.** (1991) *Beehives in Bwindi Impenetrable National Park.* Unpublished report for the Institute of Tropical Forest Conservation, Bwindi Impenetrable National Park, Uganda.

**Namara, A.** (2000) *People and Bwindi forest: a historical account as given by local community members.* Unpublished report for the Institute of Tropical Forest Conservation, Bwindi Impenetrable National Park, Uganda.

**Naughton-Treves, L.** (1998a) Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. *Conservation Biology*, 12, 1: 156-168.

**Naughton Treves, L.** (1998b) Temporal Patterns of Crop-raiding by Primates: Linking Food Availability in Croplands and Adjacent Forest. *Journal of Applied Ecology*, 35: 596-606.

**Naughton-Treves, L., A. Treves, C. Chapman and R. Wrangham** (1998) Temporal patterns of crop-raiding by primates: linking food availability in croplands and adjacent forest, *Journal of Applied Ecology*, 35, 4: 596-606.

**Naughton-Treves, L.** (1999) Whose animals? A history of property rights to wildlife in Toro, western Uganda. *Land Degradation and Development,* 10: 311-328.

**Neumann, R.P.** (1997) Primitive ideas: protected area buffer zones and the politics of land in Africa. *Developmental Change*, 28: 559-582.

**Newing, H.** (2001) Bushmeat hunting and management: implications of duiker ecology and interspecific competition. *Biodiversity and Conservation*, 10: 99–118.

**Newmark, W.D., N.L. Leonard, H.I. Sariko and D.G.M. Gamassa** (1993) Conservation Attitudes of Local People Living Adjacent to Five Protected Areas in Tanzania. *Biological Conservation*, 63: 177-183.

**Newmark, W.D., D.N. Manyanza, D.G.M. Gamassa, H.I. Sariko** (1994) The Conflict Between Wildlife And Local People Living Adjacent To Protected Areas In Tanzania - Human Density As A Predictor, *Conservation Biology*, 8, 1: 249-255.

**Ngure, N.** (1995) People-elephant conflict management in Tsavo, Kenya. *Pachyderm*, 19: 20-25.

**Nicholson, J. W.** (1929) *The future of forestry in Uganda.* Unpublished report for the Uganda Forest Department, Entebbe, Uganda.

**Noss, A. J.** (1998) Impacts of cable snare hunting on wildlife populations in the forests of the Central African Republic. *Conservation Biology*, 12, 2: 390-398.

**Nyhus, P.J., R. Tilson, and R. Sumianto** (2000) Crop-raiding elephants and conservation implications at Way Kambas National Park, Sumatra, Indonesia, *Oryx*, 34, 4:262-274.

**Osborn, F.V.** (2002) Capsicum oleoresin as an elephant repellent: Field trials in the communal lands of Zimbabwe, *Journal of Wildlife Management*, 66, 3: 674-677.

**Osborn, F.V. and G.E. Parker** (2003) Towards an integrated approach for reducing the conflict between elephants and people: a review of current research, *Oryx*, 37, 1: 80-84.

**Osmaston, H.A.** (1959) *Working plan for the Bugoma Forest: first revision period 1960-1970.* Unpublished report for the Uganda Forest Department, Entebbe, Uganda.

**Parker, I.S.C. and A.D. Graham** (1989) Men, elephants and competition. *Symposium of Zoological Society of London*, 61: 241-252.

**Pearce, J. and S. Ferrier** (2000) Evaluating the predictive performance of habitat models developed using logistic regression, *Ecological Modelling*, 133, 3: 225-245.

**Peters, C.M.** (1990) Plenty of fruit but no free lunch, *Garden*, 14, 6: 8-13.

**Peters, C.M.** (1994) *Sustainable harvest of non-timber plant resources in tropical moist forest: an ecological primer.* Biodiversity Support Program, USAID, Washington, DC, USA.

**Peuhkuri, T. and P. Jokinen** (1999) The role of knowledge and spatial contexts in biodiversity policies: a sociological perspective, *Biodiversity and Conservation*, 8: 133-147.

**Philip, A.E.** (1975) *Social work research and the analysis of social data.* Pergamon Press.

**Pimm, S.L.** (1991) *The balance of nature? Ecological issues in the conservation of species and communities.* University of Chicago Press, Chicago, USA.

**Plumptre, A.J., J.B. Bizumuremyi, F. Uwimana, and J.D. Ndaruhebeye** (1997) The effects of the Rwandan civil war on poaching of ungulates in the Parc National des Volcans. *Oryx*, 31, 4: 265-273.

**Plumptre, A.J.** (2000) Monitoring mammal populations with line transect techniques in African Forests. *Journal of Applied Ecology*, 37: 356-368.

**Plumptre A.J. and E.A. Williamson** (2001) Conservation-oriented research in the Virunga region. *In* Robbins, M.M., P. Sicotte and K.J. Stewart (eds) *Mountain gorillas: three decades of research at Karisoke*, Cambridge University Press, UK.

**Plumptre, A.J., M. Masozera, P.J. Fashing, A. McNeilage, C. Ewango, B.A. Kaplin, and I. Liengola** (2002) *Biodiversity Surveys of the Nyungwe Forest Reserve in S.W. Rwanda.* Wildlife Conservation Society Working Papers No. 18, WCS, USA.

**Robbins, M.M, P. Sicotte and K.J. Stewart** (eds) (2001) *Mountain gorillas: three decades of research at Karisoke.* Cambridge University Press, UK.

**Robbins, M.M. and A. McNeilage** (2003) Home Range and Frugivory Patterns of Mountain Gorillas in Bwindi Impenetrable National Park, Uganda. *International Journal of Primatology,* 24, 3: 467-491.

**Robertson I.T., M. Smith and D. Cooper** (1992) *Motivation: strategies, theory and practice.* Second Edition. Institute of Personnel Management, London, UK.

**Ross, S and G. Wall** (1999) Evaluating ecotourism: The case of North Sulawesi, Indonesia, *Tourism Management*, 20: 673-682.

