

Mammals in a Farm/Forest Mosaic in South-eastern Liberia

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Abstract

The study investigated the distribution and conservation status of the mammal fauna in a farm/forest mosaic in south-eastern Liberia and factors influencing wildlife persistence in the landscape. Hunters were interviewed to find out which mammal species were present, where they occurred, the habitats they used, whether they entered the agricultural lands, and whether they were hunted. Ten hunters were recruited to lead trips in the forest to verify the presence of animals and the distances they were found from the villages. The results indicate that, with the exception of the African elephant (*Loxodonta africana*), the fauna is intact, with 45 species listed as present by the Grebo farmers who live there. Thirty species (66.7%) were recorded, including animals of global and local conservation concern such as the pygmy hippopotamus (*Choeropsis liberiensis*), Jentink's duiker (*Cephalophus jentinki*), chimpanzee (*Pan troglodytes*), giant forest hog (*Hylochoerus meinertzhageni*), bongo (*Tragelaphus eurycerus*), and forest buffalo (*Syncerus caffer*). None of the study species were extirpated during 40 years of intensive logging and centuries of farming and subsistence hunting. The recent advent of commercial hunting and the consequent changes in hunting practices have resulted in the population decline of 12 (26.7%) of the species. Twenty-eight (62.2%) species are reportedly common and widespread even though hunted, and the remaining species appear to be naturally rare. The spread of agricultural lands along an expanding road network may be fragmenting populations of species that do not use the field/fallow habitats, including the endemic zebra duiker (*Cephalophus zebra*). The proximate cause of changes in hunting behaviour appears to be the desire of the Grebo people to improve their economic conditions. Because of this, finding economic alternatives to commercial hunting will need to be part of conservation efforts in the region.

Introduction

The forests of Liberia are one of the most biologically-rich ecosystems in the world (Myers *et al.*, 2000) and are home to numerous endemic mammal species including the pygmy hippopotamus (*Choeropsis liberiensis*), Jentink's duiker (*Cephalophus jentinki*), zebra duiker (*Cephalophus zebra*), and white-breasted guinea fowl (*Agelastes meleagrides*) (Robertson, 2001). This rich biodiversity and the fact that Liberia retains the highest percentage of the forest cover of any West African country, make the nation one of the most potentially significant sites for conservation of the Upper Guinean

Rainforest biome (Christie *et al.*, 2007). However, the country has received little scientific attention (Appleton, 1997), and research stopped completely during the civil wars of 1989–1996 and 1999–2003. Even though the country has been at peace for 9 years, few scientists conducted ecological studies there (Hoke *et al.*, 2007). The resulting lacuna of knowledge is unfortunate because as the country tries to surmount the devastation of the wars there is little basis for which to plan for sustainable development (Hoke *et al.*, 2007; Norris *et al.*, 2010).

Liberian forests have provided home and subsistence to various farming peoples for

centuries (Fairhead & Leach, 1998). Given the stagnant economy and lack of educational and economic opportunities, it is likely that the agricultural sector will continue to employ a large segment of the Liberian population in the future. This means that, even if efforts underway to create new protected areas are successful (Hoke *et al.*, 2007), most of the national landscape will be needed for agriculture and will remain outside of the protected areas network (Kaimowitz & Sheil, 2007). Because of this, conservation efforts will need to incorporate human-used landscapes as part of a greater national sustainable development strategy (Kaimowitz & Sheil, 2007; Vandermeer & Perfecto, 2007). To do so will require an understanding of why or why not biodiversity persists in the farm/forest mosaics (Norris *et al.*, 2010) characteristic of rural Liberia, and what, if anything, can be done to reconcile the needs for economic development and the desire for preserving biodiversity.

The study was part of an assessment of the potential of an area in River Gee County in south-eastern Liberia to serve as a site for an agroforestry project in cooperation with Grebo subsistence farmers who live there. The objective of the study was to make a rapid assessment of the conservation status of the forests and the medium and large mammals. A secondary objective was to make a preliminary assessment of the natural resource use and farming practices of the Grebo people. This paper presents the findings of the assessment and the principal issues related to the persistence of the wildlife in this farm/forest mosaic, given the changing resource use practices of the people resulting from their quest for development.

