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PARTICIPATORY ECOLOGICAL ASSESSMENT OF KIRISIA FOREST RESERVE, SAMBURU, KENYA

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Summary

The dry upland evergreen Kirisia State forest in Samburu District, northern Kenya, plays a critical role in the livelihoods of the local people. Prior to this study, no detailed assessment has been conducted to understand the forest-man-wildlife tandem required to develop sustainable conservation options. This ecological study was undertaken in November-December 2005 to generate information necessary to come up with a sustainable forest management framework, enhance environmental services such as biodiversity conser vation and promote sustainable forest use to improve livelihoods of adjacent communities. Stratified forest sampling, with four blocks, 122 0.02-ha-plots along 32 transects was used to capture forest structure, composition, diversity, regeneration, threats and wildlife. The forest is rich in tree species but only Croton megalocarpus, Juniperus procera, Olea europaea ssp africana, Olea capensis ssp hotchestetteri and Podocarpus falcatus dominate the forest canopy. The forest structure is not stable due to poor regeneration of dominant species that are exposed to a variety of damages. Anthropogenic activities were found to be among the major threats to ecological stability of the forest. Generally, the forest has great potential to support ecotourism and other nature-based enterprises which would improve conservation and sustain people's livelihoods. This study identified key issues to be emphasized in the management of Kirisia forest: participatory approach, sustainable biodiversity conservation for ecotourism development, modern commercialisation of forest products, minimizing activities that degrade the forest as wildlife habitat and catchment, forest regeneration and rehabilitation, promotion of tree planting on private land (especially community lands) in the Kirisia region, and a surveillance system to control upcoming threats.

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INTRODUCTION

Kirisia forest (78,000 ha) is a gazetted, state upland evergreen forest in the dry Samburu District, northern Kenya. Rural communities around the forest are mainly pastoralists whose livelihood highly depends on livestock. The forest is an important source of browse, grazing land and water particularly during drought. Residents of Maralal Township and adjoining human settlements depend on Kirisia forest as source of charcoal, fuelwood, timber, post and poles and a variety of non-wood forest products such as honey. The forest provides important environmental services within the region e.g. as source of rivers and as a critical habitat for rich wildlife. Most of the human activities within the Kirisia forest are not licensed; it is difficult to know the extent to which forest-based resources are over-exploited or underexploited. The Government has employed forest guards to man the Kirisia forest. However, the capacity of the Government alone to conserve the Kirisia forest proved limited and non-effective. African Wildlife Foundation (AWF) has now initiated the process of developing a participatory forest management plan and improving livelihood of people in region. AWF supports wildlife conservation initiatives both within and outside protected areas. Pursuant to its objectives, AWF has sponsored studies on Kirisia forest include broad forest assessment (Watai and Gachathi, 2003), bee-keeping potential in the area (MKK, 2005) and the development of tourism strategy for Samburu District in 2007 (Ikua & Sommerlatte, 2007). The present detailed study is an ecological characterization of Kirisia Forest Reserve which is critical to subsequent development of management plans for the forest itself and for community-based natural resource management in group ranches around the Kirisia reserve. This paper contains baseline data and information to be used to develop a participatory forest management framework, enhance sustainable forest use and improve local people's livelihoods.

Study Context and Objectives

Conservation is becoming a commercially attractive land use option that can provide space for wildlife while improving the livelihood of local people. For this reason, African Wildlife Foundation (AWF) has initiated many activities in the Samburu Heartland in Kenya such as improving the management of Kirisia Forest, developing bee keeping enterprises around the Kirisia forest, supporting natural resource management practices in community conservancies, promoting predator conservation, conducting conservation – related aerial surveys among others. The Kirisia forest ecosystem is important for biodiversity conservation because it serves as a key link in the elephant migration route from Samburu National Reserve to other habitats within the Samburu Heartland besides being of high diversity value in terms of indigenous trees, birds and many other wildlife species. It is also main source of essential goods and services for the surrounding communities (Watai and Gachathi, 2003). However, abundant wildlife and high level dependence of Samburu people on Kirisia forest may reduce the carrying capacity of the forest and degrade this vital ecosystem if no adequate management measures are put in place. It is against this background that AWF sponsored in-depth participatory ecological and socioeconomic surveys in order to better understand the biodiversity value, the challenges facing this ecosystem's integrity and its role in supporting livelihoods of adjacent communities. It was anticipated that findings would be used to craft suitable management options such as participatory forest management that involve the State and adjacent communities for sustainable conservation of the Kirisia forest system and its functions. It is now widely acknowledged that responsibilities, rights and authority over natural resources hitherto held by the centralised state, must be devolved to local communities if conservation is to be successful.

Participatory forest management (PFM) is legally entrenched in the Kenya Forest Act 2005 (GOK, 2005). It involves all stakeholders, particularly the government and organized local communities in the sustainable conservation of the resources with some arrangements on benefits-sharing as authorized under the provisions of the Forests Act 2005, Section IV. In order to participate, local communities must organize themselves into Community Forest Associations (CFAs). The user rights of the forest by the registered CFAs include extraction of non-wood products, ecotourism and recreational activities and development of community wood and non-wood forest based industries provided that none of the activities conflicts with the conservation of biodiversity (Article 47). Participatory forest management plan is a prerequisite in this form of forest resource governance. The plan must be based on sound knowledge of ecological details and socioeconomic realities on the ground. Such information is best derived from data collected through participatory forest assessment techniques which integrate both local knowledge (ethnobotany, knowledge on wildlife, and human-forest interactions) and scientific investigations using appropriate sampling techniques. Informal interviews (discussions) with field guides form part of this approach and provide some socioeconomic data about the resource and people depending on it.

To analyze forest ecosystems, several approaches are used to describe various components of forest structure and composition (Hitimana et al., 2004). Vertical structure of a forest includes its differentiation into layers between the ground and the canopy (Bourgeron, 1983) sometimes interspersed by gaps. Vertically, forests are stratified into vegetation layers of different heights and species occupying different canopy levels at maturity (Whittaker, 1975). The horizontal structure of a forest is composed of diameter size distribution of tree species considered individually or as a community (Davis and Johnson, 1987; Philip, 1994). Stocking (number of trees or basal area per unit area), reflects the spatial distribution of tree individuals within the forest and the distribution of different species in relation to one another (Whittaker, 1975; Krebs, 1989; Brower et al., 1990). Diameter size distributions are often used in management to manipulate forest stocking (Husch et al., 1982; Davis and Johnson, 1987; Dykstra et al., 1997). Generally, mixed uneven-aged tropical rain forests have diameter distributions representing all age classes in typical reversed-J shaped curve.

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[5]*African Heartland Programme is a landscape level approach to conservation that integrates both conservation and community development. Heartlands are biologically important areas, capable of maintaining healthy populations of wildlife and natural processes now and into the future. Heartland programme also encourages enterprise development to support the livelihoods of local people and to create incentives for sustainable land management. Samburu Heartland is one of the eight African heartlands rich in unique wildlife. It includes the wide Samburu ecosystem which is on the map of global biodiversity conservation and supports a myriad of wildlife species, including the increasingly endangered northern savannah specialists. Besides, this heartland is one of the few areas in Kenya where populations of wildlife species thrive outside of protected areas, thus offering an opportunity for community-based ecotourism development to bring financial returns to local residents and local authorities.*

The general model can however be modified by various environmental factors (Brunig, 1983; Denslow, 1995), e.g., biotic agents such as tree cutting, competition for resources, differences in topography or soils, irregular or seasonal climatic events. Hence, diameter distributions are commonly used to assess the disturbance effect within forests (Hett and Loucks, 1976; Davis and Johnson, 1987; Denslow, 1995) and to detect trends in regeneration patterns (Poorter et al., 1996). It can be used to gauge forest vitality with respect to stocking of different age or size classes (Rollet, 1994; Kiyiapi, 1998), and compare recruitment of different forests (Kigomo et al., 1990). Moreover, tree density distribution across different diameter classes indicates how well the growing forest is utilizing site resources. In addition, identification of most ecologically important species (Richards, 1981) is an important step towards proper ecological understanding of natural forests and for the development of sound management strategies, with respect to logging and rehabilitation programmes. This paper reports the findings of a study carried out to characterize the entire Kirisia Forest structure, composition, regeneration and disturbance to reveal the forest economic and ecological potential while identifying conservation challenges that need to be addressed when developing natural resource management plans for the forest and for adjacent group ranches. Field surveys were undertaken in October to December 2005.

Specific objectives of the in-depth ecological characterisation of Kirisia Forest Reserve were to:

- Identify and analyze key issues and/or problems affecting conservation of Kirisia.
- Determine factors influencing tree growth and vegetation types.
- Explore biological diversity of the reserve in terms of flora and fauna and its significance to forest conservation and to day-to-day livelihoods of human communities that interact with the Kirisia forest.

MATERIALS AND METHODS

Study Area

Samburu District (20,826 km2) in Kenya lies between 0°40'N-2°50'N, and 36°20'E-38°10'E. There are both gazetted and ungazetted forests in the District. Gazetted State forests that are managed by the Ministry of Environment and Natural Resources include Kirisia Forest also known as Leroghi (initially 92,000 ha but now 78,000 ha), Matthews Range (94,000 ha), Ndoto Mountains (97,000 ha) and Mt. Nyiro (46,000 ha). Ungazetted forests, mostly communal, are found on various group ranches where the land is held in Trust by the Samburu County Council. Their extent is unknown. Kirisia forest is located on the Leroghi Plateau, on the western side of Samburu District. The plateau was formed as a result of lava flow following volcanic activities during the formation of the Rift Valley. The highest points of the Samburu plateaus are Kirisia Hills. Kirisia forest is located at an altitude ranging from 2,000 m to 2,200 m above sea level, with mean annual rainfall of 600 mm to 750 mm at 1945 m a.s.l. and mean annual temperature of 24 oC to 33 oC (Jaetzold and Schmidt, 1983). Mean annual rainfall reaches 800 mm to 900 mm per year at the forest two highest points located towards both extremes of the ecosystem. There are three weak rainfall peaks in a year and two driest months (January and February).

Generally, soils are shallow and soil fertility in the forest is variable (Jaetzold and Schmidt, 1983). The middle slopes are covered with sandy clay loam (shallow to moderately deep, excessively drained, friable, rocky and stony). This soil type developed on undifferentiated basement system rocks, predominantly gneisses. The area around two summits of the forest landscape is dominated by a complex of well-drained, shallow, black to very dark brown, acid humic, very friable loam soils. Soils at the upper-level uplands are moderately deep and friable clay loam. The top soil is very thick and humic acid. Dominant top soil types in the sample plots were determined and reported in this paper.

General vegetation of the forest is described in Beentje (1990) as evergreen. Kirisia Forest is characterized by different vegetation associations, forming a mosaic of four layers. The top canopy is dominated by large tree species such as Juniperus procera, Nuxia congesta, Olea europaea ssp africana and Podocarpus falcatus on the hills. On wetter slopes Cassipourea malosana and Croton megalocarpus appear as co-dominant trees. The understorey tree species include Teclea nobilis, Maytenus undata, and Acokanthera schimperi and Mystroxylon aethiopicum. The forest vegetation is intersected by a mixture of open grassland areas, disturbed areas and rocky areas covered with Euclea divinorum, Carissa edulis, Rhus natalensis and Croton dichogamus small trees as well as shrubs.

In terms of management, the Kirisia State forest was gazetted in 1933. It is currently adjacent to thirteen group ranches out of a total of twenty found in the area (Figure 1). The day to day management of the forest is entrusted to a Forester and few Forest Guards, all under the supervision of the Samburu District Forest Officer. Most control and protection of the forest is enforced through Forest Protection Committees that were formed in group ranches. Like most natural forests in Kenya, Kirisia does not have a management plan. So far, no active management is going on. Instead, wanton exploitation of the forest is common through unauthorized tree cutting, charcoal production, cattle grazing, honey harvesting among others. Also, no investigation has so far determined the extent and impact of forest disturbance. It is important to understand the basic structure, composition and overall ecological health situation of the forest in order to get an insight in its potential to sustainably supply specific goods and services, identify and plan for needed urgent restorative interventions and ensure socially acceptable and ecologically sound and effective ecosystem management.

