Chapter 15
Fragments and Food: Red-Tailed Monkey Abundance in Privately Owned Forest Fragments of Central Uganda

[AU1]

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Abstract Understanding the strategies that primates use to survive in fragmented forest landscapes is vital for constructing informed management plans for specific regions and to enable researchers to start to make generalizations. In a 15-month study, we investigated factors that influenced the status of red-tailed monkeys (*Cercopithecus ascanius*) and their plant food resources in 20 of the few remaining privately owned forest fragments in Central Uganda. We employed transect methods for vegetation assessments and censuses with a short stop upon sighting red-tails to establish demographics and food plants consumed. While the sample involved forests of very different successional stages, forest size was the most important factor influencing both red-tail population size and the number of groups per fragment. Number of food tree species influenced only the number of red-tail groups per fragment. Basal area of food tree species and food tree abundance per fragment were not related to red-tail population size or the number of groups per fragment. Food tree species richness, total number of trees, and basal area of food trees increased significantly with fragment size. Availability of food resources was

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affected by various factors including habitat area, the nature and intensity of human exploitation, and how fragments were managed. The number of groups and abundance of red-tail monkeys declined when anthropogenic consumptive activities increased. In the future, as these forests are further degraded, the availability of food resources will continue to decline, and thus, the probability that these red-tail populations will survive much longer seems unlikely.

Introduction

Increasing anthropogenic environmental change is recognized as a major challenge to global environmental systems (Chapman and Peres 2001; Patz et al. 2004). In the past 50 years, the size of the human population grew by 3.7 billion people (Potts 2007). Consequently, the demand for resources has increased, bringing about large-scale alterations of environmental conditions for wildlife populations. This has occurred to such an extent that nowadays the world is increasingly being dominated by human-modified ecosystems (Kariva et al. 2007). In the tropics, habitat degradation and forest conversion pose such a significant threat that widespread terrestrial species extinction is predicted to occur soon (Cowlishaw 1999; Sodhi et al. 2004). Our ability to conserve biodiversity in human-dominated systems increasingly requires research into mechanisms that can maintain species in fragmented and degraded landscapes. For example, the conservation of some biodiversity in degraded tropical landscapes may be assisted through the management of diverse agroforestry systems (Bhagwart et al. 2008; Gardner et al. 2009; Omeja et al. 2009). However, a detailed understanding of which species will be affected by different types of fragmentation, and which will benefit from different types of management systems remains largely unknown.

In Uganda, threats to biodiversity are similarly grave or worse than global averages. Closed-canopy tropical forest once covered 20 % of the country, but deforestation has reduced this to just 3 % (Howard et al. 2000). Uganda lost 18 % of this remaining forest between 1990 and 2000 (Howard et al. 2000), and the most recent estimate suggests that the annual rate of loss of tropical high forest in Uganda is 7 % (Pomeroy and Tushabe 2004). At the present rate, Uganda will have lost all its forested land by 2050 (NEMA 2008). Over 80 % of the land in Uganda is used for small-scale farming and nearly 80 % of the population are farmers (UBOS 2005), which means even small fragments are surrounded by people that need the resources found in forests—intact or not. In addition, Uganda's population is growing at approximately 3.3 % annually (2005–2010) which ranks 8th in the world (UN 2010). Even more alarming than the population growth rate is the fact that Uganda has the second youngest population of the world with 49 % below 15 years of age (PRB 2010). This high rate of human population growth is expected to increase forest fragmentation and lead to a reduction in size and even complete loss of many forest fragments (Chapman

Fig. 15.1 A juvenile red-tailed monkey in a forest fragment in Uganda. Photo Credit—Colin Chapman

et al. 2007). Increased demand for food, raw materials, and wood energy due to human population increase, amidst slow technological growth and a large rural population, will lead to the loss of forest habitat and the biodiversity therein (Jacob et al. 2008; Naughton et al. 2006; Naughton et al. Submitted). The once large continuous forest in the Lake Victoria region now survives as small forest fragments. However, in spite of their sizes, they are still playing an important role in conserving biodiversity, including some primate species, among them the red-tail monkeys (*Cercopithecus ascanius*; (Baranga 2004a, b), if they can be maintained over the long-term (Fig. 15.1).

