POLICY BRIEFING

State of the Apes

Infrastructure Development and Ape Conservation





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Content developed from *State of the Apes: Infrastructure Development and Ape Conservation*
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Introduction

The *State of the Apes* series, commissioned by the Arcus Foundation, aims to raise awareness about the impacts of human activities on all non-human ape species. The series addresses the conservation of African and Asian apes, including the great apes, which are comprised of gorillas, chimpanzees, bonobos and orangutans, as well as the small apes, or gibbons. The series also considers the status and welfare of captive apes in sanctuaries, zoos and research facilities around the world. The third biennial volume examines the impacts of fixed and linear infrastructure development in ape habitats during the construction, use and decommissioning phases, with a particular focus on roads and dams. Previous volumes of *State of the Apes* dealt with the impacts of extractive industries on apes, including oil and gas exploitation, mining and logging (Volume 1), and the impacts of industrial agriculture on apes (Volume 2). Each volume contains a thematic section of chapters that discuss topical issues and present illustrative case studies from various ape range countries. Each volume then continues with a second section on the status and welfare of ape populations in their natural habitats and in captivity. This policy briefing summarizes both sections of the recent volume, presents key findings and makes best practice recommendations for local, national and global-level stakeholders.

As large, forest-dwelling mammals, apes can serve as indicator species for the broader health of the ecosystems they inhabit. The tropical forests that harbor apes are also critically important sources of food, water, medicine and shelter for indigenous people and other local communities. Furthermore, these forests maintain rich biodiversity and deliver ecosystem services, such as carbon sequestration, which are essential for the well-being of all humanity. This document is intended to help stakeholders who have influence over activities that impact apes to achieve the best possible balance between socioeconomic development and ape conservation.

Infrastructure Development

Global Drivers

As the planet's population expands and human consumption levels increase, global demand for food, water, energy and other commodities is growing rapidly. To meet these demands, people and industries are expanding farther and farther into locations that were once remote. Companies are intensifying their prospecting in previously unexplored areas, many of which are protected or have high conservation value (McNeely, 2005). While new infrastructure is essential to achieve economic development, it is too often built without regard for the negative impacts that it can have on the environment and the people who rely on natural capital for their livelihoods and well-being.

It is estimated that to meet the ambitions of the UN Sustainable Development Goals and the Paris Agreement, US$90 trillion in infrastructure investments will be needed (Global Commission, 2016). For example, China's ambitious Belt and Road Initiative, which will span 64 countries, is estimated to require more than US$8 trillion in investments (Ascensão *et al.,* 2018). New infrastructure is intended to support urban development, power generation and transportation in order to reduce poverty, provide access to energy, deliver safe drinking water and facilitate the movement of goods to markets.

Unfortunately, the development plans of many states rely disproportionately on exporting commodities, including fossil fuels, minerals, timber and agricultural products, such as palm oil, to emerging markets abroad. Under such a scenario, linear transportation and energy infrastructure is networked to fixed large-scale industrial projects, including plantations, dams and mines (Edwards *et al*., 2014). To transport commodities to mills, ports, processing plants, refineries and smelters, it is necessary to build roads, railways and waterways, but these may not facilitate sustainable and equitable economic development opportunities for the broader population.

Financing for infrastructure projects comes from multilateral development banks, emerging-market development banks, bilateral aid agencies, the governments of developing countries, as well as private companies. Between these lenders, the robustness of social and environmental safeguard schemes varies greatly. Such safeguards experienced an initial period of strengthening beginning in 1980s following adoption by the World Bank (Currey, 2013). Some have asserted, however, that lenders have since weakened the social and environmental standards attached to financing in response to the entrance of China on the global stage during the 2000s (Kahler *et al*., 2016).

China's overseas investments are growing rapidly, and the country's financing is said to come with few social and environmental constraints attached (Edwards *et al*., 2014). In 2014, China's outward direct investment was valued at more than US$123 billion, according to an International Institute for Sustainable Development analysis (IISD, 2016). The institute notes, however, that criticism of China's approach to natural resource investments may be an unfair double standard. For example, the country has recently issued voluntary environmental guidelines that apply to operations abroad.

Lenders concerned about their ability to remain competitive must be aware of the financial, operational and reputational risks associated with being involved in projects that do not have sufficient safeguards. Such projects are often plagued by poor implementation, conflicts between stakeholders, corruption, insufficient planning, lack of capacity or technical expertise and the exclusion of civil society. These factors can result in significant delays, increased or unplanned costs and negative publicity.

Infrastructure Expansion Trends in Ape Range States

Although all ape species are protected under national laws and international treaties, populations are experiencing direct and indirect threats as industrial activities encroach upon

their forest habitats. All large-scale infrastructure development, including for agricultural operations, energy production, extractive industries and other purposes, have severe deleterious impacts on ape habitats and populations. Linear infrastructure built to support these activities, such as roads, railways, pipelines and power transmission lines, also impact apes both directly and indirectly.

Many natural resources are located in remote regions with high conservation values, including critical habitats for apes. By 2030, it is estimated that industrial activities will disturb about 99% of Asian ape ranges, and more than 90% of African ape ranges (Junker *et al*., 2012; Nellemann and Newton, 2002). Alarmingly, the protected status of ape habitats is not sufficient to shield them from harm. A disturbing trend of protected area downgrading, downsizing and degazettement has been witnessed recently, particularly in Africa. Between 1993 and 2013, for example, at least 23 African protected areas were downsized or downgraded (Edwards *et al*., 2014). Further, fossil fuel exploitation has affected 30 UNESCO World Heritage Sites across 18 African countries (WWF, 2015).

Linear infrastructure

By 2050, 25 million km of new paved roads will be built, according to an estimate by the International Energy Agency (Dulac, 2013). Development agencies and governments are expected to invest US$33 trillion for road building globally. Almost 90% of the new road infrastructure is anticipated to occur in developing nations, including in areas that deliver vital ecosystem services and harbor exceptional biodiversity (Dulac, 2013; Global Road Map, n.d.). For example, Indonesia has planned a six-corridor scheme across the country's islands. Similarly, Malaysia intends to build a pan-Borneo highway, which will cut through the forests of Malaysian Borneo.

In sub-Saharan Africa, a network of 35 "development corridors" are planned in order to connect cities, ports, airports, mines and hydropower plants. In total, 53,000 km of roads, railways and power transmission lines are envisioned (Laurance *et al*., 2015b; Weng *et al*., 2013). It is anticipated that 23 of the corridors will bisect protected areas with 3,600 km of linear infrastructure, and that one-third of Africa's total

Together with industrial agriculture, linear infrastructure projects, including roads, are the leading cause of ape habitat loss and fragmentation. Road construction in Guinea.

protected areas could be negatively impacted (Sloan, Bertzky and Laurance, 2017). Some of the 400 areas at risk include those with international treaty protections, including Ramsar Wetlands of International Importance, UNESCO World Heritage Sites and UNESCO Man and the Biosphere Reserves. Ape habitats that could be impacted include Uganda's Bwindi Impenetrable National Park and Kahuzi-Biega National Park in the Democratic Republic of Congo (DRC), which are both World Heritage Sites, as well as Nigeria's Cross River National Park.

Together with industrial agriculture, linear infrastructure projects, including roads, are the leading cause of ape habitat loss and fragmentation. Often built to support larger fixed infrastructure projects, roads pose an enormous threat to biodiversity and ecosystems (Laurance *et al*., 2015a). For example, since 2000, more than 50,000 km of logging and other roads have been constructed across the Congo Basin. The roads have enabled people to enter into previously remote areas to cultivate crops, collect forest products, hunt and capture wildlife (Kleinschroth *et al*., 2015; Laporte *et al*., 2007). The World Bank forecasts that expanding roads and transportation infrastructure will be the biggest driver of deforestation in the Congo Basin through 2030 (Hourticq and Megevand, 2013).

Hydroelectric dams

Between 2014 and 2040, global capacity to generate hydropower is expected to increase by 53%–77% (IEA, 2016, p. 249). Each year, hydropower attracts about US$50 billion in global investment (Frankfurt School-UNEP Centre/BNEF, 2017). Hydropower dams are considered desirable as reliable renewable energy sources, and because they can help control flooding and provide water for agricultural irrigation. It is worrying, though, that areas with the planet's greatest freshwater biodiversity are slated for 70% of global hydropower expansion (Opperman, Grill and Hartmann, 2015). These areas are also home to wildlife and people, which rely on healthy ecosystems for their livelihoods and well-being. In ape ranges, hundreds of hydropower dams are being planned that will also require power transmission lines and road infrastructure. Six dams have already been installed in African great ape habitats, and another 64 are anticipated, along with 200 km of roads. In gibbon habitats across Asia, 55 dams are in operation, while 165 more are planned, along with 1,100 km of roads (IUCN 2016; Lehner *et al*., 2011; Zarfl *et al*., 2015).

According to an International Institute for Environment and Development review, international social standards and environmental safeguards only apply to about 10%–15% of new hydropower projects around the world (Skinner and Haas, 2014). This is concerning given that an estimated 40-80 million people have been displaced by dams, and because dams have impacts on fish migration and environmental flows (WCD, 2000). Furthermore, dam reservoirs flood agricultural land and forest resources, and release carbon into the atmosphere from decaying matter. Additional carbon emissions are generated by the creation and transportation of dam construction materials, such as concrete. The infrastructure associated with hydropower projects causes further deforestation and facilitates the movement of people into previously remote areas. Increased human access to forests enables crop cultivation, hunting and other dangers to wildlife, which are discussed in detail below.

Some experts advocate that developing nations would be better served by "leapfrogging" large-scale expensive grid-based energy (IRENA, 2015). They argue that decentralized renewables, such as solar and micro-hydro structures, better provide access to energy for rural communities. Small-scale renewables have negligible environmental impacts, and supply a more stable source of energy to rural people. Meanwhile, for investors, dams pose serious operational, financial and reputational risks. Large hydropower projects are often delayed, canceled or become more costly than anticipated. They can also infringe on the rights of indigenous peoples and cause irreparable environmental damage. (Kitzes and Shirley, 2016; Shirley and Kammen, 2015; Shirley, Kammen and Wynn, 2014).

A group of 12 large dams planned in Malaysia's Sarawak state on the island of Borneo illustrates many of these risks. Rather than to provide energy access for Sarawak's rural communities, the dams were designed to service oil palm plantations and other energy-intensive industries, such as aluminum and steel production (Shirley and Kammen, 2015). The first dam of the group, the Bakun Dam, came online eight years late, and only operates at half capacity (Sarawak Report, 2014). The construction cost soared to as much as six-times the original budget estimate (Sovacool and Bulan, 2011). Ten thousand indigenous people were relocated for the Bakun Dam, and 1,500 for the second, the Murum Dam. The third, the Baram Dam, would have displaced 20,000 residents, but was canceled after years of protests and blockades by indigenous activists (Lee, Jalong and Wong, 2014). Pollution from the Bakun Dam also decimated fish stocks that were an essential protein source for communities. If all 12 Sarawak dams were to be constructed as planned, they would harm 68% of Borneo's mammal species, including gibbons, as well as 57% of the island's bird species. In total, an estimated 110 million individual mammals would be lost, along with 3.4 million birds, 900 million trees, and 34 billion arthropods (Kitzes and Shirley, 2016).

