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Effects of human land-use on Africa's only forest-dependent felid: The African golden cat *Caracal aurata*

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ABSTRACT

Africa's equatorial forests are threatened by widespread deforestation and bushmeat hunting, with both threats spreading into formerly remote areas due to rapid human population growth and large-scale expansions of commercial resource extraction such as logging and mining, as well as forest clearing for agriculture. Many globally threatened species are endemic to these forests, but the potential effects of these threats are not well understood. Using the case of the forest-dependent African golden cat, we assess the potential effects of disturbance including logging and hunting on population density. We applied spatially-explicit capture-recapture models to camera trap data to estimate density across a human land-use gradient at five sites in central Gabon. We found density was highest at a pristine, undisturbed site (16.23 [±5.84 SE] individuals per 100 km^2) and lowest at a village site with moderate levels of mostly subsistence bushmeat hunting (3.8 [±2.23 SE] individuals per 100 km^2). Logging concessions can support important densities of the species (10.18 [±3.54 SE] and 12.84 [±4.25 SE] individuals per 100 km^2), with the higher estimate of the two for the concession certified by the Forest Stewardship Council (FSC) versus the non-certified concession. While protected intact forests are the main strongholds for golden cats, well-managed logging concessions may also play an important role in the conservation of golden cats and other threatened species.

1. Introduction

African rainforests are predicted to undergo major changes in the near future due to widespread development of mining, logging, and oil palm plantations, as well as clearing to make space for an increasing human population (Edwards et al., 2014; Wich et al., 2014; FAO, 2011). Remaining forests occur mostly in West and Central Africa, where annual forest loss during 2000–2010 was 1.1% for West Africa and 0.3% for Central Africa, and this loss is increasing (FAO, 2011). Forests in these economically poor regions are seen as a source for subsistence by rural communities and of commercial income by industry and governments. In Central Africa, where the bulk of Africa's tropical forest remains, 22.9% of forest area is designated for production, while only 3.7% is designated for biodiversity conservation (FAO, 2011). Unselective hunting of wildlife for bushmeat is also ubiquitous in the region, with forests being emptied of their wildlife to provide protein for rural communities and trade to urban centres (see "empty forest syndrome"; Abernethy et al., 2013; Wilkie et al., 2011; Redford, 1992). Human population growth rates in West and Central Africa are among the highest in the world (+2.6% per annum; FAO, 2011), thereby increasing demand for forest products and land, and accelerating the rate of forest and wildlife loss.

The African golden cat *Caracal aurata* is a medium-sized cat that weighs, on average, 6.2–14 kg (Ray and Butynski, 2013). It is Africa's only forest-dependent felid, and is endemic to equatorial Africa (Bahaa-el-din et al., 2015a). Due to its forest-specialisation, threats to Africa's forests are likely to translate directly to threats to golden cat populations. This reliance on forest habitat, and its position at the top of the food chain, make it a promising candidate indicator species for long-term sustainability of the African forest ecosystems. The golden cat is elusive and has hitherto never been studied systematically. There is no quantitative baseline information on golden cat population sizes as a result, but it is anecdotally reported as naturally rare (Hart et al., 1996; Hunter and Barrett, 2011). The golden cat is currently classified as Vulnerable on the IUCN Red List based on an estimated 30% loss of range over the last 15 years (Bahaa-el-din et al., 2015b). However,

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due to the paucity of data, assessments have relied mostly on inferences based on general trends in forest loss and bushmeat hunting. There are neither data on population size, nor an assessment of the impact of human activities on golden cat populations.

The relatively recent advent of remotely-triggered camera traps has allowed for the non-invasive study of elusive species (Meek & Fleming, 2014) such as forest felids (e.g. Mohamed et al., 2013; Wilting et al., 2012; Maffei & Noss, 2008). Further advances in spatially-explicit capture-recapture analysis (SECR or SCR; Efford, 2004; Royle and Young, 2008) permit more robust estimation of felid population density than traditional (non-spatial) capture-recapture models. SECR models incorporate the spatial information of captures, and use it to account for animal movement about their home ranges when modelling detection probability by using the location of traps relative to (estimated) activity centres of animals. They permit estimation of density for an explicitly defined area, and are not biased by ad-hoc approaches to estimating the size of the sampled area, as non-spatial capture-recapture models are. We use SECR models to produce the first density estimates of African golden cats. We applied this method across a gradient of human land-uses to assess potential impacts on golden cat populations, thereby remedying the lack of baseline population information on golden cats while using the species as an indicator for the effects of logging and hunting on forest wildlife. Prior studies on leopards *Panthera pardus* in Gabon established adverse effects of bushmeat hunting and logging on the occurrence and abundance of this species (Henschel et al., 2011). We hypothesise that golden cats are likewise negatively affected by hunting and logging and that within logging concessions, Forest Stewardship Council (FSC) certified concessions hold higher densities of golden cats than non-certified ones due to FSC requirements to follow regulations on anti-poaching and reducing structural damage to the forest.