[6] *The communal land is divided into group ranches, shared by registered members who are allowed to graze or establish homes (manyattas) anywhere in the group ranch managed by the Group Ranch Committees.*

[7] *Ongata Nanyukie, Siambu, Upper Lpartuk, Loiting, Seketet, Lower Lpartuk, Sirata Oirobi, Malaso, Tinga, Losuk, Ledero, Lkiroriti, Mbaringon, Lolmolog, Longewan, Suguta, Logorate, Lodokejek, Kirimun, Monkeek*

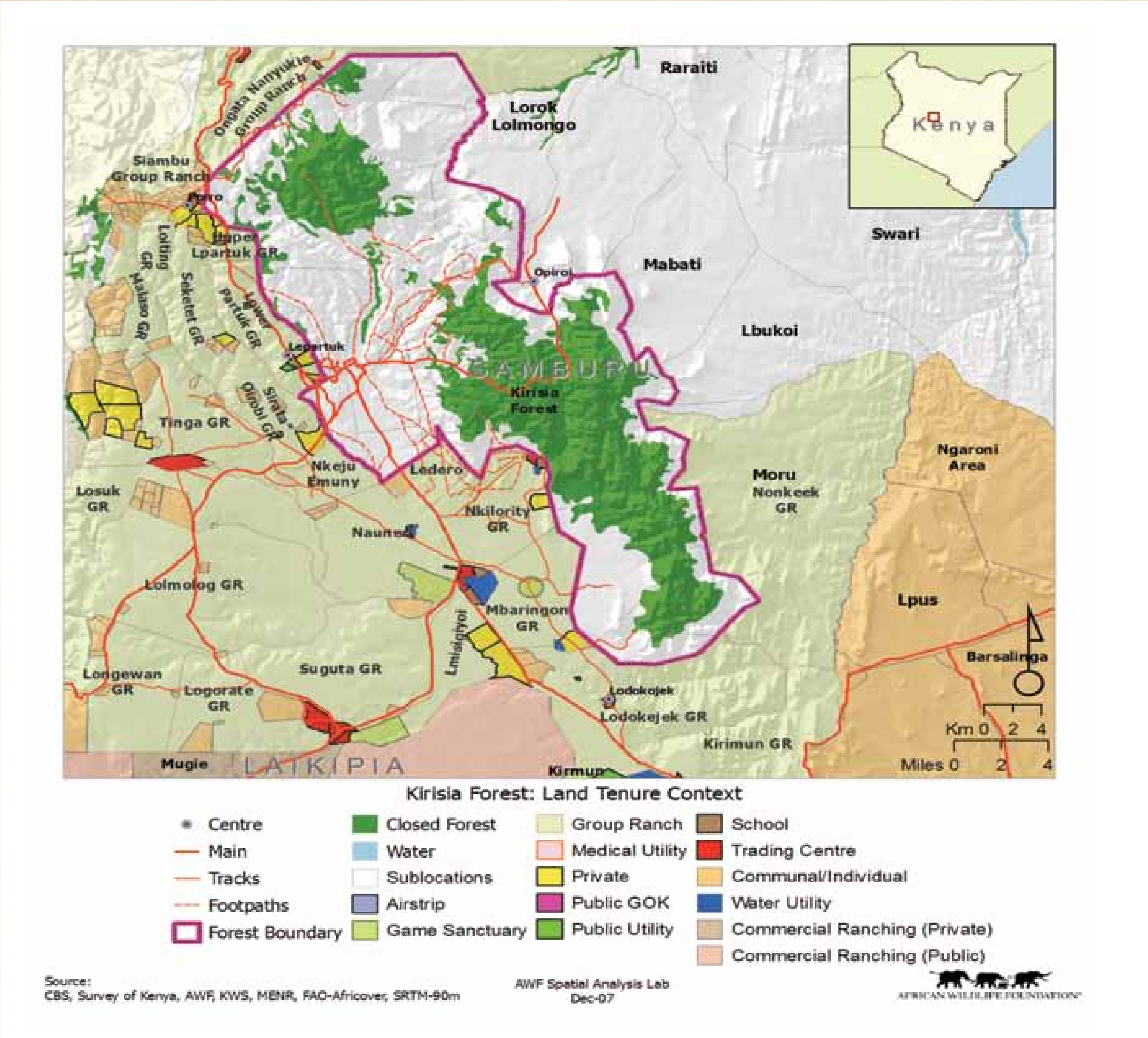

Figure 1: Land tenure context around the Kirisia Forest Reserve, Samburu Heartland

Field Procedures

Forest ecological assessment was achieved through stratified systematic sampling technique with random starting points. Thirteen entry points were identified from which three field teams started different transects heading into different directions (Figure 2). This arrangement of radial transects sought higher sampling intensity of the forest in areas close to human settlements (hypothesized to have greater human impacts). In addition radial transects starting from common points enabled easy coordination of field teams and optimum use of available transport resources.

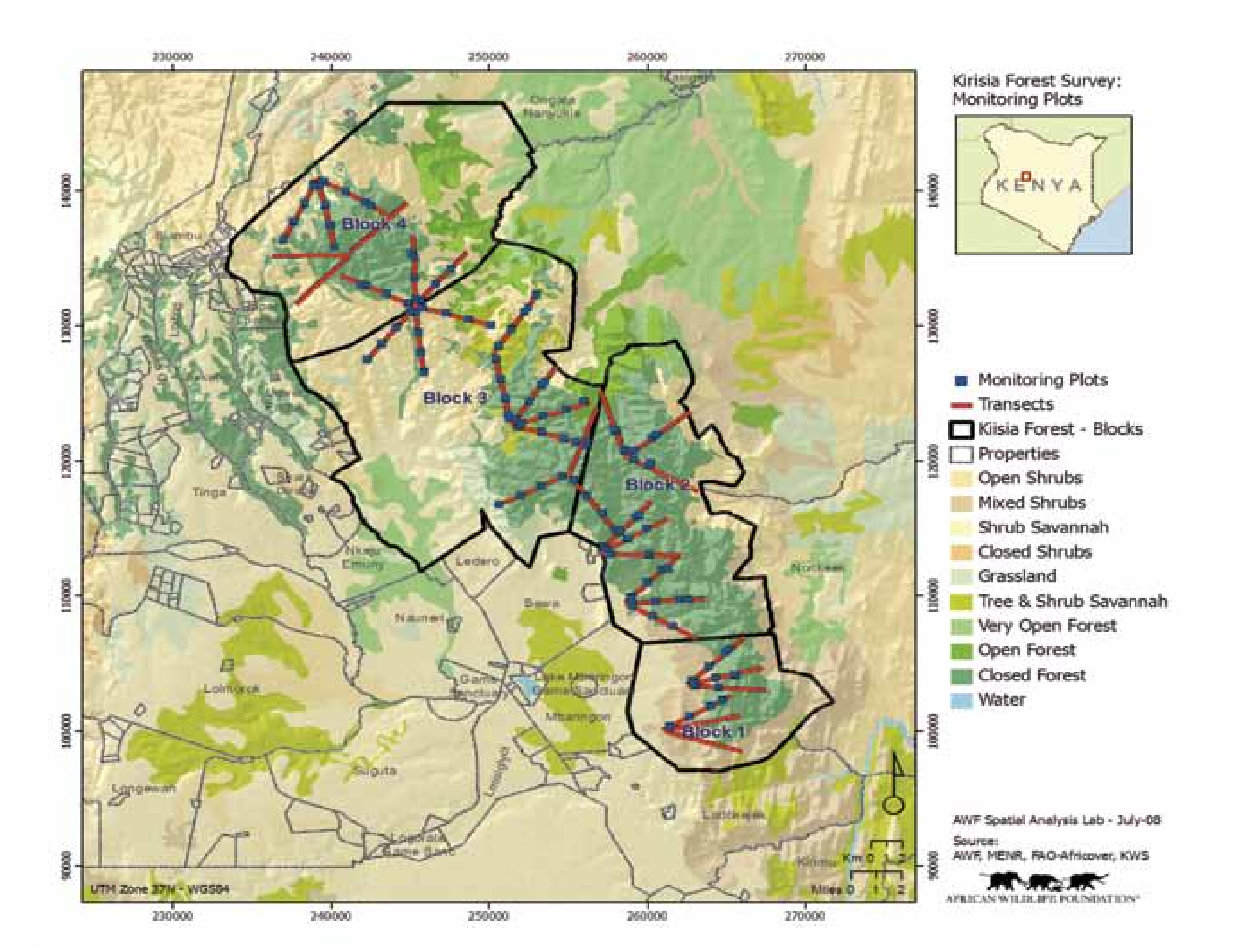

Figure 2: Distribution of belt transects and sampling plots within Kirisia Forest, 2005
Block IDs: Rapar (Block 1), Baawa (Block 2), Tamiyoi (Block 3) and Nkorika (Block 4)

During the assessment of Kirisia forest, we combined stratification, belt transects, line-plots and nested sampling techniques in one sampling strategy to ensure high level of unbiased results and to capture the multiple details of resources that were required for the general characterization of the ecosystem. The forest was divided into four blocks based on the vegetation types and proximity to settlements (Figure 2). Both the Geographic Information System referenced maps and local knowledge from resident foresters were used to divide up the forest into blocks. The four blocks were Baawa, Tamiyoi, Ltungai and Nkorika. Table 1 indicates pre-inventory descriptions of the blocks.

Blocks	Pre-inventory descriptions		
	Located in	*Vegetation*	*Human-forest interface*
Baawa	Loroki Division.	Dominated by broadleaved tree species mainly *Croton megalocarpus*.	Adjacent to few human settlements. Beekeeping and ecotourism are practiced in this part of the forest.
Tamiyoi	Kirisia Division, between Baawa and Olpiroi Dams.	Dominated by *Olea* spp and *Juniperus procera* tree species.	Closest block to Marallal Town and adjacent to high concentration of human settlement; Beekeeping and high number of livestock found in the forest.
Rapar	Kirisia Division	Open vegetation cover of grassland and shrubs intercepted by scattered trees of *Juniperus procera*.	Adjacent to high concentration of human settlements. High population of livestock is found in the forest.
Nkorika	Kirisia Division	Dominated by *Podocarpus* spp, *Juniperus procera* and *Olea africana*.	Adjacent to low concentration of human settlements; high number of livestock found in the forest.

Table 1: Pre-inventory description of different sample blocks

Block no.	*Block name*	*No. of Transects*	*No. of 0.02-ha plots*	*Sample area (ha)*			
				Seedlings	*Saplings*	*Small trees*	*Large trees*
1	Rapar	6	20	0.040	0.080	0.400	4.896
2	Baawa	10	38	0.076	0.152	0.760	8.998
3	Tamiyoi	10	39	0.078	0.156	0.780	8.798
4	Nkorika	6	25	0.050	0.100	0.500	5.590
Grand Total		**32**	**122**	**0.244**	**0.488**	**2.440**	**28.282**

Table 2: Distribution of transects, plots and sample area in Kirisia Forest Reserve, 2005.

Key: Seedlings (< 1m Height), saplings (≥ 1 m Height to < 10 cm DBH), small trees / pole-sized trees (≥ 10 cm to < 20 cm DBH), and large trees / timber-sized trees (DBH ≥ 20 cm). The transect identity (ID) are those found in Figure 2.

Direct observations of forest features were done in plots, along a total of 32 transects (up to 5 km) cutting across various forest sites and vegetation types. Supplementary information was collected from field guides based on informal interviews. The field guides were knowledgeable individuals, selected from and by the local community opinion leaders.

Forest Attributes Of Interest

a) Bio-physical environmental factors influencing tree growth and vegetation types: soil types, slope %, aspect, local topography (landform), and disturbance signs.

b) Floral data: local and scientific names of tree species categorized as timber-size, pole-size, saplings and seedlings.

c) Faunal data: wildlife corridors observed, types and distribution of animals identified through physical presence, remains, deposits, footprints, sounds based on experience of local guides

d) GPS coordinates of the assessment transects, inter-plots distances, location of plots and natural resources of interest such as rivers, water points, scenic sites etc

e) Extent of forest disturbance: number of felled trees, spatial frequency of fire incidence, types of tree damages, number of damaged trees and damaged tree species, signs of presence of charcoal production, cattle grazing, and any other form of forest utilization.