Here we investigate whether the forest fragments in the once large continuous forest surrounding the shores of Lake Victoria region can support viable red-tail monkey populations amidst increasing rates of human disturbance. Specifically we quantified the relationship between red-tail populations and the availability of potential food tree resources in the selected forest fragments in the Lake Victoria basin, Uganda.

Methods

This study was conducted in a 600 km^2 area of forest–savannah–agricultural mosaic dominated by human habitation and other human infrastructural development in central Uganda (Baranga 1995). We established two study sites within this large area from which we based our operations and sampled 20 fragments (Baranga 2004a). Site 1 had non-reserved forest fragments (0^0 05^0 N, 0^0 16^1 N and 32^0 30^1E,

32^0 38^1E) of which Zika Forest (Buxton 1952) was the largest and least disturbed, while the Kisubi Forests, owned by the Roman Catholic Church, constituted the majority of the other fragments. On the whole, 75 % of the fragments at this site were off-shore, 15 % were riparian, and 10 % were dry-mainland forest. Site 2 was based at Mpanga Forest Reserve (0^0 15^1 N, 32^0 15^1 E). It is a medium altitude moist evergreen forest (of about 4.5 km^2) considered a *Piptadeniastrum–Albizia–Celtis* forest by foresters (Howard 1991; Langdale-Brown et al. 1964). The fragments were at different stages of succession/maturity following disturbance. As a legally protected area, the Mpanga Forest Reserve was sampled to compare it to the other fragments.

Human activities and fragment size were determined directly. Stand structure was quantified by tree enumeration along 5-m wide transects divided into 10 m long plots to achieve the 'minimal area' based on the Brain-Blanquet concept (Kershaw 1973). Tree species classes (Richards 1996; Swaine and Hall 1986) were evaluated using the diameter at breast height (dbh), measured at a height of 1.3 m from the ground for all trees with a diameter of 10 cm girth and above. Tree stumps were enumerated and their diameters used to calculate tree basal area loss as an index of forest exploitation. The status of the forest fragments were assessed by allocating them scores: from 1 to 4 (1-fairly intact, 2-disturbed, 3-degraded, 4-highly degraded) based on presence or absence of distinct upper, middle, lower, and ground layers, thick undergrowth, presence of gaps, and human activities, such as tree cutting and forest clearing (Table 15.1).

As a means of describing similarities between fragments, cluster analysis (simple matching coefficient) and ordination (group average) were conducted on the basis of the woody species found in each fragment. We also did an ordination of all variables that include food tree species, forest fragment size, and number of groups and population size of red-tails in each fragment. For these analyses PC-ORD-VERSION 4 was used.

To facilitate evaluation of the red-tail populations in each fragment, a system of trails were set up so that each fragment could be searched with a minimum of disturbance to the animals. In the Mpanga Forest Reserve an existing trail system was used. Each month for 14 months, primate censuses were conducted over 2 days in each fragment with the exception of the Mpanga Forest Reserve that took 3 days each month due to its large size. During the census, the observer walked slowly (0.75 km/h) and when a group was detected the observer stopped for 20 min to estimate group size and when possible determine the age/sex composition of the group. We also determined breeding status of females and number of dependent young in each group to construct a breeding ratio (Table 15.3). Finally, we evaluated what [AU3] plant species and part red-tails were feeding on.

