CHAPTER 7

Human Encroachment and Vegetation Change in Isolated Forest Reserves: The Case of Bwindi Impenetrable National Park, Uganda

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Human modification of ecosystems is threatening biodiversity on a global scale (Whitmore 1997; W. F. Laurance 1999; Nepstad et al. 1999b; Chapman and Peres 2001). This is illustrated by the fact that an estimated 65.1 million hectares of forest were destroyed between 1990 and 1995 (FAO 1999). Many other areas are affected by forest degradation that involves logging, fire, and hunting; as a result, many conservation efforts have focused on protected areas such as national parks and reserves. However, less than 5% of the world's tropical forests are legally protected from human exploitation, and many of these are subjected to illegal exploitation (Oates 1996; Peres and Lake 2003; Fagan et al., chap. 22 in this volume). Given that a high rate of deforestation is occuring globally, and that the extent of protected areas is limited, it is important to understand how well such protected areas are protecting biodiversity.

Recent analyses have shown that areas of outstanding conservation importance often coincide with dense human settlement or impact (Dobson et al. 1997; Balmford et al. 2001; Harcourt and Parks 2003). For example, Balmford et al. (2001) found that species richness of birds, mammals, snakes, and amphibians was positively correlated with human population density in sub-Saharan Africa. Furthermore, these trends held for widespread, narrowly endemic, and threatened species. Thus, it is likely that many important biodiversity conservation areas are experiencing intense pressures from adjacent dense human settlements. Given current rates of human population growth and patterns of migration, those areas that are not currently experiencing this pressure are likely to do so in the near future. Effectiveness of conservation programs should grow in parallel to the growing threats: protected areas currently surrounded by dense human populations should have programs in place to deal with these intense pressures, whereas protected areas that are currently surrounded by few people should have plans constructed for a changing future. Effective conservation is only possible when accurate, timely information is available regarding the threats that face protected areas. Consequently, conservation biologists should seek novel approaches to determine threats and to assess the degree to which current programs have been successful.

The pressures being experienced by these protected areas will likely be concentrated along their edges. As a result, protected-area management plans should incorporate the rich data available from studies of forest fragments and edge effects (Kapos et al. 1997; W. F. Laurance and Bierregaard 1997; Benítez-Malvido 1998). However, much of the previous work in fragmented habitats has involved fragments protected from human use (Lovejoy et al. 1986; Malcolm 1994; Tutin et al. 1997). In reality, most fragments are not protected; they are on land managed by private residents who depend on them for fuel wood, medicinal products, or game (Chapman et al. 2003; Peres and Michalski, chap. 6 in this volume). In addition, the edges of protected areas in a matrix of high human population density are often not effectively protected and are encroached upon by local people for a variety of resources (Harcourt et al. 2001). The structure and composition of habitat edges will change with varying levels of management effectiveness.

The aim of this chapter is to quantify changes in resource extraction and vegetation structure as a function of distance from the forest edge into Bwindi Impenetrable National Park, Uganda. We consider resource extraction methods such as tree cutting and firewood removal, hunting, burning, grazing, vegetation clearing, and the spread of exotic plants. We also quantify changes in the vegetation structure as a function of distance from the forest edge. It is likely that the patterns we observe will be similar to those observed in other tropical reserves surrounded by dense human populations around the world.

METHODS

Study Site: Bwindi Impenetrable National Park

Data presented here are from a 22-month (May 2001–February 2003 inclusive) study of Bwindi Impenetrable National Park, located in southwestern Uganda (0°53′ –1°08′ S, 29°35′ –29°50′ E). This park is a forest island best known for its uniqueness in bird and butterfly diversity and as home to approximately half of the world's remaining mountain gorillas (*Gorilla gorilla*; approximately 650 individuals). In recognition of these values, it was declared a World Heritage Site in 1994. Topography of the region is extremely rugged and is characterized by numerous steep-sided hills and narrow valleys. Ranging from 1190 to 2607 m (Butynski 1984), the park is broadly classified as a medium- to high-altitude forest. The climate is tropical with two rainfall peaks, from March to May and from September to November. The annual mean temperature range is 7°C–15°C minimum to 20°C–27°C maximum, and annual precipitation ranges from 1130 to 2390 mm (Howard 1991).

Established in an area with a large rural population (200–400 people per km^2; the national average for Uganda is 88 people per km^2), the park boundary is typically an abrupt transition from forest to a matrix of croplands and settlements. The area's status has changed frequently with an increase in protection status and spatial extent (from 207 km^2 in 1932 to 321 km^2 in 1991). The most recent change in 1991 was its transformation from a central forest reserve, which allowed timber extraction, and a game reserve, which allowed the controlled harvest of game, to a national park, which permits very limited extraction.