Data Capture and Management

Wildlife diversity and impact on the forest structure were assessed along side forest tree composition and diversity. Within each 0.02-ha-plot, sub-sampling was done in 40 m2 (20 m x 2 m) and 20 m2 (20 m x 1 m) plots to capture forest regeneration data for the sapling (≥ 1 m Height to < 10 cm DBH) and seedling (< 1m Height) stages, respectively. Small (pole-sized) trees (≥ 10 cm to < 20 cm DBH) were recorded over 0.02-ha-plots. Large (timber-sized) trees (DBH ≥ 20 cm), disturbance signs and wildlife data were surveyed in both the 0.02-ha-plots as well as in 2-m-width strips that linked consecutive plots. Table 2 summarizes sample sizes (in hectares) for the three tree development categories as defined above. Local guides helped to capture local names of various species types.

Different types of observations were grouped per transect and per block. Later, forest averages were computed. The bio-physical environmental factors influencing tree growth and vegetation types in general (soils, slope, local topography, and climate) were summarized for separate blocks. Forest disturbance signs were categorized, quantified and ranked within and between blocks. Kirisia forest ecosystem was also characterized in terms of tree species composition and species relative importance value, richness, vertical and horizontal structure. Tree species importance values (SIV) were computed as shown below. SIV were used to rank species within and between blocks.

a) Relative density (RD%) for species i:

$$RD\% = \frac{Density\ species\ i}{\sum Densties\ of\ all\ species} \times 100$$, where Density (N ha-1) = $Number\ of\ individuals / Area\ in\ ha$

b) Relative Frequency (RF%) for species i:

$$RF\ \% = \frac{Frequency\ species\ i}{\sum Frequncies\ of\ all\ species} \times 100$$

Where Frequency = $Number\ of\ sample\ units\ containing\ the\ species \Big/ All\ sample\ units\ assessed$

c) Relative Basal Area or Relative Dominance (RDo) % for species i:

$$RDo\ \% = \frac{Basal\ Area\ species\ i}{\sum Basal\ Area\ of\ all\ species} \times 100$$

d) Species Importance Value % = $\frac{(RF\% + RD\% + RD_0\%)}{3}$ (Clarke, 1986; Brower et al., 1990)

Species diversity indices (richness and Shannon-Wiever indices) were computed for sampled forest blocks per transects. Shannon-Wiever (H') was computed using the formula below.

$H' = -\sum[(n/N) * \ln(n/N)]$, where n is the number of trees for individual species, N total number of trees (all species combined).

Top canopy ecological groups of tree species were identified. Percent vegetation cover was determined for herbs, shrubs and tree canopy. Regeneration data were summarized for seedlings and saplings and regeneration potential was compared among tree species and among blocks. From recruitment trends of individual species from one development stage to another, we derived evidence of species shifts within different blocks. The population structure was graphically analyzed for the three most dominant tree species in each development category, namely seedling, sapling, pole size and timber size stages. Types, abundance and diversity of wild animals were synthesized and vegetation associations in different plots were described and matched with wildlife presence particularly for birds, herbivores, carnivores. Endemic forest bird species and human-wildlife conflicts were derived from informal interviews with local guides.

RESULTS

Physical Site Factors Influencing Tree Growth And Vegetation Types

The four Forest blocks (Rapar, Baawa, Tamiyoi and Nkorika) are less different in terms of landform and slope (Appendix A1), slightly differ in terms of soil types and soil drainage (Appendix A2) but are more clearly distinct in terms of altitude above sea level and geographic slope orientation, that is, aspect (Appendix A3). However, the composition of groups of blocks formed along altitude gradient changes along the aspect gradient.

Forest Stratification and Vegetation Cover

Vertically, height measurements revealed that the Kirisia forest top canopy could reach up to 42 m. However, this forest is characterized by a variety of vegetation cover. Different percentage cover for ground vegetation and tree canopy layers as well as dominant tree species in the top canopy characterize the forest as shown (Table 3). Rapar block was on average characterized by 28% herb cover, 25% shrub cover, 51 % tree canopy cover and average forest height of 14.5 m (maximum 32 m). Baawa block had on average 35%, 35% and 56% herb, shrub and tree canopy covers respectively, and top height of 20 m (maximum 42 m). Tamiyoi block was on average characterized by 33%, 38%, and 18 % herb, shrub and tree canopy covers respectively and a forest height of 19.3 m (maximum 42 m). Nkorika block had on average 36%, 50% and 30% herb, shrub and tree canopy covers respectively and top height of 19.0 m (maximum 31 m).

	Sub-block	**Herb cover**	**Shrub cover**	**Tree canopy**	**Forest top height**	**Main top canopy species**
		Mean (Range)	**Mean (Range)**	**Mean(Range)**	**Mean (Range)**	
Rapar	Rapar	34% (0-95%)	23% (0-80%)	38% (0-90 %)	15 m (0 – 32 m)	*Olea europaea ssp africana* , *Croton megalocarpus*
	Nambolio	21% (0-100%)	27% (0 -70%)	63% (30 - 95%)	14 m (8 – 23 m)	*Olea capensis*, *O. europaea ssp africana*, *Croton megalocarpus*
Baawa	Naibor Keju	29% (2-80%)	32% (0 -60%)	51% (0 - 98%)	15 m (12 - 21 m)	*Olea europaea* ssp *africana*, *Juniperus procera*, *Croton megalocarpus*, *Teclea simplicifolia*
	Baawa	43% (2-100%)	39% (0 -95%)	63% (0-95%)	22 m (8 - 35 m)	*Podocarpus falcatus* , *Olea europaea* ssp *africana*, Machakudu,, *Croton megalocarpus*
	Serata	43% (10-80%)	35% (0 -90%)	53% (5 - 95%)	21 m (8 – 42 m)	*Podocarpus falcatus* , *Olea europaea* ssp *africana*, O.*capensis*, Machakudu, *Ekebergia capensis*, *Celtis africana*
Tamiyoi	Opiroi	36% (5-100%)	41% (0-90%)	35% (0 - 98%)	19 m (0 – 42 m)	*Podocarpus falcatus* , *Olea europaea* ssp *africana*, *Juniperus procera*
	Ltungai	30% (0 - 60%)	34% (0-90%)	2% (0 - 30%)	0	-
Nkorika/Angata Nanyukie		36% (10-100%)	50% (10-100%)	30% (0 - 90%)	19 m (9 - 31 m)	*Podocarpus falcatus*, *Olea capensis*, *Olea europaea* ssp *africana*, *Juniperus procera*

Table 2: Distribution of transects, plots and sample area in Kirisia Forest Reserve, 2005.

Forest Composition and Tree Species Relative Dominance

During the October –November 2005 survey, a list of 95 tree species and their uses was generated for the Kirisia Forest Reserve (Appendix B). Majority of the species (51 / 95 i.e. 54%) were locally named but their scientific names were still missing in the records of checklists consulted. This gap in knowledge to be filled by further detailed taxonomic investigations as a basis to understand and appreciate fully the diversity of plant species in Kirisia Forest. The forest canopy was dominated by 2-3 species in top and middle canopy in every block. Overall, four species dominated the forest top canopy: Olea europaea ssp africana (25-34 %), Juniperus procera (13-25%), Podocarpus falcatus (11-26 %) and Croton megalocarpus (15 %). Those species dominating the middle canopy all blocks combined were P. falcatus (12-45 %), O. ssp africana (21 -28%), J. procera (20 %), Teclea simplicifolia (13-15 %) and C. megalocarpus (12 %). Tree species that had a species importance value of 10 % and above (Table 4) were described as the most ecologically important within the ecosystem. A list of such species was made for each block and in two categories: timber-size and pole-size.

Block	Species	N / ha	BA	F %	RF%	RD %	RDo %	SIV %
Rapar	*Olea europaea*	28.39	6.55	95.24	21.74	40.88	40.43	34.35
	Juniperus procera	10.21	3.23	61.90	14.13	14.71	19.94	16.26
	Croton megalocarpus	12.25	1.96	66.67	15.22	17.65	12.07	14.98
Baawa	*Olea europaea*	33.12	8.72	82.05	16.41	33.73	32.58	27.57
	Juniperus procera	17.78	8.18	61.54	12.31	18.11	30.57	20.33
	Podocarpus falcatus	9.89	4.55	33.33	6.67	10.07	16.99	11.24
Tamiyoi	*Olea europaea*	27.05	6.37	74.36	21.17	38.98	31.97	30.71
	Juniperus procera	15.00	7.49	64.10	18.25	21.62	37.58	25.82
	Podocarpus falcatus	8.18	3.04	43.59	12.41	11.79	15.28	13.16
Nkorika	*Juniperus procera*	25.58	11.32	56.00	16.67	23.64	35.46	25.26
	Olea europaea	35.96	7.09	64.00	19.05	33.23	22.21	24.83
	Podocarpus falcatus	25.22	10.00	56.00	16.67	23.31	31.33	23.77

Block	Species	N / ha	BA	F %	RF%	RD %	RDo %	SIV %
Rapar	*Olea europaea*	60.00	11.69	55.00	19.30	19.05	48.90	29.08
	Teclea simplicifolia	52.50	1.38	45.00	15.79	16.67	5.77	12.74
	Croton megalocarpus	42.50	2.72	35.00	12.28	13.49	11.37	12.38
Baawa	*Olea europaea*	48.68	11.10	47.37	19.78	20.90	38.10	26.26
	Teclea simplicifolia	53.95	1.29	39.47	16.48	23.16	4.43	14.69
	Podocarpus falcatus	15.79	6.61	21.05	8.79	6.78	22.69	12.75
Tamiyoi	*Olea europaea*	38.46	4.04	30.77	19.35	21.90	21.32	20.86
	Juniperus procera	17.95	6.77	20.51	12.90	10.22	35.71	19.61
	Podocarpus falcatus	16.67	3.37	15.38	9.68	9.49	17.78	12.31
Nkorika	*Podocarpus falcatus*	30.00	7.45	32.00	38.10	40.54	57.17	45.27
	Olea europaea	20.00	3.21	24.00	28.57	27.03	24.62	26.74

Table 4: Species frequency (F%), Density (N/ha), Basal area (m2/ha) and importance value (SIV %), Kirisia State Forest, Samburu Heartland, 2005

Exploitation of these species in **Table 4** must be carefully planned as their uncontrolled removal would disrupt the ecological balance of the ecosystem.

Regeneration of the tree component

Table 5 show data on regeneration. Saplings (1322 individuals per hectare) had 62 out of 95 tree species recorded above 10 cm dbh. The most dominant species in this stage per block were also few (2-6) with Tamiyoi (the most grazed block) having the lowest number. Overall, only 11 species formed the bulk of regeneration in the entire Kirisia forest. Seedlings (1537 individuals per hectare) had 46 tree species among the 95 recorded in the pole and larger sizes. The data revealed that 52 % of tree species in Kirisia did not have seedlings during the time of the survey. This is a huge deficiency. Table 6 shows the most dominant species in seedlings per block.

