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Forest Certification and the High Conservation Value Concept: Protecting Great Apes in the Sangha Trinational Landscape in an Era of Industrial Logging

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Introduction

FORESTRY IN TROPICAL AFRICA: IMPACTS OF LOGGING ON GREAT APES

Ape responses to logging and environmental change are complex. Precisely defining the impact thresholds of forestry activities on chimpanzees (*Pan troglodytes*) and gorillas (*Gorilla gorilla*) is challenging due to the long life spans of these apes, their complex social systems, and relatively low densities. Reactions of apes to environmental disturbance have generally been studied in terms of before and after numeric assessments of abundances at particular sites. Conclusions suggest both *Pan* and *Gorilla* are able to persist in timber production forest with varying degrees of success in short time frames, but the long-term prospects of survival have not yet been assessed. Survival prospects do not reflect solely the impact of forestry practices, but also a myriad of indirect or collateral impacts, such as bushmeat hunting, further habitat degradation and land conversion, and introduced pathogens (Campbell et al. 2008; Wilkie et al. 2001, see also Chapman et al., chapter 25 this volume; Hartel et al., chapter 26 this volume). This makes it difficult to isolate specific responses to particular types of disturbance associated with logging practices.

Species responses to environmental disturbances vary depending on their resource use preferences. Chimpanzees and bonobos are considered ripe fruit specialists (Morgan and Sanz 2006; Newton-Fisher 1999), with a preference for primary forest (Furuichi, Inagaki, and Angoue-Ovono 1997; Tutin and Fernandez 1984). While some surveys of chimpanzees in logged and unlogged habitats have indicated a preference for less disturbed forests (Clark et al. 2009; Matthews and Matthews 2004; Poulsen, Clark and Bolker 2011; Stokes et al. 2010), other investigations provide no conclusive evidence of such preferences (Arnhem et al. 2008; Dupain et al. 2004; Plumptre and Reynolds 1994).

Beyond diet and habitat preferences, it is important to take into consideration the social disposition and ranging behavior of the African apes. Chimpanzees and bonobos have structured territorial ranges that effectively limit community members from spending considerable time outside of their home range; they rely heavily on the use of core areas. If a larger portion of the community range was disturbed, this could physically displace a group into the range of a neighboring community, which would result in social upheaval within the group and possibly lethal conflict between groups. Such a scenario has been suggested to have reduced chimpanzee densities subsequent to selective logging at Lopé, Gabon (White and Tutin 2001), and may have transpired elsewhere in the region.

In contrast to chimpanzees and bonobos, gorillas are not as territorial and do not have the same social limitations to their ranging. Gorillas are committed folivores who rely on a diet primarily consisting of herbaceous vegetation (Kuroda et al. 1996; Morgan and Sanz 2006; Tutin and Fernandez 1985, 1993), though some populations show considerably more frugivorous tendencies (Masi et al. 2009). Similar to chimpanzees, gorillas utilize a wide variety of habitat types such as primary forest, heavily inundated swamps, and secondary forests (Carroll 1988; Furuichi et al. 1997; Tutin and Fernandez 1984; Usongo 1998). This high degree of ecological flexibility has led some researchers to hypothesize that gorillas would find adequate resources in logged habitats, a view which has been supported by field surveys in some regions (Clark et al. 2009; Matthews and Matthews 2004; Stokes et al. 2010). Chimpanzee densities, however, were lower in forests logged 15 years prior to the survey in comparison to unlogged habitat (Stokes et al. 2010). If an initial reduction in chimpanzee densities occurs after logging, a time-lag response in species recovery may nonetheless follow.

Ecological impacts of timber exploitation and forest recovery potentially have long-term effects on foraging and nesting resources used by local ape populations. Since the 1960s, scientists have studied logging at Kibale National Park in Uganda, where the variation in disturbance between logging units has served as a natural experiment for examining the impact of timber removal on chimpanzee ecology and reproductive fitness. In one of the initial investigations of the impact of logging on apes, Skorupa (1988) found an inverse relationship between logging intensity and chimpanzee densities. Degree of habitat disturbance was indicated to be a potentially key factor driving the abundance of chimpanzees inhabiting post-logged forests. Subsequent research elucidated more specific influences, showing that female chimpanzees had lower reproductive success, with longer interbirth intervals and higher infant mortality, in areas with outtake rates of 17.0 m^3/ha (50.3% of basal area reduction) and 20.9 m^3/ha (46.6% basal area reduction) compared to females residing in less disturbed forests (Emery Thompson et al. 2007). The more intensive logging regimes may have reduced the food resource base for chimpanzees, with adjacent "refuge" areas potentially buffering from such impacts. Potts' (2011) research in Kibale indicates that the explanation may be more complex, as the actual impacts of logging on chimpanzee diets were low, even in cases where preferred food items were previously exploited. Overall chimpanzee abundance did not appear related to logging history, highlighting the fact that previously-logged forests, particularly those exploited only once or twice, may still retain important resource attributes for ape survival. However, it is important to reflect on the differences in spatial scales considered in these investigations as well as any possible indirect or secondary impacts that could be influencing ape densities. While timber exploitation has the potential to have both positive and negative effects on apes, the removal of timber in west and central Africa generally coincides with other potential impacts such as the growth of human population centers (Poulsen et al. 2009), and the rise of informal marketplaces related to non-timber forest products, such as the trade in bushmeat.

