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ORIGINAL PAPER

Human and natural impacts on forests along lower Tana river, Kenya: implications towards conservation and management of endemic primate species and their habitat

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Abstract Seventy-three forest patches were assessed to determine the effects of human and natural impact on native forests along the Lower Tana River flood plains in Kenya between January and March 2001. Seventeen of these forests were within the Tana River Primate National Reserve (TRPNR) while 56 were outside the protected area. Cultivation and dyke construction had the most devastating human impact, which involved partial or complete forest clearing resulting in further fragmentation of forest patches [Suleman MA, Wahungu GM, Mouria PK, Karere GM, Oguge N, Moinde NN (2001) Tana River primate census and forest evaluation. A report to Kenya Wildlife Services]. Natural impacts were either die back or flooding, which appeared to cause progressive degradation of forest structure and biodiversity. Overall, forest area in the Lower Tana significantly reduced by 34.5% ($P < 0.001$) over a 21-year period. Forest loss was greater outside the reserve (38%) than inside (29.2%) reiterating the significant role played by this protected area in habitat and species conservation. Continued forest loss increases extinction risks for the endemic primate species the Tana River Red Colobus (*Procolobus rufomitratus*) and the Crested Mangabey sub-species (*Cercocebus galeritus galeritus*). Initiation of community conservation programmes outside the reserve and introduction of sustainable micro-economic projects were recommended to enhance sustainable livelihoods and the environment.

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Introduction

There are major concerns towards the loss of biodiversity, particularly in tropical forests around the equator where these hotspots are concentrated (Myers et al. 2000; Beck et al. 2002). Deforestation of tropical forests not only jeopardizes biological diversity but also climate systems of the world (Myers 1989; Schwartzman et al. 2000). In addition to high species diversity and endemism, tropical forests are also home to rural communities in need of economic sustainability. Conservation of tropical forest is thus one of the greatest human challenges involving a delicate balance between complex-fragile ecosystems, and impoverished populations. Consequently, shifting cultivation remains the biggest threat to tropical forests (Myers 1987) and has exacerbated the natural fragmentation of landscapes affecting whole ecosystems and biotas (Bender et al. 1998).

The lower Tana riverine forests are unique because they support a high diversity of plants and animals species that exist in a semi-arid environment, which has an annual rainfall of ≤400 mm and show floristic similarities to the western and coastal evergreen forests (Marsh 1976). Of great importance, they provide remaining habitats for two endangered primates: (1) the Tana River Red Colobus (*Procolobus rufomitratus*), and (2) the Tana River Crested Mangabey (*Cercocebus galeritus galeritus*). Five other primate species are among faunal and flora taxa represented here (Suleman et al. 2001). This ecosystem is, however, under severe threat due to intense shifting cultivation practiced by the Pokomo people. These forests have been subjected to increasing destruction of forest cover due to clear cutting, burning and slashing mainly for agriculture as well as forest deterioration due to harvesting and utilization of different forest products (Decker 1994; Medley 1993).Currently, the ecosystem is highly fragmented and exists as isolated patches of various sizes (Karere et al. 2004). One of the direct effects of forest loss since the 1960s has been the notable decline in the two endangered primate populations (Marsh 1986; Homewood 1975; Decker 1994). As a management measure, a 169 km^2 area—the Tana River Primate National Reserve (TRPNR)—was set up in 1976 to protect the two endangered primates species (Marsh 1976). Conservation of these primates and their habitat has since been of high priority nationally and internationally (IUCN 1996).

Aside from the human effects, natural impacts have also had an enormous role in influencing the conditions of the forest here due to dependence on the river seepage for tree survival. The Tana riverine forest ecosystem is highly dynamic being maintained by a balance between forest patches dying off and regeneration driven by regular natural shifts in the course of the river. The Tana River has changed its course several times (Andrews et al. 1975; Butynski and Mwangi 1994a). This is evident by the presence of old river channels, ox-bow lakes and remnant forests around the flood plain due to seasonal flooding regimes (Hughes 1984). According to Hughes (1990), it is evident that the forest patches are ground water dependent and the frequency and duration of flooding of the Tana flood plain affects the distribution and composition of the forests along the lower Tana region. This dynamic nature of the Tana River has consequently led to drying of trees due to either lack of water (natural die-back) or flooding.

We examined the impacts of human activities and natural causes on forest patches in and out of the TRPNR. Herein, we discuss the implication of these impacts on conservation and management of the red colobus and crested mangabey and their habitat.