We analyzed the data by performing parametric bivariate Pearson correlations among forest fragment size, food tree richness, food tree total abundance, and food tree basal area with red-tail population abundance and number of groups in each

Table 15.1 Relationship between human activities, competition with vervets, and red-tail monkey residential status and demography in 20 selected forest fragments around Lake Victoria, Uganda

Category	Forest fragment	Major human activities	Competition with vervets	Status of groups	Groups	Popn.
1	Zika	Fuelwood collection	Present	R	3	23
	Kisubi Hospital	Fuelwood collection	Absent	R	2	14
	Kisubi Technical	Fuelwood collection	Absent	R	3	7
	Marianum Gogonya	Fuelwood collection	Absent	R	2	14
	Kisubi Kibale	Fuelwood collection	Absent	R	2	19
	Kisubi Nabinonya	Fuelwood collection	Absent	R	2	22
	Kisubi Girls	Fuelwood collection	Absent	R	1	24
	Wamala	Fuelwood collection for beer brewing	Absent	R	1	14
2	Mawanyi	Fuelwood collection + cultivation	Present	R	3	9
	Nganjo 3	Fuelwood collection + cultivation	Present	R	1	8
	Katwe	Fuelwood collection + cultivation	Present	0	0	0
3	Bunamwaya	Fuelwood collection + brick burning[a]	Present	SR	1	8
	Nganjo 1	Fuelwood collection+ poles+cultivation	Present	SR	1	7
	Sinzi	Fuelwood + tree cutting for canoes	Present	SR	1	8
	Kanywa	Fuelwood+clay quarrying+brick making	Absent	SR	1	3
4	Namulanda	Charcoal burning + water collection[a]	Absent	R	1	6
	Seguku	Paddock fencing + water collection[a]	Present	R	1	12
5	Nganjo 2	Fuelwood collection + cultivation[a]	Present	0	0	0
	Nalugala	Fuelwood collection + cultivation[a]	Present	SR	1	4
	Kisubi Paddock	Fuelwood collection + clearing	Absent	R	2	10

Key: *R* resident, *SR* semi-resident, *0* no red-tail
[a]Daily activities

fragment. We ran additional analyzes between all the forest variables with the breeding ratio (number of dependent young/ breeding females) we found in each group. We ran these analyzes in SPSS 10.0.

Results

Contrasting Forest Fragments

Cluster analysis of the forest fragments based on the food tree species found in each fragment revealed four main clusters when 0.60 is used as a minimum index for defining the clusters (Fig. 15.2). Cluster one consisted of the Zika forest. Cluster two had nine forest fragments consisting of Namulanda, Kisubi, and Wamala sites. Cluster three included the Mpanga and Kituza forests only. Finally, cluster four had ten forest fragments consisting of the smaller unprotected forests.

Ordination analysis of food tree data from the 20 fragments revealed that in most fragments food tree species were common, with the exceptions of Namulanda, Katwe, Nganjo 2, and Mpanga that had few food tree species (Fig. 15.3; Table 15.1). The forest fragments with a higher number of food tree species were Zika ($n=16$ species), Wamala (15), and Kanywa (15), and Mawanyi, Sinzi, Nganjo 3, Nalugala, Kisubi technical, and Kisubi Nabinonya each with 14 species (Table 15.2).