Block	Species[1]	N / ha	RF%	RD %	SII %
Rapar	*Teclea simplicifolia*	413	32	37	35
	Celtis Africana	163	11	15	13
	Croton megalocarpus	100	11	9	10
	Trichocladus ellipticus	113	3	10	6
Baawa	*Teclea simplicifolia*	395	17	22	19
	Machakudu / Lcokudu	105	7	6	7
	Euclea schimberi	99	7	5	6
	Acokanthera schimperi	105	6	6	6
	Ngeni-Niok [2]	138	3	8	5
	Croton dycotomous	112	1	6	4
Tamiyoi	*Teclea simplicifolia*	218	17	21	19
	Euclea schimberi	173	10	17	13
Nkorika	*Teclea simplicifolia*	190	17	16	17
	Euclea schimberi	120	9	10	10
	Carissa edulis	170	4	15	10
	Trimeria grandifolia	130	4	11	8

[1] Dominant species = high regeneration importance index and density ≥ 100 / ha

Table 5: Ecologically dominant tree species in saplings based on species importance index, Kirisia Forest, 2005

Block	Species[1]	N / ha	RF%	RD %	SII %
Rapar	*Croton megalocarpus*	600	18	32	50
	Teclea simplicifolia	250	32	14	46
	Celtis Africana	600	11	32	44
	Trichocladus ellipticus	150	11	8	19
Baawa	*Teclea simplicifolia*	263	20	16	18
	Podocarpus falcatus	276	4	17	10
	Croton megalocarpus	145	9	9	9
	Croton dycotomous	145	8	9	8
Tamiyoi	*Euclea schimberi*	385	16	29	22
	Teclea simplicifolia	244	18	18	18
	Rhus natalensis	128	11	10	10
	Olea europaea	167	4	12	8
Nkorika	*Rhus natalensis*	180	17	13	15
	Geturai / Lketurai	280	3	20	12
	Euclea schimberi	200	7	14	11
	Teclea simplicifolia	140	10	10	10
	Seketet	200	3	14	9

[1] *Dominant species = high regeneration importance index and density ≥ 100 ha-1*

[2] *Possible synonymous: Ngeni-Niok = Njeni-Nayok = Nchenaiyok = Ngene Norok*

Table 6: Ecologically dominant tree species in seedlings based on species importance index, Kirisia Forest, 2005

Forest Density and Horizontal Structure

The overall density of Kirisia Forest varied from 86 large size trees ha-1 and 1537 seedlings ha-1 (**Table 7**). The lowest averages were found at Nkorika and Tamiyoi for all stages except large trees for which Tamiyoi had actually the highest density and basal area. For pole sized trees, Baawa had the highest basal area ha-1 even though the number of stems ha-1 were fewer than at Rapar. It means that the average pole diameter was higher at Baawa than at Rapar due to reasons not yet known.

Blocks (Label)	Seedlings	Saplings	Pole-sized trees		Large trees	
	No./ha	No./ha	No./ha	m^2/ha	No./ha	m^2/ha
Rapar (Block 1)	1850	1113	315	23.9	69	16.2
Baawa (Block 2)	1658	1822	233	29.1	98	26.7
Tamiyoi (Block 3)	1346	1045	176	19.0	69	19.9
Nkorika (Block 4)	1400	1060	74	13.0	108	31.9
Average	**1537**	**1322**	**196**	**21.2**	**86**	**24**

Seedlings = Stems < 1m Ht; Saplings = Stems 1m Ht - 10 cm dbh; Pole-sized trees = Stems ≥ 10 – 20 cm dbh; Large trees = Stems ≥ 20 cm dbh

Table 7: Density levels of Kirisia Forest across Blocks and for different development

Population structure of selected dominant species

Figure 3 shows the overall structure of Kirisia forest in the four forest blocks, all species combined. Forest structure in terms of distribution of individuals across different development stages was nearly the same in Nkorika and Tamiyoi with slight deficient seedling stage, same deficiency was observed at Baawa but here the forest had higher stocking than the first two blocks. The Kirisia forest recruitment was however balanced at Rapar as the trend of decrease in stocking from smallest to largest tree categories followed reverse-J curve (Meyer, 1952).

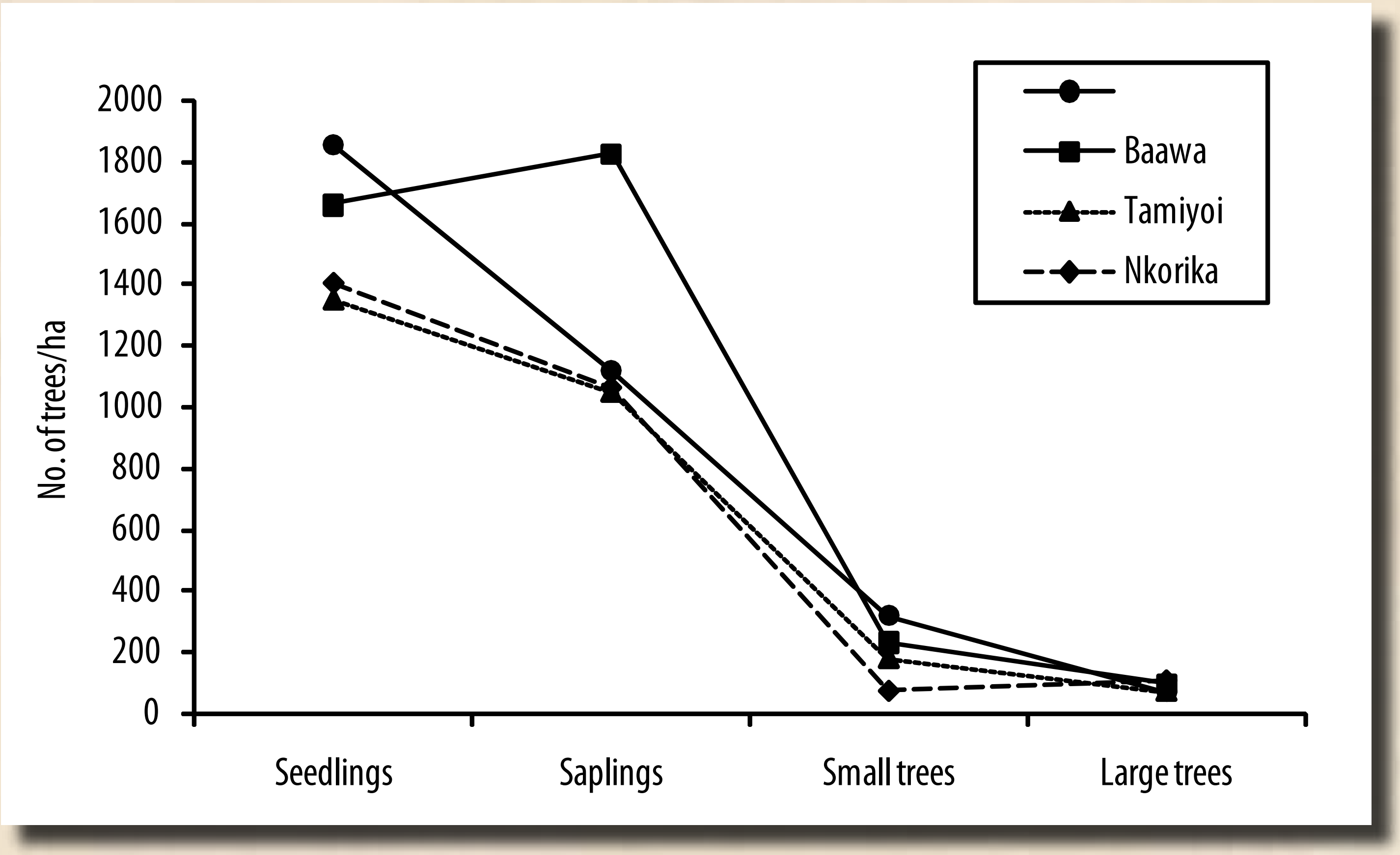

Figure 3: Forest structure, all species combined, of different blocks within Kirisia Natural Forest, Kenya, 2005.

The population structure was also graphically analyzed the most dominant tree species in each development category, namely seedling, sapling, pole size and timber size stages (Figures 4a-d).

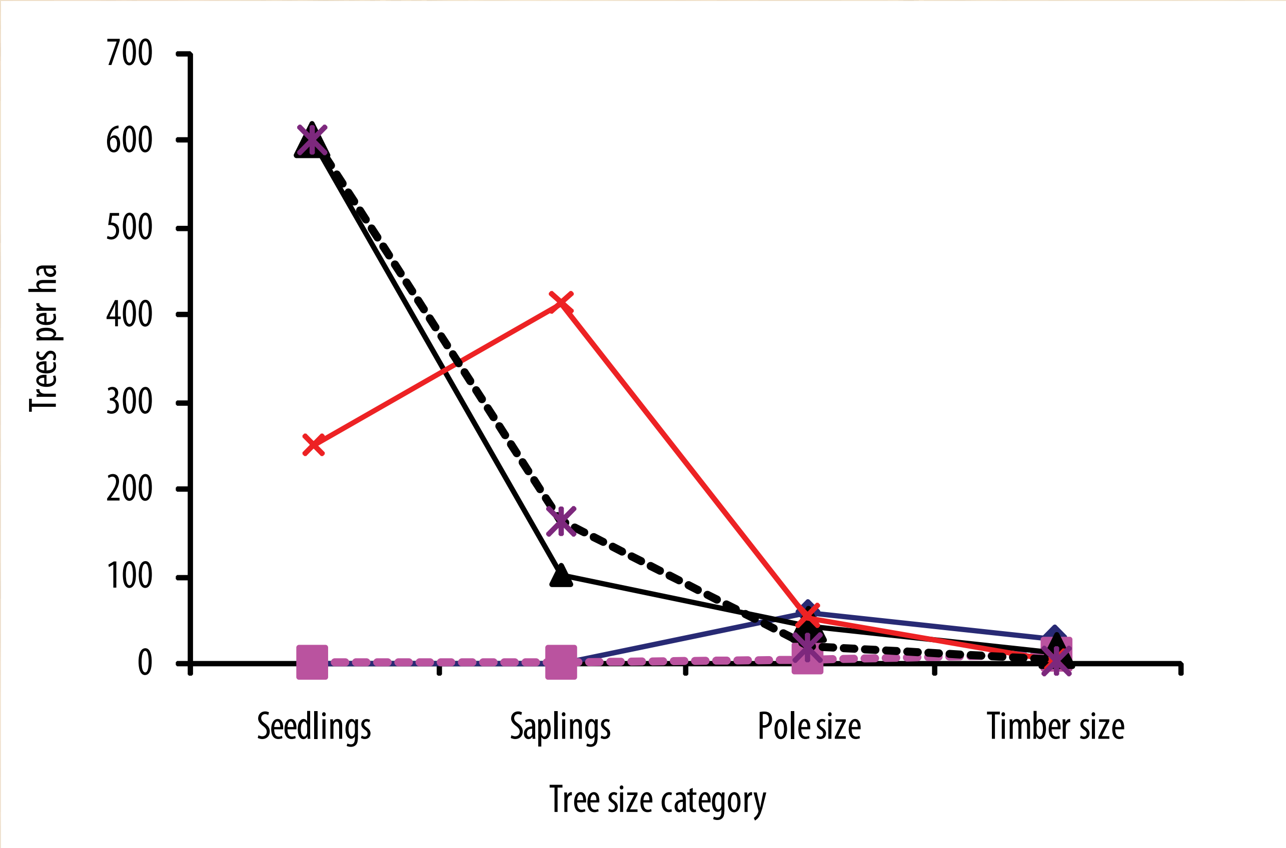

Figure 4a: Population structure of the most dominant tree species in each development category in Rapar Forest Block, Kirisia Forest, 2005.