**Rwabwoogo, M.O.** (2002) *Uganda districts information handbook 2002 edition.* Fountain publishers, Uganda.

**Sah, J.P. and J.T. Heinen** (2001) Wetland resource use and conservation attitudes among indigenous and migrant peoples in Ghodaghodi Lake area, Nepal. *Environmental Conservation*, 28, 4: 345-356.

**Saj, T.L., P. Sicotte and J.D. Paterson** (2001) The Conflict Between Vervet Monkeys and Farmers at the Forest Edge in Entebbe, Uganda. *African Journal of Ecology*, 39, 2: 195-199.

**Salafsky, N., H. Cauley, G. Balachander, B. Cordes, J. Parks, C. Margoluis, S. Bhatt, C. Encarnacion, D. Russell and R. Margoluis** (2001) A systematic test of an enterprise strategy for community-based biodiversity conservation. *Conservation Biology*, 15, 6: 1585-1595.

**Sarmiento, E.E., T. M. Butynski and J. Kalina** (1996) Gorillas of Bwindi Impenetrable Forest and the Virunga Volcanoes: taxonomic implications of morphological and ecological differences. *American Journal of Primatology*, 40 :1-21.

**Schaller, G.B.** (1964) *The year of the gorilla.* The University of Chicago, Chicago, USA.

**Schoener, T.W.** (1983) Rate of species turnover decreases from lower to higher organisms – A review of the data, *Oikos*, 41, 3: 372-377.

**Scott, P.** (1992) *Fringe benefits – minor forest collection within buffer zones as a potential tool for conflict resolution in Bwindi Impenetrable National Park, Uganda.* MSc Thesis, University of Noragric, Sweden.

**Scott, P.** (1998) *From conflict to collaboration: people and forests at Mount Elgon, Uganda.* IUCN, Gland, Switzerland and Cambridge, UK.

**Seely, M.K., J. Zeidler, J.R. Henschel and P. Barnard** (2003) Creative problem solving in support of biodiversity conservation. *Journal of Arid Environments*, 54, 1: 155-164.

**Sibanda, B.M.C.** (1995) Wildlife, conservation and the Tonga in Omay, *Land Use Policy*, 12, 1: 69-85.

**Siex, K.S. and T.T. Struhsaker** (1999) Colobus monkeys and coconuts: a study of perceived human wildlife conflicts, *Journal of Applied Ecology*, 36, 6: 1009-1020.

**Simberloff, D.** (1998) Flagships, umbrellas and keystones: is single-species management passé in the landscape era? *Biological Conservation*, 83: 247-257.

**Siriri, M.N.** (2002) *Third Knowledge and Attitudes Survey of the communities bordering Bwindi and Mgahinga National Parks in south western Uganda, and Final Survey Report.* Unpublished report for CARE-International, Kampala, Uganda.

**Sitati, N.W., M.J. Walpole, R.J. Smith and N. Leader-Williams** (2003) Predicting spatial aspects of human-elephant conflict. *Journal of Applied Ecology*, 40, 4: 667-677.

**Slavin, T.** (1996) Men in blue – the Twareg of the Air and Tenere reserve. *In* Lewis, C. (ed) *Managing conflicts in protected areas.* IUCN Gland, Switzerland and Cambridge, UK.

**Smith, A.K.K.H., E. Merode, A. Nicholas, B. Buls and A. Ndey** (1995) Factors affecting elephant distribution at Garamba National Park and surrounding reserves, Zaire, with a focus on human-elephant conflict. *Pachyderm*, 19: 39-48.

**Smith, D., R. Hughes and K. Swiderska** (1998) *Review of lessons learnt from DFID-supported biodiversity and livelihoods development projects.* Unpublished report for the UK Department for International Development.

**Songorwa, A.N.** (1999) Community-Based Wildlife Management (CWM) in Tanzania: are the communities interested? *World Development*, 27, 12: 2061-2079.

**Stem, C.J., J.P. Lassoie, D.R. Lee, D.D. Deshler and J.W. Schelhas** (2003) Community participation in ecotourism benefits: The link to conservation practices and perspectives. *Journal of Society and Natural Resources*, 16, 5: 387-413.

**Straede, S. and F. Helles** (2000) Park-people conflict resolution in Royal Chitwan National Park, Nepal: buying time at high cost? *Environmental Conservation*, 27, 4: 368-381.

**Strum, S.C.** (1994) Prospects for Management of Primate Pests. *Revue D'Ecologie*, (Terre & Vie), 49, 3: 295-306.

**Swets, J.A.** (1988) Measuring the accuracy of diagnostic systems, *Science*, 240: 1285-1292.

**Taylor, D.M.** (1990) Late quaternary pollen records from two Ugandan mires: evidence for environmental change in the Rukiga highlands of south-west Uganda, *Paleogeography*, 80: 283-300.

**Tchamba M.M. and P.M. Seme** (1993) Diet and feeding-behaviour of the forest elephant in the Santchou Reserve, Cameroon, *African Journal of Ecology*, 31, 2:165-171.

**Tchamba, M.N.** (1995) The problem elephants of Kaele: a challenge for elephant conservation in northern Cameroon. *Pachyderm*, 19: 26-32.

**Tennant, L.D.** (1963) *A report of the Game Department for the period 1962/1963.* Unpublished report for Uganda Game Department, Entebbe, Uganda.

**Thibault M. and S. Blaney** (2001) Sustainable human resources in a protected area in southwestern Gabon, *Conservation Biology*, 15, 3: 591-595.

**Thouless, C.R. and J. Sakwa** (1995) Shocking elephants - fences and crop raiders in Laikipia district, Kenya. *Biological Conservation*, 72, 1: 99-107.

**Tisdell, C.A.** (1995) Issues in biodiversity conservation including the role of local communities. *Environmental Conservation*, 22, 3: 216-222.