Methods

Study site

There are currently more than 80 forests distributed in scattered patches on both side of the Tana River varying in sizes along the lower Tana Region (Butynski and Mwangi 1994). The TRPNR, contains 27 of these forest patches, and straddles the lower Tana River and is located entirely within the lower Tana River flood plain (1°50′ S, 40°10′ E) (Fig. 1). The TRPNR, has only 9.5 km^2 out of its total area under forest cover (Medley 1990) and the rest of the reserve is covered by shrubs and grass. The Tana Delta Irrigation project (TDIP), situated south of the reserve is a large rice irrigation project administered by the Tana and Athi River Development Authority (TARDA) and is located at the northern end of the Tana Delta near Garsen (Fig. 1). The plan of the project is to eventually encompass 160 km^2 and currently covers areas that include 21 of the riverine forest patches in the Lower Tana Region. Despite the low human density in the Tana district, there are pockets of high human population concentrating along the Lower Tana River. The Pokomo are the dominant tribe along the River (Kenya Wildlife Service 1996) and are sedentary agriculturists who cultivate land within the flood plain. They practice flood recession and riverbank farming around the along the Tana River, which provides the only source of land in the region that is suitable for arable agriculture because this farming system depends both on floodwater to irrigate their crops, and on the depositions of fertile sediments that the floods bring (IUCN 2003). This form of shifting cultivation along the Lower Tana River, unlike other cultivation systems in tropical wet environments, is largely dictated by the availability of floods, where establishments of farms and their permanence are dictated by soil fertility. The Orma, Somali and Wardei are exclusively pastrolists and make use of in the dry semi-arid areas above the flood plain.

Data collection

Human and natural impact

Data was collected on human and natural impacts while concurrently conducting a primate census between January 2001 and March 2001. The forest fragments that were surveyed varied in size from approximately 500 ha to less than 2 ha. A pre-orientation workshop was held in which all participants familiarized themselves with data collecting techniques and in order to minimize inter-observer variations (Suleman et al. 2001; Karere et al. 2004). The evaluating team was divided into several observer groups consisting of two members each. The name of the forest, reference number, date and names of observers were entered onto the data sheets.