Materials and methods

Study area

The study site encompasses 20,000 ha, directly east of Fishtown, the capital of River Gee County, in south-eastern Liberia (Fig. 1). The topography is flat to undulating with isolated steep hills reaching 200 m ASL. Four small rivers and many small streams drain the site, flowing into the Cavalla river, 20 km to the east. The soils are mostly sand and gravel with exposed rock outcrops on the hill tops. With more than 2000 mm of precipitation annually and no true dry season, the entire county lies within the lowland evergreen rain forest biome. Despite centuries of occupation by swidden agriculturalists (Fairhead & Leach, 1998), the county still retains 60% of forest cover (Christie *et al.*, 2007). Today, the landscape mosaic is one of fields and fallows radiating 2–5 km out from villages, with forest buffer zones between villages, except along the roads where the farm/fallow lands form a continuous band between villages.

Collaborators previously conducting soil analyses in the area put the author in contact with respondents in five of the eight villages located within the study area. These men were all farmers aged 30–63 years old, and several were among the region's most avid hunters. Nine of the 10 men were Grebo, who were born in the landscape and one was a Lofa who had settled there 3 years previously. These 10 hunters were the key respondents and guides in the field and provided most of the information.

The survey consisted of first interviewing the men, using open-ended questions about wildlife present and hunting practices. Once the respondents proved knowledgeable about the wildlife, semi-structured interviews were conducted using an African mammal field

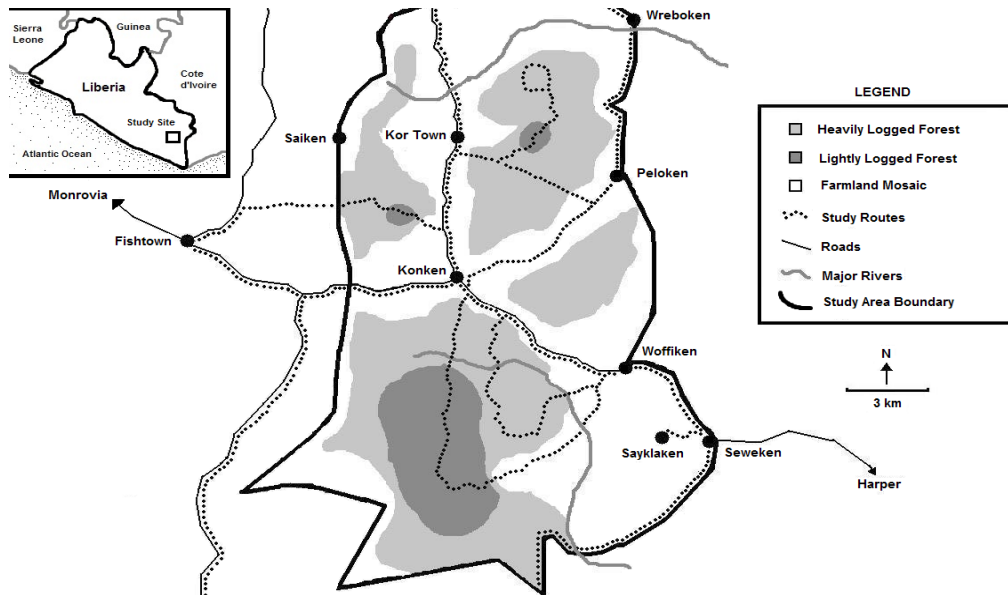


Fig. 1. Study landscape in River Gee County, south-eastern Liberia

guide (Haltenorth & Diller, 1986). Respondents were asked to identify the animals they knew to be present and when they had last seen them or their spoors. Subsequently, 10 men with the most bush experience were recruited for trips into the forest with the objective of recording wildlife and measuring the distances of the registers from the villages, as well as where the men most frequently hunted, how often, and their motives for hunting. Locations of where animals of particular conservation interest had been killed over the previous years were also recorded. During the interviews detailed questions were asked about farming practices and the history of logging.

There were 14 days of fieldwork between July 6th and 25th 2012, and 95.5 h were spent in the field, 103.5 km walked and an additional 50 km surveyed by car and motorcycle along the roads. A 1:50,000 scale topographical map provided by the County

government was used as a template for the work, GPS points were plotted on a Google Earth® image and then overlaid on the county map.