**Tukahirwa, E.M. and D.E. Pomeroy** (eds) (1993) *Bwindi Impenetrable Forest: baseline study report.* Unpublished report for the Makerere University Institute of Environment and Natural Resources, Kampala, Uganda.

**Torrington, D. and L. Hall** (1998) *Human resource management.* Fourth edition, Prentice Hall, London.

**Treves, A. and L. Naughton-Treves** (1999) Risk and opportunity for humans coexisting with large carnivores. *Journal of Human Evolution*, 35: 275-282.

**Uganda Game Department Archives 1923-1994**: *Annual reports of the Uganda Game Department from 1923 to 1994.* Uganda Game Department, Kampala, Uganda.

**Uganda National Parks** (1994) *Bwindi Impenetrable National Park Multiple Use Plan (draft).* Unpublished report for the Uganda National Parks, Kampala, Uganda.

**Uganda National Parks** (1995) *Management plan for Bwindi Impenetrable National Park 1995-1991.* Unpublished report for the Uganda National Parks, Kampala, Uganda.

**Uganda Wildlife Authority** (1999) *The Uganda Wildlife Policy.* Unpublished report for the Uganda Ministry of Tourism, Trade and Industry, Kampala, Uganda.

**UNESCO** (1964) *African timber trends and prospects.* United Nations Education and Science Cultural Organisation, Paris, France.

**Upton, G.J.G.** (1978) *The analysis of cross-tabulated data.* Chichester, John Wiley.

**Upton, G.J.G.** (1986) Cross-classified data. *In* Lovie, A.D. (ed) *New developments in statistics for psychology and the social sciences.* London and New York, The British Psychological Society and Methuen.

**Walls, M.J.P., M. Kamppinen and M. Oksanen** (1999) Management of biodiversity: natural resources and social institutions. *Biodiversity and Conservation,* 8: 1-6.

**Walpole, M.J. and H.J. Goodwin** (2001) Local attitudes towards conservation and tourism around Komodo National Park, Indonesia, *Environmental Conservation,* 28, 2: 160-166.

**Walpole, M.J.** (2001) Feeding dragons in Komodo National Park: a tourism tool with conservation complications. *Animal Conservation,* 4: 67-73.

**Walpole, M.J. and H.J. Goodwin** (2000) Local economic impacts of dragon tourism in Indonesia. *Annuals of Tourism Research,* 27, 3: 559-576.

**Walpole, M.J., M. Morgan-Davies, S. Milledge, P. Bett and N. Leader-Williams** (2001) Population dynamics and future conservation of a free-ranging black rhinoceros (*Diceros bicornis*) population in Kenya. *Biological Conservation,* 99, 2: 237-243.

**Walpole, M.J. and N. Leader-Williams** (2002) Tourism and flagship species in conservation, *Biodiversity and Conservation,* 11, 3: 543-547.

**Walsh, P.D. and L.J.T White** (1999) What will it take to monitor forest elephants?, *Conservation Biology,* 13: 1194-1202.

**Walsh, P.D.** (2001) Estimates of forest elephant abundance: projects the relationship between precision and effort, *Journal of Applied Ecology,* 38: 217-228.

**Walsh, P.D., K.A. Abernethy, M. Bermejo, R. Bevers, P. de Wachter, M.E. Akou, B. Huijbregts, D.I. Mambounga, A.K. Toham, A.M. Kilbourn, S.A. Lahmg, S. Latour, F. Maisels, C. Mbina, Y. Mihindou, S.N. Obiang, E.N. Effa, M.P. Starkey, P. telfer, M. Thibault, C.E.G. Tutin, L.J.T. White and D.S. Wilkie** (2003) Catastrophic ape decline in western equatorial Africa. *Nature*, 422, 611-614.

**Warner, M.** (2000) *Conflict management in community-based natural resources projects: experiences from Fiji and Papua New Guinea.* Working Paper, 135 Edition, London: Overseas Development Initiative.

**Watts, D.P.** (1998) Long-term habitat use by mountain gorillas (Gorilla gorilla beringei). 2. Reuse of foraging areas in relation to resource abundance, quality, and depletion. *International Journal of Primatology*, 19: 681–702.

**Weber, B. and A. Vedder** (2001) Afterword: mountain gorillas at the turn of the century. *In* Robbins, M.M., P. Sicotte and K.J. Stewart (eds) *Mountain gorillas: three decades of research at Karisoke*, Cambridge University Press, UK.

**Weladji, R.B. and M.N. Tchamba** (2003) Conflict between people and protected areas within the Benoue Wildlife Conservation Area, North Cameroon, *Oryx*, 37, 1: 72-79.

**Wells, M.P., K.E. Brandon and L. Hannah** (1992) *People and parks: linking protected area management with local communities.* The World Bank, WWF and USAID, Washington, DC.

**Wells, M.P. and K.E. Brandon** (1993) The principles and practice of buffer zones and local participation in biodiversity conservation. *Ambio*, 22, 2-3: 157-162.

**Western, D.** (1987) Africa elephants and rhinos - flagships in crisis. *Trends in Ecology and Evolution*, 2, 11:343-346.

**Western, D. and R.M. Wright** (1994) The background to community-based conservation. *In* Western, D., R.M. Wright and S. Strum (eds) *Natural connections: perspectives in community-based conservation.* Island Press, Washington, D.C.

**Wild, R.** (1992) *Wild fires inside Bwindi Impenetrable National Park in February to March 1992.* Unpublished report for the Institute of Tropical Forest Conservation, Bwindi Impenetrable National Park, Uganda.

**Wild, R.G. and J. Mutebi** (1996) *Conservation through community use of plant resources.* People and Plants Working Paper 5, UNESCO, Paris, France.

**Wilkis, D.S., B. Curran, R. Tshombe and G.A. Morelli** (1998) Managing bushmeat hunting in Okapi Wildlife Reserve, Democratic Republic of Congo. *Oryx*, 32, 2: 131-144.