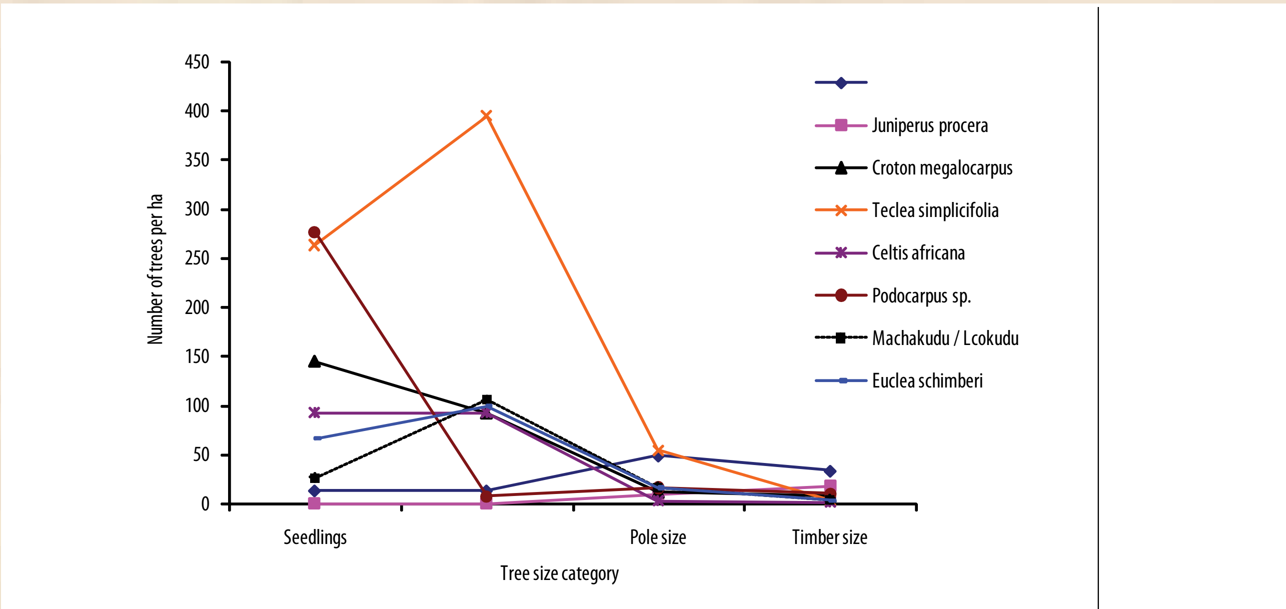

Figure 4b: Population structure of the three most dominant tree species in each development category in Baawa forest block, Kirisia – 2005.

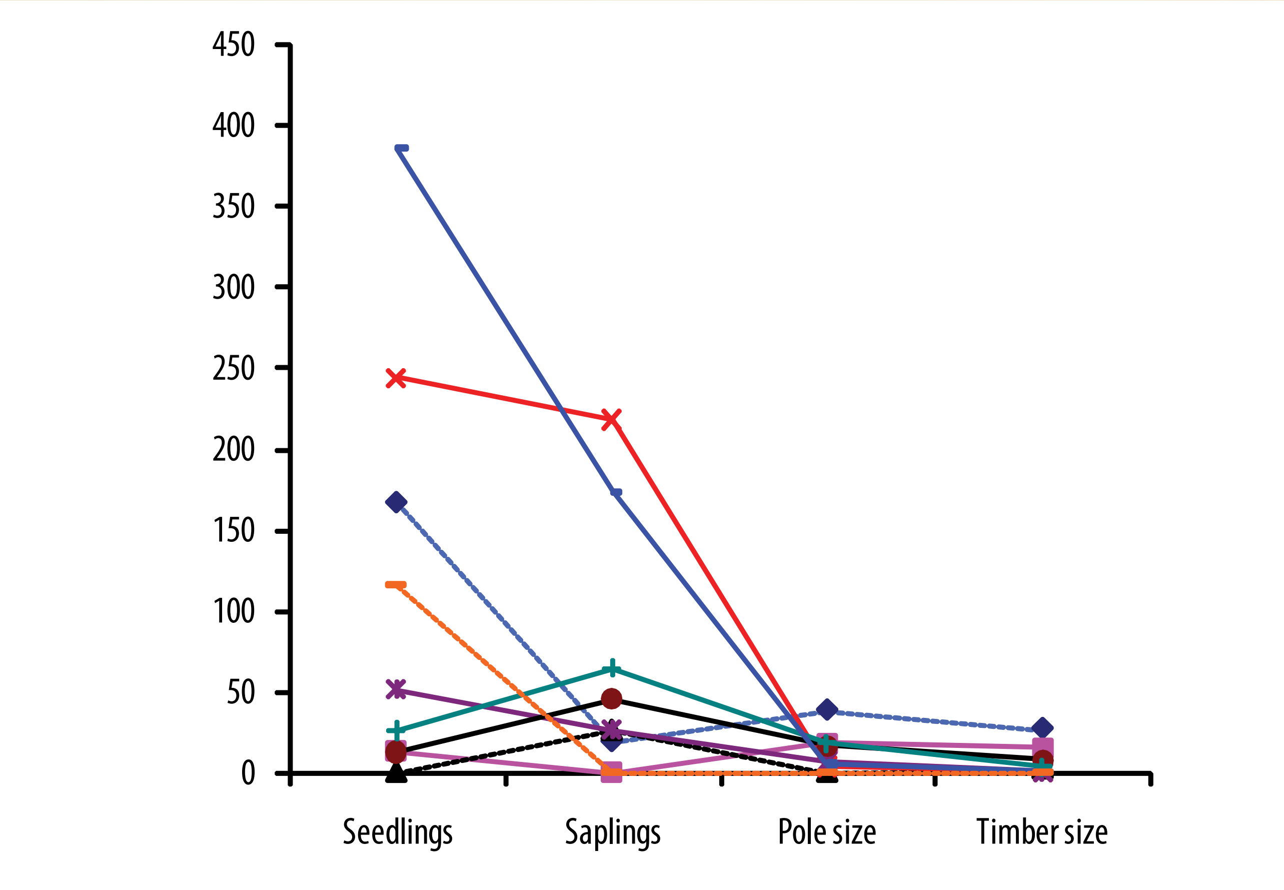

Figure 4c: Population structure of the three most dominant tree species in each development category in Tamiyoi forest block, Kirisia – 2005.

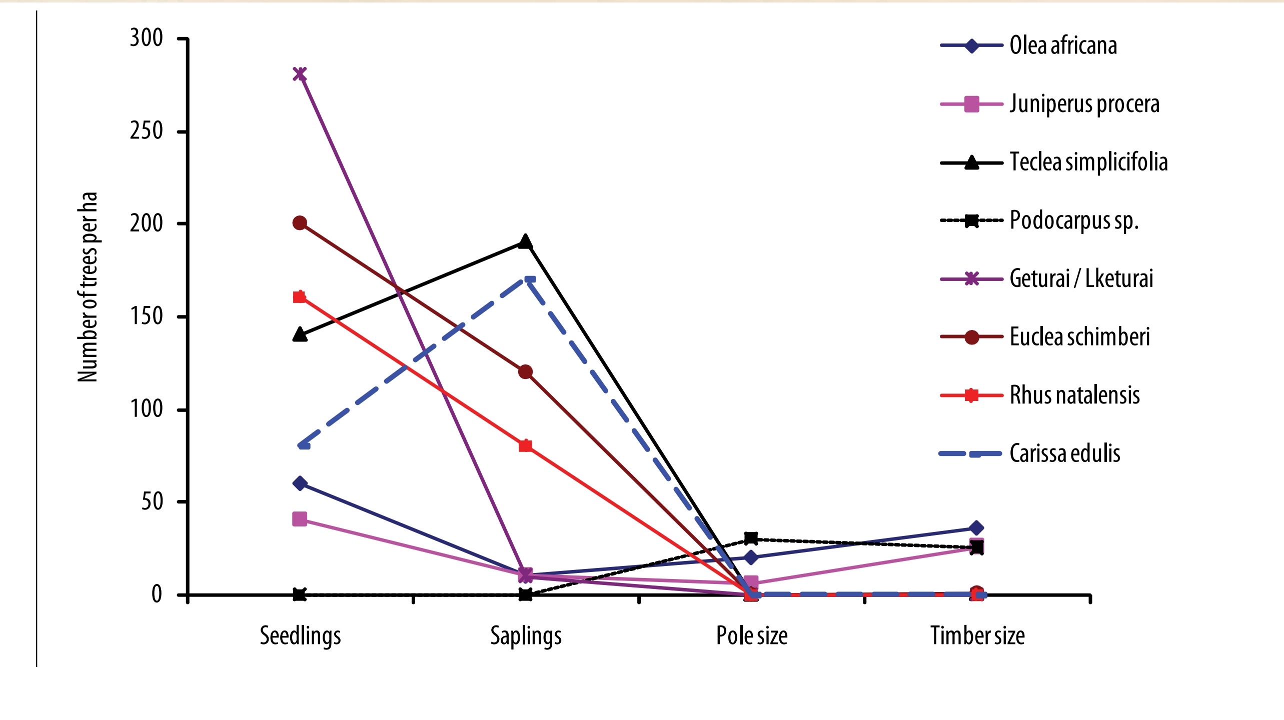

Figure 4d: Population structure of the three most dominant tree species in each development category in Nkorika forest block, Kirisia – 2005.

Tree Species Diversity Level

Species diversity indices computed for sampled forest blocks using Shannon – Wiever index of diversity (H') revealed that sapling stage was on average the most species-diverse of all categories (Table 8, Figure 5) except at Rapar. Timber size had the lowest diversity. Forest blocks with highest overall tree species diversity were Baawa and Tamiyoi; the least diverse block was again Rapar but this block had the highest diversity for pole-sized trees. At Nkorika, high species diversity was in regeneration stages and lowest in both pole and timber sized trees.

Table 8: Species diversity index values (H') in the Kirisia forest blocks, 2005

Blocks	Average	Tree development stage			
		Seedlings	Saplings	Pole size	Timber size
Rapar	2.077	1.730	2.067	2.524	1.986
Baawa	2.664	2.965	3.012	2.439	2.239
Tamiyoi	2.408	2.385	2.889	2.384	1.972
Nkorika	2.113	2.465	2.665	1.525	1.796
Average		**2.386**	**2.658**	**2.218**	**1.998**

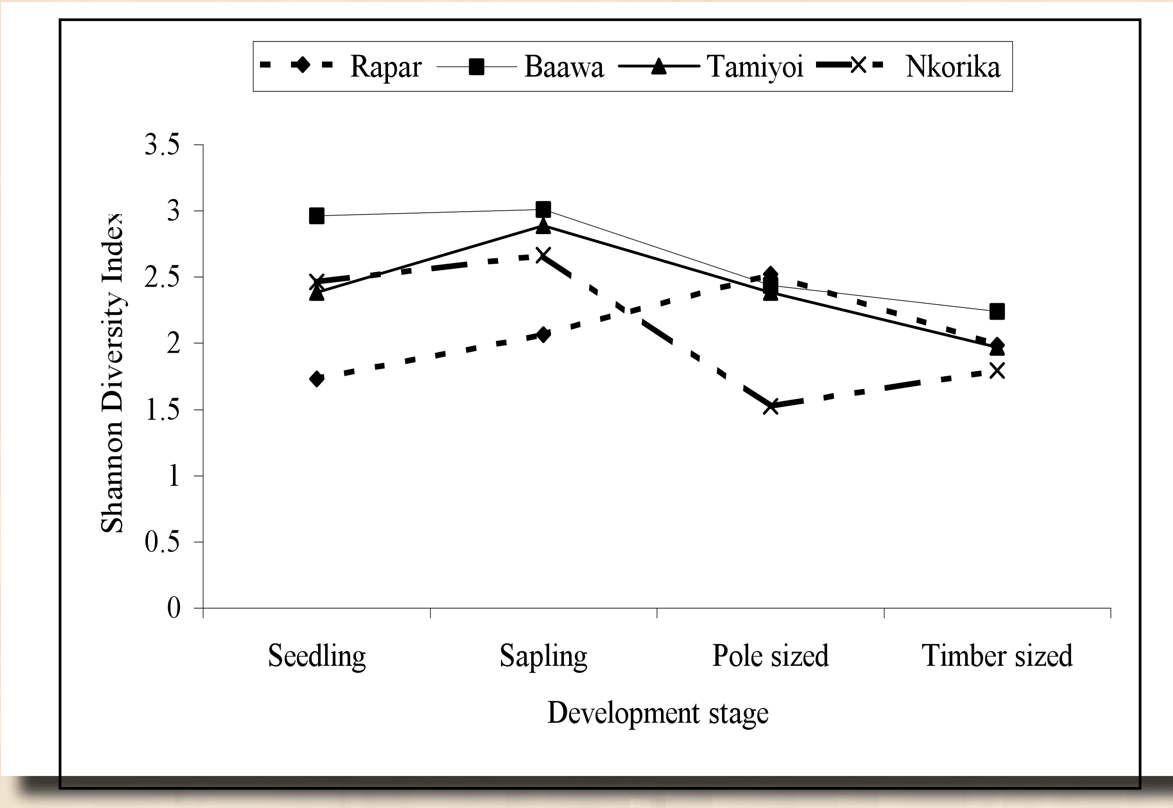

Figure 5: Changes in species diversity index across different tree development stages for the sample forest blocks in Kirisia Forest Reserve, Samburu District (Kenya) in 2005.