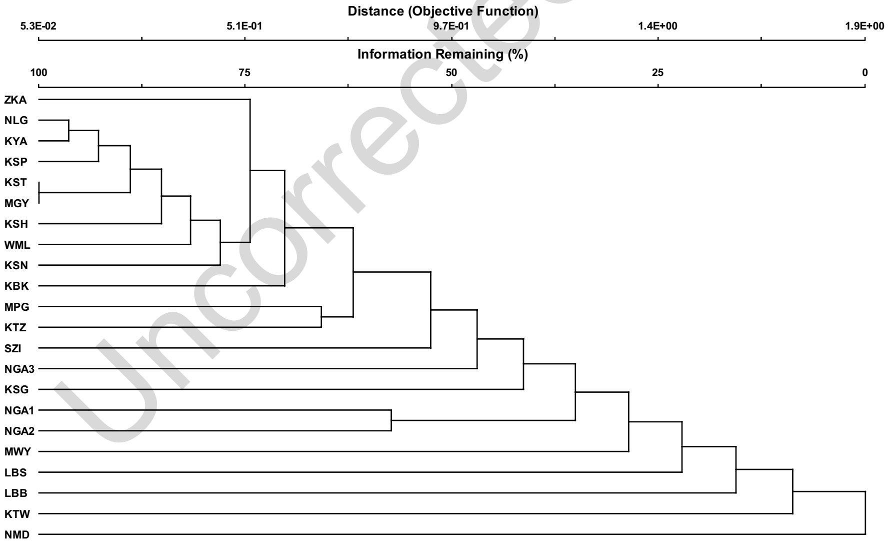

Fig. 15.2 Cluster Analysis based on food tree species in selected forest fragments around Lake Victoria Basin, Uganda. Key: Zika = ZKA, Mawanyi = MWY, Namulanda = NMD, Sinzi = SZI, Nganjo 1 = NGA1, Nganjo 2 = NGA, Nganjo 3 = NGA3, Nalugala = NLG, Kanywa = KYA, Kisubi padlock = KSP, Kisubi Kibale = KBK, Kisubi Technical = KST, Kisubi Hospital = KSH, Mariamam Gogonya = MGY, Wamala = WML, Kisubi Nabinonya = KSN, Mpanga = MPG, Kituza = KTZ, Kisubi Girls = KSG, Lubowa Seguku = LBS, Lubowa Bunamwaya = LBB, and Katwe = KTW

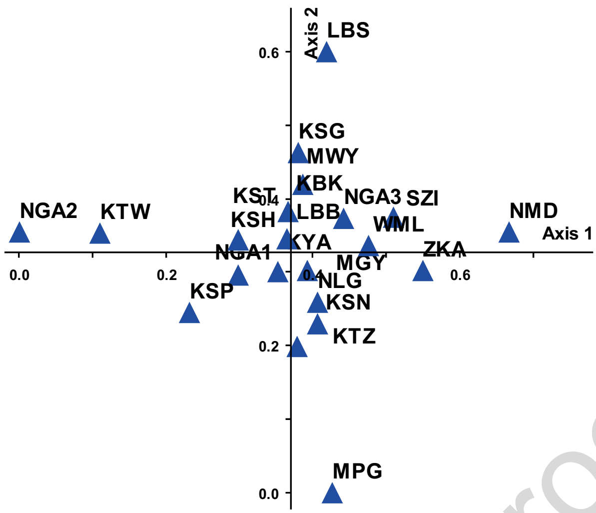

Fig. 15.3 Ordination based on the food tree species in selected forest fragments around Lake Victoria, Uganda. Key: Zika = ZKA, Mawanyi = MWY, Namulanda = NMD, Sinzi = SZI, Nganjo 1 = NGA1, Nganjo 2 = NGA, Nganjo 3 = NGA3, Nalugala = NLG, Kanywa = KYA, Kisubi padlock = KSP, Kisubi Kibale = KBK, Kisubi Technical = KST, Kisubi Hospital = KSH, Marianum Gogonya = MGY, Wamala = WML, Kisubi Nabinonya = KSN, Mpanga = MPG, Kituza = KTZ, Kisubi Girls = KSG, Lubowa Seguku = LBS, Lubowa Bunamwaya = LBB, and Katwe = KTW

Table 15.2 Fragment characteristics, the number of red-tail monkey groups, and population size for a series of fragments in the central area of Uganda

Forest type	Forest fragment size	Species richness	Pop size	Basal area	# of groups	#of redtails
Ziika	19.231	16	316	666782.9	3	23
Mawonyi	3.237	14	146	109460.9	3	9
Namulanda	0.747	10	69	128532.8	1	6
Sinzi	3.642	14	161	159792.2	1	8
Nganjo 1	1.925	11	114	67507.4	1	7
Nganjo 2	0.42	8	96	54065.5	0	0
Nganjo 3	2.295	14	140	118157	1	8
Nalugala	0.7	14	194	105914.3	1	4
Kanywa	3.187	15	251	151788.8	1	3
Kisubi Padock	3.645	13	274	244751.7	2	10
Kisubi Kibale	4.06	12	172	238038.6	2	19
Kisubi Technical	2.25	14	112	206805	3	7
Kisubi Hospital	3.55	12	157	306201.7	2	14
Mariaman Gogonya	5.8	11	146	198614.3	2	14
Wamala	9.499	15	189	385396.4	1	14
Kisubi Nabinonya	7.462	14	95	125722	3	22
Kisubi Girls	3.392	11	225	140308.2	1	24
Lubowa Seguku	0.24	11	69	24768.8	1	12
Lubowa Bunamwaya	1.24	11	116	88384.5	1	8
Katwe	5.52	9	176	276380.7	0	0