Results

Conservation status of the forest

All of the forests visited had been logged; some patches as many as four times. According to the local people logging began in the 1970s and continued through the wars, with the most recent logging operations in 2002. Most of the forest was heavily logged and now consist of a dense tangle of lianas and small trees up to 5–12 m tall with only isolated old-growth trees, mostly of one species of legume. In the more selectively-logged forests, medium-sized trees predominate with the upper canopy reaching over 20 m and spaced old-growth trees up to 30 m. The most well-preserved forests occupy the steep hill areas and the upper

canopy can reach over 40 m. Palm swamps line the waterways and occupy large areas, especially in the flatter northern section of the study landscape. The rocky outcrops of the highest hills are covered with grasses, sedges, mosses, lichens and short trees.

Human ecology

The region is the homeland of the Grebo people, who have practised swidden agriculture (agricultural practice that involves cutting and burning native vegetation before planting) there for centuries (Fairhead & Leach, 1998). Rice is the principal crop with maize and cassava as secondary crops, and lesser areas dedicated to rubber, cacao, oil palm, yams, and orchard fruits. Their principal livestock are goats and poultry, but they also raise sheep, pigs and cattle. The sand and gravel soils are nutrient-poor and the 1–4 ha fields are cultivated for one harvest only and then left fallow for 9–15 years or more. As families grow, young men must clear new forest in order to sustain their families. There was forest being felled in all of the villages visited, suggesting that the need for agricultural land is still increasing. This is a subsistence farming economy which produces little or no cash surplus. In order to earn cash income, the villagers make and sell charcoal, collect “bitter root” (a liana), sell livestock, and increasingly hunt for the market in Fishtown.

Bushmeat is a traditional source of protein and almost all men hunt. Traditionally, the Grebo hunted for subsistence, seeking game in the fields and fallows around their villages and in the forests nearby. However, today young men are increasingly hunting commercially and, consequently, penetrating further into the forests to find game as populations near the villages become

depleted. The Grebo are largely indiscriminate hunters and will kill any animal encountered, although when wildlife was more abundant they preferred larger animals. The principal weapon is a single barrel shotgun using 70 mm shot. Around the farms they set a variety of snare traps, and they use slings to scare off grain raiding birds and sling shots to kill smaller animals. Men and women fish using line and a variety of traps.

Conservation status of the medium and large mammals

Interviews indicated that, with the exception of the African elephant, *Loxodonta africana*, the medium and large mammalian fauna is intact (Table 1). Thirty (66.7%) of the 45 species listed by the respondents were recorded. At least 13 (29%) of the species are rare and only found in the most remote parts of the landscape (generally 1.5–2 h walk from the nearest village). The respondents claimed that 12 of these (giant forest hog—*Hylochoerus meinertzhageni*, pygmy hippopotamus, zebra duiker, Jentink’s duiker, yellow-backed duiker—*Cephalophus silvicultor*, bongo—*Tragelaphus eurycerus*, forest buffalo—*Syncerus caffer*, giant ground pangolin—*Smutsia gigantea*, Diana monkey—*Cercopithecus diana*, olive colobus—*Procolobus verus*, western red colobus—*Procolobus badius*, and western black and white colobus—*Colobus polykomos*) used to be more common and widespread, but that their populations have declined due to increased hunting pressure. The ratel (*Mellivora capensis*) may be naturally rare. The status of the royal antelope (*Neotragus pygmaeus*), spot-necked otter (*Lutra maculicollis*), Cape clawless otter (*Aonyx capensis*) and crested porcupine (*Hystrix*

cistata) remain to be determined. The remaining 28 (62.2%) species appear to be common and widespread even though hunted. There may be several additional species present (especially squirrels), but their presence could not be confirmed, so they were not included in the list.

All of the study species appear to find adequate habitat in the logged forests, but only 24 (53.3%) species use the farm/fallow lands. Another six (13.3%) occasionally used the farm/fallow habitats historically, but rarely, or do not do so today. Ten (22.2%) of the species never enter farm/fallow habitats. It was unclear whether five (11.1%) species used the agricultural lands.

Discussion

The mammal fauna in the farm/forest landscape of the study area was similar to that found by Hoke *et al.* (2007) in the nearby Grebo National Forest – the largest remaining block of contiguous forest in south-eastern Liberia. The fact that the medium and large mammal fauna is largely intact after centuries of hunting and farming suggests that the traditional Grebo subsistence ecology is compatible with the persistence of the rich mammal fauna found in their homeland (East, 1999; Smith, 2005; Bennett *et al.*, 2007; Padoch & Pinedo-Vasquez, 2010). The low population density, the spacing of villages with people concentrated in small areas, an agricultural landscape radiating several kilometres out of the centre and a forest buffer zone separating the various villages (CDC 2008) allowed for a sustainable use of natural resources.