Forest Faunal diversity

There is enough evidence of high diversity of wildlife in the forest, of other attractive features and of the use of the forest by ecotourists e.g. camping sites, tour guides. The faunal diversity in Kirisia Forest Reserve was very high throughout the forest and major wildlife corridors were encountered. Table 9 shows checklists of animal life as observed from different areas of Kirisia Forest in 2005. Rich bird diversity is shown in the checklist in Appendix C. The forest is on overall an important habitat for wildlife, thus a hot spot for biodiversity conservation and a potentially important attraction for tourism development. However, the rich wildlife in the forest cannot be sustainably managed without the integration of the adjacent dispersal areas and particularly without participation of the adjacent Group Ranches and individual land owners. These ranches form dispersal areas for wildlife and are crossed by several migratory wildlife routes and corridors (Figure 6). These corridors link major wildlife habitats within the region and show the critical role of Kirisia ecosystem in overall wildlife conservation within the Samburu Heartland.

Animals found in all four blocks	*Animals missing in at least one block out of the four*	*Animals found in one block (rare) out of the four*
Baboon	Warthog	Antelope
Bees	Aardvark	Dik dik
Birds	Bushbuck	Hyena
Buffalo	Eland	Kelly frankolin
Elephant	Gazelle	Lion
Livestock	Insects	Porcupine
Waterbuck	Leopard	Zebras
Bush pig	Tree Squirrel.	

Table 9: Checklists of Wildlife presence within Kirisia Forest (Oct-Nov 2005)

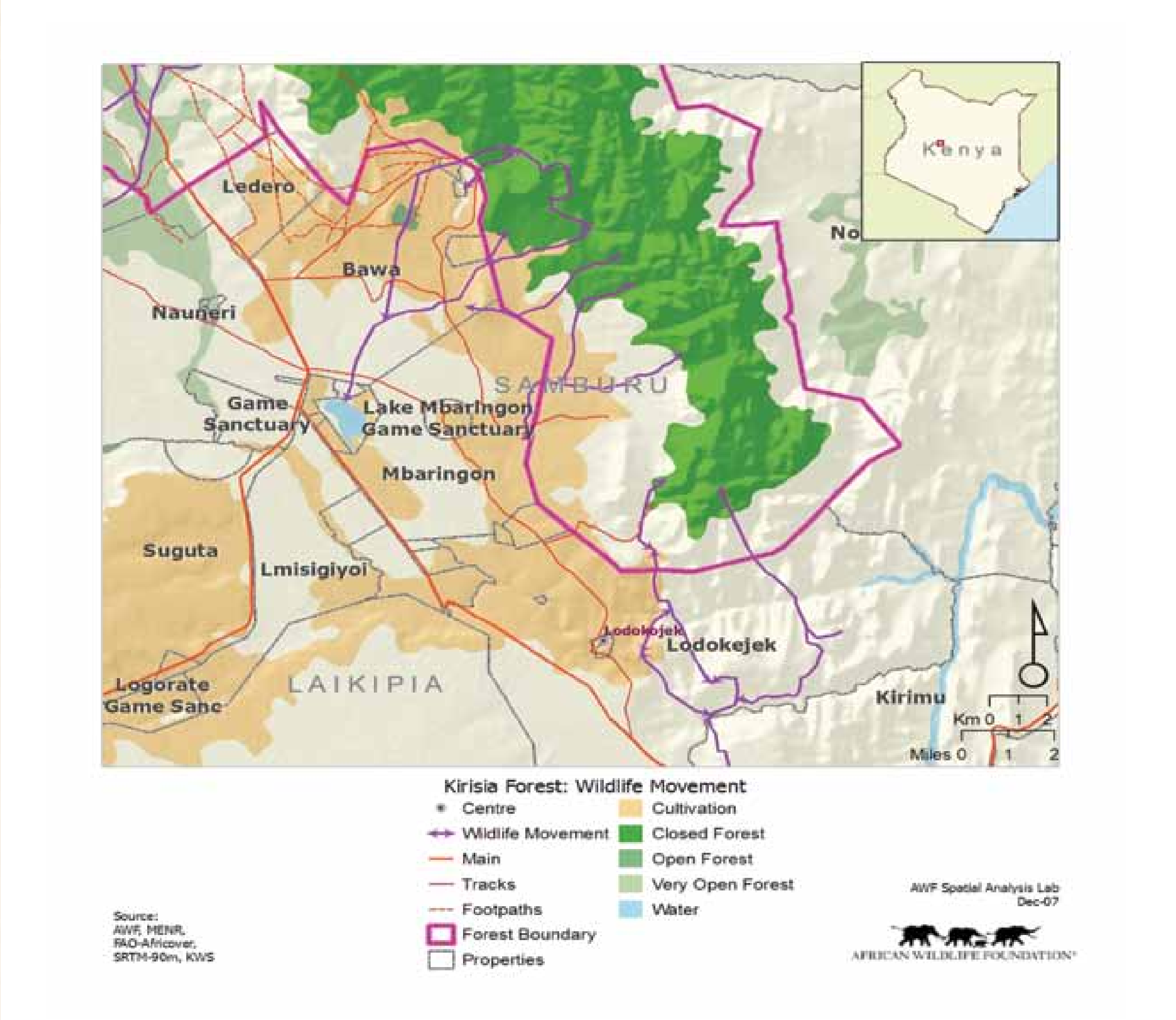

Figure 6: Movement of wildlife within and around Group Ranches west of Kirisia Forest Reserve, Samburu Heartland.

DISCUSSION

In order to establish a benchmark for monitoring the forest conditions over time to guide conservation and management initiatives, a database was developed with geo-referenced attributes (Ref: AWF, Nairobi GIS-Laboratory). All transects, sampling plots and fixed features were mapped and geo-referenced. Mapping and geo-referencing ecological, water and eco-touristic resources within the forest will guide management interventions such as the development of eco-friendly enterprises to boost livelihoods of local communities.

Variability in Forest Composition

The same species (Croton megalocarpus, Juniperus procera,Olea europaea ssp africana, Podocarpus falcatus) dominated the top and middle canopy and are all of economic importance owing to the wood of high quality. Exploitation of trees for wood products has the potential to completely wipe away the forest top and middle canopies, thus finishing away the forest. such management option would be very disastrous in the region and would impact negatively on wildlife, biodiversity in general, tourism and environment. Some tree species dominated timber-size in all sites while other species such as Croton megalocarpus dominated in selected areas. Such species may be adapting differently across the prevailing range in environmental conditions. In the pole-size category, Juniperus procera declined in its relative dominance and was only dominant in one site, Tamiyoi. Other species maintained their dominance in same blocks where they dominated in the larger tree size category. Juniperus procera population was thus the most negatively affected by destructive activities going on in Kirisia forest. With the exception of Croton megalocarpus, all species dominating the pole and timber-sizes were conspicuously missing saplings. This deficiency points to a potential shifts in future species composition in the forest canopy whereby light-demanding pioneer species would be replaced by shade-tolerant ones. This is a normal phenomenon in forest succession process (Whittaker, 1975). The regeneration for other species was also low and the number of species with good transition from seedlings to saplings decreased in blocks adjacent to high human settlements. Human activities are again possible cause of regeneration irregularities observed in Kirisia forest. Unlike the sapling stage, Olea europaea ssp.africana and Podocarpus falcatus were also dominating in the seedlings, but in a few blocks. The level of regeneration for other species including J. procera was not satisfactory.

Variability in Forest Regeneration and Recruitment

Data on regeneration, recruitment and population structure of different tree species revealed that many tree species did not have seedlings (individuals less than 1 m tall) even though, for all species combined, the seedling stocking level was satisfactory. These species include those preferred by local communities for various products. The species well represented in the sapling stage (individuals as tall as 1 m and above but less than 10 cm DBH) also decreased in forest blocks next to high human settlements. Low regeneration levels could therefore be as a result of anthropogenic or livestock influence. Many more tree species were however most deficient in the pole-sized tree stage (individuals ≥ 10 cm to < 20 cm DBH) and this stage was the least stocked for the entire forest, most probably due to harvesting. The pole stage was the most vulnerable. Adequate management and protective measures are required to enhance its recovery within the Kirisia Forest. A regular monitoring system is needed to identify threats to the recovery of the forest cover and that of the most affected species.

Forest Structure and Stability

Forest structural stability was gauged based on the population structure of the dominant species as the pillars of the ecosystem. Dominant species are described as the most ecologically successful and to a large extent determine the conditions under which other organisms associated with them live (Richards, 1981). Species with reverse J-curve shapes show population stability, regular regeneration and recruitment in their respective blocks. At Rapar, stable populations included those of Croton megalocarpus and Celtis africana. Olea europaea ssp africana and Juniperus procera populations were ageing as indicated by low rates of regeneration. Teclea species was deficient for the seedling stage. At Baawa, same trends were observed as in Rapar block. In addition, Machakudu species and Euclea schimperi were also deficient in seedlings. Regeneration of Podocarpus sp was picking up. In Tamiyoi forest block, both Euclea and Teclea populations are reasonably stable. Olea europaea ssp africana and Rhus natalensis and Celtis africana regeneration was also coming up. For other species, regeneration was not balanced (deficient seedling stage). In Nkorika forest block, regeneration of Carissa and Teclea species was, deficient for the seedling stage and the Podocarpus population was on a decline (an ageing population). Lketurai, Euclea and Rhus species had a good regeneration. Though the levels of J. procera and O. europaea ssp africana were on the rise, these levels were still low.

Tree Species Diversity And Biophysical Environment Interface

Kirisia Forest Reserve is characterized by high plant and animal biodiversity. Baawa block was the most diverse in seedlings, saplings and timber-sized trees. In other areas, species diversity may have declined in post-sapling stages due to wildlife and human influence (browsing and harvesting). For example at Tamiyoi, the block next to Malalal Township with highest agglomeration of people around the Kirisia Forest Reserve, species diversity of timber sized trees dropped sharply (Figure 5). Some plant specimens were not captured in existing national Flora such as Kenya Trees, Shrubs and Lianas by Beentje (1994). The Kirisia forest ecosystem is characterised by richest tree species diversity in saplings as compared with other development tree stages: seedlings, pole-sized, and timber-sized trees. Prevailing soil texture indicates variable soil drainage and fertility conditions and the presence of rock-outcrops and predominance of sand indicate that soil depth could be shallow as documented (Jaetzold & Schmidt, 1983). It was expected that blocks with same soil characteristics and elevation classes (such as Nkorinka and Tamiyoi on one hand and Baawa and Rapar on the other) would show same level of biodiversity richness. However, this trend was not observed. The effect of chemical and physical environmental factors on tree biodiversity was overshadowed by the influence of biological factors on vegetation such as human activities, grazing and physical damages by livestock and herbivorous wildlife.

Forest biodiversity utilization and conservation strategies

Kirisia Forest Reserve is characterized by an extremely high biodiversity in terms of plants (herbs, shrubs and trees) of high socio-economic importance to locals, animals at different trophic levels (herbivores, carnivores, birds and insects) and of different sizes. The forest is also very rich in birds and insects. This ecosystem is potentially an important site for research in biodiversity issues and for ecotourism development; all for the benefit of local communities, the country and humanity. For example it was noted that several migratory birds from as far as Europe and Asia visit the forest at different parts of the year. In terms of future efforts to promote effective ecosystem management, specific studies are needed to document conservation status of different species of organisms that inhabit the forest e.g. identify endemic, threatened and rare species for plants, insects, birds, reptiles, herbivores and carnivores. It is critical to point out the uniqueness of the Kirisia forest ecosystem and its high economic potential it has for the society at large. The local communities are endowed with a wealth of knowledge about the different uses of most of the plants, which shows high socio-economic value the forest has for the locals. There is need for a study to quantify the impact of the forest in households' economy for people in the region. There is also need for exhaustive taxonomic and ethno-botanical studies as well as laboratory tests to ascertain quality of products derived from the forest (e.g. medicinal herbs, honey, seeds) and modernize their commercialisation. High presence of forest wildlife and other physical scenic features were observed in the forest including many camping sites. There are several animal corridors and trails distributed throughout the forest. In all blocks, there was high variability in vegetation cover (habitat types) from herb layer to forest tree canopy, supporting high diversity of faunal species. The entire forest ecosystem is thus unique and should be protected in totality for biodiversity conservation and other services. There is need to conserve these habitats sustainably by minimizing activities that lead to degradation of ecologically fragile sites within the forest. The potential for ecotourism development in Kirisia forest is high but should be anchored in the overall participatory management plan.