In regions such as northern Republic of Congo, the potential for such direct and indirect impacts is considerable considering the amount of continuous forest and wildlife inhabiting such regions (Blake et al. 2008; Strindberg et al. 2018). The forests surrounding the Trinational de la Sangha landscape were recently designated a United Nations Education, Science, and Cultural Organization World Heritage site (fig. 27.1). This landscape consists of four officially recognized national parks and one reserve spanning Cameroon, Central African Republic, and Republic of Congo. While the setting aside of these protected areas is important to conservation, they are surrounded by large logging concessions. The first small-scale inroads into this remote landscape were established in the early 1970s but it was not until the early 2000s (Laporte et al. 2007) that a surge in road construction occurred, forever changing the accessibility of these once "frontier" and "last of the wild" expanses (Bryant, Nielsen, and Tangley 1997; Sanderson et al. 2002). The Intact Forest Landscape (IFL) technique uses medium spatial resolution satellite information to map boundaries of contiguous forest mosaics and associated habitats with an area at least 500 km^2 (50,000 ha). These continuous areas are reasoned to signify the likely existence of stable flora and fauna due to the absence of overt anthropogenic disturbance (Potapov et al. 2008). From 2000 to 2013, a 77% reduction in IFLs occurred in this region, which is the most rapid

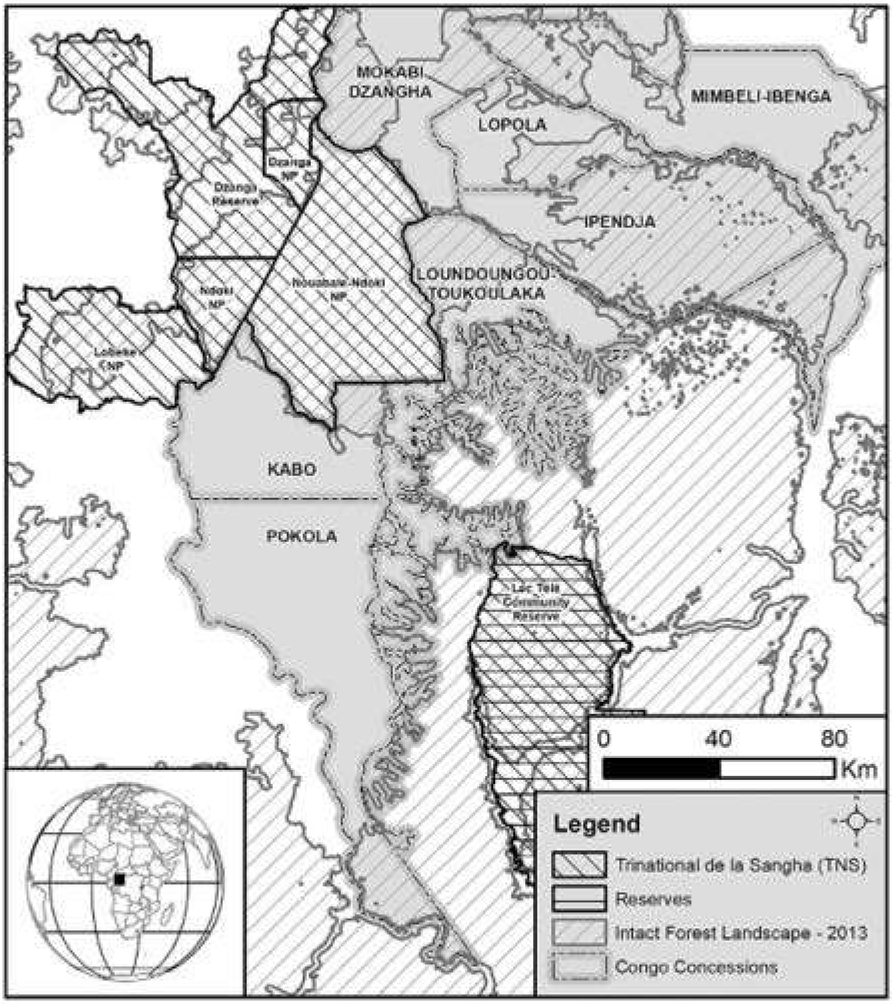

FIGURE 27.1. Protected areas of the Sangha Trinational Landscape and timber concessions contained important Intact Forest Landscape (IFL) as of 2013. Decline of Intact Forest Landscape (IFL) in the Kabo, Pokola, and Mimbeli-Ibenga concessions has been extensive.

change in all the tropics (Potapov et al. 2017). Most of this resulting change stemmed from the industrial timber industry.

Initial surveys in the logging concessions across the Sangha Trinational Landscape indicated that the Forest Stewardship Council (FSC) certification processes had produced positive results, which occurred over a five-year time frame, benefiting conservation of wildlife in the context of timber exploitation (Stokes et al. 2010). However, assessment of the full influence and any benefits accrued from certification necessitates a long-term approach. It also requires the establishment of an appropriate and timely monitoring regime to ensure that management practices are effective in their aims. There are valid