Ordination analysis of the relationship between forest size, food tree species, food tree abundance, basal area, and the number of groups and population size of red-tails in each fragment showed that Kisubi, Nabinonya, and Zika fragments conserve red-tail populations and their food tree species well and that Katwe and Nganjo2 were the worst fragments for conservation (Fig. 15.4).

In all fragments we found evidence of cutting of trees for the collection of fuelwood. Other activities present in some fragments, but not others, included: brewing beer, active cultivation, brick making, charcoal production, cutting large trees for timber or for making boats, and cutting of poles to build fences (Table 15.1). Since vervet monkeys (*Cercopithecus aethiops*) are potential competitors of red-tail monkeys, we determine in which fragments they were present (Table 15.1). The fragments with lower red-tail population size are Nganjo 2, Katwe, Nalugala, and Kanywa and there are more than two human activities in all these fragments (Table 15.1).

Food Tree Species

Twenty-two commonly consumed food tree species for red-tail monkeys were identified from observations made in all of the 20 fragments. These species were the following: *Harungana madagascariensis*, *Blighia unijugata*, *Measopsis emnii*, *Pseudospondias microcarpa*, *Pycnanthus angolensis*, *Trichilia drageana*, *Sterculia dawei*, *Manilkara dawei*, *Solanum mauritianum*, *Margaritaria discoideus*, *Chaetacme aristata*, *Alchornea cordifolia*, *Teclea nobilis*, *Ficus capensis*, *Pittosporum manii*, *Albizia coriaria*, *Sapium ellipticum*, *Antiaris toxicaria*, *Craterispermum laurinum*, *Ficus urceolasis*, and *Spondianthus preusii*. The forest fragments that had many of these 22 food tree species were: Zika (with 16 of the 22 food tree species) Wamala (15), Kanywa (15), Sinzi (14), and Kisubi Nabinonya (14). The food tree species that occurred in at least 75 % of the forest fragments were *H. madagascariensis*, *B. unijugata*, *M. eminii*, *P. microcarpa*, *P. angolensis*, *T. drageana*, *S. dawei*, *M. dawei*, *S. mauritanum*, ranging from 17 to 21 out of 22 species.

Red-Tail Populations and Resources

As would be expected as fragment size increased, there was an increase in the number of food trees ($r=0.601$, $p=0.005$), food tree basal area ($r=0.899$, $p=0.000$), and the number of food tree species ($r=0.503$, $p=0.024$; Table 15.2). The number of red-tail groups per fragment increased with increased fragment size ($r=0.488$, $p=0.048$) and the number of food tree species ($r=0.579$, $p=0.008$). There was no significant increase in the number of red-tail groups with food tree basal area ($r=0.377$, $p=0.102$) or the abundance of food trees ($r=0.172$, p $=0.468$) in a