Cameroon's Lom Pangar Hydropower Project presents a similar cautionary example. The dam was constructed to enable growth of aluminum smelting operations owned by the world's largest mining company, Rio Tinto. The company receives preferential electricity rates from the project (Ndobe and Klemm, 2014). Deng Deng National Park is immediately adjacent to the Lom Pangar dam and its reservoir, which began partial impoundment in late 2015. The park and a logging concession on its border harbor 300-500 gorillas, as well as chimpanzees, forest elephants, pangolins and other rare and iconic wildlife species. Conservationists are concerned that critical ape habitat is being flooded as the reservoir fills and that animals could be stranded on isolated islands. Construction of power transmission lines will further degrade and destroy habitat while also posing a risk of electrocution. Furthermore, the project's environmental and social

impact assessment (ESIA) predicted that 7,000-10,000 people would move into the area seeking employment (Goufan and Adeline, 2005). Such in-migration increases agricultural expansion, behavioral disturbance, hunting pressure, pollution and the risk of human-wildlife conflict. As gold is found in the area, artisanal mining can also be anticipated.

Ape Socioecology

Four species of non-human great apes are found in Africa, and three species of great apes are found in Asia. All 20 species of small apes, or gibbons, are found in Asia (Mittermeier, Rylands and Wilson, 2013). Ape habitat is predominantly lowland tropical forest, and all species require large intact forest blocks, or reliable connectivity between smaller, isolated blocks, for their survival. Chimpanzees have the most flexible ranging behavior and some populations can be found in savannah-woodland mosaic landscapes or at higher elevations (Maldonado *et al*., 2012). Some bonobos also use savannah-woodland mosaic landscapes, and some gorillas and orangutans also live at higher elevations.

Vulnerability Factors

Many ape populations have declined substantially in recent decades, and now exist only in small, fragmented groups. For example, the critically endangered Grauer's gorilla, also known as the eastern lowland gorilla (*Gorilla beringei graueri*), which is endemic to the DRC, has declined by an estimated 77–90% in the last two decades (Plumptre *et al*., 2015). Apes are found in countries rich in biodiversity and natural resources, but many of these countries have weak institutions and are struggling to meet the resource demands of rapidly growing populations. As a result, ape habitats have suffered from anthropogenic pressures, such as infrastructure development, agricultural conversion, oil and gas exploitation,

FIGURE 1

Great Apes

Species/subspecies	Range state(s)	Population in natural habitat	IUCN Red List classification	Trend	Canopy density threshold
Bonobo a.k.a pygmy chimpanzee (*Pan paniscus*)	DRC	15,000–20,000	Endangered	Decreasing	50%
Chimpanzee Central chimpanzee (*Pan troglodytes troglodytes*) Eastern chimpanzee (*Pan troglodytes schweinfurthii*) Nigeria-Cameroon chimpanzee (*Pan troglodytes ellioti*) Western chimpanzee (*Pan troglodytes verus*)	Angola, Burundi, Cameroon, Central African Republic, Democratic Republic of Congo (DRC), Equatorial Guinea, Gabon, Ghana, Guinea, Guinea Bissau, Ivory Coast, Liberia, Mali, Nigeria, Republic of Congo, Rwanda, Senegal, Sierra Leone, Sudan, Tanzania, Uganda	345,000–470,000	Endangered	Decreasing	15–30%
Gorilla Cross River gorilla (*Gorilla gorilla diehli*) Grauer's gorilla a.k.a eastern lowland gorilla (*Gorilla beringei graueri*) Mountain gorilla (*Gorilla beringei beringei*) Western gorilla (*Gorilla gorilla gorilla*)	Angola, Cameroon, Central African Republic, DRC, Equatorial Guinea, Gabon, Nigeria, Republic of Congo, Rwanda, Uganda	154,930–245,980	Critically endangered	Decreasing, unknown	50–75%
Orangutan Northeast Bornean orangutan (*Pongo pygmaeus morio*) Northwest Bornean orangutan (*Pongo pygmaeus pygmaeus*) Southwest Bornean orangutan (*Pongo pygmaeus wurmbii*) Sumatran orangutan (*Pongo abelii*) Tapanuli orangutan (*Pongo tapanuliensis*)	Indonesia, Malaysia	>120,800	Critically endangered	Decreasing	50%

Data sources: IUCN, 2016; Mittermeier, Rylands and Wilson, 2013. See also Apes Index (pp. xii-xvi) and Annex X (p. 275) in the full publication.

FIGURE 2

Small Apes (Gibbons)

Species	Range state(s)	Population in natural habitat	IUCN Red List classification	Trend	Canopy density threshold
***Hoolock* genus** Eastern hoolock (*Hoolock leuconedys*) Gaoligong hoolock a.k.a. Skywalker hoolock (*Hoolock tianxing*) Western hoolock (*Hoolock hoolock*)	Bangladesh, China, India, Myanmar	295,700–372,500	Endangered, vulnerable	Decreasing	75%
***Hylobates* genus** Abbott's gray gibbon (*Hylobates abbotti*) Agile gibbon a.k.a. dark-handed gibbon (*Hylobates agilis*) Bornean gray gibbon a.k.a. northern gray gibbon (*Hylobates funereus*) Bornean white-bearded gibbon a.k.a Bornean agile gibbon (*Hylobates albibarbis*) Kloss's gibbon a.k.a Mentawai gibbon (*Hylobates klossii*) Lar gibbon a.k.a. white-handed gibbon (*Hylobates lar*) Moloch gibbon a.k.a Javan gibbon, silvery gibbon (*Hylobates moloch*) Müller's gibbon a.k.a. Müller's gray gibbon, southern gray gibbon (*Hylobates muelleri*) Pileated gibbon a.k.a. capped gibbon, crowned gibbon (*Hylobates pileatus*)	Brunei, Cambodia, China, Indonesia, Lao People's Democratic Republic (PDR), Malaysia, Myanmar, Thailand	360,000–400,000	Endangered	Decreasing	75%
***Nomascus* genus** Cao Vit gibbon a.k.a. eastern black crested gibbon (*Nomascus nasutus*) Hainan gibbon a.k.a. Hainan black crested gibbon, Hainan black gibbon, Hainan crested gibbon (*Nomascus hainanus*) Northern white-cheeked crested gibbon a.k.a. northern white-cheeked gibbon, white-cheeked gibbon (*Nomascus leucogenys*) Northern yellow-cheeked crested gibbon a.k.a. northern buffed-cheeked gibbon (*Nomascus annamensis*) Southern white-cheeked crested gibbon a.k.a. southern white-cheeked gibbon (*Nomascus siki*) Southern yellow-cheeked crested gibbon a.k.a. red-cheeked gibbon, buff-cheeked gibbon, buffy-cheeked gibbon (*Nomascus gabriellae*) Western black crested gibbon a.k.a. black crested gibbon, black gibbon, concolor gibbon, Indochinese gibbon (*Nomascus concolor*)	Cambodia, China, Lao PDR, Viet Nam	<1,653	Critically endangered, endangered	Decreasing, Stable	75%
***Symphalangus* genus** Siamang (*Symphalangus syndactylus*)	Indonesia, Malaysia, Thailand	Unknown	Endangered	Decreasing	75%

Data sources: IUCN, 2016; Mittermeier, Rylands and Wilson, 2013. See also Annex X in the full publication.

mining and logging. Complicating conservation measures is a lack of baseline data on species behavior, including seasonal variations.

A number of biological and behavioral factors make apes particularly vulnerable to decline as a result of encroachment into their habitats. Apes are dependent on natural forests to provide them with a sufficient quantity and quality of food and nesting resources. Using exceptional memory and mental mapping, they are capable of foraging in complex forest environments (Normand and Boesch, 2009). With their geographic distribution already limited, any loss of habitat is detrimental to ape survival. Furthermore, only a small percentage of ape habitats are afforded formal protected area status. In fact, as of 2000, protected areas covered only 26% of African ape ranges and 21% of Asian ape ranges. Only 25% of orangutans live within protected areas, which leaves 75% particularly vulnerable (Meijaard *et al*., 2010; Wich *et al*., 2012). It is important to note, however, that protected area status does not prevent all threats, and that encroachment occurs in many protected areas.

Ape species vary from entirely to partially arboreal, meaning that they spend some or all of their time in trees. Therefore, all require some degree of connected canopy cover (see Figures 1 and 2). Each group has a set home range, and many species are strongly territorial. Deadly conflicts can occur when anthropogenic activities force groups to compress into overlapping areas of forest. In addition, exceeding the natural carrying capacity of a forest can lead to stress, malnutrition or even starvation. No non-human ape is capable of swimming, and all species are reluctant to cross large open spaces. As such, bodies of water and areas of deforestation create additional barriers that fragment ape habitat and prevent movement.

Apes must be in good health for successful reproduction and their reproductive rates are slow. Births are widely spaced, occurring on average every 4–7 years in African apes, every 6–8 years in Bornean orangutans and every 9 years in Sumatran orangutans. A mother usually gives birth to a single offspring, and remains heavily invested in the infant's development until it matures. This makes it very difficult for a population to recover from losses, if it ever does (IUCN, 2014a). Given their genetic similarities to humans, apes are susceptible to human diseases, and they can also contract pathogens from domestic livestock or unsanitary conditions in settlements. Coming into more frequent contact with people and human-altered landscapes increases apes' vulnerability. Humans, too, are placed at risk of contracting diseases from apes and other wildlife upon entering remote forest areas.

Gibbons rarely come to the ground, so the construction of roads, and other infrastructure, dissects their habitat and results in intense fragmentation. Wildlife bridges allow animals to cross artificial barriers. © Marc Ancrenaz/HUTAN–Kinabatangan Orang-utan Conservation Project

Impacts of Infrastructure Development

All ape range states have infrastructure projects planned or underway, and these projects have impacts on apes during all stages: construction, use and decommissioning. Direct impacts include behavior change, disturbance, habitat loss, injury and mortality. Furthermore, indirect impacts, such as disease and hunting, result from increased access for people and human settlement.

Direct Impacts on Apes

Habitat loss

In order to survive, apes must have access to large or connected forest areas where they can feed, nest and reproduce. Loss of habitat is a major factor contributing to the decline of ape populations (Geissmann, 2007; Hickey *et al*., 2013; Plumptre *et al*., 2016; Stokes *et al*., 2010; Wich *et al*., 2008). According to Global Forest Watch, a satellite monitoring service, more than 10% of the overall ape range was lost between 2000 and 2014. A large majority of that loss occurred across Asia. Asian ape habitat was reduced by 21%, while African ape habitat shrank by 4%. While losses occurred both inside and outside of protected areas, satellite data shows that areas with formal safeguards were impacted to a lesser extent. Protected African ape habitats lost a median of 1% of their forests, compared to a median 5% of protected Asian ape habitats. Meanwhile, unprotected ape range in Africa was reduced by a median 3%, compared with a median 10% for unprotected habitats in Asia.

If deforestation continues at the rate witnessed between 2000 and 2014, nine species of gibbons can be expected to lose the entirety of their habitats (Clements *et al*., 2014; Gaveau *et al*., 2009). Of the remaining forests where apes and other primates are found, 65% are fragments smaller than 1 km² (Harcourt and Doherty, 2005). These areas are not large enough to support great apes without connectivity to other suitable forests. Further illustrating the extent of the problem, Cross River gorillas have lost 60% of their forest habitat, while Grauer's gorillas have lost half, and bonobos have lost 30% (Junker *et al*., 2012). Additionally, orangutan habitat, already greatly imperiled by oil palm plantations, is predicted to shrink by another 16% through 2030.

Deforestation of ape habitats has been caused by the expansion of large-scale agricultural plantations, and by both legal and illegal extractive operations, such as oil and gas exploitation, mining and logging. For example, the ranges of 15 ape subspecies are overlapped partially by timber, oil palm or rubber plantations. In 12 of those areas, land clearing for plantations is responsible for more than half of documented forest loss. Where illegal logging occurs, it not only threatens forest ecosystems, but also undermines national economies through loss of revenue. Globally, timber prices are deflated by 7–16% as a consequence of the trade in illegal wood (Seneca Creek Associates and Wood Resources International, 2004). For further information about the threats posed by extractive industries and industrial agriculture, see *State of the Apes*, Volumes 1 and 2, respectively.