**Wilkie, D. S., B. Curran, R. Tshombe and G.A. Morelli** (1998) Modelling the sustainability of subsistence farming and hunting in the Ituri forest of Zaire. *Conservation Biology*, 12, 1: 137-147.

**Wilkie, D.S. and J.F. Carpenter** (1999a) Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. *Biodiversity and Conservation*, 8: 927–955.

**Wilkie, D.S. and J.F. Carpenter** (1999b) The potential role of safari hunting as a source of revenue for protected areas in the Congo Basin. *Oryx*, 33, 4: 339-345.

**Wilkie D., E. Shaw, F. Rotberg, G. Morelli and P. Auzel** (2000) Roads, development, and conservation in the Congo basin, *Conservation Biology*, 14, 6: 1614-1622.

**Williams, A.C., A.J.T. Johnsingh and P.R. Krausman** (2001) Elephant-human conflicts in Rajaji National Park, northwestern India, *Wildlife Society Bulletin*, 29, 4: 1097-1104.

**Wunder, S.** (2000) Ecotourism and economic incentives - an empirical approach. *Ecological Economics.* 32, 3: 465-479.

**Wunder, S.** (2001) Poverty alleviation and tropical forests – what scope for synergies? *World Development,* 29, 11: 1817-1833.

**Van Noten, F.** (1979) The early Iron Age on the Interlacustrine Region: the diffusion of iron technology. *Azania,* 14: 61-80.

**Varady, R.G.** (1982) *Draft environmental profile of Uganda.* Unpublished report on USAID project RRSA SA/TOA: 1-77. USAID, Kampala, Uganda.

**Vasquez R. and A.H. Gentry** (1989) Use and misuse of forest harvested fruits in the Iquitos area, *Conservation Biology,* 3, 350-361.

**Vedder, A.L.** (1984) Movement patterns of a group of free-ranging mountain gorillas (*Gorilla gorilla beringeri*) and their relation to food availability, *American Journal of Primatology,* 7, 73: 73-88.

**Zhang, L., and N. Wang** (2003) An initial study on habitat conservation of Asian elephant (Elephas maximus), with a focus on human elephant conflict in Simao, China. *Biological Conservation,* 112, 3: 453-459.

**Zar, J.H.** (1996) *Biostatistical Analysis.* Prentice-Hall International, Inc., London

# Appendices

## Appendix A

### Encounters with bushmeat poaching by rangers on long and day patrol

Data were extracted from records of law enforcement patrols that comprised 765 days on long patrols, and 3067 days on day patrols carried out from 1986 to 2000, except for the lack of reports from 1990 to 1991. Law enforcement and poaching encounters per patrol day were summed for the north, centre, east, south and west of Bwindi, per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol in each area were included for analysis (1986-2000 monthly totals across all areas; n = 558).

The few encounters with poaching per long and per day patrol did not permit analysis by the three periods of gazettement and harvest zones used for poaching incidents in Chapter 4. The monthly totals were instead grouped into the same two periods of before (1986-1994 monthly total: n = 281) and after (1995-2000 monthly total: n = 277) harvest zones were established that were used for encounters with poachers (see methods described in section 4.2) and gorillas (see methods described in section 9.2). Furthermore, medium harvest zones were omitted from analysis because of the low number of encounters with poaching per long and per day patrol.

Poaching encounters were adjusted by patrol days to arrive at a catch per unit effort index. This index of poaching was log transformed, but the distribution still remained significantly different from normal (Kolmogorov-Smirnov $Z = 4.50$; $p < 0.001$). Sizes of snare clusters were examined by the number of snares that rangers collected per snare cluster (1986-2000 monthly totals n = 258). The number of snares per cluster was not correlated with patrol days ($r_s = 0.06$; $p > 0.05$) and was therefore employed for analysis. Analyses were conducted using the non-parametric tests of Kruskal-Wallis and Mann Whitney U.

## 1. Poaching before harvest zones

Rangers on long patrol encountered poaching more frequently than rangers on day patrol before harvest zones were established (Table 1.1). During this period, encounters with poaching were negatively correlated with the proportion of forest boundary sectors patrolled ($n = 226$; $r_s = -0.14$; $p < 0.05$). This indicated that the higher coverage of interior areas on long patrol contributed to the success of long patrols in encountering poaching. The correlation also indicated that poaching in Bwindi was concentrated in the interior before harvest zones were established.

Table 1.1 Mean±SE encounters with poaching incidents and the proportion of boundary forest sectors patrolled per month by long and patrols in Bwindi from 1986 to 1994

| | Long patrol (n = 97) | Day patrol (n = 184) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| All poaching encounters | 0.58±0.1 | 0.34±0.03 | -3.71 | < 0.001 |
| Proportion boundary sectors patrolled | 0.65±0.02 | 0.99±0.001 | -15.54 | < 0.001 |

## 2. Long patrol encounters before harvest zones

Most poaching encounters by rangers on long patrol were snare clusters (68.8%) and there were few encounters with poaching signs (18.2%) and directly with poachers (13.0%). Thus before establishment of harvest zones, ranger teams on long patrol were mainly collecting snares and rarely encountered poachers in the forest. With regard to future low and high harvest zones of Bwindi (Table 2.1), long patrol encounters with poaching tended to be higher in future low harvest zones. Long patrol encounters with snare clusters and with poachers also tended to be higher in future low harvest zones, although encounters with poaching signs were similar. The density of snares, however, differed between future harvest zones. Rangers collected an average of 14 snares per snare cluster in future low harvest zones, compared with an average of 10 snares in future high harvest zones. Therefore, before harvest zones were established, long patrol encounters with poaching were no higher in future low harvest zones, but rangers encountered larger snare clusters in these zones than in the future high harvest zones.