Under this land tenure system the principal impact of Grebo hunting pressure was mostly restricted to within 4 km of the village.

Extensive fallows, with 9–15 year or more planting intervals, created a mosaic near the villages dominated by farm bush that provides habitat for several preferred game species (*e.g.* black duiker–*Cephalophus niger*, Maxwell's duiker–*Philantomba maxwellii*, bushbuck–*Tragelaphus scriptus*, spot-nosed guenon–*Cercopithecus petaurista*, and cane rat–*Thryonomys swinderianus*) (East, 1999; Newing, 2001). Active farms also attracted forest wildlife that was killed while raiding crops, diversifying the fauna hunted without the need to enter far into the forest to pursue these animals. The distance between villages (6–12 km) was sufficient to allow for wildlife to persist in forest buffer zones and probably to maintain contiguous populations across the regional landscape. The practice of not planting in the hills created largely hunter-free areas that acted as refuges for species susceptible to over-hunting. Even if these animals were occasionally killed when approaching farms or the forests adjacent to the farms, there was enough forest with low hunting pressure to allow them to persist.

Thirty years (early 1970–2002) of intensive logging altered the forest structure radically, eliminating most of the old-growth trees and creating extensive areas of short tree/liana tangles. Most of the remaining old-growth trees are of a few species that overwhelmingly dominate the canopy emergent stratum in the more heavily-logged forests. Logging activities are almost always accompanied by intensive bouts of hunting (Wilkie *et al.*, 1992; Bowen-Jones & Pendry, 1999), and this likely occurred in this region as well. Nonetheless, none of the study species were extirpated during the years of logging operations (East, 1999; Norris *et al.* 2010), although logging might have affected individual species abundances (Waltert *et al.*,

TABLE 1
 Medium and large mammals in the farm/forest mosaic landscape of River Gee County, South-eastern Liberia

<i>Species¹</i>	<i>Register type, #</i>	<i>Distribution in landscape and conservation status</i>	<i>Value (US \$²)</i>
<i>Cetartiodactyla</i>			
<i>Potamochoerus porcus</i>	T, R	Common and widespread; used all forest types and farm bush; sometimes raid fields. Difficult to hunt; only three killed by informants in past 2 years.	\$60–85
Red river hog			
Red hog Bauchu	18		
<i>Hylochoerus meinertzhageni</i>	T, R	Rare with a patchy distribution; likely divided into two isolated populations separated by 8–12 km of farms and farm bush, heavily hunted forest, and a highway. Only found in the more remote forests several hours walk from the villages. Used to occasionally raid rice farms. Difficult to hunt; last killed in 2002.	\$85
Giant forest hog			
Black hog Buleh	3		
<i>Hyemoschus aquaticus</i>	I	Common and widespread. Uses forest and farm bush. Frequently hunted.	
Water chevrotain Water deer Toawn			
<i>Choeropsis liberiensis</i>	T	Rare and declining. Although recently killed only an hour's walk from Kor Town and I found tracks 40 min walk from this village, further searches and reports indicate that it has almost disappeared from the landscape. Only found in the more extensive swamp forests in the northern section of the landscape. Most recently killed in 2012, 2009 (2 killed in one incident), 2006, and 2003.	
Pygmy hippopotamus Hippo			
Nueh	1		
<i>Philantomba maxwellii</i>	S, T, F	Common and widespread; uses all forest types, farm bush and fields. Frequently hunted.	\$13
Maxwell's duiker Giseh	13		
<i>Cephalophus dorsalis</i>	S, T, F	Common and widespread; uses all forest types, but less commonly found in farm bush. Occasionally raids fields. Frequently hunted.	\$20–22
Bay duiker			
Red-back deer Baleh	20		
<i>Cephalophus ogilbyi</i>	S, T	Common and widespread; uses all forest types, but not farm bush or fields. Frequently hunted.	\$23–26
Ogilby's duiker			
Red-back wide-ear deer Gireh	6		
<i>Cephalophus niger</i>	S, T	Common and widespread; prefers farm bush and raids farms. Frequently hunted.	\$21–32
Black duiker			