Prior to its establishment as a national park, the forest was under severe human pressure. Butynski (1984) estimated that between 512 and 1049 people entered the forest daily to illegally remove wood, bamboo, livestock forage, minerals, honey, and meat. Until 1991, timber extraction, gold mining, and hunting were the gravest threats, leading to one of the highest anthropogenically related gap sizes and frequencies known for tropical forests (Babaasa et al. 2001) and the extinction of at least two mammal species from the area: buffalo (*Synerus caffer*) and leopard (*Panthera pardus*; Butynski 1984). Timber extraction, greater than 80% of which was illegal, was widespread throughout the reserve (Butynski 1984), although it was probably more intense along the edge than in the interior (Howard 1991). Evidence of hunting was common throughout the area (Butynski 1984).

Once it achieved national park status, the forest was transformed from an extractive reserve to an officially protected area. Currently, under multiple-use agreements, local communities are permitted limited extraction of weaving and medicinal products in designated areas. The extent to which these and other conservation efforts have reduced illegal activity is not clear. When this study began, most threats were thought to have been reduced. Agricultural encroachment and mining were believed to have been eliminated, but forest burning was considered a continuing threat. In addition, exotic plants were known to occur, but their distribution was unknown.

Field Methods

Fieldwork was conducted with the help of 8 to 10 assistants. Three sampling procedures were used: boundary walks, 100 m edge–interior transects, and 1 km edge–interior transects. Sampling was stratified by the 22 governmental administrative units surrounding the park, known as parishes (fig. 7.1). Boundary walks (146 km) were conducted to obtain information on the distribution of resource extraction within the immediate edge for all parishes and involved sampling an area up to 60 m into the park for signs of human incursions such as tree cutting, firewood extraction, and game hunting. All signs of resource harvest visible within

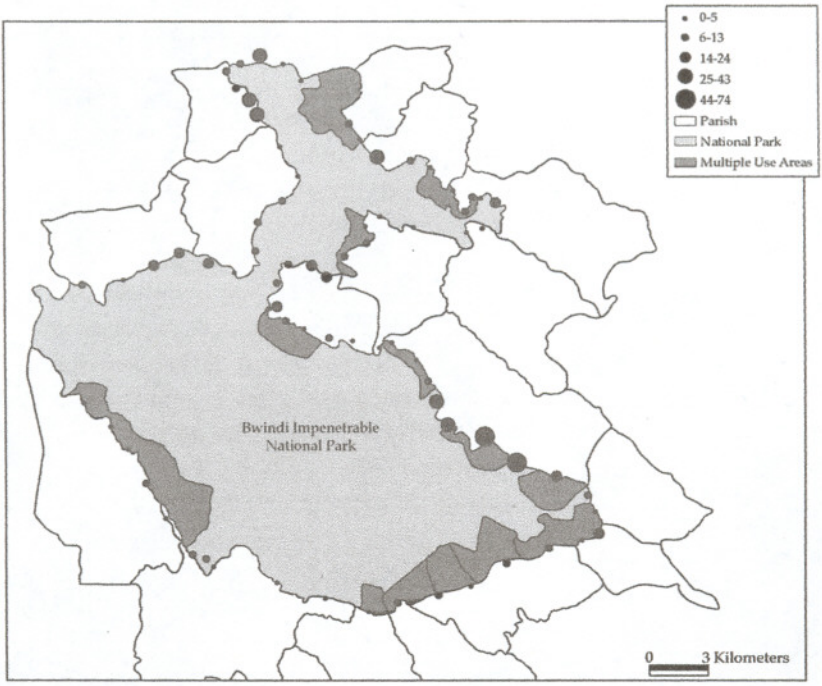

Figure 7.1. Map of Bwindi Impenetrable National Park, Uganda, showing the distribution patterns of forest-resource extraction near the park edge. Size of circles represents the intensity of pole extraction at that point near the edge. Lines demarcating clear spaces indicate parish boundaries. Dark gray areas within the park depict multiple-use zones.

a 5 m radius of each observed harvest were identified and noted. To do this, we walked a 5 m radius around each harvest sign to establish if there were other harvest locations nearby. When no other signs of harvest were visible, the observer returned to the park boundary line. Instances of resource extraction were detected by walking the boundary and looking for signs, by entering into the forest 5 to 10 m at randomly set distances along the edge, and by following human trails and footpaths from the edge to 20 to 30 m into the park. For resource extraction, only signs less than 2 years old were considered. Aging of felled trees was conducted using a method given by Sheil (1997), which involves scratching the surface of a stump with the tip of a fingernail. A stump was considered to be less than 2 years old if the surface was firm to the scratch. Because extractions are often clumped and more evident near the edge than in the interior, this method yields data more suitable for parish-level comparisons than that obtained from transects.