Table 2.1 Mean±SE encounters with poaching incidents and snares per snare cluster per month by long patrols in future harvest zones of Bwindi from 1986 to 1994

| Future harvest zone and statistical comparison | Poaching / long patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All encounters | |
| **Low (n = 53)** | 0.44±0.1 | 0.09±0.03 | 0.15±0.05 | 0.67±0.1 | 14.31±1.8 |
| **High (n = 44)** | 0.28±0.04 | 0.11±0.04 | 0.06±0.03 | 0.46±0.1 | 9.85±2.2 |
| **Mann Whitney U (z value)** | -1.30 | -0.81 | -0.77 | -1.63 | -2.51 |
| ***P*** | NS | NS | NS | NS | < 0.05 |

## 3 Day patrol encounters before harvest zones

The pattern of encounters on day patrols was similar to long patrols before harvest zones were established. Most day patrol encounters with poaching were snare clusters (57.8%) and there were fewer encounters with poaching signs (22.5%) and directly with poachers (19.7%). Furthermore, encounters with poaching tended to be higher in future low harvest zones (Table 3.1). There was no difference between future harvest zones in day patrol encounters with poaching signs or poachers, although the higher snare clusters in future low harvest zones tended to significance ($p = 0.07$). However, in contrast to long patrols, there was no difference between future harvest zones in the number of snares per snare cluster. Therefore, rangers patrolling boundary forest areas for a single day before harvest zones were established mainly collected snares, which were set at similar densities between future low and high harvest zones, and rarely encountered poachers in the forest.

Table 3.1 Mean±SE encounters with poaching incidents and snares per snare cluster per month by day patrols in future harvest zones of Bwindi from 1986 to 1994

| Future harvest zone and statistical comparison | Poaching / day patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All encounters | |
| Low (n = 104) | 0.27±0.04 | 0.08±0.02 | 0.07±0.02 | 0.42±0.05 | 9.49±1.2 |
| High (n = 80) | 0.13±0.02 | 0.04±0.01 | 0.08±0.02 | 0.26±0.04 | 10.53±1.8 |
| Mann Whitney U (z value) | -1.82 | -1.51 | -0.63 | -1.63 | -0.07 |
| *P* | NS | NS | NS | NS | NS |

## 4 Long patrol encounters before and after harvest zones

Encounters with poaching on long patrols declined after harvest zones were established (Table 4.1). There was a decline in snare clusters after harvest zones were established, but a non-significant decline in the number of snares that rangers collected per snare cluster. Rangers collected an average of 12 snares before, and 7 snares after, harvest zones were established. Encounters with poachers also tended to decline, although the sample size did not permit statistical analysis. However, in contrast to snare cluster and poacher encounters, encounters with poaching signs increased after harvest zones were established. Thus taken overall, poaching encounters declined after harvest zones were established. However, the type of poaching encounter changed, as rangers mainly encountered snare clusters before harvest zones were established when large ranger teams covered the forest interior. In contrast, when smaller ranger teams covered more of the forest boundary after harvest zones were established, most encounters were of poaching signs.

Table 4.1 Mean±SE encounters with poaching incidents and snares per snare cluster per month by long patrols in Bwindi during the periods before (1986-1994) and after (1995-2000) harvest zones were established

| Period and statistical comparisons | Poaching / long patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All encounters | |
| Before (n = 97) | 0.37±0.04 | 0.10±0.02 | 0.11±0.03 | 0.58±0.1 | 12.18±1.4 |
| After (n = 33) | 0.26±0.1 | 0.17±0.04 | 0.02±0.01 | 0.45±0.1 | 6.70±1.3 |
| Mann Whitney U (z value) | -3.31 | -2.68 | - | -2.03 | -1.60 |
| *P* | < 0.01 | < 0.01 | - | < 0.05 | NS |

## 5 Day patrol encounters before and after harvest zones

Encounters with poaching on day patrols were similar to long patrols before and after harvest zones were established (Table 5.1). Encounters with snares declined, and the number of snares per cluster also declined from an average of 10 snares before, to 4 snares after, harvest zones were established. There was a decline in encounters with poachers and an increase in poaching signs. However, overall, poaching encounters declined after harvest zones were established.

Table 5.1 Mean±SE encounters with poaching incidents and snares per snare cluster per month by day patrols in Bwindi during the periods before (1986-1994) and after (1995-2000) harvest zones were established

| Period and statistical comparisons | Poaching / day patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare clusters | Poaching signs | Poachers | All encounters | |
| Before (n = 184) | 0.21±0.02 | 0.06±0.01 | 0.08±0.01 | 0.35±0.03 | 9.93±1.0 |
| After (n = 244) | 0.08±0.01 | 0.12±0.01 | 0.03±0.01 | 0.22±0.02 | 4.14±0.4 |
| Mann Whitney U (z value) | -5.00 | -3.51 | -2.75 | -2.88 | -4.65 |
| *P* | < 0.001 | < 0.001 | < 0.01 | < 0.01 | p < 0.001 |

## 6. Poaching after harvest zones

Rangers on long patrol continued to encounter poaching more frequently than rangers on day patrol after harvest zones were established (Table 6.1). In addition, poaching encounters were negatively correlated with patrol coverage of forest boundary sectors ($r^s = -0.17$; $p < 0.01$). The correlation indicated that the greater coverage of forest interior areas by rangers on long patrol contributed to the success in encountering poaching, and that poaching after harvest zones were established remained concentrated in the forest interior.

Table 6.1 Mean±SE encounters with poaching incidents and the proportion of boundary forest sectors patrolled per month by long and patrols in Bwindi from 1995 to 2000

| | **Long patrol (n = 33)** | **Day patrol (n = 244)** | **Mann Whitney U (z value)** | ***P*** |
|---|---|---|---|---|
| All poaching encounters | 0.45±0.1 | 0.22±0.02 | -2.22 | < 0.05 |
| Proportion boundary sectors patrolled | 0.77±0.02 | 0.99±0.002 | -11.86 | < 0.001 |

## 7. Long patrol encounters after harvest zones

Most encounters on long patrols were poaching signs (51.9%) and there were fewer encounters with snare clusters (38.0%) and directly with poachers (10.1%). With regard to the established harvest zones, poaching was encountered more frequently in low than in high harvest zones (Table 7.1). Rangers encountered snares more frequently in low harvest zones. However, the number of snares per snare cluster was higher in high harvest zones. Thus rangers encountered snares less frequently in high harvest zones after harvest zones were established, although snare clusters were larger in high harvest zones. There was also no difference in encounters with poachers between harvest zones. However, long patrol encounters with poaching signs were no higher in low than in high harvest zones.