Bush goat; black deer Nyah	6		
<i>Cephalophus zebra</i> Zebra duiker Mountain deer Neneh	I 1	Rare with a patchy distribution; probably divided into three isolated populations each separated by 6-10 km of farmlands, heavily hunted forests and roads. Only found in the more remote forests several hours walk from the villages. Habitat largely restricted to upland forests, but uses all hill forest types including heavily logged forests. Does not use farm bush or fields. Less frequently killed than other duikers of similar size, although two killed during study period.	
<i>Cephalophus jentinki</i> Jentink's duiker White antelope Inhanweh	T 3	Rare with a patchy distribution; probably divided into three isolated populations each separated by 6-10 km of farmlands, heavily hunted forests and roads. Only found in the more remote forests several hours walk from the villages. Use all forest types including heavily logged forest. Historically entered farm bush. Infrequently killed; two killed by informants in past 3 years.	\$28–64
<i>Cephalophus silvicultor</i> Yellow-backed duiker Black antelope Buruinyanweh	T 3	Rare with a patchy distribution; probably divided into three isolated populations each separated by 6-10 km of farmlands, heavily hunted forests and roads. Only found in the more remote forests several hours walk from the villages. Use all forest types including heavily logged forest. Historically entered farm bush. Infrequently killed; three killed by informants in past 3 years.	
<i>Tragelaphus scriptus</i> Bushbuck Red deer Dreeh	T 4	Common and widespread; prefers farm bush and fields. Frequently hunted.	\$50
<i>Tragelaphus eurycerus</i> Bongo Earth deer Keah	T 4	Rare with a patchy distribution; probably divided into two isolated populations separated by 8-12 km of farms and farm bush, heavily hunted forest, and a highway. Only found in the more remote forests several hours walk from the villages. Uses all forest types, but avoids farm bush and fields. Difficult to hunt; only three of the ten informants have killed bongos. Most recently killed in 2009 and 2003.	
<i>Neotragus pygmaeus</i> ³ Royal antelope?	I	Status and distribution unclear due to confusion about this species during the interviews.	
<i>Syncerus caffer</i> Forest buffalo Buffalo; Bush cow	T 3	Rare with a patchy distribution; probably divided into two isolated populations separated by 8-12 km of farms and farm bush, heavily hunted forest and a	

Tuweh		highway. Only found in the more remote forests several hours walk from the villages. Uses all forest types, occasionally entering farm bush near fields. Dangerous and difficult to hunt; only three of the ten informants have killed buffalo. Last killed in 2007.	
Hyracoidea			
<i>Dendrohyrax dorsalis</i>	H	Common and widespread. Killed when encountered	
Western tree hyrax		Associated with witchcraft.	
Weah	2		
Pholidota			
<i>Phataginus tricuspis</i>	S	Common and widespread. Uses all forest types and farm bush. Killed when encountered.	\$5
White-bellied pangolin			
Small anteater?	1		
<i>Uromanis tetradactyla</i>	S	Common and widespread. Uses all forest types and farm bush. Killed when encountered.	\$5
Long-tailed pangolin			
Small anteater	1		
Semeyan			
<i>Smutsia gigantea</i>			
Giant ground pangolin	I, B	Rare and declining; one to possibly three isolated populations. Only found in the more remote forests several hours walk from the villages. Uses all forest types. Killed when encountered, but only three of the informants had killed giant pangolins (2010, 2004, and 2003). A Peloken hunter reportedly killed one in 2011.	
Big anteater	1		
Soeh			
Rodentia			
<i>Atherurus africanus</i>	T	Common and widespread. Uses all forest types and farm bush. Killed when encountered.	\$6–10
African brush-tailed porcupine			
Small porcupine			
Trenh	3		
<i>Hystrix cistata</i>	I	Rare? All men were familiar with this animal but there were no reports of recent killings. Uses all types. Killed when encountered forest.	\$8–14
North African crested porcupine			
Big porcupine			
Plaey			
<i>Cricetomys emini</i>	B	Common and widespread, although I only found one active burrow. Uses all forest types. Killed when encountered.	
Emin's giant rat			
Tabadu	1		
<i>Thryonomys swinderianus</i>	S	Common and widespread. Prefers fields and farm bush. Frequently killed.	
Cane rat			
Ground hog	2		
Uwenh			