The infrastructure built to support industrial and other economic development activities, and the influx of people drawn by them, further contribute to the decline of ape habitats. Deforested areas and hydroelectric dam reservoirs create barriers to ape movement and reduce their access to food, shelter, water and other gene pools. As apes are reluctant to cross large open spaces, they can become isolated in fragmented and degraded areas of forest (Tutin, White, and Mackanga-Missandzou, 1997). This can lead to malnutrition, illness and eventual population declines as a result of mortalities and reduced reproductive success (Das *et al*., 2009). If all 12 proposed Sarawak dams, discussed above, were to go forward as initially planned, nearly 2,500 km² of Malaysian rainforest would be destroyed for construction sites, resettlement sites and reservoirs (Kitzes and Shirley, 2016). Similarly, a proposed geothermal project in Indonesia's Gunung Leuser National Park would further denigrate the endangered Tropical Rainforest Heritage of Sumatra World Heritage Site, which is the only remaining place where orangutans, tigers, elephants and rhinos coexist. In preparation for the project, the company and Aceh's governor have requested that a 50 km² area be rezoned to accommodate construction activities, equipment and worker settlements (HAkA *et al*., 2016; Modus Aceh, 2016). Additional forest would be cut down to facilitate human access to the remote area, which is more than 10 km from the nearest road (Baabud *et al*., 2016). Additionally, transmission lines would be built in order to reach the nearest power substation, which is more than 150 km away.

A large percentage of new transportation infrastructure planned through 2050 will traverse the tropical forests of Southeast Asia and Central Africa. These same forests host exceptional biodiversity, including apes (Dulac, 2013). Millions of kilometers of new roads and railways will trigger extensive deforestation as areas are opened to human settlement and activities, such as agriculture and artisanal mining (Dulac, 2013; Quintero *et al*., 2010). Forest loss is highly contagious regardless of an area's protected status. It expands along new roads and leads to a web of secondary and tertiary roads, which also experience deforestation (Boakes *et al*., 2010). For example, in the DRC, when a palm oil company began redeveloping three abandoned colonial era plantations, the number of access roads increased by 34% in fewer than three years (Feronia, 2014). Also in the DRC, the Pro-Routes transportation network improvement project, funded by the World Bank, is expected to result in a 10-20% increase in habitat loss within 2 km of upgraded roads (Damania *et al*., 2016). Similarly, when a road in Aceh, Sumatra, Indonesia was improved in 2009, canopy loss 5-10 km from the road multiplied six-fold, according to 2014 Global Forest Watch data. Satellite imaging taken the same year also revealed forest loss as far as 25–30 km from two newly built roads in Tanzania.

The density of roads through an ape habitat, as well as their width, design and traffic intensity can affect the severity of anticipated negative impacts on apes (Blake, 2002; Malcolm and Ray, 2000; Wilkie *et al*., 2000). Ape abundance has been

Deforested areas and hydroelectric dam reservoirs create barriers to ape movement and reduce their access to food, shelter, water and other gene pools. Grand Poubara dam, Gabon.
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shown to decline in proximity to roads and settlements due to the associated hunting pressure that results from increased human access to ape habitats (Fa, Ryan, and Bell, 2005; Kuehl *et al*., 2009; Laporte *et al*., 2007; Marshall *et al*., 2009; Poulsen *et al.,* 2009; Poulsen, Clark and Bolker, 2011); Wilkie *et al*., 2001). Other linear infrastructure can have similar effects, as demonstrated by the Chad-Cameroon oil pipeline, which facilitated forest access for poachers and illegal loggers. Power transmission lines linked to hydroelectric dams can also fragment ape habitat (Andrews, 1990; White and Fa, 2014). Additionally, when constructing dams and filling their reservoirs, habitat is destroyed and natural river processes are halted (O'Connor, Duda and Grant, 2015).

Disturbance and behavior change

Infrastructure development activities can make loud noises, cause vibrations or otherwise disturb apes. Seismic blasts used to detect subterranean oil and gas deposits are particularly disruptive to wildlife. Apes tend to move away from noise and other anthropogenic disturbances while they occur, and sometimes for many months after they have ended (Rabanal *et al*. 2010). A group is likely to flee to a neighboring range to feed or nest while its home range is disrupted. With territorial ape species, range compression can result in stress, illness, conflict and even mortalities (Arnhem *et al*., 2008; Hashimoto, 1995; Matthews and Matthews, 2004). Competition for food can increase aggression or result in stress, injury or starvation (Mitani, Watts and Amsler, 2010; Watts *et al*., 2006). Female orangutans and their offspring are particularly vulnerable to starvation when forced out of their home ranges (Wich *et al*., 2012). Even within a group's home range, construction equipment, activities and infrastructure can create artificial barriers that disrupt apes' use of their habitat. These barriers could prevent apes from reaching essential food or nesting trees (Bortolamiol *et al*., 2016). As apes only reproduce when they are in good health, food scarcity and stress can reduce their reproductive success or result in illness. Further, isolation from other groups due to artificial barriers can restrict gene pools and genetic diversity.

Injury and mortality

Closed-canopy forests provide the most suitable ape habitats. As previously discussed, many ape species are very reluctant to cross non-forested areas, such as roads. When they do, severe injuries and mortalities can occur from collisions with vehicles (McLennan and Asiimwe, 2016). Similarly, accidents involving vehicles threaten the safety of passengers. Hydropower dam construction can also pose physical

danger to apes. As no ape specie can swim, individuals can drown or get trapped on islands and succumb to starvation (GVC, BIC and IRN, 2006). Furthermore, due to their arboreal nature, apes may use power transmission lines to traverse forest clearings. As apes cannot differentiate between natural vines and man-made wires, severe injuries and mortalities from electrocution have been documented (Ampuero and Sá Lilian, 2012; Chetry *et al*., 2010; Kumar and Kumar, 2015; Rodrigues and Martinez, 2014; Slade, 2016). To reduce the risk of ape electrocution, transmission lines and transformers should be insulated (Printes, 1999; Refuge for Wildlife, n.d.). This also helps to avoid costly infrastructure damage, service outages and potential criminal liability (Printes *et al*., 2010). It can also be helpful to prune nearby trees so that apes cannot easily transfer from the canopy to power lines (Lokschin *et al*., 2007). In order to maintain habitat connectivity, aerial bridges can be effective, although these must be monitored to guard against poaching (Jacobs, 2015; Lokschin *et al*., 2007).

Indirect Impacts on Apes

Increased access and human settlement

Infrastructure facilitates easier and more frequent human access to previously remote and undisturbed areas (Laurance, Goosem and Laurance, 2009). New roads are responsible for the largest increases in access (Clements *et al*., 2014). The first cut through an undisturbed area spurs a contagion of secondary and tertiary roads deeper into the forest. Furthermore, people who settle in newly-accessible areas are likely to deforest land for cultivation, grazing or artisanal mining. This further reduces the area available for wildlife and native vegetation and creates competition for natural resources (Asner *et al.,* 2009; Laurance *et al*., 2009).

In the DRC's Kahuzi-Biéga National Park, for example, thousands of artisanal miners attracted by gold, coltan, tantalum and tin deposits have cleared newly-accessible land for subsistence agriculture and felled trees for fuel wood (UNEP and McGinley, 2009; Conservation International, 2010). Pollution from human waste and mercury has also been documented there, as well as ivory poaching (Mazina and Masumbuko, 2004). Kahuzi-Biéga is a World Heritage Site home to Grauer's gorillas, chimpanzees and many other imperiled species. In the Central African Republic's Dzanga-Sangha landscape, which is another World Heritage Site with gorillas and chimpanzees, the closing of a sawmill supporting a timber concession led to an increase in subsistence cultivation. The percentage of households engaged in smallholder agriculture increased from 39% to 76% after the sawmill closed (Sandker *et al*., 2011). At Cameroon's Lom Pangar dam, an estimated 2,000 workers were recruited for construction activities, and as many as five-times that amount were expected to move into satellite communities (Agence Ecofin, 2012; Goufan and Adeline, 2005). Additional people may be attracted to the dam area once the reservoir is fully impounded, as commercial fishing will be allowed (EDC, n.d.).

Following deforestation, the second greatest peril apes face from in-migration is illegal killing and capture (IUCN, 2014b; Vanthomme *et al*., 2013). Hunting, discussed in further detail below, has the potential to decimate ape populations faster than direct threats related to habitat loss (Hicks *et al*., 2010; Ripple *et al*., 2016). Once access is established, subsistence hunters, small-scale commercial hunters, poachers and traffickers can capture or kill wildlife very effectively, using indiscriminate snares or targeted weapons (Blake *et al*., 2007; Poulsen *et al*., 2009; Robinson, Redford and Bennett, 1999). For instance, in Gunung Leuser National Park, in Indonesia, a road expansion project first fragmented the habitats of orangutans and gibbons, then enabled people from nearby settlements to enter the park illegally to extract timber and to poach wildlife (McCarthy, 2002; Singleton *et al*., 2004).

Infrastructure projects attract an influx of workers, people hoping for work, and others providing products and services to workers. Forests are cleared and converted into accommodation and recreation compounds for workers and satellite communities, as well as for forest groups that have been displaced by industrial operations, such as hydropower reservoirs. Human settlement leads to the further destruction and degradation of ape habitats as a result of illegal logging, smallholder agriculture, livestock grazing, fuel wood collection, charcoal production and artisanal mining (Cuaron, 2000; Trombulak and Frissell, 2000; van Vliet *et al*., 2012). Settlements near protected areas often encroach upon their boundaries over time (Laurance *et al*., 2012). In Indonesia's Gunung Leuser National Park, for example, illegal loggers have clear-cut river banks and expanded their settlements into the park's protected forest (McCarthy, 2002; Singleton *et al*., 2004). As protected areas can be negatively impacted by environmental changes that occur in their immediate surroundings, buffer zones should be implemented to keep human activities at an appropriate distance.

Human settlements in or near ape habitats also increase the risk of mortalities from hunting and human-ape conflict (Poulsen *et al*., 2009). Apes are able to incorporate new food sources into their diets, such as crops cultivated by smallholders. The presence of apes can cause conflicts due to crop raiding, or out of fear for human safety (Abram *et al*., 2015). In Uganda, chimpanzee attacks on children have been reported, including some resulting in fatalities (McLennan, 2008; Reynolds, 2005; Reynolds, Wallis and Kyamanywa, 2003). People have responded to the destruction of crops and safety concerns by killing apes in retaliation (Ancrenaz, Dabek and O'Neil, 2007; Bryson-Morrison *et al*., 2017; Campbell-Smith *et al*., 2011; Humle, 2015; McLennan and Hill, 2012; McLennan and Hockings, 2016).

Killing and capture

The severe threat that hunting poses to ape survival is correlated with human settlement (Poulsen *et al*., 2009; Wilkie and Carpenter, 1999; Wilkie *et al*., 2000). The term hunting includes killing for wild meat, as well as killing or capture for the illegal wildlife trade, which is also known as poaching. Industrial projects attract people seeking economic opportunities, and linear infrastructure networks facilitate their access to remote areas (Blake *et al*., 2007; Hickey *et al*., 2013; Laurance

Deforestation along the access road for the Dawei road link, east of Myitta, Myanmar. © WWF-Myanmar/Adam Oswell

et al., 2008; Maisels *et al*., 2013; Stokes *et al*., 2010; WCS, 2015). Routes cleared for the construction of roads, pipelines and transmission lines provide forest access for hunters to kill wildlife with guns and bows and to set and check snares. Entry by vehicle allows hunters to kill or capture a higher volume of wildlife, and then to make a speedy and inconspicuous escape (Fimbel, Grajal, and Robinson, 2001). For instance, one Republic of Congo logging concession saw 3,000 km of tree inventory transects established in a single year. These transects reduced travel time through the area from four days to one (Wilkie *et al*., 2001).