Table 7.1 Mean±SE encounters with poaching incidents and snares per snare cluster per month by long patrols in harvest zones of Bwindi from 1995 to 2000

| Harvest zone and statistical comparison | Poaching / long patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare cluster | Poaching signs | Poachers | All encounters | |
| Low (n = 19) | 0.43±0.2 | 0.22±0.1 | 0.02±0.01 | 0.67±0.2 | 4.66±1.0 |
| High (n = 14) | 0.03±0.01 | 0.10±0.04 | 0.02±0.01 | 0.15±0.04 | 11.20±2.7 |
| Mann Whitney U (z value) | -2.18 | -1.14 | - | -2.37 | -2.57 |
| *P* | < 0.05 | NS | - | < 0.05 | < 0.05 |

## 8. Day patrol encounters after harvest zones

Poaching encounters by rangers on day patrol after harvest zones were established were similar to long patrols. Firstly, most day patrol encounters with poaching were poaching signs (55.3%), and there were fewer encounters with snares (30.9%) and poachers (13.8%). Secondly, day patrol encounters with poaching were higher in low harvest zones than in high harvest zones, and there was no difference between zones in the encounters with poachers (Table 8.1). However, in contrast to long patrol encounters, day patrol encounters with snares were similar between low and high harvest zones. The number of snares per snare cluster was also similar between harvest zones. In addition, rangers encountered more poaching signs in low harvest zones.

Table 8.1 Mean±SE encounters with poaching incidents and snares per snare cluster per month by day patrols in harvest zones of Bwindi from 1995 to 2000

| Harvest zone and statistical comparison | Poaching / day patrol day | | | | Snares per snare cluster |
|---|---|---|---|---|---|
| | Snare cluster | Poaching signs | Poachers | All encounters | |
| Low (n = 131) | 0.08±0.02 | 0.18±0.02 | 0.03±0.01 | 0.29±0.03 | 4.34±0.6 |
| High (n = 113) | 0.07±0.02 | 0.18±0.02 | 0.03±0.01 | 0.14±0.02 | 3.95±0.5 |
| Mann Whitney U (z value) | -0.32 | -4.99 | - | -3.70 | -0.32 |
| *P* | NS | p < 0.001 | - | < 0.001 | NS |

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# Appendix B

## The parish in which poachers resided, and the court and punishment for arrested poachers, before harvest zones were established

In the north of Bwindi there were 2 encounters (1987 and 1989) with a total of 5 Bakiga poachers before harvest zones were established. These poachers were all from Kitariro village, which is in Rutugunda parish that became a harvesting parish of the harvest zone programme. There was no patrol report on the court for these poachers. The only patrol report on the court for poachers arrested in the north was in 1993, when rangers took a Bakiga poacher to the Kanungu police.

Bakiga poachers arrested in the centre before harvest zones were established were from Musherero village in Bujengwe parish (1 encounter in 1987 with 4 Bakiga poachers), which did not become a harvesting parish, and from Mpungu village in Mpungu parish (1 encounter in 1994 with 4 Bakiga poachers), which did become a harvesting parish. There was no court record for the poachers from Musherero. The poachers from Mpungu were fined a jerrycan of porridge (equivalent to 3000 UgSh) by the Mpungu parish court, which the rangers noted was not a heavy fine because the poachers said that they did not understand the rules of the National Park. Patrol reports from the centre also showed that, in 1993, a Bakiga poacher arrested carrying spears for chasing baboons from his crops was warned and released by his village court, and a boy arrested with vines (*Smilax anceps*) for making traps was fined a jerrycan of tonto beer (equivalent to 4000 UgSh) by his village court. In 1994, rangers took a Bakiga poacher to the Kabale police. In addition, in 1986 before National Park gazettement, rangers patrolling the centre ambushed a trail inside the National Park that they noted was used every week on market day "*by people bringing meat from the forest*".

Rangers patrolling the east before harvest zones were established arrested poachers who were from villages adjacent to the centre. In 1987, poachers arrested were from Mpungu village (1 encounter with 3 Bakiga poachers) and Kanyamisinga village (1 encounter with 4 Bakiga poachers), which are both villages in Mpungu parish that became a harvesting parish, and from Muramba village (1 encounter with 2 Bakiga poachers) and Kabuga village (1 encounter with 1 Bakiga poacher), which are both villages in Muramba parish that also became a harvesting parish. The poachers from Mpungu, which the rangers noted were leaders of hunters in their area, were fined 70,000 UgSh by the policeman accompanying the patrol. Rangers gave part of the fine to the community members who assisted the patrol, and took the remaining 20,000 UgSh to the Game Warden of Kabale. The poachers from Kanyamisinga was fined 100,000 UgSh by Kitojo village court, which is in the east Kitojo parish that became a harvesting parish, as this village was adjacent to the forest area where the poachers were arrested. The poachers from Muramba and Kabuga were arrested during the same encounter and were fined 200,000 Ugsh by Kitojo parish court.

Rangers patrolling the east also arrested poachers from the east area. Poachers were from Ndego village (1 encounter in 1988 with 4 Bakiga poachers), who were taken to the Kabale police, and from Nyundo village (1 encounter in 1993 with 1 Bakiga poacher). There was no patrol report of the court for the poacher from Nyundo. Both Ndego and Nyundo villages are in Kashasha parish that became a harvesting parish. There was 1 encounter in the east with beekeepers of the harvest zone programme. In 1994, rangers arrested 2 beekeepers for poaching and both men were from the harvesting parish of Kitojo. The beekeepers were each fined 20,000 UgSh by Katoma village court of Kitojo parish. Also in the east, there was an incident when a poacher arrested in 1988 had been previously arrested by rangers, and an incident in 1993 when a poacher was fined 40,000 UgSh by the Kabale police.