Squirrel	S	Common and widespread. Uses farm bush extensively, especially palm trees. Infrequently hunted.
Kriboh	6	
CARNIVORA		
<i>Genetta</i> sp. ⁴	I	Common and widespread. Uses all forest types and farm bush. Killed when encountered.
Genet species		
Bush cat		
Topi; Kolapanbeh		
<i>Civettictis civetta</i>	I	Common and widespread. Uses all forest types, fields and farm bush. Killed when encountered.
African civet		
Raccoon		
Bueh		
<i>Nandinia binotata</i>	H	Common and widespread. Uses all forest types. Killed when encountered.
Two-spotted palm civet		
Tree coon	3	
Maun		
<i>Atilax paludinosus</i>	T	Common and widespread. Prefers swamp forests; enters swamps in farm bush. Killed when encountered.
Marsh mongoose		
Bush dog	2	
Beol		
<i>Crossarchus obscurus</i>	S, R	Common and widespread. Uses all forest types and farm bush. Killed when encountered.
Cusimanse		
Sacrah	3	
<i>Herpestes sanguineus</i>	S	Common and widespread. Prefers fields, farm bush, and villages. Killed when encountered.
Slender mongoose”		
Chicken rogue”	5	
Belechon		
<i>Mellivora capensis</i>	I	Rare and distribution unknown, but appears to only be found in the most remote forests. Only two hunters reported the species as present.
Ratel		
Bear		
<i>Lutra maculicollis</i>	T	Rare or infrequently seen. Killed when encountered.
Spot-necked otter		
Beaver	1	
Pareh		
<i>Aonyx capensis</i> ⁵	I	Presence uncertain. If present, rare or infrequently seen.
Cape clawless otter?		
<i>Panthera pardus</i>	I	Widespread, but status unknown. Mostly in forests more remote from villages, but occasionally enter farm bush. May have a contiguous population in the landscape. Killed when encountered. At least six killed in the past 10 years. Most recent sightings and track registers in 2012, 2011, 2010, 2009 and 2007.
LeopardLeopard		
Tchi		

<i>Caracal aurata</i>	I	Widespread, but status uncertain; some hunters say it is common, others that it is rare. Uses all forest types and farm bush. May have a contiguous population in the landscape. Killed when encountered. Most recently killed near Woffiken (three killed in 2011/2012), Seweken (2012, 2010), and Kor Town (date unspecified).	
Golden cat			
Tiger			
Sukleh			
Primates			
<i>Galagoides demidovii</i>	H	Common and widespread. Uses all forest types and farm bush. Infrequently killed.	
Demidoff's galago			
Slacheh	1		
<i>Perodicticus potto</i>	I	Common and widespread. Uses all forest types and farm bush. Killed when encountered.	
Potto			
Sofre sofre			
<i>Cercopithecus petaurista</i>	S, H	Common and widespread but probably declining. Uses all forest types and farm bush and may still have a contiguous population in the landscape. Frequently hunted. Killed during the study period.	\$5–7
Lesser spot-nosed guenon			
White nose Taloueh	8		
<i>Cercopithecus campbelli</i>	H	Widespread but declining. Probably divided into three isolated populations. Uses all forest types but now less frequently found in farm bush. Frequently hunted. Killed during the study period.	
Campbell's monkey			
Big jaw; Lion monkeyTouen	1		
<i>Cercopithecus diana</i>	I	Rare and declining; only found several hours walk from the villages. Probably divided into 2-3 isolated populations separated by 8–12 km of farms and farm bush, heavily hunted forest, and a highway. Uses all forest types but not farm bush. Frequently hunted. Killed in 2012.	\$11
Diana monkey			
Colored monkey			
Kreh			
<i>Cercocebus atys</i>	S, H	Common and widespread but declining. Uses all forest types and farm bush. May have a contiguous population in the landscape. Frequently hunted and sometimes kept as pets. Killed during the study period.	\$10–15
Sooty mangabey			
Jakoh Katneh	4		
<i>Procolobus verus</i>	I	Rare and declining; only found several hours walk from the villages. Probably only in one or two isolated populations separated by 8–12 km of fields and farm bush, heavily hunted forest, and a highway. Uses all forest types but not farm bush. Frequently hunted. Killed during the study period.	\$7
Olive colobus			
Four finger			
Tabaoo			
<i>Procolobus badius</i>	I	Rare and declining; only found several hours walk from the villages. Probably only in one or two isolated populations separated by 8–12 km of fields	\$11–19
Western red colobus			
Red monkey			