Examples of increases in hunting and poaching in once isolated areas have been well documented (Auzel and Wilkie, 2000; Poulsen *et al*., 2009; Wilkie *et al*., 2001). Illegal killing of apes has caused populations to decline, and ape densities to decrease as human presence increases (Espinosa, Branch and Cueva, 2014; Clements *et al*., 2014; Geissmann, 2007; Hickey *et al*., 2013; Laurance *et al*., 2009; Plumptre *et al*., 2016; Quintero *et al*., 2010; Stokes *et al*., 2010; Wich *et al*., 2008). Hunting intensity has been found to be greatest within 10 km of roads, and examples show that chimpanzees, bonobos and elephants have declined as a result (Laurance *et al*., 2009).

As all apes are protected, killing or capturing them is illegal regardless of the motivation, which can include hunting for food, in retaliation for crop damage or to supply the illegal wildlife trade (Nijman, 2005; Meijaard *et al*., 2011). A study on wild meat consumption patterns by the Zoological Society of London (ZSL) found that incentives were both financial and nutritional (White and Fa, 2014). Regardless of the motive, the impact on wildlife around the two logging concessions ZSL assessed was severe, with an estimated 20,000 animals killed or captured each year. Additionally, monitoring of large-scale industrial plantations in the DRC, Gabon, Ivory Coast, Nigeria and Republic of Congo has also documented the severe impact of hunting on apes (Campbell *et al*., 2008; FAO, 2014; USAID, 2008; Walsh *et al*., 2003). Furthermore, in Indonesia, records show between 2,383 and 3,882 orangutans are killed in plantations annually (Meijaard *et al*., 2012).

Apes are known to sometimes raid agricultural crops when planted in or near their ranges (Hockings and Humle, 2009; Hockings and McLennan, 2012). A group of 2,000 chimpanzees monitored in Sierra Leone, for example, was witnessed moving between unprotected primary forest fragments, secondary forests and farms (Brncic, Amarasekaran and McKenna, 2010). In that degraded environment, the chimpanzees relied heavily on crops. As apes are reluctant to venture far from tree cover, most raiding occurs within a half kilometer of forest edges (Ancrenaz *et al*., 2015; Naughton-Treves, 1997, 1998). As mentioned previously, crop raiding can lead to serious conflicts between apes and humans, including retaliatory killing.

Disease

The threat of disease is closely associated with the influx of people to previously uninhabited areas. This is due to the fact that apes are susceptible to pathogens from humans and livestock. As remote areas lack sanitation services, waste and pollution can result in apes catching infectious diseases (Laurance *et al*., 2006; Leendertz *et al*., 2006). Disruption to the forest canopy can force arboreal apes to travel on the ground, which increases their potential exposure to pathogens and parasites that have been brought into ape habitat by people and their domesticated animals (Das *et al*., 2009). Humans are also susceptible to diseases that emerge from previously-inaccessible areas, which have caused serious outbreaks in the past.

BOX 1

Avoiding Impacts on People

Indigenous groups and other forest communities depend on forests for food, medicinal plants, shelter and water, as well as for their social and cultural identities. Infrastructure projects can displace forest people, restrict their access to land, and reduce their livelihood opportunities. For example, in January 2016, a superhighway project in Nigeria's Cross River State dispossessed 185 communities of their land rights (Abutu and Charles, 2016; MLUD, 2016). In Cameroon, an oil pipeline threatened the sacred sites of an indigenous group and displaced their camps (Nelson, 2007). In Aceh, Sumatra, Indonesia, a road expansion project cut off the water supply to lowland communities, and threatened the water security of several million other residents. The road also posed fire suppression, erosion and flood control risks (van Beukering, Cesar and Janssen, 2003; Wich *et al*., 2011).

To uphold the civil liberties of indigenous groups, it is essential that community land tenure is secure, and that customary ownership is recognized. National legal systems should guarantee the rights of indigenous people to self-determination and self-governance. Their participation in decision-making processes should be guided by the internationally recognized principles of free, prior and informed consent (FPIC) as enshrined in the 2007 *United Nations Declaration on the Rights of Indigenous Peoples*. Infrastructure planning at the national, subnational regional and local levels should begin with assessments of the natural capital, biodiversity and ecosystem services upon which indigenous groups depend. Also, the boundaries, key resources and sacred sites of customary territories should be mapped using georeferencing technology.

Development decisions should be taken in close collaboration with communities that are likely to be impacted, and with their well-being as a priority. Developers have a responsibility to provide comprehensive, timely and accurate information about projects. Stakeholders from non-governmental organizations (NGOs) and civil society groups can be engaged to help build capacity among indigenous groups about their rights and options. NGOs are a useful resource for facilitating relationships and networking between stakeholders. They can also assist with monitoring, evidence gathering and filing of grievances under complaint procedures, should that be necessary. High profile organizations can also provide global visibility and accountability, as well as advocate with stakeholders at the international level, such as lending institutions. Finally, should compensation be due to indigenous groups, NGOs can help oversee delivery and provide expertise on necessary adaptation measures.

Best Practice Principles

Good Governance

The term governance encompasses all elements of societal functioning. These elements include institutions, laws, mechanisms, policies, processes and regulations. In order for good quality governance to thrive, a strong political commitment is necessary to foster the appropriate enabling conditions. Achieving good governance can be a complex, difficult and lengthy process considering the many pressures placed upon leaders in developing countries. At the most basic level, **a culture of accountability, openness and transparency must be established**. This includes zero tolerance for corruption, which undermines the functioning of governmental systems.

With regard to management of natural resources, support from the highest level of state must be secured in order for all necessary agencies to unify around conservation. Without buy-in from senior government officials across all relevant ministries, precious resources will be unsustainably exploited to the detriment of society. To prevent this, existing **laws and regulations must be implemented robustly, and compliance strictly enforced**. If legal regimes are weak in regard to social and environmental safeguards for infrastructure projects, they should be strengthened.

Adaptive management should be used to monitor and evaluate approaches, and to adjust as contexts change and new threats emerge. In developing economies, the allocation of appropriate resources can be a challenge. Adaptive management requires both financial resources and technical expertise. For example, in Cameroon's Deng Deng National Park there are only 17 rangers permanently assigned to protect 680 km² of forest, but the park's management plan calls for 70 ecoguards (EDC, 2011; MINFOF, 2015). Worldwide it is common for rangers to be inadequately equipped or trained for the numerous and varied requirements of their challenging, and sometimes dangerous, profession.

National and Landscape Level Strategic Planning

In order to maintain large blocks of intact forest and connectivity between forest patches that are essential for ape survival, system-scale approaches are necessary. **Land use planning must be conducted at the national and landscape levels in order to determine the least harmful spatial configuration of large-scale industrial projects and the linear infrastructures that support them** (Sayer *et al*., 2013). National plans should incorporate economic, environmental and social considerations, and ensure equitable and sustainable management of land and resources. Decisions should be evidence-based and inclusive, and implementation processes should be monitored and evaluated to minimize negative impacts on forest communities and biodiversity. Areas of high conservation value, and those that are essential for the well-being of forest peoples, should be identified and protected.

Engaging lenders early in the strategic planning process can help guide funding to the least damaging projects (Laurance *et al*., 2015a). Governments may seek to explore potential methods for funding sustainable choices, such as entry or impact fees, payment for ecosystem services schemes, public-private partnerships and sale of certified premium-priced goods. For example, in 2014, Norway and Liberia struck a deal to conserve the West African country's forests, which are home to chimpanzees. Under the agreement, Liberia will receive US$150 million to: address drivers of deforestation, issue a moratorium on new logging contracts, make payments to communities that are sustainably managing forests, place 30% of forests under formal protection and report on forest carbon emissions (Norway and Liberia, 2014). Similarly, Nigeria has received a total of US$16 million under the REDD+ scheme to combat climate change and improve forest governance (Uwaegbulam, 2016). When considering tenders and evaluating financing options, parties can include contractual requirements, such as minimum contributions to biodiversity conservation and local development. For instance, as a condition of World Bank funding for the Lom Pangar hydropower dam in Cameroon, a portion of the tariffs are allocated to sustaining nearby Deng Deng National Park (World Bank, 2012).

Pursuing certification regimes and other global standards can help ensure that development is sustainable and equitable. Some well-known certification examples include Fair Trade, Fairmined, Forest Stewardship Council, Rainforest Alliance, Roundtable on Sustainable Palm Oil and UTZ. Although no global certification system yet exists for infrastructure projects, the Leadership in Energy and Environmental Design (LEED) Green Building Rating System provides a potential model for creating one. LEED is active in 167 countries and territories, and has certified 1.6 million residences, 39,000 commercial projects, more than 6,000 schools, and nearly 4,000 government buildings (United States Green Building Council, 2016). Furthermore, helpful guidance can be found in relevant elements of other existing certification schemes that include requirements for associated infrastructure.

When producing national and landscape level strategies for infrastructure development, governments should convene all necessary experts and stakeholders, including representatives from local and indigenous communities. Together, they can determine the best way to optimize economic development, while limiting social and environmental costs. The groups should explore options including boosting agricultural yields, building roads in higher density areas, using already degraded land and developing small scale-renewable energy systems that do not require large scale infrastructure or networks of roads, railways and power transmission lines.

Furthermore, **reducing the number, length and width of roads can reduce their impacts on apes**. Reusing existing roads, rather than opening up new networks, can help keep deforestation to a minimum. In Aceh, Sumatra, Indonesia, for example, rather than building a road through Gunung Leuser National Park, a better alternative could have been improving coastal roads through degraded areas that are closer to agriculture plantations and human settlements. This option would have benefitted more residents and had fewer environmental costs (CIFOR, 2015; Laurance and Balmford, 2013).

Before any decisions are taken about a landscape, a strategic environmental assessment (SEA) should be conducted that integrates the area's environmental and social values. It cannot be stressed enough that SEAs should be undertaken at the very earliest stages of planning

Many ape species are very reluctant to cross non-forested areas, such as roads. When they do, severe injuries and mortalities can occur from collisions with vehicles. © Matt McLennan

and decision-making. That way their overarching policies can best enhance development effectiveness and sustainability. Waiting until the project-specific environmental and social impact assessment (ESIA) stage is too late. **It is critical that SEAs consider not only direct impacts to the immediate vicinity of each proposed project, but also the indirect impacts of projects, and the cumulative impacts of all economic activities taking place in a landscape**. The International Finance Corporation (IFC) defines cumulative impacts as the incremental impacts of one project, combined with the past, present and foreseeable impacts arising from other developments within the same geographic and connected area (IFC, 2012). To minimize cumulative impacts, governments can facilitate collaboration between neighboring projects. In order to reduce their combined footprint, for example, developers can take actions such as sharing transportation infrastructure.

Protection of Ape Habitat

To successfully feed, nest and reproduce, apes must have sufficient, connected forest habitat. Yet to meet resource demands, industrial activities are encroaching deeper into primary forests. As a result, apes are increasingly taking refuge in areas that are under formal protection (Geissmann, 2007; Tranquilli *et al*., 2012; Wich *et al*., 2008). These include areas with different types of safeguards and management approaches, such as national parks, nature reserves and community conservancies. As indigenous groups also rely on healthy ecosystems for their well-being, it can be valuable to integrate nearby residents in community-based natural resource management projects, including ape conservation. For example, indigenous trackers can be excellent resources for obtaining baseline data on ape food trees, paths and trails used. This information can be deployed during land use and infrastructure planning to help projects avoid areas that are critical for ape survival.