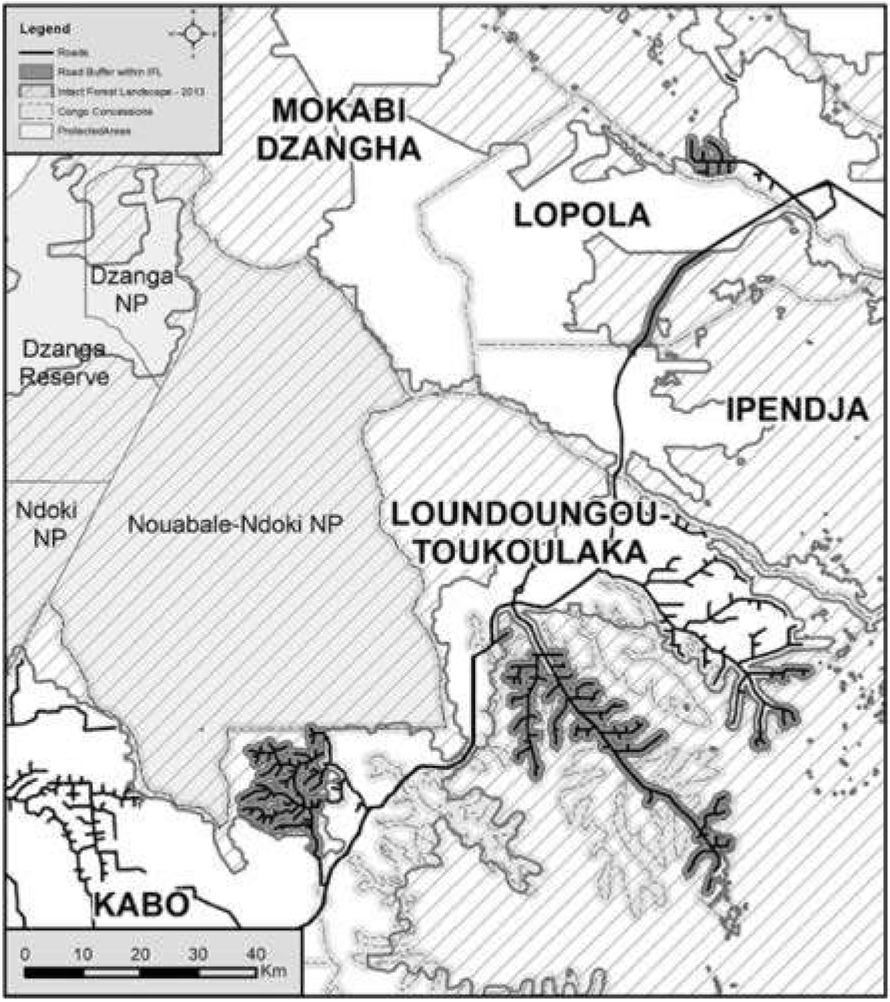

FIGURE 27.2. Regions of Intact Forest Landscape (IFL) loss in the Kabo, Loundougou-Toukoulaka, Lopola, and Mimbeli-Ibenga concessions. Different development strategies can be depicted based on the road placement and extent of area covered. Loss of forest canopy mostly coincided with proximity to roads and within mixed species forest.

concerns leveled at certified forestry operators and associated detrimental impacts within production zones, such as elevated levels of primary forest loss (Potapov et al. 2017) and deforestation (Brandt et al. 2016). In this chapter, we take a stepwise approach to identifying and assessing High Conservation Value Forests (HCVF) surrounding the Sangha Trinational Landscape. In the process, we update the IFL 2000–2013 inventory (Potapov et al. 2017) with a new estimate up to 2017 for the seven logging concessions neighboring the Sangha Trinational Landscape in Republic of Congo (fig. 27.2). At the landscape scale, we also provide an estimate of habitat suitability for chimpanzees and gorillas in the region based on satellite imagery analysis and species habitat use.

Advocates have argued for a more time sensitive and spatially explicit analytical research approach toward addressing anthropogenic disturbances that includes stakeholders and scientists working across disciplines (Bruenig 1996; Lindenmayer 2010; Nasi, Billand, and van Vliet 2012). Here, we provide a case study detailing such involvement including foresters, NGOs, and independent scientists. The HCVF approach is followed, placing emphasis on environmental values, which is at the core of principles of the forest certification standard (FSC 2009). Scaling down to the Forest Management Unit level, we estimate past and future impacts of primary roads in an active logging concession and relate development to deforestation. We use these results as a means to address the current debate surrounding the actual impact of logging IFL and influence on associated HCFVs within and outside these identified landscapes. Our overall aim is to improve conservation management policies to ensure the long-term survival of great apes and other wildlife in certified and non-certified logging concessions across the Congo Basin.

Approach

STUDY SITE

We analyzed seven logging concessions (Mokabi-Dzangha, leased by Rougier; Lopola, leased by BPL; Ipendja, leased by Thanry; Mimbeli-Ibenga, leased by SCTB; and Loundoungou-Toukoulaka, Kabo, Pokola, all leased by OLAM) along a vast stretch of lowland Guineo-Congolian forest that were allocated for timber harvesting. All but Mimbeli-Ibenga concessions included within this study were operated according to Management Plans that set regulations on timber regimes (Lescuyer et al. 2015). Various summary statistics were estimated at the concession level. Within the Kabo concession we focused on a Unite Forest Production (UFP) area (228.3 km^2) where active timber removal was taking place. The UFP3 consisted of three areas marked for exploitation from 2015 to 2019. The size and shape of each area was determined by timber inventories and the abundance of marketable timber species present (FAO 2016; Karsenty 2016).

Direct observational studies of gorilla and chimpanzee were carried out by the Goualougo Triangle Ape Project. The main study site and habituated ape groups are located in the unlogged IFL located between the Ndoki and

Goualougo Rivers. The Goualougo Triangle Ape Project was initiated in 1999 and is an ongoing project with studies located inside and outside of the Nouabalé-Ndoki National Park.

INTACT FOREST LANDSCAPE ACROSS THE TRINATIONAL DE LA SANGHA LANDSCAPE

We used the IFL inventory map (Potapov et al. 2008) to define "intactness" of the forest landscapes. This map is based on the extent of roads and settlements documented from Landsat images (of 30-m resolution) up to 2013 (Potapov et al. 2017). The regions highlighted are areas >500 km and >10 km wide that fall outside a 1-km buffer around such infrastructure (Potapov et al. 2008). However, new road networks have been established within the concessions surrounding the Sangha Trinational Landscape and within the IFL since 2013. Information on these new roads was provided by the timber operating company and projected in ArcGIS. We used satellite imagery to georeference roads and verify placement and subsequently updated the IFL inventories generated for areas of interest following Potapov et al. (2008).

PREDICTIVE CHIMPANZEE AND GORILLA HABITAT MODELING

The basis for our habitat suitability modeling was a Landsat ETM1 satellite image (collected on February 9, 2001) displayed in bands 4,5,3 (RGB) that overlaid the study area. Seventeen habitats were classified based on ground-truthed data within the image. Apes require two basic types of resources to persist on a landscape: nesting substrates and foraging resources. The model, therefore, requires estimates of availability of both of these resource types for each land cover type in the map. We ranked habitat types with a score of increasing preference from 0 to 10. Habitats were assessed separately in terms of quality for feeding and nesting, and later combined to produce a habitat landscape for each species.