Tuleh		and farm bush, heavily hunted forest, and a highway. Uses all forest types but not farm bush. Frequently hunted. Three killed during the study period.	
<i>Colobus polykomos</i>	I	Rare and declining; only found several hours walk from the villages. Probably only in one or two isolated from the villages. Probably only in one or two isolated populations separated by 8–12 km of fields and farm bush, heavily hunted forest, and a highway. Uses all forest types but not farm bush. Frequently hunted. Killed in 2012.	\$20
Western black and white colobus			
Black monkey			
Pleh			
<i>Pan troglodytes</i>	H	Widespread but declining. Mostly found several hours walk from the villages, but will occasionally approach farms. Recent sightings in several parts of the landscape (including 20 minute walk from Peloken). The fact that they still approach farms suggests that the population may still be contiguous in the landscape. Uses all forest types, farm bush and fields. May still raid maize and cacao farms. Hunted when encountered; young sold live. Most recently killed or wounded in 2012 (two) and 2007 (four). One informant has killed 16 in the past 10 years.	\$9–10 piece
Chimpanzee			
Chimpanzee	1		
Weh			

S = sighting; T = tracks; F = faeces; R = rooting/diggings; B = burrow; H = heard; I = interview.

¹ Species names: Latin binomial; English; Pidgin English, Grebo (as best as I could transliterate).

² Market values are for smoked animals. Values converted to US \$ calculated as 1 US \$ = 70 L \$.

³ Only two of the hunters described an animal that sounded like the royal antelope, so I have included it as possibly occurring there. Both Hoke *et al.* (2007) and East (1999) list the species as present in the region.

⁴ The genet plates in the field guide confused all of the hunters, probably because with all the species displayed on a single page, they could not distinguish which species is present based on the drawings. Although the distribution maps in the field guide indicate that two species might occur there, the informants all claimed there is one species of “bush cat”.

⁵ People rarely see otters and only one hunter had killed one. Some of the hunters said that there were two species present so I include both in the list, but I only registered tracks of the spot-necked otter.

2002; Rist *et al.*, 2009). The post-logging mosaic of heavily-logged forests and farms in the flatlands, more lightly-logged forests in the hills, swamp forests along the waterways, and forest buffer zones between villages provided conditions that allowed for the fauna to persist until recently.

Today, as an increasing number of young hunters adopt commercial hunting as a means

to gain cash income, several species are in danger of being extirpated as has occurred in many African forests (Refisch & Kone, 2005; Bennett *et al.*, 2007; Fa & Brown, 2009) and with the African elephant in the study landscape (last seen in the late 1960s). The traditional system of open-access resource use that imposes no restrictions on how much, when or where humans harvest

wildlife, is no longer adequate for protecting certain species from over-harvesting (Verschuren, 1983; Noss, 1997; Bennett *et al.*, 2007; van Vilet *et al.*, 2012). As hunters have expanded their hunting ranges up to 10 km outside of the village centre, neighbouring village hunting zones now overlap and there are no longer hunter-free areas. As a result of this new hunting ecology the abundance and distribution of 12 (26.7%) of the 45 extant mammal species are changing in ways that suggest that once contiguous populations are increasingly fragmented and declining. All of the hunters complained that wildlife had declined within the proximity of the villages. As a result, hunters are travelling deeper into the forest to find game.

Whereas traditionally hunting excursions were loop walks starting and ending in the village, today the young commercial hunters set up base camps far from the villages in order to hunt in more remote areas. Hunters reported that even a few years ago they did not waste cartridges on smaller animals (e.g. palm civets—*Nandinia binotata* and brush-tailed porcupines—*Atherurus africanus*) but that now they shoot whatever they find. They all reported declines in kill rates (Waltert *et al.*, 2002), from highs of 8–12 animals killed/week several years ago to 3–5 animals killed/week today claimed by the most successful hunters. Evidence from this rapid assessment suggests that if the current trends continue at least some of these species are in danger of being extirpated. These species include several of global conservation significance (chimpanzee, pygmy hippopotamus, Jentink's and zebra duikers, giant pangolin, the Diana monkey, and the three colobus monkey species), as well as regional (bongo, forest buffalo, and giant forest hog).