All remaining areas of high conservation value in ape habitats, such as ape feeding, dispersal and migratory routes, biodiversity hot spots and primary forests should be placed under formal legal protection. Establishing large reserves is favorable to creating smaller ones, which could leave apes isolated from other groups. However, in areas that have experienced high levels of forest loss or degradation, small reserves are essential to protect the remaining forest patches. To allow for adequate access to food, ranging and dispersal, these small reserves must be linked together with natural or man-made corridors.

Once established, the territorial integrity of protected areas must be maintained to ensure that they can serve as refuges for apes and other wildlife. **Large-scale industrial activities should be prohibited in or near reserves, and core areas of parks should remain free of roads**. A precautionary approach should be taken at all times due to the lack of data on the severity and duration of impacts that infrastructure projects can have on apes. See Chapter 2 for suggested research that could help to reduce these knowledge gaps.

Finally, because human activities taking place immediately outside protected areas often expand inside their boundaries, appropriate buffer zones should be delineated (Laurance *et al*., 2012). Buffer zones can help ensure that community use of natural resources is done sustainably.

Responsible Financing

Apes are rare and iconic mammals that serve as flagship indicator species for broader environmental health. As such, they attract high levels of global interest and scrutiny. Historically, economic development projects in ape range states have suffered from challenges including corruption, environmental damage, human rights issues, poor quality existing transportation networks, insufficient regulatory frameworks, labor disputes, political instability, poor communication networks and weak compliance (von Maltitz and Stafford, 2011). Until these issues are addressed in a sustainable manner, developers may experience cost overruns, delays, stranded assets or even legal liability. Investors, therefore, should be aware of the many financial, institutional and reputational risks associated with funding large-scale infrastructure projects in ape ranges. To avoid these risks, **lenders should take a triple bottom line approach that equally considers economy, equality and ecology**. Under current international norms, a government's invitation is no longer considered sufficient justification for infringing on the universal human rights of indigenous peoples or destroying the environment.

Instead, lenders should offer technical support to governments to enable long-term, system-level planning, which would boost investor confidence and attract capital. Ideally, this support should include multinational and trans-boundary plans and approaches. **Lenders should attach strict environmental and social conditions to funding**, and ensure that safeguards are in place at the system and landscape levels, not just at project scale. They should also take responsibility for ensuring borrowers' compliance with policies. Noting that governments may need guidance and assistance with implementation, investors should solicit support from experts, including conservationists from non-governmental organizations and relevant certification regimes (BIC, 2016).

Responsible investing should take a precautionary approach to natural resource management, and ensure that economic development does not harm biodiversity or disrupt the provision of essential ecosystem services to society. **Decision-making processes should be inclusive and integrate local communities into project planning and implementation**. Further, projects should protect customary land rights, and maintain forest access for traditional uses. Projects should also avoid encroachment on critical areas of forest in order to conserve habitats and biodiversity.

There are a number of international standards and frameworks available to provide guidance to lenders on best practices. According to the 2012 Performance Standards issued by the IFC, which is part of the World Bank Group, "special

consideration should be given to great apes (i.e., family Hominidae) given their anthropological and evolutionary significance in addition to ethical considerations." (IFC, 2012, p. 24). The World Bank was an early leader on environmental and social safeguards, and in October 2018 is launching an expanded framework that will apply to all new lending initiated after that date. The new framework broadens existing standards and procedural guidance related to environmental and social risks, and includes specific guidance on project monitoring and reporting. All lenders should continue to strengthen safeguards and their enforcement through effective implementation that is monitored and evaluated to ensure adequate and meaningful social and environmental protection.

In recent years, as China's overseas investments have grown, government agencies have issued a number of so-called green guidelines. These include Measures for Overseas Investment Management, Guidelines for Environmental Protection in Foreign Investment and Cooperation, Green Credit Guidelines, and a Guide for Chinese Enterprises on Sustainable Silviculture Overseas. The documents urge best practices that are consistent with international standards. They also require Chinese companies to abide by the laws and regulations of the countries in which they operate, including environmental obligations and social responsibilities. However, China's green guidelines remain voluntary and do not provide for compliance monitoring.

Management of environmental and social risks is also of concern to lenders in the private sector. In response, 92 financial institutions across 37 countries have adopted the Equator Principles, and committed to implementing them through their internal policies and procedures (Equator Principles, n.d.). The principles draw heavily on the IFC Performance Standards. As of 2016, the group adhering to Equators Principles represented more than 70% of international project finance debt in emerging markets (BankTrack, 2018).

Tools and resources are readily available to help lenders and developers assess the risks that infrastructure projects may pose to apes, such as the Open Standards for the Practice of Conservation. Furthermore, databases including the A.P.E.S. Portal, the Digital Observatory for Protected Areas, and the Integrated Biodiversity Assessment Tool contain geographic information about ape ranges and high conservation value areas. Also, to track deforestation in ape habitats, Global Forest Watch offers free weekly satellite monitoring. Those considering new large-scale dam projects should consult the Hydropower Sustainability Assessment Protocol, and consider using the "Hydropower by Design" approach developed by The Nature Conservancy. These tools provide valuable resources for use during the planning process. It is essential, however, that appropriate and qualified technical expertise is brought in to contribute throughout the project lifespan. Finally, **all projects in ape habitat should employ the mitigation hierarchy**, described in detail below, and draw upon the assistance of ape and biodiversity experts from academia and NGOs.

Environmental and Social Impact Assessments (ESIAs)

Although common, not all infrastructure projects are required by law or under lending conditions to conduct environmental and social impact assessments (ESIAs). Additionally, many assessments are carried out too late to be effective at preventing critical habitat loss, environmental degradation and social impacts. In practice, rather than focusing on prevention, which is key, ESIAs often target mitigation. In Nigeria's Cross River State, for instance, land clearing for construction of the Cross River superhighway began long before approval of an impact assessment. In fact, that assessment remains in dispute despite its fourth iteration. As an illustration of the internal conflicts that can plague projects, the federal environment ministry has placed a stop order on the highway, which is a priority project of the state governor (Ihua-Maduenyi, 2016).

When done properly, an ESIA allows sufficient time to conduct and incorporate a thorough baseline scoping. In ape habitats, this means **at least 12 months of data collection in order to document seasonal changes**. In addition, time for thorough analysis is required to fully understand the potential impacts of proposed activities. To facilitate knowledge sharing and to help close data gaps, baseline and ongoing monitoring data should be made public. Further, **assessments should be conducted in collaboration with all relevant stakeholders**. External support and advice from conservationists, academics and park authorities can add valuable knowledge and credibility to a project. Community representatives must also be incorporated fully into all project stages in accordance with the concepts of free, prior and informed consent (FPIC).

In order to avoid fragmentation that can isolate ape populations, **ESIAs should put forward ways to minimize forest destruction and retain connectivity corridors between ape habitats**. Where linear infrastructure bisects ape ranges, well-designed and well-located wildlife crossings should be incorporated, and the width of forest destruction kept to the strict minimum necessary. In Myanmar, for instance, academics using advanced computer modeling have helped developers determine the best locations for wildlife crossings on the Dawei road link (Tang and Kelly, 2016). For road projects, speed bumps and cautionary signage should also be employed. Further, developers of revenue-generating projects should consider dedicating a portion of profits to conservation efforts and local development projects in nearby communities. This can help ensure sustainability, encourage local support and minimize reputational risk.

Industrial activities within protected areas should remain a safe distance from core ape habitat areas and locations with high densities of fruiting trees. Outside of reserves, appropriate buffer zones should be established based on assessments of each individual context, and taking into consideration traditional land uses and potential threats. Support should be provided for the basic livelihood activities of workers, such as provision of sufficient meat, fish, fruit,

vegetables and grains (McNeely, 2005). Subsistence hunting should be tightly controlled, including a strict ban on the hunting, sale and possession of wild meat from endangered species. Further, indiscriminate hunting methods, such as snares that may harm or kill apes unintentionally, should be prohibited. Also, access points should be controlled and vehicles searched for contraband upon entry and exit.

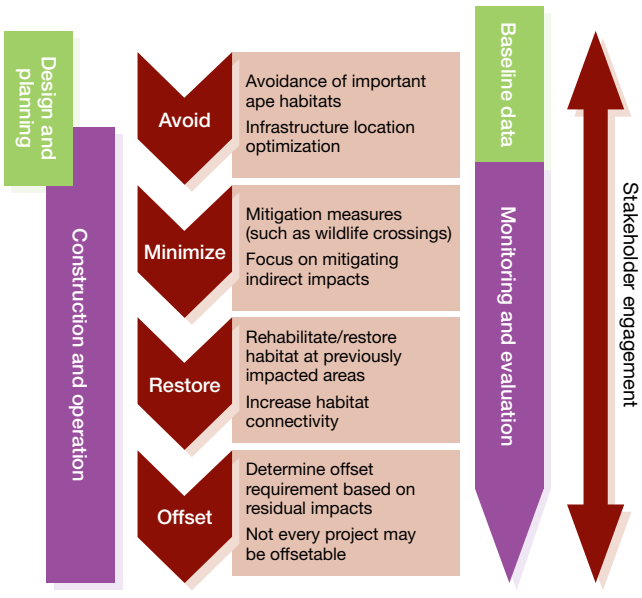
Useful lessons can be learned from examples of best practice. For instance, when developing its National Chimpanzee Management Plan, Tanzania applied principles from the Open Standards for the Practice of Conservation to evaluate the potential threats posed by road expansion. Stakeholders evaluated the potential scope of damage, the expected severity of damage and the likelihood that damage could be reversed and habitat restored (TAWIRI, 2017). In the Indonesian state of Kalimantan on the island of Borneo, a gold exploration company established a foundation to ensure that community members could fully exercise their rights to free, prior and informed consent (FPIC). The foundation facilitated a tripartite collaboration with civil society and local government for planning, information sharing, institution building and capacity building. Further, in a different Kalimantan gold concession, all materials, goods and personnel are transported in and out by helicopter rather than by linear infrastructure networks, thereby reducing deforestation (White and Fa, 2014).

Mitigation Hierarchy

The mitigation hierarchy is a best practice approach to managing biodiversity risk (Quintero *et al*. 2010). First and foremost, the approach advocates for avoiding or preventing adverse impacts to biodiversity whenever possible (see Figure 3).

FIGURE 3

The Mitigation Hierarchy Applied to Infrastructure Projects within Ape Habitats



Source: © TBC, 2017

Avoidance is most effective when applied early in the development process, such as at the national strategic planning stage, or during landscape-level strategic environmental assessments. Although avoidance should also be prioritized during project-specific ESIAs, stakeholders should not wait until that time to begin considering how to prevent biodiversity impacts. The second step in the hierarchy is minimizing and reducing any impacts that cannot be avoided. Third, impacts that cannot be avoided should be rehabilitated, repaired or restored following completion or decommissioning of the project. Finally, biodiversity impacts that cannot be avoided and repaired should be offset. The steps in the mitigation hierarchy are described in greater detail below.

Avoidance and Prevention of Impacts

All stakeholders should strive to achieve economic development that has a net-positive impact on biodiversity or that results in zero net loss of biodiversity. Unfortunately, such development is rarely a reality. At the international and national levels, companies, governments and lenders should solicit and incorporate technical support to help establish sustainable development policies, regulatory frameworks and voluntary standards that seek to avoid and prevent deleterious impacts on biodiversity. Avoidance and minimization are always more effective and less costly than rehabilitation, repair, restoration and offset.