Foraging preferences were based on our direct observations of ape foraging behavior in the Goualougo Triangle (unpublished data; Morgan et al. 2006), with consideration of reports of ape feeding ecology published from other sites (Doran et al. 2002; Morgan and Sanz 2006; Moutsambote et al. 1994; Remis et al. 2001; Rogers et al. 2004; Sabater-Pi 1979; Tutin and Fernandez 1985, 1993; Williamson et al. 1990). Suitability of habitat for nesting was based on studies of habitat use by gorillas and chimpanzees from line-transect

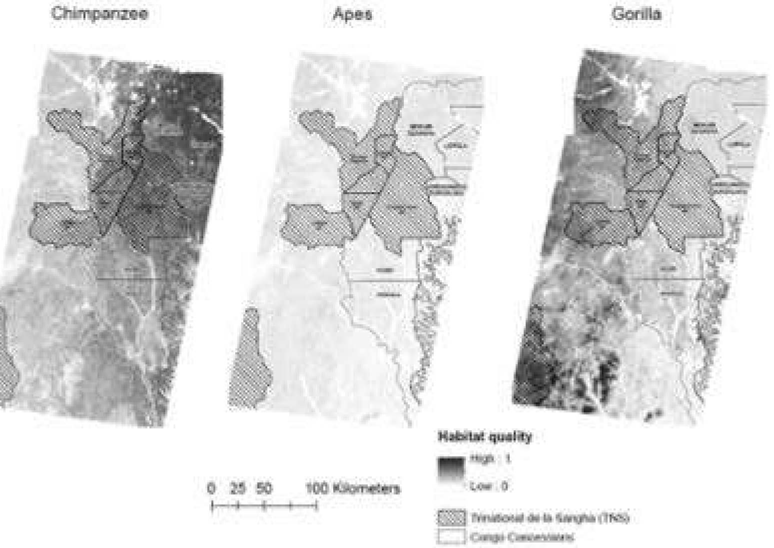

FIGURE 27.3. Spatial distribution of potentially-preferable foraging habitat gives a better understanding of distribution of potential High Conservation Value Forest (HCVF) for chimpanzees (left), great apes (center), and gorillas (right) across the Sangha Trinational area and adjacent forestry concessions. High quality habitat for gorillas and chimpanzees is indicated as increasing from gray to black. Less preferred habitat by species is indicated by lighter shading. Although habitat preferences overlap, there are distinct patterns in the spatial distribution of high quality habitat for gorillas and chimpanzees.

nest surveys and direct observations (Morgan et al. 2006). When scoring habitat preferences for each species, we also took into consideration the reports of ape nesting and habitat use from this region (Blake et al. 1995; Dupain et al. 2004; Fay et al. 1989; Furuichi et al. 1997; Matthews and Matthews 2004; Morgan 2001; Poulsen and Clark 2004; Tutin and Fernandez 1984; Tutin et al. 1995). Rather than base our ratings of preferred habitats on the Goualougo site, we attempted to estimate the likelihood that either species would select that habitat if its availability was equal to all other resources in an area. Apes use nesting habitat each evening and move into foraging habitats during the day, and their foraging distances, in combination with arrangement of different habitats, affect their likely persistence and abundance in a given landscape. Our model therefore also requires a typical foraging distance for chimpanzee and gorilla based on direct observations at Goualougo.

The first step of our model was to translate a land cover map (fig. 27.3) into a nesting suitability map and a forage resource availability map. Then, based on the amount and location of nesting and foraging resources, we calculated an overall habitat suitability score for chimpanzees and gorillas.

Nesting Suitability Map

The first step in calculating the ape habitat suitability score at each parcel was to identify the proportion of suitable ape nesting habitat (*HN*) in a parcel *x* as a function of land cover *j*:

(equation 1)
$$\mathbf{HN_x} = \sum_{j=1}^{J} \mathbf{N_j P_{jx}}$$

where $N_j \in [0,1]$ represents compatibility of land cover *j* for nesting and p_{jx} is the proportion of parcel *x* that is covered by land cover *j*. This provides a landscape map of nesting suitability where $HN_x \in [0,1]$ (fig. 27.3). A score of 1 would indicate that the entire area of the parcel provides habitat suitable for nesting while a score of 0.2 would indicate 20 percent of the parcel's area provides suitable nesting habitat.

Forage Resource Map

We also calculated the proportion of suitable foraging habitat surrounding a parcel *x*, given by $HF_x \in [0,1]$. We assume that foraging frequency in parcel *m* declines exponentially with distance to a suitable nest site, and that apes forage in all directions with equal probability. Therefore, parcels farther away from nest parcel *x* contributed less to total resource availability than parcels nearby, and leads to the following prediction for the potential foraging resources available to ape nesting in parcel *x*, HF_x:

(equation 2)
$$\mathbf{HF_x} = \frac{\sum_{m=1}^{M} \sum_{j=1}^{J} \mathbf{F_j\, p_{jm}} e^{\frac{-D_{mx}}{\alpha}}}{\sum_{m=1}^{M} e^{\frac{-D_{mx}}{\alpha}}}$$

where p_{jm} is the proportion of parcels *m* in land cover *j*, D_{mx} is the Euclidean distance between parcels *m* and *x*, α is the expected foraging distance for the ape, and $F_j \in [0,1]$ represents relative amount of foraging resource in land cover *j*. The numerator is the distance-weighted resource summed across all *M* parcels. The denominator represents the maximum possible amount of forage in the landscape. This equation generates a distance-weighted proportion of habitat providing foraging resources within foraging range, normalized by the total forage available within that range (Winfree et al. 2005). Since ape abundance is potentially limited by both nesting and foraging resources, the overall suitability score on parcel *x* is simply the product of foraging and nesting such that $HS_x = HF_x HN_x \in [0,1]$.

DEFORESTATION

We used two measures of forest-cover loss. First, we estimated annual forest loss rates based on the examination of Landsat 8 data at a 30m spatial resolution from 2000 to 2016 (image GFG_10N_010) (Hansen et al. 2013). Cell counts from the global data set (cells = 30 m × 30 m) constituted the output.

Our second forest-cover loss analysis focused on the direct localized impact of road development and removal of trees. We estimated total area of forest lost due to land clearance for roads by placing a 20 m buffer around any new road. Estimated road width was 20 m based on Kleinschroth (2016). We modeled the removal of preferred ape foods, which were ranked according to frequency of use based on direct observations of feeding events by chimpanzees and gorillas, feeding traces encountered while following the apes, and fecal analysis in the Goualougo Triangle from 1999 to 2014 (Morgan and Sanz 2006). These included tree species within the fruit-bearing genus such as *Dialium*, *Chrysophyllum Greenwayodendron*, *Irvingia*, and *Pterocarpus*.