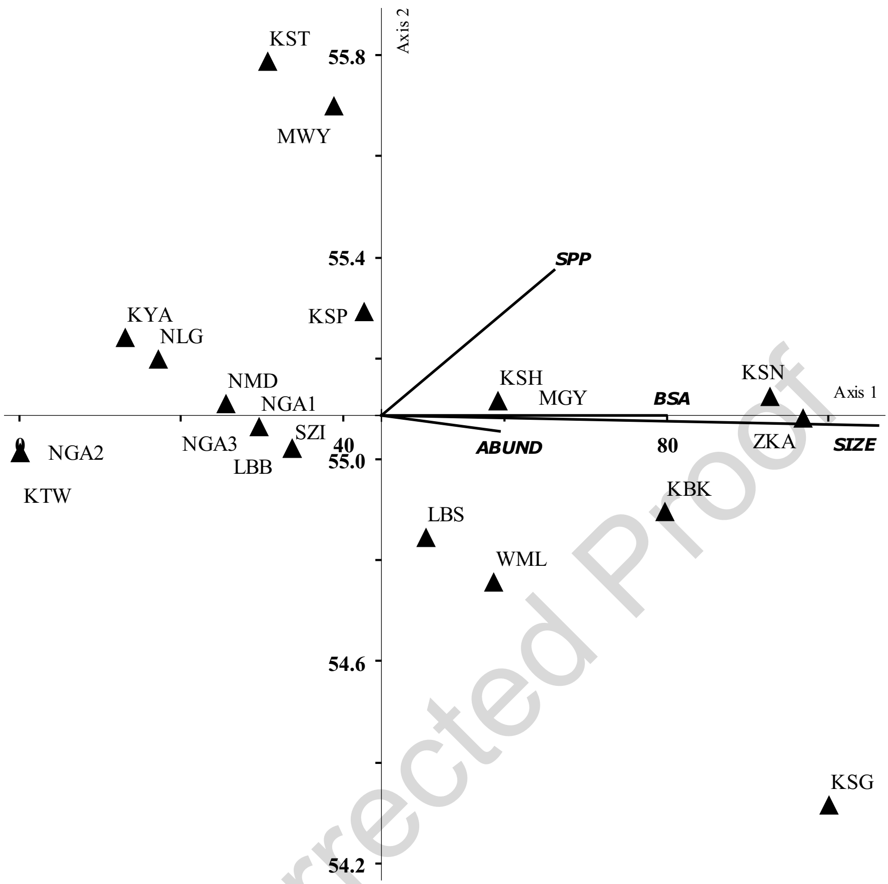

Fig. 15.4 Ordination of the relationship between forest size, food tree species, food tree abundance, basal area and the groups and population of red-tail monkeys in selected forest fragments around Lake Victoria, Uganda. KEY: Zika = ZKA, Mawonyi = MWY, Namulanda = NMD, Sinzi = SZI, Nganjo 1 = NGA1, Nganjo 2 = NGA, Nganjo 3 = NGA3, Nalugala = NLG, Kanywa = KYA, Kisubi padlock = KSP, Kisubi Kibale = KBK, Kisubi Technical = KST, Kisubi Hospital = KSH, Mariamam Gogonya = MGY, Wamala = WML, Kisubi Nabinonya = KSN, Kisubi Girls = KSG, Lubowa Seguku = LBS, Lubowa Bunamwaya = LBB, and Katwe = KTW

fragment. The size of the red-tail populations in the fragments increased with forest size ($r = 0.571$, $p = 0.009$) and marginally so with basal area of food tree species ($r = 0.432$, $p = 0.057$). However, the populations did not increase as a function of the number of food trees ($r = 0.329$, $p = 0.156$) or with the food tree total abundance per fragment ($r = 0.282$, $p = 0.228$). As what might be expected, the higher the number of red-tails groups, the higher their population ($r = 0.569$, $p = 0.009$).

We also found that there were no correlations between forest size, tree species richness and abundance, and basal area with breeding ratio (number of breeding females/dependent young per site). However, there were significant correlations between number of juveniles and forest fragment size ($r = 0.481$, $p = 0.032$), number of breeding females with forest fragment size ($r = 0.525$, $p = 0.018$), and with total basal area ($r = 0.457$, $p = 0.043$). These last results likely reflect the fact that population size is highly correlated to forest fragment size per se as we demonstrated above. Finally, we found that forest fragment size, food tree number, and basal area, as well as total abundance of food trees, were highly correlated among themselves. This prevented us from performing a multiple regression analysis using these variables to predict red-tail population size or number of groups.