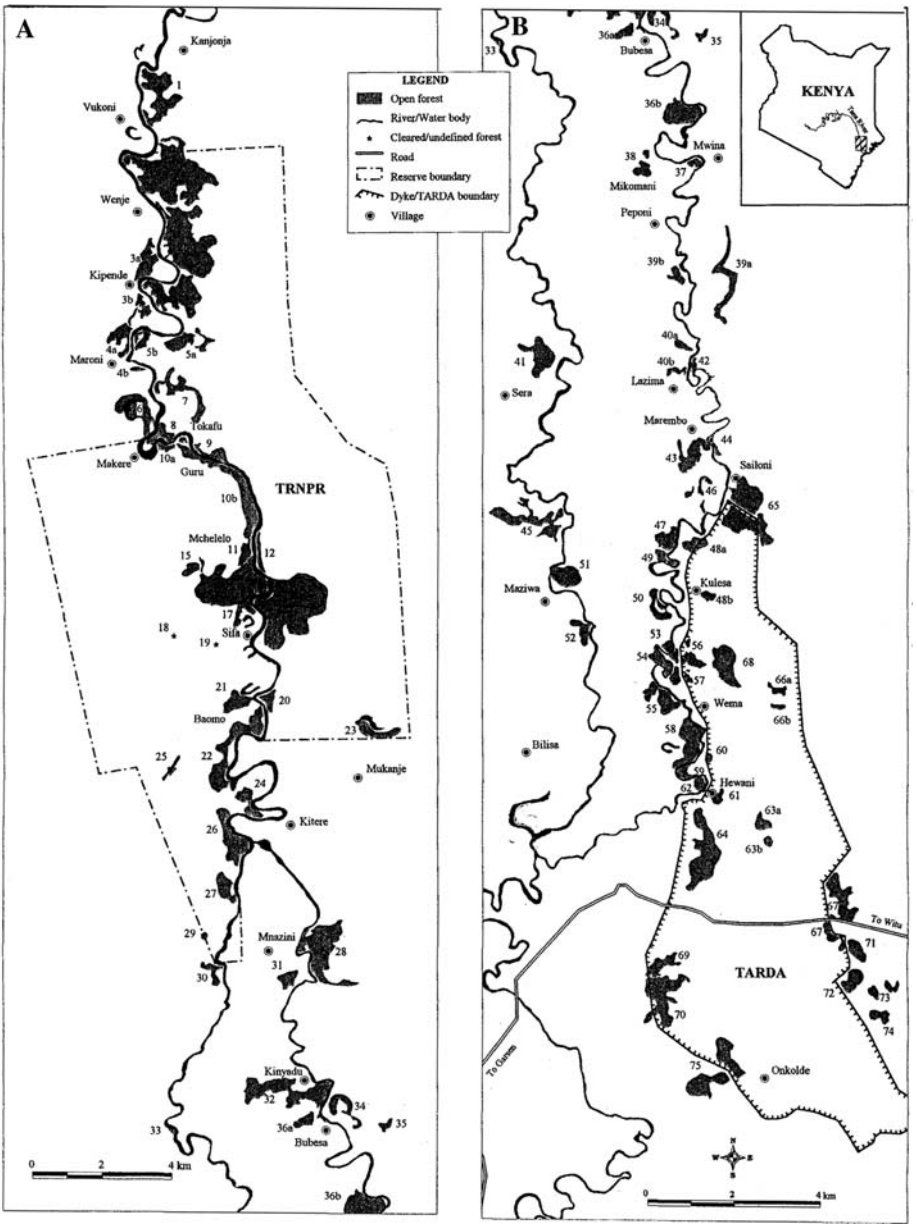

Fig. 1 Distribution of forest patches along the Lower Tana River from Nkanjonja to Onkolde

The observer groups walked parallel to each other (approximately 50–100 m apart, depending on the shape and size of the forest) along pre-determined routes in the forest with the aid of compasses. The observers identified and examined human activities, natural impacts and their frequency of occurrence. Human activities and natural impacts were categorized as follows:

(1) Resource utilization is defined as human practices that do not necessarily result in partial/complete forest cover removal but resulted into deterioration of forest stature. These activities included:

Tree harvesting, which included cutting plant parts for various human utilizations such as thatching, wine tapping, constructions of animal traps and sometimes firewood collection. Thatching and wine tapping involved the chopping off the crowns of trees and tapping of the sap, respectively. Animal trapping involved the use of snares. Firewood collection involved gathering dried twigs and to a lesser extent cutting young stems and branches.

Honey harvesting, which involved digging a hole on a tree stem where bees had a natural hive or cutting the whole tree to harvest the honey.

Logging, which includes cutting trees for construction of canoes, beehives, furniture, building materials and charcoal burning. Charcoal burning involved burning of felled logs under earth mounds from various tree species.

(2) Land use practices are defined as human activities that resulted to partial or complete removal of forest canopy cover. These were identified as follows:

Cultivation entailed the complete or partial clearances of areas of forest for agriculture through slash and burn techniques, which affected all species. This practice sometimes also causes fragmentation of the affected forest patch.

Dyke construction for rice irrigation by the Tana Athi Development Agency (TARDA) which generally destroyed natural vegetation across 50–60 m wide swaths resulting in losses of forest area and further fragmentation of affected forest patches.

(3) Natural Impacts are as a result of excess flooding and natural die back resulting in progressive degradation of forest structure and biodiversity and eventual loss of forest cover. Indicators of natural impacts included:

Excess flooding made evident by swampy forest conditions caused by very heavy rain such as the El Ninõ Southern Oscillation (ENSO) that occurred in 1998, causing the river water to overflow its banks and the excess water remains stagnant for a long period of time in the adjacent forests. This caused the tree roots to suffocate due to lack of aeration and consequently resulted to senescence.

Natural dieback made evident by the drying up of canopy trees and fallen trees due to river dynamism resulting to insufficient ground water seepage to forest adjacent to old river courses.

Forest status

Data obtained from human and natural impact evaluation was used to provide overall assessment of the status of forests surveyed. Each observer group recorded levels of forest disturbance, based on the frequency and effects of human activities and natural impacts on a forest. Disturbance levels were categorized as detailed by Muoria et al. (2002) from level 1 to 4 as follows:

Level 1: Little or no destruction. More specifically little or no human resources utilization and no land use practices and natural impacts observed. Otherwise forest could be pristine.

Level 2: Moderate destruction. Human resource utilization are being observed at a higher frequency as compared to level 1 but less frequently observed than in level 3.