2. Methods

2.1. Study area

The study was conducted at five sites (each of ca. 20 km^2; Table 1, Fig. 1) in central Gabon, where human population density is low (1.5–2.0 inhabitants/km^2), and more than 95% of the region is covered by mature lowland semi-evergreen rainforest (Henschel et al., 2011). The terrain is undulating with elevations ranging between 100 and 1000 m. Lopé National Park and Ivindo National Park are located within this forest landscape, while much of the forests outside these parks consist of logging concessions (Fig. 1). The climate within this area is equatorial with two rainy seasons and two dry seasons and average yearly precipitation of 1300–2000 mm (Vande Weghe, 2006; Vande Weghe, 2011).

We selected sites according to a disturbance gradient to assess variation in golden cat density in response to anthropogenic impacts. We use descriptive site names throughout according to the land-use or habitat at that site (Table 1), including: “Pristine” for a protected site with no history of disturbance; “Mosaic” for a protected site at the edge of a forest-savannah mosaic; “FSC-logged” for a logging concession certified by the Forest Stewardship Council; “Logged” for a logging concession that is not certified; and “Village” for a site adjacent to a village.

We attributed a disturbance score to each site based on combined scores from four criteria: 1) distance to closest village; 2) hunting intensity, ranked according to the number of camera trap photo-captures of hunters, 3) management, scored in relation to the level of wildlife protection; and 4) structural damage to forest, based on author judgement (Table 2, for ranks and details of ranking procedure). We found no sign of hunting in the two National Parks, some old sign of elephant hunting (that authors believe not to affect golden cats) at the FSC-logged site, and recent sign of bushmeat hunting at the Logged and Village sites.

All sites consisted of continuous forest habitat with the exception of the Station D'Etudes des Gorilles et Chimpanzes (SEGC) in Lopé NP. This site constitutes a forest-savannah mosaic (Fig. 2), with the savannahs originating during the last ice age, and nowadays maintained by annual burning to stop forest encroachment (Leal, 2001).

2.2. Camera trapping and data preparation

At each site, we started with a reconnaissance period where we recorded golden cat sign (footprints and scats) and trail type (see below) by GPS (Garmin eTrex Legend HCx). We based placement of 38–41 camera trap stations per site on field sign and trails, mapped using ESRI's ArcGIS software (version 9.3), in order to maximise golden cat captures. We placed cameras on a variety of existing trails, including logging roads, skidder trails, elephant trails and smaller game trails (Fig. 2).

We placed stations 600–800 m apart based on finding during a pilot study that 1 km spacing did not allow for many individual recaptures of females (Bahaa-el-din et al., 2011). Each station consisted of two cameras facing each other with a slight offset to avoid flash interference. We used 40–70 Panthera camera traps (models v3 & v4; panthera.org), supplemented with 6–20 ScoutGuard (model SG565F; Boly Media Communications (Asia) Co., Ltd.) and 4–24 DeerCam (model 200 with 35 mm film; Non Typical Inc., Park Falls, Wisconsin, USA). We used white-flash camera trap models to ease identification of

Table 1
Details of our five study sites in central Gabon.

Site name	Descriptive site name (used hereafter)	Management	Trapping Location	Elevation range (m)	Forest description	Disturbance history	Period	Survey duration (days)
Langoué, Ivindo NP	Pristine	National Park	0°8′–0°12′S, 12°31′–12°34′ E	380–581	Mature semi-evergreen rainforest	Pristine forest, with no evident past disturbance	Sep–Nov 2011	55
Station D'Etudes des Gorilles et Chimpanzes (SEGC), Lopé NP	Mosaic	National Park	0°11′–0°14′S, 11°34′–11°38′ E	216–583	Forest-savannah mosaic, with post-logging and colonising secondary forest	Logged in 1970s	Sep–Dec 2013	102
PreciousWoods, Milolé	FSC-logged	Logging concession (FSC-certified)	0°20′–0°24′S, 12°40′–12°42′ E	229–323	Mature semi-evergreen rainforest, with post-logging secondary forest	Logged 2 years prior	June–Aug 2011	54
CoraWood, Mouyabi	Logged	Logging concession (not-certified)	0°17′–0°20′S, 12°27′–12°30′ E	349–533	Mature semi-evergreen rainforest, with post-logging secondary forest	Logged 2 years prior	Aug–Oct 2012	79
Moukagno	Village	Village hunting area (ca. 21 households)	1°10′–1°12′S, 12°3′–12°7′E	461–711	Mature semi-evergreen rainforest, with post-logging secondary forest	Hunting, logged in 1990s	May–Aug 2013	89

FSC = Forest Stewardship Council.