Specific avoidance techniques include data collection, analysis and mapping, as well as advance planning for alternatives. It is essential to fully understand the project area's natural and social environment, including boundaries, cultivation status, customary ownership, land tenure, resource potential and user rights. Additionally, a forest management inventory should be conducted to quantify biodiversity values and the ecological and behavioral requirements of resident apes, including seasonal variations. These requirements include food, shelter, space and social dynamics. Once potential biodiversity risks from all project phases are identified, including potential threats to apes, spatial planning tools can be used to determine prevention, avoidance and minimization measures, such as re-routing linear infrastructure to avoid critical habitats.

Minimization of Unavoidable Impacts

Negative impacts that cannot be avoided should be minimized by reducing their extent and intensity. This should be coupled with effective and targeted social and behavior change programs to raise awareness and influence people's behavior in areas near ape habitat. For example, to reduce the risk of collisions between apes and vehicles on new roads, wildlife crossings and canopy bridges should be constructed and paired with cautionary road signage and speed bumps. Canopy bridges can also be used to provide apes with safe passage through forest gaps or across power transmission lines and transformers, which should be insulated to prevent electrocution (Das *et al*., 2009). It is important that canopy bridges are maintained to prevent falls and patrolled to prevent poaching.

To minimize the impacts of human settlements, protocols should be put in place to reduce human-wildlife conflict, as well as to prevent hunting of endangered species and their capture as pets or for the illegal wildlife trade. Access points should be restricted and vehicles searched upon entering and leaving sites. Closing roads and access points at night should also be explored. Workers should be prohibited from clearing land and required to control their domestic animals. Also, environmental education efforts should be undertaken to raise the level of awareness among communities. NGOs and local civil society groups can be helpful in this regard.

Deforestation tracking tools, such as the Global Forest Watch mobile app, should be used to monitor ape habitats near infrastructure and human settlements. Weekly tree cover change data, based on satellite imaging, is available gratis for most ape ranges. Finally, sanitation facilities and waste management must be provided to workers and satellite communities to avoid the outbreak of illnesses and the transmission of pathogens between apes and humans.

Rehabilitation, Repair and Restoration

Biodiversity impacts that have occurred during the course of infrastructure development should be addressed immediately once construction activities and use cease. Equipment and temporary infrastructure should be dismantled and removed, and human access should be closed off. Invasive plants should be extracted, and deforested or degraded areas reforested with native vegetation. It is critical, in particular, to restore connectivity between fragmented ape habitats to reestablish migration corridors. Ape experts can advise on the most appropriate food and nesting tree species to plant.

Offsets

Developers should make compensation for all social and environmental damage that could not be avoided or fully rehabilitated, repaired or restored. In the case of biodiversity offsets, the goal should be a net increase or, at minimum, no

Efforts must focus on building infrastructure in a manner that avoids harm to forests, wildlife and people, and retains the environmental services upon which they all depend.

net loss. Technical expertise will be necessary to produce and implement an effective offset program. Experts will use species distribution models and systematic conservation planning tools to achieve best practice biodiversity offset outcomes. Legal and financial mechanisms should be established to ensure that offsets are permanent, and lessons learned should be documented to inform better mitigation of impacts in the future.

Hydropower by Design

Similar to the mitigation hierarchy, The Nature Conservancy has developed a methodology specifically for large-scale dams. In brief, "Hydropower by Design" guides stakeholders through a process to: (i) avoid building dams in particularly damaging sites; (ii) minimize impacts by using best practices; (iii) restore key processes such as fish passage and environmental flows; and (iv) offset or compensate to achieve no net loss of biodiversity.

The Role of NGOs and Civil Society Groups

Non-governmental organizations (NGOs) and civil society groups are useful stakeholders that should have a role in infrastructure development processes. For instance, they can provide technical expertise as part of multidisciplinary teams involved in data collection, mapping, modeling and monitoring (Laurance and Balmford, 2013). Additionally, those with experience in community-based natural resource management can help integrate local people into the conservation of their customary forests.

NGOs and civil society groups can facilitate collaborative relationships between communities, companies and government stakeholders. At times they also serve to advocate with governments, companies and institutions for better practices, and for greater support to protected area managers and indigenous groups. Furthermore, high profile international organizations are able to raise global awareness in order to hold stakeholders publicly accountable for their actions. They can also serve local civil society by building local capacity to organize.

International NGOs are often the catalyst behind certification regimes, and can assist governments seeking to adopt global sustainability standards. Organizations desiring to do more for ape conservation should contribute to global mapping projects, such as RoadFree, OpenStreetMap, Roadless Forest and LoggingRoads. These initiatives, discussed in Chapter 4, can help identify ape migratory routes, primary forests, sensitive habitats and other unique natural areas that linear and fixed infrastructure should avoid.

Conclusion

Ape species across Africa and Asia are coming under increasing threat from infrastructure development driven by global economic trends. Unless linear and fixed infrastructure projects take ape conservation into account from the outset, ape populations will experience severe deleterious impacts as a result of deforestation, hunting and other human activities. Apes are important indicator species for the health of forest ecosystems, and are of particular concern due to their sentience, complex social relationships and close genetic relatedness to humans. The conservation status of all great ape and most gibbon species is endangered or critically endangered and all are highly vulnerable to disturbances and threats from humans.

Despite these challenges, it is possible to achieve socioeconomic development goals while ensuring sustainability and facilitating ape conservation. To achieve this ambition, it is critical that civil society groups, communities, governments, industry, lenders and NGOs work together in close collaboration. Their efforts must focus on building infrastructure in a manner that avoids harm to forests, wildlife and people, and that retains the environmental services upon which they all depend. Immediate improvements can be made by preserving large and connected natural forest areas to sustain people and wildlife, conducting strategic infrastructure planning at the national and landscape levels, ensuring strong and realistic environmental and social impact assessments and applying the mitigation hierarchy to all projects.

Abbreviations and Acronyms

DRC	Democratic Republic of Congo
ESIA	environmental and social impact assessment
FPIC	free, prior and informed consent
IFC	International Finance Corporation
IISD	International Institute for Sustainable Development
km	kilometer
km²	square kilometer
LEED	Leadership in Energy and Environmental Design
Lao PDR	Lao People's Democratic Republic
NGOs	non-governmental organizations
Ramsar	The Convention on Wetlands
REDD+	Reducing emissions from deforestation and forest degradation
SEA	strategic environmental assessment
UNESCO	United Nations Educational, Scientific and Cultural Organisation
ZSL	Zoological Society of London

References

Abram, N.K., Meijaard, E., Wells, J.A., *et al.* (2015). Mapping perceptions of species' threats and population trends to inform conservation efforts: the Bornean orangutan case study. *Diversity and Distributions*, *21*, 487–99. DOI: 10.1111/ddi.12286.

Abutu, A. and Charles, E. (2016). C/River communities reject superhighway. *Daily Trust*, March 9, 2016. Available at: https://www.dailytrust.com.ng/news/environment/c-river-communities-reject-superhighway/137088.html.

Agence Ecofin (2012). *Cameroun: 2000 Emplois Camerounais pour le Barrage de Lom Pangar.* Agence Ecofin. Available at: https://www.agenceecofin.

com/hydroelectricite/0701–2818-cameroun-2000-emplois-camerounais-pour-le-barrage-de-lom-pangar.

Ampuero, F. and Sá Lilian, R.M. (2012). Electrocution lesions in wild brown howler monkeys (*Alouatta guariba clamitans*) from São Paulo city: importance for conservation of wild populations. *ESVP/ECVP Proceedings*, *146*, 88.

Ancrenaz, M., Dabek, L. and O'Neil, S. (2007). The costs of exclusion: recognizing a role for local communities in biodiversity conservation. *PLoS Biology*, *5*, e289. DOI: 10.1371/journal.pbio.0050289.

Ancrenaz, M., Oram, F., Ambu, L., *et al.* (2015). Of pongo, palms and perceptions a multidisciplinary assessment of Bornean orang-utans *Pongo pygmaeus* in an oil palm context. *Oryx*, *49*, 465–72. DOI: 10.1017/S0030605313001270.

Andrews, A. (1990). Fragmentation of habitat by roads and utility corridors: a review. *Australian Zoologist*, *26*, 130–41. DOI: 10.7882/az.1990.005.

Arnhem, E., Dupain, J., Vercauteren Drubbel, R., Devos, C., and Vercauteren, M. (2008). Selective logging, habitat quality and home range use by sympatric gorillas and chimpanzees: a case study from an active logging concession in Southeast Cameroon. *Folia Primatologica*, *79*, 1–14.

Ascensão, F., Fahrig, L., Cleveneger, A.P., *et al.* (2018). Environmental challenges for the Belt and Road Initiative. *Nature Sustainability*, *1*, 206–209. https://www.nature.com/articles/s41893-018-0059-3.

Asner, G.P., Rudel, T.K., Aide, T.M., Defries, R., and Emerson, R. (2009). A contemporary assessment of change in humid tropical forests. *Conservation Biology*, *23*,1386–95.

Auzel, P. and Wilkie, D.S. (2000). Wildlife use in northern Congo: hunting in a commercial logging concession. In *Hunting for Sustainability in Tropical Forests*, ed. J.G. Robinson and E. Bennett. New York, NY: Columbia University Press, pp. 413–26.

Baabud, S.F., Griffiths, M., Afifuddin and Safriansyah, R. (2016). *Total Economic Value (TEV) of Aceh's Forests.* European Union Delegation for Indonesia and Brunei Darussalam. Vienna, Austria: CEU Consulting GmbH.

BankTrack (2018). *The Equator Principles Track and Chase Project.* Nijmegen, Netherlands: BankTrack. Available at: https://www.banktrack.org/show/pages/equator_principles.

Blake, S. (2002). *Ecology of forest elephant distribution and its implications for conservation*. PhD thesis. Edinburgh, UK: University of Edinburgh.

Blake, S., Strindberg, S., Boudjan, P., *et al.* (2007). Forest elephant crisis in the Congo Basin. *PLoS Biology*, *5*, e111. DOI: 10.1371/journal.pbio.0050111.

Boakes, E.H., Mace, G.M., McGowan, P.J.K. and Fuller, R.A. (2010). Extreme contagion in global habitat clearance. *Proceedings of the Royal Society B: Biological Sciences*, *277*, 1081–5. DOI: 10.1098/rspb.2009.1771.

Bortolamiol, S., Cohen, M., Jiguet, F., *et al.* (2016). Chimpanzee non-avoidance of hyper-proximity to humans. *The Journal of Wildlife Management*, *80*, 924–34. DOI: 10.1002/jwmg.1072.

Brncic, T.M., Amarasekaran, B., and McKenna, A. (2010). *Sierra Leone National Chimpanzee Census.* Freetown, Sierra Leone: Tacugama Chimpanzee Sanctuary.

Bryson-Morrison, N., Tzanopoulos, J., Matsuzawa, T. and Humle, T. (2017). Chimpanzee (*Pan troglodytes verus*) activity and patterns of habitat use in the anthropogenic landscape of Bossou, Guinea, West Africa. *International Journal of Primatology*, *38*, 282–302. DOI: 10.1007/s10764–016–9947–4.

Campbell, G., Kuehl, H., Kouame, P.N.G. and Boesch, C. (2008). Alarming decline of West African chimpanzees in C.te d'Ivoire. *Current Biology*, *18*, 903–4.

Campbell-Smith, G., Campbell-Smith, M., Singleton, I. and Linkie, M. (2011). Raiders of the lost bark: orangutan foraging strategies in a degraded landscape. *PLoS One*, *6*, e20962. DOI: 10.1371/journal.pone.0020962.