Level 3: Extensive human disturbances and natural impacts. Higher frequency of resource utilization, partial clearing of forest cover due to difference land use impacts such as cultivation and dykes or complete or partial flooding or dieback resulting to overall degradation of forest structure and biodiversity.

Level 4: The highest scale of destruction where larger portions or all of the forest area had been cleared. Clearing of all or large portion of forest area for cultivation or the combinative impact of cultivation and natural dieback or cultivation and flooding resulting to high portions or complete loss of forest area.

Observer groups derived the overall disturbance level in each forest from the average of the disturbance indices recorded. Therefore, the disturbance level that was assigned to each forest was an overall qualitative and accumulated assessment of all human activities and/or natural impacts indicators that had been observed.

Changes in forests sizes

Satellite imagery for the year 2000 and 1979 topographic maps of the study area were used as sources of land cover information and were digitized using MapInfo Version 5.5 (MapInfo Corporation 1985–1999) to obtain forest sizes. Differences in forest sizes between the 2 years were used to determine changes in size of the forests.

Results

Anthropogenic activities in the forest patches along the Tana River

The main human activities observed were logging, tree harvesting and cultivation (Table 1).

Logging was observed in 69 forests and accounted for 39% of human activities, tree harvesting in 45 (25%), and cultivation in 43 (24%). Honey harvesting and dyke constructions were observed in 16 (9%) and 6 (3%) forests visited, respectively. Where observed, cultivation and dyke construction had the most devastating effects on forest cover due to partial or complete vegetation clearance. The most affected species due to tree harvesting were *Borassus aethiopuim*, *Phoenix reclinata* and *Hyphaene compressa*. While the most preferred tree species for construction of canoes and beehives were *Diospyros kabuyeana, Ficus sycomorus, Mimusops fruticosa* and *Mangifera indica*. Bee keeping appeared more sustainable than honey harvesting because although the hives are constructed from a felled tree, the hive can be used for a long period of time while harvesting of honey from standing natural tree hives looked very destructive. Furniture was constructed from *Spyrostachys venenifera*, while building materials were obtained largely from *Phoenix reclinata*.

Table 1 Frequencies and proportional occurrence of categorized human activities in 73 forest patches along the Lower Tana River basin

Activities	Frequency	%
Logging	69	39
Tree harvesting	45	25
Cultivation	43	24
Honey harvesting	16	9
Dyke construction	6	3
Total	179	100

Eight forest patches, severely impacted by cultivation alone were Nkanjonja (no. 1), Wenje Complex (nos. 2a–c), Baomo East (no. 20), Baomo North (no. 21), Baomo South (no. 22), Lazima East (no. 42), Hewani East 1 (no. 59) and Hewani West 2 (no. 2) (Fig. 1). Four forests affected by dyke construction alone were Kulesa East 1 (no. 48a), Wema East 1 (no. 56), Hewani East 2 (no. 60) and Mitapan 2 (no. 70) (Fig. 1). Three forests, Hewani East 1, Hewani East 3 and Hewani West 2 (numbers 59, 61 and 62, respectively) were heavily impacted by human activities and yet satellite imagery indicated an increase in area by 8.2% to 161 ha.

Excess flooding in forest patches along the Tana River

Six forest patches affected by excess flooding included Kipendi 1 (3a), Kipendi 2 (3b), Maroni West 1 (4a) and Maroni West 2 (4b), and are all along channel 2, the current river course (Fig. 1).

Natural die back in forest patches along the lower Tana River

Along the old river channel (channel 1), only one forest patch, Maziwa North (forest no. 51), was affected by natural die back (Fig. 1). Four other forest patches affected by dieback are near the current river channel (Fig. 1). They include Wema East 4 (no. 68), Hewani South 1a (no. 63a), Hewani South 2 (no. 64) and Bvumbwe South 2 (no. 66b) (Fig. 1).

Forests impacted by both natural impacts and human activities along the lower Tana River

Forests impacted by both natural dieback and cultivation were Matalani South (no. 33), Sera (no. 41), Giritu woodlands (no. 45) and Maziwa South (no. 52) (Fig. 1). Flooding and cultivation impacted only Maroni East 1 (5a) and Maroni East 2 (no. 5b) (Fig. 1). Two forest patches impacted by both dieback and dyke constructions were Bvumbwe North (no. 65) and Lango La Simba (67a) (Fig. 1).