The influence of road development on ape resources was estimated by linking species-specific preferences to georeferenced commercial timber inventory data for this study area. For 2014 to 2017, the commercial timber inventory data corresponded with locations of new road construction within the UFP3 area. The inventory included tree stems with minimum diameter of exploitation ranging between 60 to 100 cm at breast height depending upon species (Congolaise Industrielle de Bois 2006). The spatially explicit inventory of individual trees surveyed in the UFP3 included stems from 40 different species of marketable and non-marketable trees. For this study, any tree stem falling within the pre-defined road buffer was considered removed during the development of the road. To assess potential carbon loss associated with forest disappearance, we used 395.7 Mg ha^{-1} as a reference, based on Lewis et al.'s (2013) calculation for mature forest in the Congo Basin.

Results

LANDSCAPE LEVEL ASSESSMENT OF INTACT FOREST LANDSCAPE

From 2013 to 2017, we estimate that 609 km^2 of intact forest was removed across five of the seven concessions inventoried in this study (fig. 27.2). There were differences in total amount of road-less area (km^2) being impacted between concessions during this time period (table 27.1). In Loundoungou-Toukoulaka, the reduction was equivalent to 358 km^2 over the last four years,

TABLE 27.1. Extent of road lengths and area reduction of Intact Forest Landscape (IFL) within timber concessions bordering the Sangha Trinational area.

Concession	*Area (km²)*	*Total Length of Roads (km)*	*Total IFL (km²)*	*Reduction in IFL 2013–2017 (km²)*
Pokola	5,277	784	656.48	0.07
Kabo	2,960	526	525.97	206.95
Ipendja	4,585	24	3,588.08	2.34
Lopola	1,970	36	746.32	40.72
Loundoungou-Toukoulaka	5,608	671	2,268.87	358.46
Mimbeli-Ibenga	6,716	160	2,811.48	42.00

Note: Concession database was obtained from the World Resource Institute (http://www.wri.org/resources/maps/republic-congo-logging-concessions-and-protected-areas). Logging road spatial database was provided by OLAM Ltd.

whereas the IFL loss in Kabo was 207 km². We found very little IFL remaining in the Pokola concession, which has experienced one or two cycles of timber exploitation throughout most of the area. IFL loss in Pokola was concentrated in inundated areas to the south of the concession where road placement was in close proximity to flooded forests. IFL loss in Lopola concession resulted from a long linear road that bisected the largest remaining extent of IFL in the concession area. While the expansion into this road-less area was comparatively low, it fragmented the remaining IFL in the region. To the east, and in neighboring Mimbeli-Ibenga concession, 42 km² of IFL was lost as a result of logging activity.

PREDICTIVE CHIMPANZEE AND GORILLA HABITAT MODELING

The spatial distribution of preferred-foraging habitat gives a better understanding of the distribution of potential areas of High Conservation Value (HCV) for chimpanzees and gorillas across the Sangha Trinational Landscape and adjacent forestry concessions. Although the habitat preferences of these apes overlap, there are distinct patterns in the spatial distribution of high-quality habitat for chimpanzees and gorillas. Areas estimated to be high in habitat suitability for chimpanzees corresponded with IFL within the Nouabalé-Ndoki National Park in Republic of Congo and Ndoki National Park in Central African Republic (fig. 27.4). The highest average habitat suitability for gorillas was found in the Lobeke National Park (Cameroon) and the Dzanga Reserve (Central African Republic). Both of these areas had regions not included in the IFL inventory, as harvesting of timber occurred in these forests in the early 1970s. Logging has only recently been re-initiated in Dzanga Reserve.

DEFORESTATION IN THE KABO CONCESSION

Changing our focus from concession-scale analysis to the UFP3 area of interest, we found that IFL remained largely free of roads within the Kabo concession until 2014. Annual deforestation data from Hansen and colleagues (2013) indicated the forest of UFP3 was largely stable for the period spanning from 2001 to 2014, at which time forestry activities began to expand into this previously road-less area. From 2014 to 2016, forestry activities resulted in tree cover area loss ranging from 0.77 km^2/year to 2.35 km^2/year. The resulting forest-cover loss during this time period in the UFP3 totaled 4.92 km^2 of forest loss, most of which was spatially associated with logging roads (fig. 27.2). The forest removal was estimated to amount to 92,989.5 Mg AGB lost in the UFP3 from forestry activities during this period.

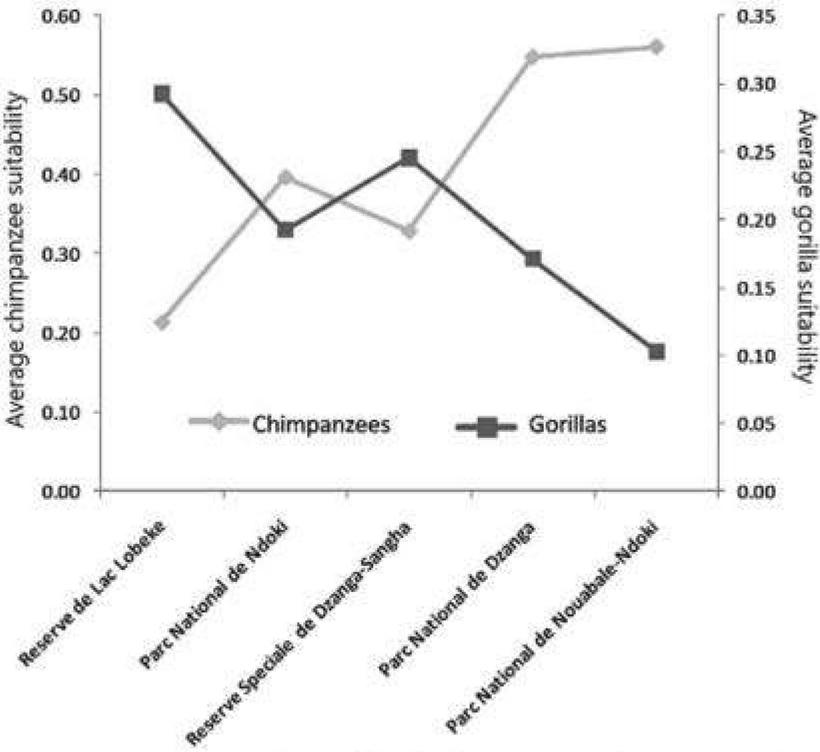

FIGURE 27.4. Protected average habitat suitability for chimpanzee and gorillas. The protected areas on the x-axis are arranged from west to east and show a chimpanzee-to-gorilla habitat gradient. The western parks protect relatively more gorillas while the eastern parks protect relatively more chimpanzees.