The team sampled 100 m edge–interior transects while conducting boundary walks. These transects were used to quantify how far different types of resource extractions occur into the park. Transects were 400 m apart along the edge and transect intervals were determined by measuring distance with a hip chain. Along these transects, sampling was done in 5 m radius circular plots, placed at 10 m intervals with the zero mark on the park's boundary. Within each plot, we counted the number of trees (diameter at breast height [dbh] >10 cm), poles (young trees between 5 and 10 cm dbh), and saplings (young trees >2 m high and <5 cm dbh). We also quantified all forms of people–park interactions and counted numbers of dead trees and exotic plants. A total of 375 of such transects were sampled.

Edge-interior transects of 1 km were used to understand how extraction levels and vegetation structure changed from the edge to the interior; we sampled 104 such transects. Eight parallel transects were established along each parish–park boundary more than 5 km long (11 parishes). On two occasions, two adjacent parishes were combined to achieve this minimum length; thus, 13 parish units were sampled. Within each parish, transects were placed equidistantly along, and ran perpendicular to, the park's boundary. Transects were marked at 50 m intervals (corrected for slope). At each 50 m point, we recorded slope (in degrees of inclination), slope location (bottom, lower slope, midslope, upper slope, and ridge top), elevation, and aspect (N, NE, E, SE, S, SW, W, NW). Within 50 × 5 m plots, we counted all forms of human disturbance as well as the number of exotic plants and dead trees. In 50 × 2 m plots, we quantified regeneration patterns by counting the number of poles and saplings. Tree density, size, and diversity were assessed in variable-area plots placed at 100 m intervals starting at the zero mark on the boundary line. Fifteen trees nearest the 100 m mark were identified and dbh measurements were taken. For each plot, sampling was only performed when the nearest tree was less than 5 m from the mark and if the fifteenth tree was no more than 40 m away; otherwise, the plot was recorded as "open." Thus, some plots with very few trees were classified as open.

To explore what determines the intensity of resource extraction, we collated, by parish, data collected through boundary walks and determined population density as estimated during the 1991 population census. Each parish was categorized according to district (table 7.1), whether or not it had a multiple-use program, whether it had no multiple-use program or one based on beekeeping or resource harvesting (the Ugandan Wildlife Authority does not consider beekeeping to be a detrimental form of resource extraction), whether or not settlements in the parish generally tended to be near or far from the edge, and whether the edge ran along some kind of barrier (large river, deep gorge, steep hill).

Using a general linear model (GLM), we employed the backward stepwise regression procedure to determine the best predictors for tree-cutting intensity, pole-cutting, and firewood-harvest intensity. GLM is preferred when the influence of categorical variables or a mixture of con-

Table 7.1 Results of multiple regression analyses to assess factors influencing resource extraction in different parishes at the edge of Bwindi Impenetrable National Park, Uganda. In addition to using data on population density, each parish was categorized according to its district, whether or not it had a multiple-use program (MuP1), whether it had no multiple-use program versus one based on beekeeping or resource harvesting (MuP2), whether settlements in the parish were generally near or far from the edge (proximity), and whether the edge ran along some kind of barrier, such as a large river, deep gorge, or steep hill (accessibility). *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns: not significant.

	Response variables		
Predictors	**Trees**	**Poles**	**Firewood**
Population density	ns	ns	ns
District	ns	ns	ns
MuP1	**	ns	*
MuP2	***	***	***
Proximity	ns	ns	ns
Accessibility	ns	***	***
R^2	0.792	0.522	0.737

tinuous and categorical variables is being examined. In exploring determinants of tree and pole cutting, we also included tree and pole density within 50 m of the edge as determined from 100-m-long transects. Using multiple linear regression, we examined several predictors for edge–interior variation in tree regeneration, density, size, and diversity (as estimated by the Shannon-Wiener index; table 7.2). The predictor variables included distance from the edge, elevation, slope, slope location, and aspect. Statistical analyses were performed using SYSTAT version 10.2. To plot variables measured on different scales on the same axes, each variable was standardized by subtracting the variable's sample mean from each value and then dividing the difference by the sample standard deviation.