Forest status

Out of the 73 forest fragments evaluated, 28 had little or no disturbance while 21 were heavily disturbed. Of the heavily impacted forests, six were in the reserve and 15 outside the protected area (Table 2).

Causes of forest area loss in forest patches along the Tana River

Natural dieback alone impacted on Maziwa North (no. 51) and Hewani South 1a (no. 63a) resulting to area loss of 28.9% and 22.4%, respectively (Table 3). Of the forest patches impacted by flooding alone, Maroni West 2 (no. 24b) and Kipendi 2 (no. 3b) had the highest habitat loss of 85% and 57.1%, respectively (Table 2). Baomo East (no. 20) and Nkanjonja (no. 1) forests were most affected through cultivation with losses of 80.7% and 50.1%, respectively. Construction of irrigation dykes greatly impacted on Kulesa East 1 (no. 48a) resulting in loss of 71.7% of forested area (Table 3).

Table 2 Intensity of destruction of forests and their current areas in and out of the Tana River National Primate Reserve using a scale of 1–4

Destruction levels	Forests in reserve			Forests out of reserve		
	Numbers	Area (ha)	%	Numbers	Area (ha)	%
1	6	469.1	35	22	744.1	27
2	5	486.8	29	12	421.4	21
3	0	0.0	0	7	362.3	13
4	6	595.0	35	15	509.1	39
Total	17	1550.9	100	56	2036.9	100

Scale 1, little or no destruction; scale 2, moderate levels of destruction; scale 3, extensive human destruction with no section of forest completely cleared; scale 4, highest levels of destruction with sections of the forest completely cleared

Four forest patches were affected by a combination of cultivation and natural diebacks. Matalani South (no. 33), Sera (no. 41), Giritu woodlands (no. 52) and Maziwa South (no. 45) forests had area loss of 99, 75.8, 71.1, and 46.8%, respectively (Table 3). Maroni East 1 (no. 5a) and Maroni East 2 (no. 5b) were affected by both cultivation and flooding resulting to a total forest area loss of 50% each (Table 3).

Table 3 Changes in forest sizes and their respective causes in the lower Tana River between 1979 and 2000

Forest patch	No.	Area (ha)		Change in area (%)	Factors leading to loss of area			
		1979	2000		Cult.	Dyke	D/back	Flooding
Nkanjonja	1	168.8	84.2	50.1	+			
Wenje complex	2a–c	683.6	534	21.9	+			
Kipendi 1	3a	55.9	37.4	33.1				+
Kipendi 2	3b	34.5	14.8	57.1				+
Maroni West 1	4a	69.1	30.9	55.3				+
Maroni West 2	4b	27.4	4.1	85.0				+
Maroni East 1,2	5a–b	133.6	54.3	59.4	+			+
Baomo East	20	73.7	14.2	80.7	+			
Baomo North	21	46.1	30.2	34.5	+			
Baomo South	22	261.4	99	62.1	+			
Matalani South	33	240.3	2.3	99.0	+		+	
Sera	41	204.1	59	71.1	+		+	
Lazima East	42	15.5	8.9	42.6	+			
Giritu	45	327.5	79.2	75.8	+		+	
Kulesa East 1	48a	68.1	19.3	71.7		+		
Maziwa North	51	61.2	43.5	28.9			+	
Maziwa South	52	40	21.3	46.8	+		+	
Wema East 1	56	30	28.1	6.3		+		
Hewani East 2	60	7.9	4.2	46.7		+		
Hewani South 1	63a	20.1	15.6	22.4			+	
Bvumbe North	65	260.6	136.5	47.6		+	+	
Lango la Simba	67a	86.4	79.2	8.3		+	+	
Mitapani 2	70	105.3	76.7	27.2		+		
Total		3021.1	1476.9	48.9				

Four factors driving change were identified as cultivation (cult.), dyke construction (dyke), natural dieback (D/back) or flooding. Forests affected by the various factors are specifically indicated by a positive (+) sign

Overall forest area reduced significantly from 5,439 ha to 3,564 ha ($t = 3.807$, $n = 76$, $P < 0.001$) accounting for a 34% decrease between 1979 and 2000 (Table 4). The loss of forest area outside the reserve was 38% from 3,283 ha to 2,037 ha ($t = 2.929$; $n = 57$; $P < 0.005$) and 28.1% from 2,156 ha to 1,551 ha ($t = 2.522$; $n = 21$; $P < 0.02$) in the protected area (Table 4).