Kirisia Forest Management Challenges

Forces shaping the biological conditions of Kirisia forest include physical abiotic factors, pressure from high population of large-bodied herbivores (elephants and buffalos) and of livestock and pressure from human destructive activities including fires. These are the major forces to be controlled through a participatory management approach. Data on regeneration, recruitment and population structure of different tree species also revealed that many specific tree species did not individually have enough seedlings even though, for all species combined, the seedling stocking level was satisfactory. The regeneration problem of trees was more severe in areas (forest blocks) next to high human settlements, most likely as a result of anthropogenic or livestock influence. Many more tree species were however most deficient in the pole-sized tree stage than in seedlings and saplings. This stage was the least stocked throughout the entire forest, most probably due to harvesting for poles and posts used in construction of houses and fences. There is need to protect this stage to avoid local species extinction in the long run.

Unfortunately, most species that have regeneration deficiencies in the forest are those preferred by local communities for various products which is spelling doom for future generations who might struggle to benefit from the same species unless appropriate measures are taken today to protect over-exploited species in the natural habitat and promote them through rural afforestation programmes, forest restoration and tree planting on farms, in group ranches and around homes. A regular monitoring system is needed to identify persistent and upcoming threats (such as weeds) to the recovery of the entire forest and that of specific species. In the long-term management plan, there is need to enhance and promote research to guide forest managers and other stakeholders including the wider public of the new potentials and challenges and adapt to changing conservation, market and socio-economic needs. The success of tree planting activities outside the forest will reduce human pressure on the current Kirisia forest ecosystem as a source of tree products (including honey and fodder) and bring along other environmental services such as soil conservation control, climate regulation among others.

CONCLUSION AND RECOMMENDATIONS

Kirisia Forest Reserve is characterized by high plant and animal biodiversity. It has great ecological and socioeconomic potential. However the forest stability is under threat due to low regeneration of the dominant upper canopy tree species caused by destructive human activities in the forest including settlements, livestock herding and honey hunting. High population of elephants and buffalos also damage trees in some areas but the wildlife-forest interaction may be naturally sustained if man factor can be controlled. The effect of chemical and physical environmental factors on tree biodiversity is so far overriding the influence of biological factors on vegetation. The increasing human population settling around the forest including growth of Maralal town pose challenges to Kirisia forest as the only source of wood materials in the region. Efforts are required to establish plantations and promote tree planting on private land to avoid future ecological crisis. Meanwhile, alternative sources of poles and posts need to be identified and used to reduce pressure on the forest. To effectively manage destructive forces within the Kirisia forest, it is imperative to develop and implement management plans for sustainable use of natural resources available both in the forest and on adjacent group ranches. Participatory approaches bringing on board key stakeholders mainly local communities should be used throughout the planning process and during implementation of the developed plans.

This study identified the following key issues to be emphasized in the plans:

1) Research to support sustainable biodiversity conservation for ecotourism development and to promote modern commercialisation of forest products.
2) Monitoring endemic and endangered species of plants and animals
3) Utilization or marketing plans of useful forest products and services based on principles of sustainability (ecosystem management approach)
4) Strategies to secure wildlife habitat, physical scenic features, wildlife corridors
5) Strategies to minimize activities that degrade fragile sites within the forest.
6) Strategies to manage populations of wildlife in the ecosystem particularly large mammals
7) Strategies to enhance forest regeneration, recruitment and rehabilitation especially for over exploited species such as Juniperus procera, Olea europaea ssp africana, Croton megalocarpus, and Podocarpus species.
8) Strategies to promote rural afforestation programmes and tree planting on farms, in group ranches and around homes to reduce reliance by local people on the natural forest as source of wood.
9) A surveillance system to control upcoming threats such as weeds, diseases etc.

Ultimately, this plan should be part of the road map to establishing participatory forest management with communities around Kirisia Forest for sustainable management of the forest.

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APPENDICES

APPENDIX A: PHYSICAL CHARACTERISTICS OF FOREST BLOCKS (STRATA) IN KIRISIA FOREST

A1. LOCAL TOPOGRAPHY AND STEEPNESS OF TERRAIN IN KIRISIA STATE FOREST

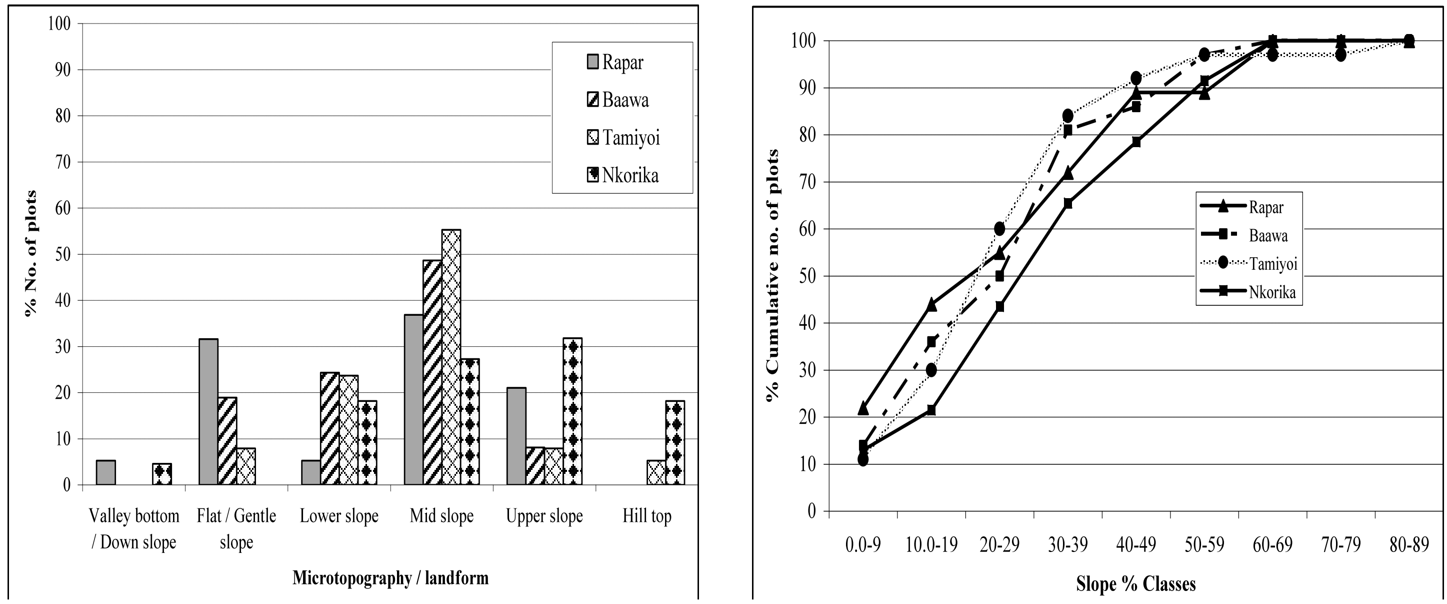

Figure x: Local topography (landform) and steepness (slope) frequently encountered in blocks making the Kirisia Forest Reserve.

Tamiyoi Block is mainly on a sloping terrain but the steepness is relatively moderate whereby very steep areas (over 30%) being found in 40 % of the sample units; a lower percentage compared to other blocks. The local topography and steepness data show that Kirisia Forest would be highly vulnerable to soil erosion caused by surface water runoff if soil vegetation cover is destroyed or not protected. This risk is shared among all blocks.

A.2. DISTRIBUTION OF SOIL TYPES AND DRAINAGE CONDITIONS IN KIRISIA FOREST

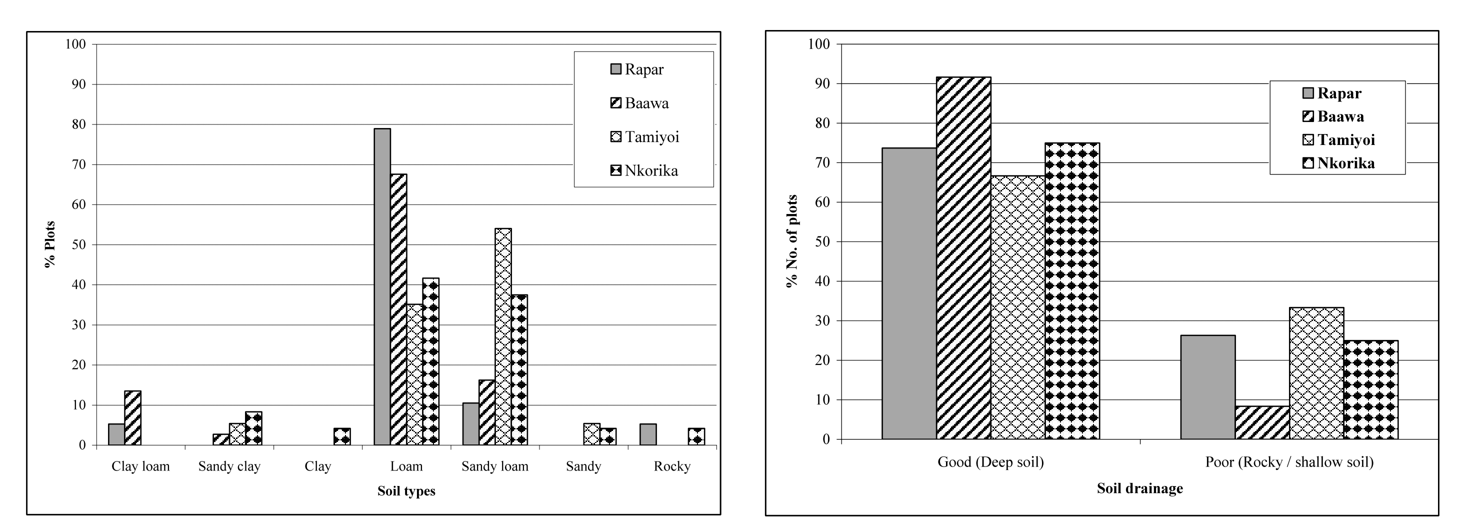

Figure xx: Soil types and drainage conditions frequently encountered in the four blocks making the Kirisia Forest Reserve. T he most dominant types are loam (within Rapar and Baawa) and Sandy loam (in Tamiyoi). Nkorika is the most heterogeneous in soil types. Clayey soils are less frequent; they are mostly found at Baawa and Nkorika. Soil drainage, one of the main determinants of soil productivity, is generally good in the Kirisia Forest; best at Baawa (92 %) followed by Nkorika (75 %) and Rapar (74%). Tamiyoi, the most disturbed block, had the lowest proportion of well-drained areas.