ROAD IMPACT ON GREAT APE RESOURCE BASE

The spatial distribution of deforestation obtained from global Landsat data largely aligned with the location of physical land clearing related to the establishment of primary and secondary roads. From 2014 to 2017, approximately 134.4 km of new roads were opened in UFP3. Forest removal resulting from direct impacts of road clearance was estimated at 2.69 km^2 of forest lost within this 227 km^2 area of the UFP3. Within 2017 alone, this likely resulted in the clearance of 199 individual tree stems representing 30 species of woody tree. The most common species removed was *Entandrophragma cylindricum*, followed by *Diospyros crassiflora* and *E. angolense*. Of the total estimated tree species removed during route placement, 11 species are included in the diet of chimpanzees and seven species are fed upon by gorillas.

Discussion

The forests of the Sangha Trinational Landscape are renowned for their high abundances of gorillas and chimpanzees. Through species-specific habitat modeling, we found that IFL in the Sangha Trinational Landscape corresponded with higher levels of suitable habitat for chimpanzees whereas non-IFL had elevated levels of predicted preferred gorilla habitat. Abundance estimates of both ape species based on nest surveys confirm these findings. They also provide further evidence that single or twice selectively logged forests may be altered at least initially to the benefit to gorillas and less so for sympatric chimpanzees. We also revealed that a significant percentage of road-less Sangha Trinational Landscape forest had been penetrated by extraction networks since the last assessment of intact forest, resulting in an estimated 650 km^2, or 6%, decrease of IFL since 2013. The loss of IFL was largely restricted to route construction associated with selective logging in dry mixed-species forests. Our estimate of IFL also included flooded and swamp forests, which are prevalent in the Loundoungou-Toukoulaka and Pokola concessions. Following the HCV approach, we tabulated the current physical extent of IFL in the region and also identified site-level HCVs and associated forestry impacts. Route construction patterns differed between adjacent concessions but were largely concentrated in mixed-species forest, which is preferred habitat for both chimpanzees and gorillas. Primary road construction resulted in a greater percentage of chimpanzee food resources being removed than those of gorillas. Flora regeneration likely depends on route type and associated damage, which could differentially impact chimpanzees and gorillas. Here we provide guidance on interpreting the HCV concept for other stakeholders interested in the use of this tool for conserving chimpanzees, gorillas, and other wildlife in active logging concessions.

As of 2017, road development in the Kabo and Loundoungou-Toukoulaka concessions was shown to be extensive. This is partially due to the large sizes of these concessions, which are 4,514 km^2, on average. However, the extent of forest impacted also varied with the different strategies of the operators. In all but one concession (Mokabi), the operators focused on road placement in pristine forests rather than returning to previously logged habitat. The greatest decline in IFL occurred in the Loundoungou-Toukoulaka concession, with an estimated 358 km^2 impacted since 2013. The road network in this concession traversed a previously road-less area to reach southern Annual Allowable Cut areas. The linearity of the main access road in this region was a reflection of the topography. The exploitable dry mature forest in this region was long and narrow extending into extensive flooded forests that buffered it on both sides. We documented a much denser road network for timber removal in the Kabo concession. The denser road network resulted in less impact on IFL with a total reduction of 206 km^2 over a three-year period. However, it did mark the arrival and expansion of exploitation into one of the last remaining expansive IFL within this concession. It also provided evidence of the operator's focus on timber removal, rather than construction of new extraction roads in this remote area.

INTACT FOREST LANDSCAPE AND HIGH CONSERVATION VALUE FORESTS

The boundaries of the Sangha Trinational protected area network were established in the late 1980s and early 1990s using threat indices that were developed as *ad hoc* functions of remoteness of the areas. The Parc National de Ndoki in Central African Republic and Nouabalé-Ndoki National Park in Republic of Congo were created largely encompassing IFL, which remains intact as of 2017. Our analysis verified there has been no illegal logging within the Nouabalé-Ndoki National Park, which is a concern for some other regions in the Republic of Congo, as estimates suggest that 70% of timber produced from Republic of Congo has been illegally sourced (Lawson 2014). Other protected areas within the Sangha Trinational Landscape (such as Lobeke National Park in Cameroon, Special Reserve de Dzanga Sangha and Parc National de Dzanga in Central African Republic) included once selectively logged forest within their boundaries. Our predictive modeling of suitable ape habitats indicated a high abundance of gorilla habitat within certain areas of Lobeke National Park and Special Reserve de Dzanga Sangha. The habitat disturbance associated with previous logging may have resulted in more open canopy forest, which is the preferred habitat of gorillas. While further monitoring is required, these results support a potential log-and-protect strategy that Rice, Gullison, and Reid (2001) proposed if stakeholders are interested in focusing conservation efforts on gorillas.

FSC Principle 9 requires that timber operators evaluate concessions to determine whether areas within the concession contain attributes that should be considered HCV. Concessions containing significant concentrations of great apes are considered to be HCV areas because all great ape species are listed as Endangered on the IUCN Red List of Threatened Species (IUCN 2016). Our coarse-grained regional scale analysis was a first step in the HCV assessment (fig. 27.5) and verified that the Sangha Trinational protected areas and bordering concessions qualify as an HCV 1. The suitability of the Sangha Trinational region to support high chimpanzee and gorilla populations is further validated by independent abundance estimates (Brncic, Maisels, and Strindberg 2018; Morgan et al. 2006; Stokes et al. 2010). Following FSC Principle 9, it is incumbent upon operators to consider the findings and guidance of independent scientists and NGOs when such information is available (FSC 2017). Large areas of IFL remain within northern Republic of Congo, but based on projections from road and settlement data, Potapov and colleagues (2017) estimated that the remaining IFL in the country will be lost within the next 60 years. Our updated estimates on the disappearance of IFL in this region support such claims. Further, we predict that all remaining IFL in the Kabo concession will be exploited in 2018 and 2019.