Discussion

Human activities and natural impacts on the riverine forests along the lower Tana River region

Our study has shown that through shifting cultivation, dyke constructions, flooding and dieback, human activities, and natural impacts have had a devastating effect on the status of the lower Tana riverine forests leading to loss and increased fragmentation of unique habitats. Anthropogenic activities in the forests persist in the form of slash-burn agriculture, selective logging and several other deleterious uses of forests (Table 1). The resultant change in forest structure, especially removal of large canopy tree species, is of great concern in the conservation of the endangered primates, the Tana red colobus (*Procolobus rufomitratus*) and the Tana crested Mangabey (*Cercocebus galeritus galeritus*). Both species are dependent on gallery forests for food and sleeping groves (Homewood 1976; Marsh 1981; Wahungu 1998; Suleman et al. 2001). Shifting cultivation combined with some natural impacts contributed to a total loss of 1,208 ha or 78.2% of affected forests that were ground ''truthed.'' Dyke construction resulted to a total loss of 210.6 ha or 13.6% of the affected forests that were ground ''truthed.'' The most impacted forest, Matalani south (no. 33), was affected by both cultivation and natural dieback with loss of 99% of area and only 2.3 ha is left standing from 240.3 ha in 1979. Hewani East 1 (59), Hewani West 2 (62) and Hewani East 3 (61) forest patches are reflected on satellite images as indigenous forest patches but upon ground ''truthing'' it became evident that these patches have mostly been cleared for cultivation and have been replaced by exotic tree species. These three examples provide evidence of the importance of ground ''truthing'' instead of only using satellite imagery to determine the true status of forests in affected areas.

Our study recorded a loss of 34.5% of total forest area between 1979 and 2000 (Table 4). The loss outside the Tana River National Primate Reserve (1,246 ha) was significantly ($P < 0.005$, $t = 2.929$) larger than loss within the reserve (629 ha) reiterating the significant role played by this protected area in habitat and species

Table 4 Comparison of forest area reduction in and out of the reserve and overall forest area reduction along the Lower Tana River between 1979 and 2000

Location	Number of forests inspected	Area (ha)			% change	
		1979	2000	Loss of area (ha)		
Reserve	21	2156	1527	629	29.2	$P < 0.020$
Outside	57	3283	2037	1246	38.0	$P < 0.005$
Total	76	5439	3564	1875	34.5	$P < 0.001$

conservation. The loss of 29.2% of forest area within the protected area in 21 years is nonetheless of major concern and suggests a loss rate of 29 ha per year. With only 1,527 ha of forest remaining within this reserve, these habitats constitute a biodiversity in risk of extinction within approximately the next five decades. The rate of loss of forest habitats outside the reserve, at 59 ha per year, is twice that of the protected area and the remaining 2,037 ha may disappear in approximately in three and a half decades unless urgent conservation programmes are put in place. Twenty-eight forest patches have experienced the highest levels of destruction (Level 3 & 4) (Table 2). This has accounted for 1,348 ha of forest loss and has, of consequence, severely impacted primate habitats. This equals a loss of 24.8% from the total forested area that existed in 1979 and should be the focus of immediate conservation effort.

The impact of flooding and natural dieback on the forests in the lower Tana River region is enormous. Changes caused by both dieback and flooding in the Lower Tana riverine forests do not necessary immediately remove forest cover, instead they are more likely to cause progressive degradation of forest structure and biodiversity. In the long-term, this progressive degradation leads to partial or complete loss of forest cover. Thus, these impacts share the quality of being difficult to perceive by satellite imagery and are difficult to evaluate without monitoring by ground truthing (Dale et al. 1994). It would be important to note that a forests like Hewani South 2 and Wema East 4 (forest nos. 64 and 68, respectively) where natural dieback occurred, appear to have increased, while in reality the interior of the forest have been affected by tree dieback.

One important aspect that was not evaluated during this study was the loss of mature forest due to bank erosion. This type of evaluation would necessitate long-term monitoring of these potential sites, which was beyond the scope of this research study. Future studies should incorporate the impact of bank erosion and evaluating its role as a natural impact on the forests.

As a whole, the combinative impact of cultivation and natural dieback or cultivation and flooding has resulted in the highest percentage forest area loss in the Lower Tana Region. Both human and natural impacts are responsible for changes in forest cover and forest stature. As this study has indicated, areas that have experienced significant area loss due to the Tana River dynamism could be significantly related to changes in human activities, which further complicates current and potential conservation and management strategies in and out of the reserve.