Table 7.2 How specific descriptors of the tree community are influenced by five ecological variables in Bwindi Impenetrable National Park, Uganda. This correlational analysis was done over three different distances into the national park from the edge. *$P < 0.05$; **$P < 0.01$; ***$P < 0.001$; ns: not significant.

	Distance from edge (m)			
Response variable	**300**	**600**	**1000**	**Trend from edge**
Tree density				
Distance from edge	***	ns	*	increasing
Elevation	***	***	***	decreasing
Topographic location	**	***	ns	increasing
Slope	ns	*	**	decreasing
Aspect	*	ns	ns	increasing
N	51	90	140	
Tree species diversity				
Distance from edge	ns	ns	ns	no trend
Elevation	***	**	***	decreasing
Topographic location	ns	*	ns	decreasing
Slope	ns	ns	ns	no trend
Aspect	*	ns	ns	increasing
N	50	88	137	
Tree size				
Distance from edge	ns	ns	ns	decreasing
Elevation	ns	ns	ns	decreasing
Topographic location	ns	ns	ns	increasing
Slope	ns	ns	ns	decreasing
Aspect	ns	ns	ns	increasing
N	50	88	137	

Continued

Response variable	Distance from edge (m) 300	600	1000	Trend from edge
Pole regeneration				
Distance from edge	ns	ns	ns	no trend
Elevation	***	***	ns	decreasing
Topographic location	***	***	***	increasing
Slope	ns	**	***	decreasing
Aspect	**	ns	ns	increasing
N	78	156	260	
Sapling regeneration				
Distance from edge	ns	ns	*	decreasing
Elevation	***	***	***	decreasing
Topographic location	***	**	ns	increasing
Slope	ns	ns	*	decreasing
Aspect	***	ns	ns	increasing
N	78	156	260	

RESULTS

Resource Extraction

In 283 km sampled for this study, no fresh mining pits were observed inside the park and only nine trees were recorded as having been pit-sawn for timber. Most cut trees were small (<20 cm dbh), perhaps used for building or felled incidentally during the setting of beehives (total number of cut trees, 313; number of cut poles, 1750). Larger trees ($n = 6$) were cut to extract honey or to make beehives. We established that agricultural encroachment, although minimal (seven new incidences; average size = 1264 m^2, range = 33–3037 m^2), nevertheless still existed, contrary to information available before the study commenced. The agricultural plots were in hidden locations within the park or along the edge. The hidden plots were established to grow marijuana (*Cannabis sativa*), passion fruit (*Passiflora incarnata*), or tree tomato (*Cyphomandra betacea*). Plots along the edge were planted with tea (*Camellia sinensis*) or alfalfa (*Medicago sativa*), but the majority had not been planted with any crop.

Evidence of hunting was found on 31 occasions, all of which involved snares. The 1 km edge–interior transects indicate that, other than hunting, which was still widely distributed in the park (see also McNeilage et al. 1998; Uganda Wildlife Authority, unpublished data), most resource extraction was concentrated near the park's periphery (figs. 7.2 and 7.3). The distribution of resource extraction was clumped (fig. 7.1) and most extraction occurred within 300 m of the park edge (fig. 7.2). Exotic plants, especially cypress (*Cupressus lusitanica*), *Lantana camara*, and tea, were most abundant within 150 m of the edge. The density of exotics within the first 150 m of edges was 2.66 stems and clumps per square meter, whereas deeper into the reserve their density was 0.08 stems and clumps per square meter. Damage from fire was most extensive within 150 m of the forest edge, but there were still areas that were extensively damaged within 500 m of the park's edge. In total, 17% of plots within 150 m of the forest edge had evidence of burning compared to 8% of the plots along the remainder of the transect. Tree/pole mortality was closely correlated with burning ($r = 0.74$, $P < 0.001$).

A regression of tree, pole, and firewood extraction on several predictor variables showed a strong positive relationship between resource extraction and multiple-use programs; extraction was particularly high in areas designated for beekeeping (table 7.1). Population density and the