Discussion

With Uganda's high human population density and growth rate and the fact that a very large proportion of the population are small-scale farmers, forest fragments are almost inevitably surrounded by intensive human activities. Thus, our results suggest that if they do not receive some sort of protection that the fragments become rapidly and extensively encroached upon. The positive impact of protection is indicated by the segregation of the forest patches into the four major clusters that partly reflect the legal status that reflected the degree of degradation. Zika forest was a natural climax (under government institutional protection), while Cluster 2 mainly consisted of Kisubi forests which were on the whole mixed forests. Mpanga and Kituza forests were quite distinct from others as fairly large gazetted forests, with Mpanga being protected. The rest of patches were small and largely colonizing secondary forests with some of them (Nganjo 1 and 2, Kanywa, Sinzi, Namulanda, and Nalugala) in a retrogressive state due to cultivation. Since, most of the fragments were studies are not protected they are likely to be reduced in size in the future as anthropogenic activities such as fuelwood collection, cultivation, and collection of building poles take their toll.

Our study illustrates the importance of maintaining forest size since it was related to red-tail population size and the number of groups per fragment. In addition, forest size predicted other variables that might also be important for red-tail monkeys, such as the number of food trees, food tree basal area, and the number of food tree species. This produces a very simple management statement: the most effective means to protect red-tail populations in fragmented landscapes will be to protect fragments so that they are not reduced in size.

Since the majority of these fragments are privately owned or owned by organizations that will likely exploit them at some time (e.g., the Catholic Church), this calls for conservation strategies that will protect the fragments while at the same time meet the needs of the local people. The needs of the local people must be met since they are the owners of the fragments and thus have the right to exploit them. The goals of these strategies, protection and meeting the goals of local people, are in direct opposition to each other. The only way that we can see advances being made to satisfy both of these goals is if government or conservation agencies work with the local community to provide the resources that farmers would extract from the fragments from elsewhere. To make such an effort a success each member of the community, and particularly those families living directly opposite to the fragments, would have to agree not to exploit resources from the fragments if they were provided the resources from elsewhere. This of course raises a number of questions. The most important of which is, "Where would the replacement resources come from?" This is a landscape where all the land is officially or unofficially owned by someone (Naughton et al. Submitted; Naughton et al. 2006). Other questions include: How does the government or conservation agency compensate landowners living adjacent to the fragment for crop-raiding done by animals like red-tail monkeys? How can cheating by community members be prevented? What justification can be given to the community to make a priority of protecting forest fragments when disease, poor nutrition, and lack of fees for school are more immediate priorities to most local farmers? How can an education program cover areas as large as 600 km^2? All of these questions would need to be addressed and the funding raised for the program before any plan that met both goals would have a good chance to succeed. We view that this is very unlikely to occur, and thus, the long-term future of these forest fragments and the red-tails they support looks grim.

Conclusions and Recommendation for Future Research

The few remaining forest patches in 'Kampala Area' are faced with different levels of human disturbance ranging from low in privately owned forests to high in forest on public land with minimal protection. With a range of common human activities and especially forest clearing and cultivation, forest size was on the decline, yet it was a crucial factor influencing key parameters (number of food trees, food trees species and their basal area, as well as the number of red-tails groups and their populations per fragment). Therefore, the continuing forest exploitation by the local communities around the forest fragments is likely to lead to diminishing or even complete elimination of the red-tail monkey populations. This will probably be through anthropogenic effects causing a decrease in fragment size that ultimately leads to scarcity in food resources and consequently declining red-tail populations. To reverse the present trends would require a major conservation effort, on a scale and of a nature that is not typically done. To stop the fragments from being cleared would require the cooperation of the local people, since this is their land or it is the community members that are using protected lands. Alternative sources of income would have to be found (e.g., ecotourism), fuelwood supplies from elsewhere would have to be made available (e.g., a large scale woodlot project), fuelwood demand would have to be reduced (solar or biogas stoves), and a great deal of effort would have to be placed in education and outreach to obtain the willing support of all the communities.

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