A.3. ALTITUDE AND ASPECT (SLOPE DIRECTION) CHARACTERIZING KIRISIA FOREST

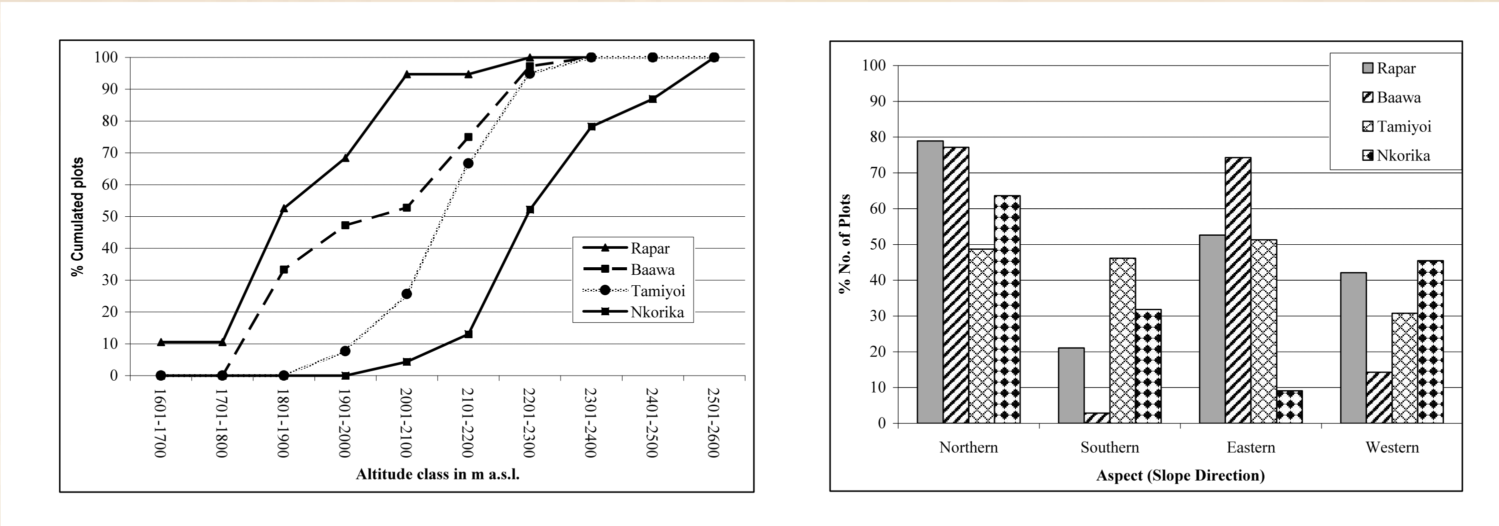

Figure xxx: Altitude and slope direction (aspect) characterizing four blocks of the Kirisia Forest Reserve. The figure indicates that higher altitude sites are more frequent in Nkorika, followed by Tamiyoi. The lower altitude sites are more frequent in Rapar followed by Baawa. In terms of East and West slope directions, Nkorika is more dominated by western aspect than eastern aspect; Baawa faces more the eastern aspect than the western one. Tamiyoi and Rapar are, each, shared among the east and the west aspects. In terms northern and southern aspects, the main slopes in Baawa, Rapar and Nkorika are mostly facing north as opposed to south. Tamiyoi is more or less balanced between the two aspects.

APPENDIX B

LIST OF USED PLANT SPECIES FROM KIRISIA FOREST IN 2005

No.	Species names	Vernacular names (Samburu - Kirisia area)	Uses
1	*Croton dycotomous*	Lakiridnkai	Medicinal against flu
2	*Clausena anisata*	Lmatasia / Matasia	Tooth brush, medicinal
3	*Teclea simplicifolia*	Lgirai	Fodder, bark eaten by elephant, tooth brush
4	*Olea europaea*	Lngeriyoi	Fodder, medicinal (deworming livestock, bark extract removes placenta during delivery)
5	*Grewia tembensis*	Irri / Iriei	Livestock fodder
6	*Juniperus procera*	Sepetei	Bark used to cover houses / manyattas; edible resin
7	*Ficus thoningii*	Sebei / Sepetei	
8	*Croton megalocarpus*	Maruguwet	Medicinal bark extract against homa and chestpains; bark is chewed; used to carry honey, shade
9	*Euclea schimberi*	Nchinyei / Lshingei	Medicinal, fodder for elephants, leaves eaten as vegetables
10	*Mystroxylon aethiopicum*	Lodonganayioi / Saramonai	Fodder, bee forage
11		Lcheno-Orok	Walking stick
12	*Tarenna graveolensis*	Lmasei	Medicinal shrub, used to clean/brushing traditional milk gourds
13		Lnjenoik	Seeds are monkey food
14	*Aloe secundiflora*	Sonkoroi	
15	*Trichocladus ellipticus*	Balagalagi / Lpalagilagi	Fodder for elephants
16		Ltingei	
17		Lmasi	
18	*Podocarpus falcatus*	Lpiripirinti	Bark extract mixed with soup for good digestion
19	*Justicia sp.*	Sigiit	Tooth brush
20	*Olea capensis ssp hotchstetteri*	Loliontoi	Gourd making, twigs and leaves -dry season fodder,
21		Lorekiri	
22	*Acokanthera schimperi*	Murichoi / Lmurijoi/ Murujoi/Lmorijoi	Poisonous leaves, fruits eaten by elephants and man
23	*Celtis Africana*	Lekere / Lekiri / Ngisitet / Nekiri	Leaves used as livestock and wildlife fodder
24		Seiti	
25		Ngeni-Niok / Njeni-Nayok / Nchenaiyok / Ngene Norok	Livestock fodder
26	*Cordia abyssinica?*	Leshashuri / Lachachuri	Tool handles, curving (Ehretia cymosa?)
27		Lngeri	
28		Lebaawa	Tool handles e.g. axe
29		Ngriei	
30		Lmai	Edible wild fruits
31		Marrwet / Marakwet / Marikwet	Medicinal use
32	*Pavetta abyssinica*	Ljeni Ebor	Fodder
	Ilex mitis	Njaniabor	

Appendix B. Continued

No.	Species names	Vernacular names (Samburu - Kirisia area)	Uses
33		Lamaroki / Lamarogi	Fodder
34		Lrashat / Larashat / Lerashat / Lerachat	Firewood, (no other special use)
35	*Turraea parvifolia*	Ltunturi / Njeniarok / Nchinioik	Fruits for birds
36		Lamuriai	Fodder for livestock,
37		Elkokolai	
38		Lpalaklal	
39		Lmelelek	
40	*Carissa edulis*	Sangumai / Sakumai / Sagumai	Fodder
41		Lomunyanyi	
42	*Acacia xanthophloea*		
43	*Calidendrum capense*	Larashi	Fodder for elephants, ornamental
44		Lpinai / Lbenai	Bee forage, flowers in august-September, medicinal – abortion drug / honey not good for pregnant women
45	*Posqua poperose*		
46		Machakudu / Lcokudu	Poles –good to fix TV aerials, bee forage, a browse, ornamental
47		Ngutut	
48		Lkurut	
49	*Psiadia punctulata*	Labaai	
50		Markeroi	
51	*Toddalia asiatica*	Leparmunyo	Medicinal against cold / flu
52	*Erythroccoca bongensis*	Leshapirik / Lechopiriki / Lesopirik	Fodder for livestock
53		Nashashurui	Sheath for swords
54	*Ekebergia capensis*	Songoroi / Lsungurui / Lsungoroi	Medicinal against stomachache; stimulant – energiser, aphrodisiac,
55	*Pavonia urens*	Sulubei	
56		Kosintet / Ngositet	Fodder
57		Lerachat	
58	*Trimeria grandifolia*	Leadat / Ledad/Ledat	Roots / leaves extract mixed with sugar to treat joints, roots and leaves extract treat malaria
59		Lgormoshio / Olgormosioi	Edible fruits
60	*Nuxia congesta*	Nepironito/Neporonito	No known use
61	*Vangueria sp*	Lgumi / Lgomi	
62	*Gomphorcarpus stenophyllus*	Lepiroi/Lpiroi	
63	*Rhamnus prinoides*	Lkinyil/Nkinyeri	Medicinal, treatment of malaria (-mixed drug)
64	*Calodendrum capense*	Larashi	Natural perfume, tooth brush
65	*Vangueria madag*		Edible fruits
66		Lililai	Medicinal
67	*Rhus natalensis*	Msigioi / Lmisigiyioi / Lmisigiei	Fodder for livestock, edible fruits for birds,
68		Nkociteti	
69		Losepetei	
70		Lkalkawa	Dental treatment
71	*Prunus africana*		

Appendix B. End

No.	Species names	Vernacular names (Samburu - Kirisia area)	Uses
72	*Dovyalis abyssinica*	Lmoroo / Moroo	Edible seeds
73		Lepirenta / Lepirenito	
74		Lokujok	Appetizer, digester - used as extract of bark to treat stomachache
75		Lukukut / Lkukut/ Lakukut	Beehives making
76	*Shrebera alata*		
77		Longariboi	Medicinal climber – aphrodisiac
78	*Euphorbia candelabrum*	Sirai	Medicinal
79		Lmalanay	
80		Ngeriyoi	
81		Ngaroboi	
82		Nado Massei	
83	*Dombeya sp.*	Lporokwai	Fodder for livestock
84		Saali	
85		Geturai / Lketurai	
86		Loisoki	
87		Seketet	
88	*Cussonia holstiii*	Lbolorio	
89		Losiai	
90		Saralnai	
91		Lkukurai / Lkukulai	Roots extract to treat malaria and
92		Lmuzungach	Bee forage
93		Ljibilikwa	
94		Mukinyeyi	Medicinal herb to treat stomach disorders, bee forage
95		Lominyanyi	Herb – aromatic spice

Appendix C. Key Bird Species Recorded From Kirisia Forest (Oct-Nov 2005)

Common names	Scientific names
(African) Paradise Flycatcher	*Terpsiphone viridis*
(Nominate) Baglafecht Weaver	*Ploceus sp*
(White?) Yellow Throated Nicator	*Nicator vireo*
Abyssinian Crimsonwing	*Cryptospiza salvadorii*
Abyssinian Ground Thrush	*Turdus piaggiae*
African Dusky Flycatcher	*Alseonax adustus*
African Little Sparrow Hawk	*Accipiter minullus*
Augur Buzzard	*Buteo rufofuscus*
Barbet	
Black Fronted Bush Shrike	*Malaconotus migrifrons*
Black Kite	*Milvus migrans*
Black-Headed Oriole	*Oriolus larvatus*
Blue capped Cordon-Bleu	*Uraeginthus cyanocephalus*
Brown-Headed (crowned) Tchagra	*Tchagra australis*
Cinnamon Bracken Warbler	*Bradypterus cinnamomeus*
Collarded Sunbird	*Anthreptes collaris*
Common (Namaqua) Dove	*Oena capensis*
Common Bulbul	
Fan-Tail Raven	*Corvus rhipidurus*
Green Backet Twinspot	*Mandingoa nitidula*
Grey Apalis	*Apalis cinerea*
Grey Backed Camaroptera	*Camaroptera brevicaudata*
Grey Cockoo Shrike	*Coracina caesia*
Grey Parrott	*Psittacus erithacus*
Hartlaub's Turaco	*Tauraco hartlaubi*
Lemon Dove	*Aplopelia larvata*
Lesser Honey Guide	*Indicator minor*
Long-Tailed Fiscal (Shrike)	*Lanius cabanisi*
Northen Double Collarded Sunbird	*Nectarinia preussi*
Nubian Wood Pecker	*Campethera nubica*

Olive Thrush	*Turdus olivaceus*
Robin Chat	*Cassypha caffra*
Rossy Patched Bush Shrike	
Scaly Francolin	*Francoline squamatus*
Slivery-Cheeked Hornbill	*Bycanistes brevis*
Sooty Ant Eater	
Speckled Mousebird	*Colius striatus*
Square-Tailed Drongo	*Dicrurus ludwigii*
Squirrel	
Streaky Seed-eater	*Serinus striolatus*
Superb Starlling	*Spreo superbus*
Tropical Boubou	*Laniarius ferrugineus*
White (Stared) Throated Robbin	*Irania gritturalis*
White Eyed Slaty Flycatcher	*Dioptrornis fischeri*
Yellow White Eye	
Yellow-Whiskered Greenbul	*Andropadus latirostris*

Source: Field Survey (Oct – November 2005), identification by Robert Rosano Lentareia (Filed guide) and edited based on Williams and Arlott (19985)- A Filed Guide to the Birds of East Africa.

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The AWF Technical Paper Series has been designed to disseminate to partners and the conservation community, aspects of AWF current work from its flagship African Heartlands Program. This series aims to share work experiences and to provoke discussions on what is working or not and how best conservation action can be undertaken to ensure that Africa's wildlife and wild lands are conserved forever.

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