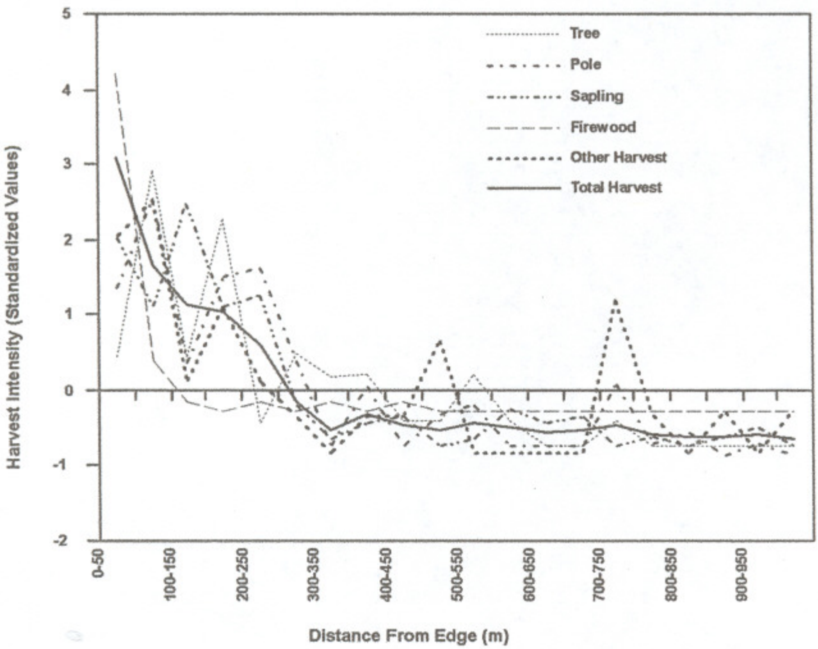

Figure 7.2. Changes in intensity of resource extraction along a gradient from the edge to 1000 m inside Bwindi Impenetrable National Park, Uganda. All values are standardized to facilitate comparisons among different threats.

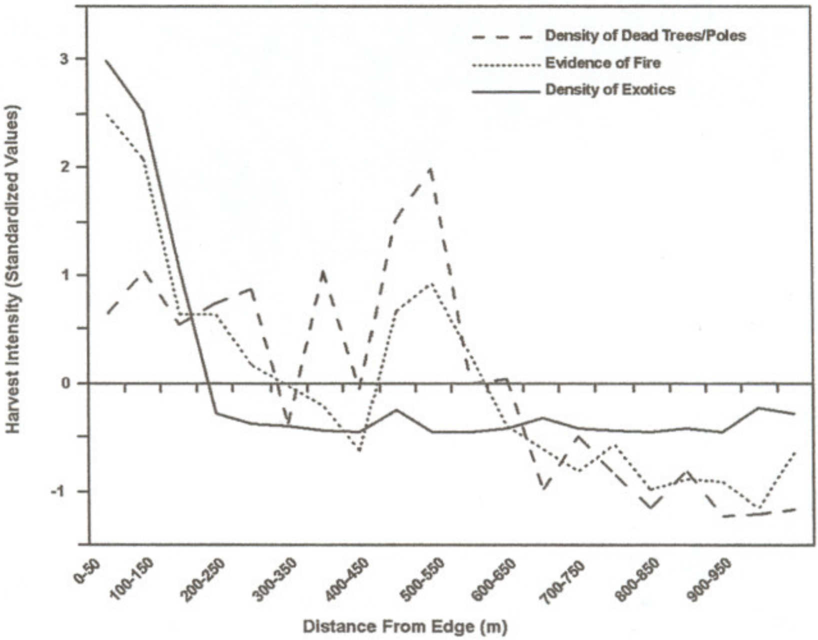

Figure 7.3. Changes in density of dead trees and poles, evidence of fire, and density of exotic plants along a gradient from the edge to 1000 m inside Bwindi Impenetrable National Park, Uganda. All values are standardized to facilitate comparisons among different threats.

other factors considered did not account for much of the variance in intensity of resource extraction (table 7.1).

Global threats of the spread of exotic species are well documented (Williamson 1996). In Bwindi, two small plantations of *Eucalyptus* occurred near the edge, one in the southeast and another in the northern part of the southern sector. Distribution of cypress (*Cupressus lusitanica*) was related to their use as boundary trees. In the northern lower-elevation areas, *Lantana camara* occurred in gaps near the edge, in previously burned sites, and in adjacent old, previously unmanaged tea plantations. Tea and *Acacia mearnsii* plants were predominant in a previously settled area in the northeastern edge in the southern sector. Only *L. camara* and *Camellia sinensis* were known to be reproducing and successfully recruiting without human assistance.