Chetry, D., Chetry, R., Ghosh, K. and Singh, A.K. (2010). Status and distribution of the eastern hoolock gibbon (*Hoolock leuconedys*) in Mehao Wildlife Sanctuary, Arunachal Pradesh, India. *Primate Conservation*, *25*, 87–94. DOI: 10.1896/052.025.0113.

CIFOR (2015). *Sumatran Road Plan Could Spell a Dark New Chapter for Storied Ecosystem: Study.* Bogor, Indonesia: Center for International Forestry Research (CIFOR). Available at: http://blog.cifor.org/27018/leuser-ecosystem-aceh-spatial-plan-ladia-galaska-road?fnl=en.

Clements, G.R., Lynam, A.J., Gaveau, D., *et al.* (2014). Where and how are roads endangering mammals in southeast Asia's forests? *PLoS One*, *9*, e115376. DOI: 10.1371/journal.pone.0115376.

Conservation International (2010). *Maiko-Tanya-Kahuzi-Bi.ga Landscape: landscape land use plan, for the Annual Report 2010 for the CARPE Programme.* Available at: http://carpe-infotool.umd.edu/IMT/LS10_Maiko-Tayna-Kahuzi-/Landscape/LS10_MP_Maiko_Tayna_Kahuzi__Management_Plan_2010.pdf.

Cuaron, A.D. (2000). Global perspective on habitat disturbance and tropical rainforest mammals. *Conservation Biology*, *14*, 1574–9.

Currey, K. (2013). *Social and environmental safeguard policies at the World Bank: historical lessons for a changing context.* Draft internal briefing note. New York, NY: Ford Foundation.

Damania, R., Barra, A.F., Burnouf, M. and Russ, J.D. (2016). *Transport, Economic Growth, and Deforestation in the Democratic Republic of Congo: A Spatial Analysis.* Washington DC: World Bank. Available at: https://openknowledge.worldbank.org/handle/10986/24044.

Das, J., Biswas, J., Bhattacherjee, P.C. and Rao, S.S. (2009). Canopy bridges: an effective conservation tactic for supporting gibbon populations in forest fragments. In *The Gibbons: New Perspectives on Small Ape Socio-ecology and Population Biology*, ed. D. Whittaker and S. Lappan. New York, NY: Springer, pp. 467–75. DOI: 10.1007/978–0-387–88604–6_22. Available at: https://doi.org/10.1007/978–0-387–88604–6_22.

Dulac, J. (2013). *Global Land Transport Infrastructure Requirements to 2050.* Paris, France: International Energy Agency.

EDC (2011). *Réformulation de l'étude d'impacts et du Plan de Gestion Environnementale et Sociale du Barrage de Lom Pangar: Mise en Oeuvre de la Compensation Biodiversité: Parc National de Deng-Deng.* Yaoundé, Cameroon: Electricity Development Corporation (EDC). Available at: http://www.edc cameroon.org/IMG/pdf/sde/ANNEXE%204%20PNDD%20projet%20110111.pdf.

EDC (n.d.). *La Pêche s'Organise Autour de Lom Pangar.* Yaoundé, Cameroon: Electricity Development Corporation (EDC). Available at: http://www.edc-cameroon.org/francais/societe/nos-activites/article/la-peche-s-organise-autour-de-lom.

Edwards, D.P., Sloan, S., Weng, L., *et al.* (2014). Mining and the African environment. *Conservation Letters*, *7*, 302–11. DOI: 10.1111/conl.12076.

Espinosa, S., Branch, L.C. and Cueva, R. (2014). Road development and the geography of hunting by an Amazonian indigenous group: consequences for wildlife conservation. *PLoS One*, *9*, e114916. DOI: 10.1371/journal.pone.0114916.

Equator Principles (n.d.). *The Equator Principles.* Poole, United Kingdom: Equator Principles Association. Available at: http://equator-principles.com/about.

Fa, J.E., Ryan, S.F., and Bell, D.J. (2005). Hunting vulnerability, ecological characteristics and harvest rates of bushmeat species in afrotropical forests. *Biological Conservation*, *121*, 167–76.

FAO (2014). *FAOSTAT Database on Agriculture.* Rome, Italy: Food and Agriculture Organization of the United Nations (FAO). Available at: http://faostat.fao.org.

Feronia (2014). *Management's Discussion and Analysis for the Three Months ended March 31, 2014.* Feronia Inc. Available at: http://www.feronia.com/md_and_a/categories/2014.

Fimbel, R.A., Grajal, A., and Robinson, J.G. (2001). Logging and wildlife in the tropics: impacts and options for conservation. In *The Cutting Edge:*

Conserving Wildlife in Logged Tropical Forests, ed. R.A. Fimbel, A. Grajal, and J.G. Robinson. New York, NY: Columbia University Press, pp. 667–95.

Frankfurt School–UNEP Centre/BNEF (2017). *Global Trends in Renewable Energy Investment 2017.* Frankfurt, Germany: Frankfurt School of Finance and Management. Available at: http://fs-unep-centre.org/sites/default/files/publications/globaltrendsinrenewableenergyinvestment2017.pdf.

Gaveau, D.L.A., Wich, S., Epting, J., *et al.* (2009). The future of forests and orangutans (*Pongo abelii*) in Sumatra: predicting impacts of oil palm plantations, road construction, and mechanisms for reducing carbon emissions from deforestation. *Environmental Research Letters*, *4*, 034013.

Geissmann, T. (2007). Status reassessment of the gibbons: results of the Asian primate red list workshop 2006. *Gibbon Journal*, *3*, 5–15.

Global Commission on the Economy and Climate (2016). *The Sustainable Infrastructure Imperative: Financing for Better Growth and Development. The 2016 New Climate Economy Report.* Washington DC: New Climate Economy. Available at: http://newclimateeconomy.report/2016/wp-content/uploads/sites/4/2014/08/NCE_2016Report.pdf.

Global Road Map (n.d.). *Key Facts about Roads.* Cairns, Australia: James Cook University. Available at: http://www.global-roadmap.org/about/.

Goufan, J.-M. and Adeline, T. (2005). *Etude Environnementale du Barrage de Lom Pangar. Etude de l'Urbanisation (thème 10) – Volet 'Afflux de population' – Rapport Après Consultation.* Yaoundé, Cameroon: Ministry of Water Resources and Energy. Available at: https://www.iucn.org/sites/dev/files/import/downloads/t10_urbanisation_vol1_v4_lom_pangar.pdf.

GVC, BIC and IRN (2006). *In Whose Interest? The Lom Pangar Dam and Energy Sector Development in Cameroon.* June, 2006. Global Village Cameroon (GVT), Bank Information Center (BIC) and International Rivers Network (IRN). Available at: https://www.internationalrivers.org/sites/default/files/attached-files/whoseinterest.pdf.

HAkA, KPHA, OIC, *et al.* (2016). *The Importance of the Kappi Area in the Gunung Leuser National Park and Further Support for its Current Core Area Status.* Medan, Indonesia: ALERT, Forest, Nature, and Environment of Aceh (HAkA), Koalisi Peduli Hutan Aceh (KPHA), Orangutan Information Centre (OIC), PanEco Foundation, Sumatran Orangutan Society (SOS) and Yayasan Ekosistem Lestari (YEL) Available at: https://static1.squarespace.com/static/51b078a6e4b0e8d244dd9620/t/586645cc414fb5c4d35e8c87/1483097562011/Report+to+Minister.pdf.

Harcourt, A.H., and Doherty, D.A. (2005). Species-area relationships of primates in tropical forest fragments: a global analysis. *Journal of Applied Ecology*, *42*, 630–7.

Hashimoto, C. (1995). Population census of the chimpanzees in the Kalinzu Forest, Uganda: comparison between methods with nest counts. *Primates*, *36*, 477–88.

Hickey, J., Nackoney, J., Nibbelink, N., *et al.* (2013). Human proximity and habitat fragmentation are key drivers of the rangewide bonobo distribution. *Biodiversity and Conservation*, *22*, 3085–104.

Hicks, T.C., Darby, L., Hart, J., *et al.* (2010). Trade in orphans and bushmeat threatens one of the Democratic Republic of the Congo's most important populations of eastern chimpanzees (*Pan troglodytes schweinfurthii*). *African Primates (Print)*, *7*, 1–18.

Hockings, K.J. and Humle, T. (2009). *Best Practice Guidelines for the Prevention and Mitigation of Conflict Between Humans and Great Apes.* Gland, Switzerland: IUCN/SSC Primate Specialist Group. Available at: www.primatesg.org/best_practice_conflict.

Hockings, K.J. and McLennan, M.R. (2012). From forest to farm: systematic review of cultivar feeding by chimpanzees: management implications for wildlife in anthropogenic landscapes. *PLoS One*, *7*, e33391.

Hourticq, J. and Megevand, C. (2013). *Deforestation Trends in the Congo Basin: Reconciling Economic Growth and Forest Protection. Working Paper 1: Agriculture.* Washington DC: World Bank Publications.

IEA (2016). *World Energy Outlook 2016.* Paris, France: International Energy Agency (IEA). Available at: https://www.docdroid.net/IOBt86G/world-energy-outlook-2016.pdf#page=4.

IFC (2012). *International Finance Corporation's Guidance Notes: Performance Standards on Environmental and Social Sustainability, 1 January 2012.* Washington DC: International Finance Corporation (IFC). Available at: https://www.ifc.org/wps/wcm/connect/efdaaa80436491429476 96d3e9bda932/Guidance+Notes+to+Performance+Standards+on+Environmental+and+Social+Sustainability.pdf?MOD=AJPERES

IISD (2016). *What China's overseas investment means for the rest of the world.* Geneva, Switzerland: International Institute for Sustainable Development (IISD). Available at: https://www.iisd.org/media/what-chinas-overseas-investment-means-rest-world-0.

Ihua-Maduenyi, M. (2016). FG stops work on Cross River superhighway. *Punch*, March 14, 2016. Available at: http://punchng.com/fg-stops-work-on-cross-river-superhighway.

IRENA (2015). *Africa 2030: Roadmap for a Renewable Energy Future.* Abu Dhabi, UAE: International Renewable Energy Agency (IRENA).

IUCN (2014a). *Plan d'Action Régional Pour la Conservation des Gorilles de Plaine de l'Ouest et des Chimpanzés d'Afrique Centrale 2015–2025.* Gland, Switzerland: Groupe de Spécialistes des Primates de la CSE/UICN.

IUCN (2014b). *Regional Action Plan for the Conservation of Western Lowland Gorillas and Central Chimpanzees 2015–2025.* Gland, Switzerland: International Union for Conservation of Nature Species Survival Commission (IUCN SSC), Primate Specialist Group. Available at: https://d2ouvy59podg6k.cloudfront.net/downloads/wea_apes_plan_2014_7mb.pdf.

IUCN (2016). *The IUCN Red List of Threatened Species. Version 2016.2.* Gland, Switzerland: International Union for Conservation of Nature (IUCN). Available at: http://www.iucnredlist.org.

Jacobs, A. (2015). *Factors affecting the prevalence of road and canopy bridge crossings by primates in Diani Beach, Kenya*. Masters thesis. Canterbury, UK: University of Kent.

Junker, J., Blake, S., Boesch, C., *et al.* (2012). Recent decline in suitable environmental conditions for African great apes. *Diversity and Distributions*, *18*, 1077–91.

Kahler, M., Henning, C.R., Bown, C.P., *et al.* (2016). *Global Order and the New Regionalism.* Discussion Paper Series on Global and Regional Governance. (September). New York, NY: Council on Foreign Relations. Available at: https://www.cfr.org/report/global-order-and-new-regionalism.