Most decisions about land allocations in the region have been made without detailed empirical data on species of concern. This information is now available from ongoing studies and can be used to better define "core areas" for conservation at large landscape scales (HCV 2), or for conserving forest attributes such as particular resources important to species-specific behaviors. Recent results indicate the number of behavioral repertoires documented across chimpanzee communities declines with increasing human disturbances, suggesting unique cultures of social groups are disappearing (Kuehl et al. 2019). Chimpanzees in this region are renowned for their tool-using propensities such as gathering honey from particular tree species or termites from earthen mounds (Sanz and Morgan 2009; Sanz, Morgan, and Gulick 2004). Protection measures for these particular resources should be appraised when planning exploitation of timber. Such protection measures have already been developed for identifying valued or "sacred" trees to local indigenous populations in some certified concessions (Hopkin 2007). Another potential avenue of

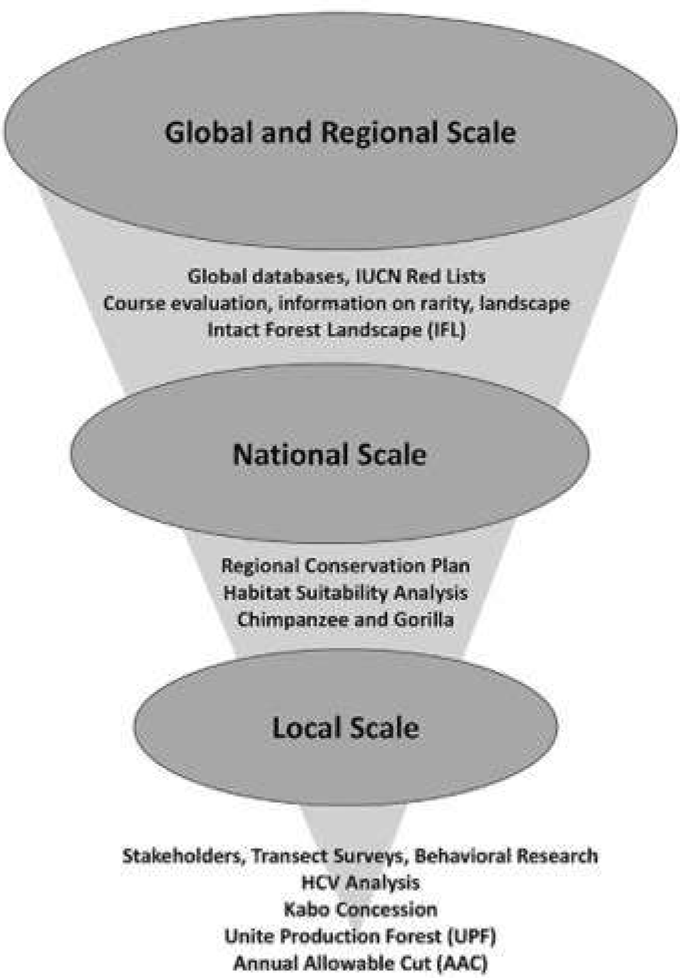

FIGURE 27.5. Following the High Conservation Value (HCV) approach, we show how different levels of information and data sources were used at various scales. At the regional level, coarse information, such as the Intact Forest Landscape (IFL) inventory, was used in identifying priority landscapes. Moving down to the national level and the Sangha Trinational protected area network, we found potential differences between apes in these varying conservation contexts using transect survey data and satellite imagery. Future potential sources of ape data could include regional distribution maps (see Junker et al. 2012; Maisels et al. submitted). At the local level, our HCV assessment utilized industry data (timber inventory and georeferenced spatial data on land-use and infrastructure such as roads, and annual allowable cut [AAC] areas) that was combined with information on chimpanzee and gorilla feeding ecology from direct observations of wild apes in this region. Critically, results from HCV value evaluation should be provided to local stakeholders (protected area managers, industry, and Forest Stewardship Council Regional Standard Committee).

expanding the impact of sustainability measures is to combine forest inventory data with information on the ecological needs of particular endangered species to generate quantitative parameters to inform selection of core areas or set-asides. For example, floristically interesting forests within remaining IFL located to the north and northeast of the Nouabalé-Ndoki National Park in the Loundoungou-Toukoulaka region deserve consideration (WWF 2017). We suggest an area within the IFL of the Loundoungou-Toukoulaka concession be inventoried for botanical attributes to verify whether this ecosystem qualifies as HCV 3 and potentially requiring environmental protection measures. Timber inventories provide an additional source of floral information typically lacking for the most at-risk regions, such as those outside protected areas where nearly 80% of chimpanzees in the region reside (Strindberg et al. 2018). Logging operators have already begun engaging with the academic community to enhance efforts to understand the ecological characteristics of production forests at a variety of spatial scales (Baccini et al. 2008; ter Steege 1998; Réjou-Méchain et al. 2008).

In most cases, outright protection through creation of key national protected areas is not possible. Approximately 14.9% of Republic of Congo's forests are IUCN Category 1 protected areas (Strindberg et al. 2018), which exceeds the Congo Basin average of 12.2% of forests designated as protected area across Central Africa (Mackinnon et al. 2016). It is urgent that a monitoring scheme following the HCV's principles aimed at habitat management in production forests be developed that is adaptable depending on local contexts. In fact, this is a unique opportunity to evaluate the cost and benefits of certified versus uncertified forestry following the HCV approach. Stakeholders concerned with impacts of exploitation on particular species or habitats should be able to predict potential changes associated with alteration in current forestry exploitation regimes. For example, the depletion of current marketable timber stocks and known natural tree growth trajectories in this region have led ecologists to recommend operators expand the diversity of timber species exploited and decrease the amount of canopy closure (Hall et al. 2003; Karsenty and Gourlet-Fleury 2006; Kleinschroth 2016). These prescriptions have been recommended as necessary to maintain timber production yields, but they also run counter to FSC timber certification standards. Greater emphasis on identifying and mitigating cumulative changes in quality and quantity of foraging and nesting resources over time and space is needed to ensure the long-term viability of chimpanzee and gorilla populations in these timber concessions. Given the accelerated loss of these forests, there is limited time to actualize such opportunities.