Vegetation Changes as a Function of Distance from the Park Edge

The 100 m edge–interior transects show an abrupt increase in the density of trees, poles, and saplings between the edge and 20 m into the interior,

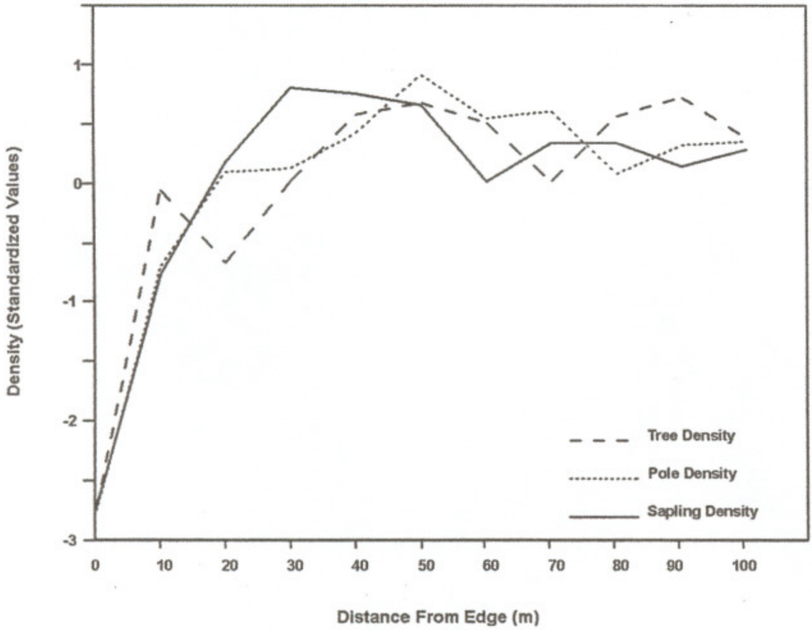

Figure 7.4. Variation in tree, pole, and sapling density along 100 m transects from the edge of Bwindi Impenetrable National Park into the interior of the park. Transects were 400 m apart along the edge.

but there was little change over the remainder of the 100 m transect (fig. 7.4; $n = 375$ transects). Similarly, after about the first 20 m, there were no clear patterns in the density, species diversity, size, or regeneration of trees on the 1 km transects (figs. 7.5 and 7.6; $n = 102$ transects); multiple middistance peaks were apparent for all variables.

Detailed analyses were conducted on data from the 1 km edge–interior transects to describe how environmental factors (e.g., elevation, slope, distance from the edge) were related to descriptors of the tree community. We considered such relationships using three different distance categories (table 7.2). Within 1 km of the edge, only tree density and sapling regeneration were related to distance from the edge and when analyzed only at some of the distance categories. Tree density generally increased toward the interior, whereas sapling density decreased. Within 600 m of the edge, no edge effect was evident. Within the 300 m zone from the edge, tree density increased with distance from the edge, and tree density, tree-species diversity, and pole and sapling regeneration all increased with a change in aspect. Within this zone, north-facing slopes tended to have lower values for each of these variables than slopes facing northeast, which had lower values

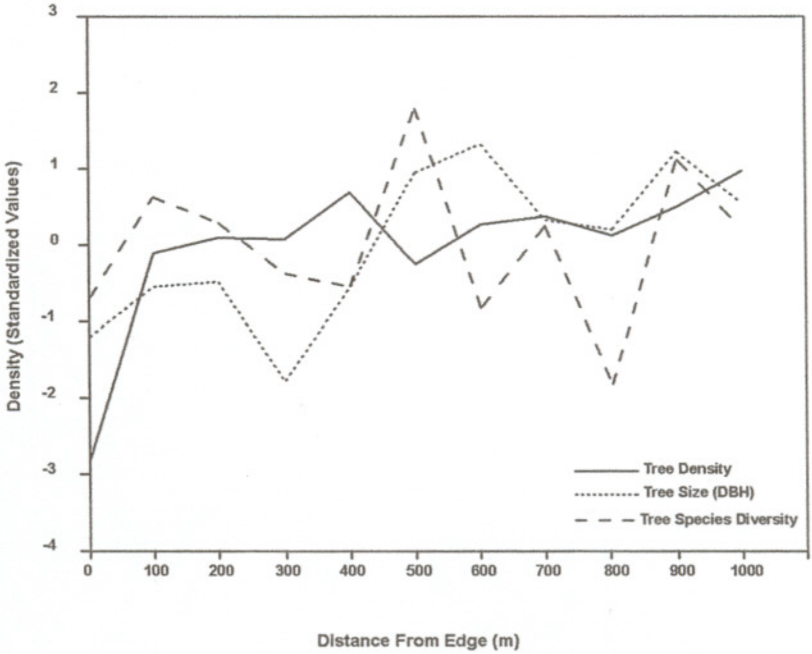

Figure 7.5. Variation in density, size, and species diversity of trees along 1 km transects from the edge of Bwindi Impenetrable National Park into the interior of the park ($N = 104$ transects)

than slopes facing east, and so on. Elevation and slope location (which affect temperature and soil moisture, respectively) had strong influences at any distance from the edge. The influence of slope angle was only important toward the interior.