There were 3 patrol reports detailing the resident parish of poachers arrested in the south before harvest zones were established. In 1986, rangers arrested 4 Batwa poachers from Bubale village in Rubuguli parish, which did not become a harvesting parish. The Batwa were fined 50,000 UgSh and 1 jerrycan of tonto beer by Rushaga village court, which is in Rubuguli parish, and the court received 10,000 UgSh of the fine. In 1994, 7 Bakiga poachers arrested while collecting vines for making traps were all from Rubuguli parish. The poachers were taken to Nombe village court, which is in Rubuguli parish, although the outcome of the court was not recorded. Also in 1994, rangers arrested a woman while she was cutting bean-stakes from the

National Park boundary and found that she was carrying snares. The woman was from Rushaga village and was fined 40,000 UgSh and 1 jerry can of tonto beer by Rushaga village court. There were 3 patrol reports detailing only the courts for arrested poachers. These reports comprised 2 encounters with a total of 8 Batwa poachers in 1993 and in 1994, and 1 encounter with 4 Bakiga poachers in 1994. Both the Batwa and Bakiga poachers were taken to the Rubuguli police.

The Batwa poachers arrested in the west before harvest zones were established were all from Nteko parish, which became a harvesting parish. There was 1 encounter in 1986 with 2 Batwa poachers who told the rangers that they were poaching for a local businessman who was paying them 10,000 UgSh for duiker meat. There was 1 encounter in 1993 with 3 Batwa poachers during a patrol that the rangers had organised with villagers following complaints by the village chief of Nteko that Batwa were stealing from villagers and hiding in the National Park. The Batwa were taken to Rugubuli parish court where they received lashes. Also, in patrol reports of 1994, rangers noted a problem that village courts were fining offenders only with purchases of tonto beer for the court, which the rangers suggested was because conservation officials had not fully advised the courts.

Therefore, before harvest zones were established in Bwindi, poachers arrested in the north and east were from parishes that became part of the harvest zone programme. This could be expected because most parishes bordering the north and east became part of the programme, as the north and east were designated as high harvest zones. However, poachers arrested in the east were also from parishes adjacent to the centre, which became a low harvest zone. These poachers and poachers arrested in the centre were from parishes that became and did not become harvesting parishes. Poachers arrested in the south, which became a low harvest zone, were only from Rubuguli parish that did not become a harvesting parish. The Batwa arrested in the west were only from Nteko, which became part of the harvest zone programme.

# Appendix C

## The parish in which poachers resided, and the court and punishment for arrested poachers, after harvest zones were established

One patrol report from the north detailed information on poaching after harvest zones were established. The report detailed an encounter with a Bakiga poacher who was from the harvesting Rutugunda parish in 1998.

Reports from the centre after harvest zones were established showed that, in 1999, a Bakiga poacher from Bujengwe parish, which was not a harvesting parish, was arrested with bushmeat in his house and taken to the Butogota police. In 2000, there were two encounters with poachers from Nyamishamba village of Bujengwe parish. The first encounter involved a Bakiga poacher, who was fined 80,000 UgSh by Nyamishamba village court. The second encounter involved the wife of a Bakiga poacher who was arrested because her husband was absent when rangers found bushmeat at the poacher's house. The wife was fined 10,000 UgSh by Nyamishamba village court. Also during 2000, a Bakiga man from Musherero village of Bujengwe parish was fined 150,000 UgSh by Musherero village court for killing two monkeys that were feeding on his crops.

Reports from the east after harvest zones were established showed that, in 1995, a Bakiga poacher from Ndego village, which is in the harvesting Kashasha parish, was fined 10,000 Ugsh by Ndego village court. In 1996, there were 2 encounters when Bakiga poachers were arrested for killing duikers that were crop raiding in community fields. First, a man from Ndego village was fined 50,000 UgSh and given 20 lashes by Ndego village court for killing a crop raiding duiker. Ndego is in the harvesting Nyamabare parish. Second, five boys from the harvesting Kitojo parish were fined 50,000 UgSh and each given 5 lashes by Kitojo village court and by beekeepers of the harvest zone programme. Then in 1998, a Bakiga poacher from Katoma village of Kitojo parish was arrested. Also during 1998, rangers found evidence that poachers in the east were from parishes adjacent to the centre, as snares collected around

Mubwindi swamp were similar to the snares that rangers collected during a patrol in the centre.

No patrol reports on poachers or courts existed for the south after harvest zones were established. However, rangers commented on poaching in their reports and noted in 1995 "*hunting with dogs is done almost everyday*" and in 1998 "*poacher trails are going deep into the forest*".

There was one report by rangers patrolling the west that documented poachers after harvest zones were established. In 1995, 3 Bakiga poachers from Buhoma village, which is in the tourism non-harvesting parish of Mukono, were arrested and the Warden of Law Enforcement for Bwindi ordered lashes as the punishment.

Therefore, after harvest zones were established in Bwindi, poachers arrested in high harvest zones of the north and east were from harvesting parishes, although no resource users of the harvest zone programme were arrested for poaching in these areas. As before harvest zones were established, there was an indication that poachers active in the east were from parishes adjacent to the low harvest zone of the centre. After harvest zones were established, poachers arrested in the centre were from non-harvesting parishes, and in the west were also from non-harvesting parishes.

Thus, from 1986 to 2000, poachers arrested in the north of Bwindi were from the harvesting parish of Rutugunda, in the centre were from the harvesting parishes of Muramba and Mpungu and non-harvesting Bujengwe parish, in the east were from the harvesting parishes of Kitojo and Kashasha, in the south were from the non-harvesting Rubuguli parish, and in the west were from the harvesting parish of Nteko and the non-harvesting Mukono parish.