UNDERSTANDING THE IMPACT OF ROADS IN REMOTE FORESTS

The construction of roads and associated extraction routes have different short- and long-term consequences for continued exploitation of natural resources (Fuller et al. 2018) and resident wildlife populations (Laurance et al. 2006). As of 2017, an estimated 134 km of new road was opened and led to the immediate clearance of 2.69 km^2 of forest in the UFP3 area of the Kabo concession. By calculating total forest removed from an area of ape habitat, we provide a conservative estimate of potential direct impact on ape resources. In terms of ranging behavior, this represents an area equivalent to 15% of a chimpanzee "core area" of use based on estimates of community ranging made in the Goualougo Triangle (Morgan 2007). Not all route construction has the same spatial or floral impact. This study focused on primary roads, which result in the removal of more trees and the movement of greater amounts of soil than other routes such as secondary roads and skidder trails. Future studies on the immediate disturbance associated with primary, secondary, and skidder road development, followed by continuous monitoring of natural forest regeneration dynamics will provide valuable information on their implications for local apes.

Changes associated with road clearance had an immediate impact on apes: 35% of the removed trees were identified as food items of chimpanzees and 23% were included in gorilla diets. Research across the Sangha Trinational Landscape has shown that road construction associated with selectively logged forests has led to notable changes in tree species richness (Malcom and Ray 2000). The disturbance can lead to uniformity in the local floral assemblage and structurally altered habitats (Guariguata and Dupuy 1997). In the near term (<8 years), fruit-bearing tree resources removed will largely be replaced by non-woody vegetation at the ground level (Kleinschroth 2016; Malcom and Ray 2000). Such species may be favored by gorillas, but are typically less utilized by chimpanzees. This expansion of the foraging and nesting niches of gorillas likely has implications on local ranging patterns as well as population numbers. Forests logged at a greater intensity, with associated elevated levels of disturbance, could result in higher numbers of gorillas frequenting these areas after logging. Along primary logging roads, evidence from other sites suggests that the foraging prospects for chimpanzees may improve with time. Based on chronological surveys along primary logging roads in the region, the upper story of the forest will initially be typified by reduced canopy closure (Kleinschroth 2016) until fifteen years after exploitation, when pioneer tree species such as *Musanga cercopioides* grow and dominate the floral biomass and canopy. Chimpanzees in exploited forests of east Africa were found to incorporate the flowers and fruits of this tree species into their diets (Hashimoto 1995). Anecdotal observations in the Kabo logging concession also suggest chimpanzees make use of this new food and nesting resource. Stokes and colleagues (2010) found chimpanzee abundances in forests logged 15 years earlier were elevated and close to densities found in unlogged areas, indicating potential benefits of changing resources. This resource is temporary, however, and will last only three decades before a natural decline in abundance occurs as the forest transitions to include other tree species. An additional factor influencing the transition and ultimate legacy of roads is whether a road remains open after logging has ceased, either as a transport route for wood and commerce or for domestic travel. New routes provide easy and near complete access to once remote areas in concessions (Wilkie et al. 2001), which were previously buffered from threats such as hunting and pathogens of human origin known to be of threat to apes. Importantly, the vast majority (roughly 80%) of logging roads in northern Republic of Congo are temporary transport routes that are abandoned once logging has ceased, with inevitable natural forest regeneration to follow (Kleinschroth et al. 2015, 2016). Such road closures are mandatory with FSC certification as a measure to hinder illegal incursions or potential zoonotic disease transmission events. Most forests in this region have been exploited only once, and it remains unknown how these changes could influence great ape survival and fitness over longer time scales. An important avenue of future research will be to assess the dynamics of logging extraction routes and the transition of floristic communities influencing great ape populations.

Conservation Outlook for Great Apes

There are several reasons for cautious optimism when considering the conservation outlook of *Pan* and *Gorilla* in the context of timber exploitation in Africa. Until recently, logging disturbance across most of the region has been typified by relatively low rate and highly selective removal of a few timber species (Pérez et al. 2005). Two species (*Aucoumea klaineana* and *Entandrophragma cylindricum*) comprise 56% of the total timber production in the Congo Basin sub-region (Pérez et al. 2005). Neither of these species are of importance to great apes from a foraging or nesting perspective. Many of the concessions within the Republic of Congo and Gabon were located within IFL with low cumulative human influence. Therefore, remaining exploited forests in many of these concessions present an opportunity to assess and maintain identified natural attributes important to the survival of great apes. The relatively high abundance of great apes in this region is influenced by the distribution of closed or open canopy forest, which varies considerably over small spatial scales across this region. Understanding of species-specific preferences for particular habitat types and forest structures will continue to evolve with more complete information on ape ecology and be further enhanced by technological advances in remote sensing (Devos et al. 2008).

We previously identified the highest priority indicators for incorporation into Congo Basin FSC standards for promoting great ape conservation (Morgan and Sanz 2007; Morgan et al. 2013). In this study, we demonstrated how the HCV approach can be applied to conserving chimpanzee and gorillas in a timber production forest. From the landscape scale to the local area of interest, we identified habitat and resources impacted during exploitation that may pose a threat to great apes. This information is targeted for stakeholders and developers of High Conservation Value National Interpretations, which have already been drafted or finalized in five African countries (Republic of Congo, Democratic Republic of Congo, Cameroon, Gabon, and Liberia). We hope that the results presented will support discussions by a Standard Development Group on exploitation and preservation in IFL as well as inform reduced impact logging requirement of the Republic of Congo FSC indicators. The implications could be far reaching for remaining great ape populations.

Despite increasing human pressure and severe fragmentation of habitat, chimpanzees and gorillas defiantly persist (Bergl et al. 2012; Pusey et al. 2007; Robbins et al. 2011; Strindberg et al. 2018). Shifts in resource use and behavior observed across a continuum of human influence highlight the flexibility of apes in adapting to environmental changes and opportunities (Hockings, Anderson, and Matsuzawa 2009; Hockings et al. 2012; Meijaard et al. 2010; Morgan et al. 2017). Although these observations are encouraging, they also reflect the fact that apes are in crisis. The demise of our closest living relatives will be averted only by integrating ape resource needs into adaptive forestry management plans, which must become mandatory across the range states of African apes.

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