Road construction and its consequent effects on land use patterns likely play a role in the decline of wildlife as well (Wilkie *et al.*, 2000; Laurance *et al.*, 2006). Villages are now concentrated and agricultural development has tended to spread along the roads, creating field/fallow corridors that fragment the larger forest blocks (Christie *et al.*, 2007; Norris *et al.*, 2010). Wildlife that historically did not enter the farmlands (e.g. zebra and Ogilby's—*Cephalophus ogilbyi* duikers, pygmy hippopotamus, bongo, giant ground pangolin, Diana monkey, and the three colobus monkey species) would probably suffer population fragmentation even in the absence of hunting as a result of the expanding road network. The remaining species historically entered the farmlands (even if infrequently) suggesting that in the absence of heavy hunting pressure these agricultural corridors might not be isolating barriers. Roads also facilitate access to forest for hunters and to markets where they can sell their meat (Bowen-Jones & Pendry, 1999; Wilkie *et al.*, 2000; van Vilet *et al.*, 2012).

While forest is still being cleared for farming in all the villages, the plots cleared were small (1–4 ha), and most agriculture is established on fallow lands. As the study landscape retains a large percentage of forest cover, deforestation does not appear to be an imminent threat to the forest dependent wildlife.

Conclusion

The study landscape lies in one of the most forested regions of Liberia (Christie *et al.*, 2007), and, thus, probably represents a best case scenario for wildlife persistence in agricultural areas when compared to parts of the country with less forest cover. In this

scenario, wildlife and farmers can co-exist in the absence of commercial hunting, and even with heavy hunting pressure it is likely that 62.2% of the fauna will persist (even if in reduced abundances). However, if hunting pressure continues as it is (or increases as appears to be happening), and forest fragmentation increases (as is likely due to an improving road network), 26.7% of fauna is unlikely to persist in this landscape in the long-term.

The principal proximate cause for the wildlife declines is commercial hunting stimulated by a desire of Grebo farmers to participate in the global economy, a chronic demand for bushmeat in the urban areas, and an improving and expanding transportation infrastructure (Norris *et al.*, 2010; van Vilet *et al.*, 2012). As killing animals is part of the Grebo tradition, no one believes that it is ethically wrong to do so, and as there are no restrictions on harvesting these animals, commercial hunting is a legitimate immediate solution for earning cash income (Asibey & Child, 1990). Trying to convince them that killing animals is wrong for ethical or ecological reasons is unlikely to make sense to the Grebo interviewed in this study. The County Development Committee (2008) estimates that up to 33% of household incomes in River Gee come from trading game meat, clearly indicating the importance of hunting for the regional economy. Because of this, commercial hunting is unlikely to abate unless the people are offered more attractive economic alternatives.

As the Grebo in the study landscape are largely illiterate farmers with limited access to schools and job training opportunities, the economic solutions are likely to come through agriculture. While the traditional rice swidden

system still provides subsistence for the Grebo, it does not allow them the surplus income necessary to attain their new material needs (CDC, 2008). Alternative agricultural models will be essential if they are to participate in the global cash economy. It remains to be determined whether the course of action will be to shift to agroforestry systems that link the local economy to international commodity markets or some combination of swidden and agroforestry with crops of the former planted for food security and of the latter for generating income. The national infrastructure is improving and there are agricultural firms and NGOs in the region seeking partnerships with farmers, so if some agreement is reached, perhaps, the quest for an improved economic condition need not result in the extirpation of mammals species.

Alternative agricultural models only address the most proximate cause for commercial hunting (i.e. a hunter's desire for an increased income), however, and this solution will not address the market demand for game meat (Robinson & Bennett, 2002). It is certainly possible that even if the Grebo farmers stop commercial hunting, outsiders will enter the forests to take their places. Given the dire poverty of most Liberians and the multi-faceted challenges faced by the government in trying to develop the country, it is unlikely that protecting wildlife will be a top priority in human-used landscapes. Because of this, it is likely that wildlife populations will continue to decline in the near future. This rapid assessment suggests that while heavily-hunted human-used landscapes in the most forested regions of Liberia are likely to sustain 62.2% of the medium and large mammal species, a functioning protected area network will be

necessary for preserving intact fauna. These results provide insights to the complex challenge of including human-used landscapes in biodiversity corridors proposed to link disparate forest reserves in Liberia (Hoke *et al.*, 2007).

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