# Appendix D

## Encounters with gorillas by rangers on long and day patrol

Data were extracted from records of law enforcement patrols of encounters with gorillas inside Bwindi that comprised 765 days on long patrol and 2071 days on day patrol carried out from 1986 to 2000, except for the lack of patrol reports for 1990 and 1991. The analysis excluded patrols covering the north of Bwindi, as gorillas are absent from these areas, and only included patrols covering the centre, east, south and west (Butynski, 1984; McNeilage *et al*, 2001). Law enforcement and gorilla encounters per patrol day were summed for the centre, east, south and west of Bwindi, per calendar month per year to analyse data by monthly totals. Only months with 15 or more days on patrol in each area were included for analysis (1986-2000 monthly totals across all areas; $n = 441$).

The few encounters with gorillas per long and per day patrol did not permit analysis by the three periods of gazettement and harvest zones used for poaching incidents in Chapter 4. The monthly totals were instead grouped into the two periods of before (1986-1994 monthly total: $n = 226$) and after (1995-2000 monthly total: $n = 215$) harvest zones were established that were used for encounters with poachers (see methods described in section 4.2). Furthermore, medium harvest zones were omitted from analysis because of the low number of encounters with gorillas per long and per day patrol.

Gorilla encounters were adjusted by patrol days to arrive at a catch per unit effort index. This index of poaching was log transformed, but the distribution still remained significantly different from normal (Kolmogorov-Smirnov $Z = 9.80$; $p < 0.001$). Analyses were conducted using the non-parametric tests of Kruskal-Wallis and Mann Whitney U.

## 1. Gorilla encounters before harvest zones

Rangers on long patrol encountered gorillas more frequently than rangers on day patrol before harvest zones were established (Table 1.1). During this period, encounters with gorillas were negatively correlated with the proportion of forest boundary sectors patrolled ($r^s$ = -0.37; $p < 0.001$). This indicated that the higher coverage of interior areas on long patrol contributed to the success of long patrols in encountering gorillas. The correlation also indicated that gorillas were concentrated in the forest interior of south Bwindi before harvest zones were established.

Table 1.1 Mean±SE encounters with gorillas and the proportion of boundary forest sectors patrolled per month by long and patrols in Bwindi from 1986 to 1994

| | **Long patrol (n = 130)** | **Day patrol (n = 428)** | **Mann Whitney U (z value)** | ***P*** |
|---|---|---|---|---|
| Gorilla encounters | 0.13±0.02 | 0.02±0.01 | -6.44 | < 0.001 |
| Proportion boundary sectors patrolled | 0.65±0.02 | 0.99±0.001 | -15.54 | < 0.001 |

Rangers on long patrol encountered gorillas more frequently in future high harvest zones than in future low harvest zones before harvest zones were established (Table 1.2). In contrast, encounters with gorillas by rangers on day patrol were similar between future high and low harvest zones, although the numbers of encounters were low.

Table 1.2 Mean±SE encounters with gorillas per month by long and day patrols in future harvest zones of Bwindi from 1986 to 1994

| **Patrol encounters** | **Future harvest zone and statistical comparison** | | | |
|---|---|---|---|---|
| | **Low** | **High** | **Mann Whitney U (z value)** | ***P*** |
| Gorillas / long patrol day | (n = 53) 0.13±0.05 | (n = 44) 0.19±0.03 | -2.98 | < 0.01 |
| Gorillas / day patrol day | (n = 104) 0.02±0.01 | (n = 25) 0.02±0.01 | -1.06 | NS |

## 2 Gorilla encounters before and after harvest zones

Encounters with gorillas on long patrols declined after harvest zones were established (Table 2.1). Day patrol encounters with gorillas remained similar between the harvest zone periods, although again the numbers of encounters were low.

Table 2.1 Mean±SE encounters with gorillas per month by long and day patrols in Bwindi during the periods before (1986-1994) and after (1995-2000) harvest zones were established

| Patrol encounters | Harvest zone period and statistical comparison | | | |
|---|---|---|---|---|
| | Before zones | After zones | Mann Whitney U (z value) | *P* |
| Gorillas / long patrol day | (n = 97) 0.16±0.03 | (n = 33) 0.04±0.02 | -2.63 | < 0.01 |
| Gorillas / day patrol day | (n = 129) 0.02±0.01 | (n = 182) 0.03±0.01 | -1.16 | NS |

## 3. Gorillas after harvest zones

There was no difference in gorilla encounters between rangers on long patrol and rangers on day patrol after harvest zones were established (Table 3.1). However, gorilla encounters were negatively correlated with patrol coverage of forest boundary sectors ($r^s = -0.19$; $p < 0.01$). The correlation indicated that gorillas remained concentrated in the forest interior after harvest zones were established.

Table 3.1 Mean±SE encounters with gorillas and the proportion of boundary forest sectors patrolled per month by long and patrols in Bwindi from 1995 to 2000

| | Long patrol (n = 33) | Day patrol (n = 182) | Mann Whitney U (z value) | *P* |
|---|---|---|---|---|
| Gorilla encounters | 0.04±0.02 | 0.03±0.01 | -0.75 | NS |
| Proportion boundary sectors patrolled | 0.77±0.02 | 0.99±0.002 | -11.86 | < 0.001 |

Encounters with gorillas in high and low harvest zones by rangers on long and day patrols were similar after harvest zones were established (Table 3.2).

Table 3.2 Mean±SE encounters with gorillas per month by long and day patrols in harvest zones of Bwindi from 1995 to 2000

| **Patrol encounters** | **Harvest zone and statistical comparison** | | | |
|---|---|---|---|---|
| | **Low** | **High** | **Mann Whitney U (z value)** | ***P*** |
| Gorillas / long patrol day | (n = 19) 0.05±0.04 | (n = 14) 0.04±0.03 | -0.18 | NS |
| Gorillas / day patrol day | (n = 131) 0.03±0.01 | (n = 51) 0.01±0.01 | -0.38 | NS |