Effects of forest degradation, destruction and fragmentation on the endangered primate population along the Lower Tana Region

Human exploitation of forest resources can involve rapid, non-sustainable harvesting of particular species (Gentry and Vásquez 1988) while flooding and natural dieback can result in a progressive degradation of forest structure and biodiversity that leaves behind standing but biologically and economically depleted forests. The riverine habitats on the lower Tana River are highly vulnerable to perturbations due to the Tana River dynamism and the continual human overexploitation. An ever-increasing human population continually exacerbates this problem. Many of the tree species that are important to the endangered primates are also vital to the local communities for construction of canoes, poles and other wood products (Marsh 1981; Medley 1990; Kahumbu 1992). This competition for diminishing resources is likely to result

in a reduction in the carrying capacity for the endangered primates in the lower Tana region riverine forests (Kahumbu and Davies 1993).

According to the recent primate census (Karere et al. 2004), about 50% of both the red colobus and the crested mangabeys were found outside the protected area. The riverine forests within the protected area represents only 24% of the forest ecosystem and may thus be inadequate to provide resources to stem the current decline in endangered primate populations. However, the importance of the unprotected forest patches situated outside the reserve for the survival of both endangered primate species cannot be overemphasized. The survival of these species depends on the future management and conservation of the majority of forest patches that are situated out of the reserve. The fact that the greatest area of forest loss was outside the reserve implies the immediate need to initiate conservation programmes outside the protected area. That the Tana red colobus, over the last 7 years, have experienced a 15% loss in population outside the reserve (Suleman et al. 2001; Karere et al. 2004) exemplifies these urgent needs. Previous studies conducted in the lower Tana have shown the impact of forest destruction on the red colobus (Marsh 1978; Decker 1989; Mbora and Meikle 2004) and the crested mangabey (Kinnaird 1990; Homewood 1975) populations. Forest destruction can result in declining primate populations (Myers 1987; Gillespie et al. 1999) and in extreme situations, extinction (Yongzu et al. 1989; Boinski 1994). Since these forest patches do not fall under the management of the organization that manages the parks and reserves in Kenya, i.e., Kenya Wildlife Service (KWS), management and conservation strategies should directly involve the participation of the local communities.

A prominent issue that should seriously be addressed in the Lower Tana region is the effect of forest fragmentation on the two endangered primate species because primates have specific responses to fragmentation making them valuable candidates for examining its effect (Estrada and Coates-Estrada 1996; Tutin et al. 1997). Forest fragmentation not only isolates floral and faunal population but it also impedes gene flow between forest patches (Marsh et al. 1987). A study that was conducted on the effect of fragmentation on the Tana river red colobus (Mbora and Miekle 2004) suggests that this primate species may prefer more disturbed forests. However, according to Suleman et al. (2001), the number of primate groups in any given forest along the Tana River was significantly correlated with forest area; suggesting that both endangered primate species along at the Lower Tana region are prone to forest loss and fragmentation. Many primate studies at the Lower Tana region appear to focus on the impact of human activities on these endangered species. This study demonstrates that the effects of natural impacts are just as important, and therefore, future studies should not only examine the long-term effects natural impacts on the endangered primate species, but also study the combinative effects of both natural and human impacts on these species.

Conservation of the riverine forests in the Lower Tana region and the local communities

According to Butynski and Mwangi (1994b), local people living, in the vicinity of the Tana riverine forests are aware of the direct benefits they receive from the remaining forests. The Pokomo, have traditional laws and norms governing land use that determine who can clear land for cultivation and how much may be cleared (CARE-International-Kenya 1992) known as the ''Wakijo'' (Bunger 1979; Decker 1989). It is

not known, however, to what extent these laws actively protect the forest resources or control exploitation. Decker (1989) explains that the traditional forest management was conservative and proposed that their indifference towards forest degradation is more recent phenomenon caused by the displacement of the traditional management by the current protectionist management of the TRPNR. This was an observation that continued to be noted during the duration of this study. The extent to how far these traditional conservation laws are still practiced and their potential effectiveness on the sustainability of the existing forest patches should be examined to reinforce the present management strategies. This type of information is vital to provide guidelines that would assist in strengthening the already existing efforts, if any, of the local communities. The importance of the local communities' full participation in actively and sustainably managing these forest patches is the only way these remaining forests can continue to persist as well as sustain their rich biodiversity.

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