DISCUSSION

A great deal has been learned about the nature and distribution of edge effects in fragmented habitats (Murcia 1995; W. F. Laurance and Bierregaard 1997). Many species of plants (Helle and Muona 1985; N. R. Webb 1989; Matlack 1994; Camargo and Kapos 1995; Turton and Freiburger 1997; W. F. Laurance 2000) and animals (Kroodsma 1982; K. S. Brown and Hutchings 1997; Schlaepfer and Gavin 2001; Beier et al. 2002) respond to edge proximity. However, in Bwindi Impenetrable Reserve, little was previously known about the effect of edge proximity on species abundance and distribution. Andama (2000) found that side-striped jackals (*Canis adustus*) and African civets (*Viverra civetta*) were

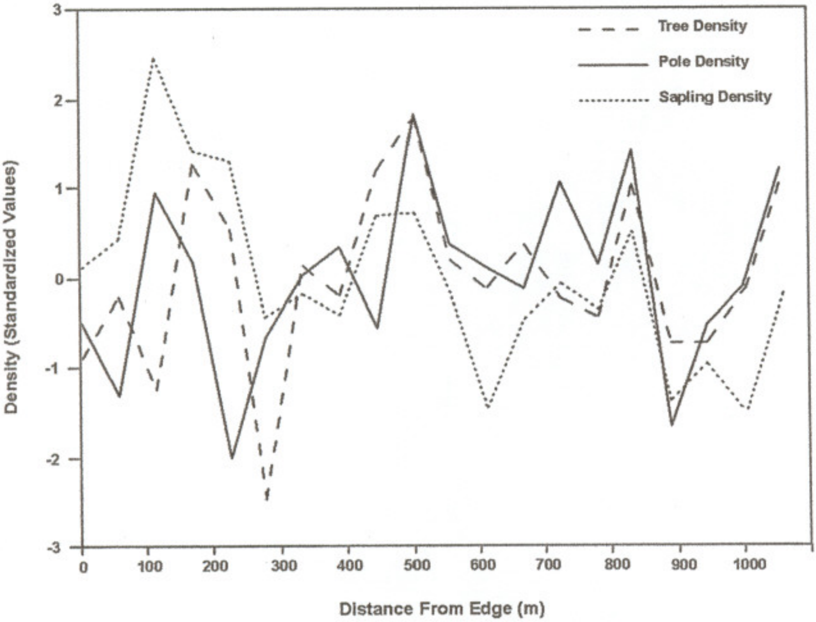

Figure 7.6. Variation in tree, pole, sapling density along 1 km transects from the edge of Bwindi Impenetrable National Park into the interior of the park (*N* = 104 transects)

more frequently located at the edge than were other carnivores, whereas Bataamba (1990) reported that four raptor species were edge dwellers. McNeilage et al. (1998) also found that all monkeys were more common around the edges of the park than in other parts of the forest.

The results of this study suggest that edge effects at Bwindi Reserve are influenced by a combination of abiotic changes and greater levels of resource extraction near the edge. At Bwindi, the increase in tree density with distance from the edge likely reflects the fact that resource extraction was most intense near the park edge and that fires were also frequent within this zone (see also W. F. Laurance, chap. 5 in this volume; Peres and Michalski, chap. 6 in this volume). However, similar trends have been reported near forest edges that did not experience resource extraction (Chen et al. 1992; Malcolm 1994; Camargo and Kapos 1995; Young et al. 1995). Several studies on tree regeneration have documented a decrease in sapling density farther from edges and have suggested that this may represent a regeneration response to disturbance, where many younger individuals are recruited into the locations left vacant by the death of older trees (Malcolm 1994; Camargo and Kapos 1995). The death of older trees may result from changing microclimates and increased wind turbulence associated with forest edges (Malcolm 1994; Camargo and Kapos 1995; W. F. Laurance et al. 1998; W. F. Laurance, chap. 5 in this volume).

Unlike some earlier studies, which found an increase in saplings and small trees near the edges, our results from the 100-m transects show an opposite trend, with saplings and poles both increasing farther from the edges. This probably results from resource extraction that involves harvesting poles, trampling seedlings, and fire encroachment often associated with harvesting honey and likely represents a fundamental difference between forest edges protected from human activities and those that are not. In reserves that are surrounded by dense human populations—especially those that do not have effective procedures to limit forest exploitation—it is likely that all size classes of trees will decline in density near the edges. It is unknown whether saplings and poles will be reduced to a level where they cannot replace adult trees that are harvested by local people or that succumb to edge effects. If they are reduced beyond replacement level, the edge will recede and the habitat area of the park will decline.

At a pantropical level, fire is common around forest edges and is more frequent in cleared areas (Lovejoy et al. 1984; Viana et al. 1997; Nepstad et al. 1999b; W. F. Laurance, chap. 5 in this volume; Peres and Michalski, chap. 6 in this volume). Correspondingly, at Bwindi, fire is likely the most important factor that affects the forest understory (Babaasa et al. 1999; Kasangaki et al. 2001). To stop the high mortality of trees near the edge, burning has to be controlled through implementation of a fire-management plan. Fires in Bwindi are mainly accidental, spreading from neighboring fields or from activities associated with honey harvesting (Babaasa et al. 1999). Some of the measures that need to be developed and implemented to control such fires at Bwindi include educating beekeepers and developing better methods of handling fire used in honey harvesting, maintaining effective reserve boundaries, educating communities on ways to prevent fire from adjacent fields entering the forest, and, where gaps near the edge predispose the forest to burning, planting trees to facilitate tree regeneration. Because fire is often associated with agriculture (Nepstad et al. 1999b), effective control systems will likely be important in all parks surrounded by high human population density.

In an effort to secure support from communities near protected areas, Uganda adopted a policy of community-based conservation in 1988 (Mugisha 2002). This decision was based on a global trend that advocated a sharing of both the responsibility and the benefits of managing protected areas between government agencies and local communities (McNeely 1989; Brandon 1998). This perspective was a backlash against the purely protectionist approaches that were often previously adopted.

The rationale for establishing community-based conservation projects was based on the assumption that local communities will take on responsibility for resource management when they receive direct benefits from conservation (see also Whitten and Balmford, chap. 17 in this volume).

In the extensive area that adjoins Bwindi Reserve, the presence of multiple-use programs in local parishes had a strong negative impact on tree and pole density and firewood extraction; these effects were especially strong in areas designated for beekeeping. In contrast, human population density accounted for a small proportion of the variance in intensity of local resource extraction, although the presence of nearby settlements was important (table 7.1). This suggests that, although local communities enjoy the benefits of the Bwindi community-based conservation project, they do not necessarily accept responsibility for careful management of the reserve. Hackel (1999) presented a series of case studies from throughout Africa to illustrate that community-based conservation projects do not engender the local communities to comply with conservation laws. In addition, attitudes of residents toward parks in Uganda do not differ between parks that have community-based conservation projects and those that do not (Mugisha 2002). Our findings, in combination with those from Mugisha (2002), suggest that community-based conservation programs in their current form do not meet their objectives in parks surrounded by dense human populations; thus, the programs should be modified. Possible modifications to mitigate threats in Bwindi include better supervision of beekeeping programs, community education, providing alternatives to park resources, deploying effective ranger patrols, and developing ways to improve honey yield.

CONCLUSIONS AND IMPLICATIONS

1. Recent analyses have demonstrated that areas of outstanding conservation importance often coincide with dense human settlements. The edges of forest reserves in such areas will likely experience both negative abiotic effects caused by proximity to the edge and encroachment by local people who extract natural resources.

2. Using 282 km of transect samples, we quantified spatial changes in resource extraction and vegetative structure as a function of distance from the edge into the interior of Bwindi Impenetrable National Park, Uganda. Resource extraction was the most intense within 300 m of the park's edge, as was the density of exotic plant species; however, signs of hunting activity were not limited to the edge of the park.

3. The increase in tree (>10 cm diameter) density with distance from the edge likely reflects the fact that resource extraction was most intense near the park edge and that fires were also frequent within this zone. Unlike previous studies of edge effects in areas where resource extraction does not take place, we additionally found reduced sapling and small-tree density near edges, which was evidently a result of local harvesting and fires. This probably represents a fundamental difference between edges protected from human activities and those that are not and raises the question of whether the Bwindi edge could recede in the future.

4. Regression models showed a strong positive relationship between tree, pole, and firewood extraction and the presence of multiple-use programs, particularly beekeeping. In contrast, population density did not account for much of the variance in intensity of resource extraction. This suggests that, while local communities were receiving the benefits of the community-based conservation project, they were not carefully managing the resources in these parks. For this reason such programs should be modified.

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