Kitzes, J. and Shirley, R. (2016). Estimating biodiversity impacts without field surveys: a case study in northern Borneo. *Ambio*, *45*, 110–9. DOI: 10.1007/s13280–015–0683–3.

Kleinschroth, F., Gourlet-Fleury, S., Sist, P., Mortier, F. and Healey, J.R. (2015). Legacy of logging roads in the Congo Basin: how persistent are the scars in forest cover? *Ecosphere*, *6*, 1–17. DOI: 10.1890/ES14–00488.1.

Kuehl, H.S., Nzeingui, C., Yeno, S.L.D., *et al.* (2009). Discriminating between village and commercial hunting of apes. *Biological Conservation*, *142*, 1500–6.

Kumar, V. and Kumar, V. (2015). Seasonal electrocution fatalities in free-range rhesus macaques (*Macaca mulatta*) of Shivalik hills area in northern India. *Journal of Medical Primatology*, *44*, 137–42. DOI: 10.1111/jmp.12168.

Laporte, N.T., Stabach, J.A., Grosch, R., Lin, T.S., and Goetz, S.J. (2007). Expansion of industrial logging in central Africa. *Science*, *316*, 1451.

Laurance, W.F. and Balmford, A. (2013). A global map for road building. *Nature*, *495*, 308. DOI: 10.1038/495308a.

Laurance, W.F., Croes, B.M., Guissouegou, N., *et al.* (2008). Impacts of roads, hunting, and habitat alteration on nocturnal mammals in African rainforests. *Conservation Biology*, *22*, 721–32. DOI: 10.1111/j.1523–1739.2008.00917.x.

Laurance, W.F., Croes, B.M., Tchignoumba, L., *et al.* (2006). Impacts of roads and hunting on central African rainforest mammals. *Conservation Biology*, *20*, 1251–61. DOI: 10.1111/j.1523–1739.2006.00420.x.

Laurance, W.F., Goosem, M. and Laurance, S.G.W. (2009). Impacts of roads and linear clearings on tropical forests. *Trends in Ecology & Evolution*, *24*, 659–69. DOI: https://doi.org/10.1016/j.tree.2009.06.009.

Laurance, W.F., Peletier-Jellema, A., Geenen, B., *et al.* (2015a). Reducing the global environmental impacts of rapid infrastructure expansion. *Current Biology*, *25*, R259-R62. DOI: https://doi.org/10.1016/j.cub.2015.02.050.

Laurance, W.F., Sloan, S., Weng, L. and Sayer, J.A. (2015b). Estimating the environmental costs of Africa's massive 'development corridors'. *Current Biology*, *25*, 3202–8. DOI: https://doi.org/10.1016/j.cub.2015.10.046.

Laurance, W.F., Useche, D.C., Rendeiro, J., *et al.* (2012). Averting biodiversity collapse in tropical forest protected areas. *Nature*, *489*, 290. DOI: 10.1038/nature11318. Available at: https://www.nature.com/articles/nature11318#supplementary-information.

Lee, T., Jalong, T. and Wong, M.C. (2014). *No Consent to Proceed: Indigenous Peoples' Rights Violations at the Proposed Baram Dam in Sarawak.* Fact finding mission report. Sarawak, Malaysia: Save Sarawak Rivers Network. Available at: http://www.forestpeoples.org/sites/fpp/files/publication/2014/08/noconsenttoproceedbaramreport2014–1.pdf.

Leendertz, F.H., Pauli, G., Maetz-Rensing, K., *et al.* (2006). Pathogens as drivers of population declines: the importance of systematic monitoring in great apes and other threatened mammals. *Biological Conservation*, *131*, 325–37.

Lehner, B., Liermann, C.R., Revenga, C., *et al.* (2011). High-resolution mapping of the world's reservoirs and dams for sustainable river-flow management. *Frontiers in Ecology and the Environment*, *9*, 494–502. DOI: 10.1890/100125.

Lokschin, L.X., Rodrigo, C.P., Hallal Cabral, J.N. and Buss, G. (2007). Power lines and howler monkey conservation in Porto Alegre, Rio Grande do Sul, Brazil. *Neotropical Primates*, *14*, 76–80. DOI: 10.1896/044.014.0206.

Maisels, F., Strindberg, S., Blake, S., *et al.* (2013). Devastating decline of forest elephants in central Africa. *PLoS One*, *8*, e59469. DOI: 10.1371/journal.pone.0059469.

Malcolm, J.R. and Ray, J.C. (2000). Influence of timber extraction routes on central African small-mammal communities, forest structure, and tree diversity. *Conservation Biology*, *14*, 1623–38.

Maldonado, O., Aveling, C., Cox, D., *et al.* (2012). *Grauer's Gorillas and Chimpanzees in Eastern Democratic Republic of Congo (Kahuzi-Biega, Maiko, Tayna and Itombwe Landscape): Conservation Action Plan 2012–2022.* Gland, Switzerland: International Union for Conservation of Nature (IUCN).

Marshall, A.J., Lacy, R., Ancrenaz, M., *et al.* (2009). Orangutan population biology, life history, and conservation. In *Orangutans: Geographic Variation in Behavioral Ecology and Conservation*, ed. S.A. Wich, S. Utami Atmoko, T. Mitra Setia and C.P. van Schaik. New York, NY: Oxford University Press, pp. 311–26.

Matthews, A. and Matthews, A. (2004). Survey of gorillas (*Gorilla gorilla gorilla*) and chimpanzees (*Pan troglodytes troglodytes*) in southwestern Cameroon. *Primates*, *45*, 15–24.

Mazina, N. and Masumbuko, M. (2004). *The mercury situation in the Democratic Republic of Congo: another problem that needs to be addressed (La pollution par le mercure, une guerre que la R.publique D.mocratique du Congo doit mener).* Presented at the Regional Awareness-Raising Workshop on Mercury Pollution: A Global Problem that Needs to be Addressed. Session 3. Current Knowledge with Regard to Global/Regional/National Releases of Mercury to the Environment, November 22–25, 2004, Dakar, Senegal. United National Environment Programme (UNEP) Chemicals.

McCarthy, J.F. (2002). Power and interest on Sumatra's rainforest frontier: clientelist coalitions, illegal logging and conservation in the Alas Valley. *Journal of Southeast Asian Studies*, *33*, 77–106. DOI: 10.1017/S00224634020000048.

McLennan, M.R. (2008). Beleaguered chimpanzees in the agricultural district of Hoima, western Uganda. *Primate Conservation*, *23*, 45–54.

McLennan, M.R. and Asiimwe, C. (2016). Cars kill chimpanzees: case report of a wild chimpanzee killed on a road at Bulindi, Uganda. *Primates*, *57*, 377–88. DOI: 10.1007/s10329–016–0528–0.

McLennan, M.R. and Hill, C.M. (2012). Troublesome neighbours: changing attitudes towards chimpanzees (*Pan troglodytes*) in a human-dominated landscape in Uganda. *Journal for Nature Conservation*, *20*, 219–27. DOI: https://doi.org/10.1016/j.jnc.2012.03.002.

McLennan, M.R. and Hockings, K.J. (2016). The aggressive apes? Causes and contexts of great ape attacks on local persons. In *Problematic Wildlife: A Cross-Disciplinary Approach*, ed. F. M. Angelici. Cham, Switzerland: Springer, pp. 373–94. DOI: 10.1007/978–3-319–22246–2_18. Available at: https://doi.org/10.1007/978–3-319–22246–2_18.

McNeely, J.A. (2005). *Friends for Life: New Partners in Support of Protected Areas.* Gland, Switzerland and Cambridge, UK: IUCN.

MINFOF (2015). *Annual Report of the Deng Deng National Park.* Yaoundé, Cameroon: Ministère des Forêts et de la Faune (MINFOF).

Mitani, J.C., Watts, D.P. and Amsler, S.J. (2010). Lethal intergroup aggression leads to territorial expansion in wild chimpanzees. *Current Biology*, *20*, R507-R8. DOI: https://doi.org/10.1016/j.cub.2010.04.021.

Mittermeier, R.A., Rylands, A.B. and Wilson, D.E., ed. (2013). *Handbook of the Mammals of the World. Volume 3: Primates*. Barcelona, Spain: Lynx Edicions.

Meijaard, E., Albar, G., Nardiyono, *et al.* (2010). Unexpected ecological resilience in Bornean orangutans and implications for pulp and paper plantation management. *PLoS One*, *5*, e12813.

Meijaard, E., Buchori, D., Hadiprakoso, Y., *et al.* (2011). Quantifying killing of orangutans and human-orangutan conflict in Kalimantan, Indonesia *PLoS One*, *6*, e27491.

Meijaard, E., Wich, S., Ancrenaz, M. and Marshall, A.J. (2012). Not by science alone: why orangutan conservationists must think outside the box. *Annals of the New York Academy of Sciences*, *1249*, 29–44.

MLUD (2016). *Public Notice: Notice of Revocation of Rights of Occupancy for Public Purpose Land Use Act 1978. January 22.* Calabar, Nigeria: Ministry of Lands and Urban Development (MLUD), Government of Cross River State of Nigeria.

Modus Aceh (2016). *Kenapa harus ngotot proyek PT Hitay Panas Energy di Lapangan Kafi.* Banda Aceh, Indonesia: Modus Aceh. Available at: http://www.modusaceh.co/news/kenapa-harus-ngotot-proyek-pt-hitay-panas-energy-di-lapangan-kafi/index.html.

Naughton-Treves, L. (1997). Farming the forest edge: vulnerable places and people around Kibale National Park, Uganda. *Geographical Review*, *87*, 27–46. DOI: 10.1111/j.1931–0846.1997.tb00058.x.

Naughton-Treves, L. (1998). Predicting patterns of crop damage by wildlife around Kibale National Park, Uganda. *Conservation Biology*, *12*, 156–68.

Ndobe, S.N. and Klemm, J. (2014). *The Lom Pangar Hydropower Dam Project. Evaluating the Project's Impacts within the Framework of the World Bank Safeguard Policies. Lessons for the World Bank Safeguards Review.* March. Synchronicity Earth.

Nellemann, C. and Newton, A. (2002). *The Great Apes, The Road Ahead: A GLOBIO Perspective on the Impacts of Infrastructure Development on the Great Apes.* United Nations Environment Programme (UNEP), GRID-Arendal, World Conservation Monitoring Centre. Available at: http://www.globio.info/downloads/249/Great+Apes+-+The+Road+Ahead.pdf.

Nelson, J. (2007). *Securing Indigenous Land Rights in the Cameroon Oil Pipeline Zone.* Moreton-in-Marsh, UK: Forest Peoples Programme. Available at: http://www.forestpeoples.org/sites/fpp/files/publication/2010/08/cameroonpipelinejul07lowreseng.pdf.

Nijman, V. (2005). *Hanging in the balance: an assessment of trade in orangutans and gibbons on Kalimantan, Indonesia*. Report for TRAFFIC Southeast Asia. Petaling Jaya, Selangor, Malaysia: TRAFFIC Southeast Asia.

Normand, E. and Boesch, C. (2009). Sophisticated Euclidean maps in forest chimpanzees. *Animal Behaviour*, *77*, 1195–201. DOI: https://doi.org/10.1016/j.anbehav.2009.01.025.

Norway and Liberia (2014). *Letter of Intent: Cooperation on Reducing Greenhouse Gas Emissions from Deforestation and Forest Degradation (REDD+) and Developing Liberia's Agriculture Sector.* Governments of Liberia and Norway. Available at: https://www.regjeringen.no/contentassets/b8b93fa03bda4ac893d065d26d64075b/letterofintentliberia.pdf.

O'Connor, J.E., Duda, J.J. and Grant, G.E. (2015). 1000 dams down and counting. *Science*, *348*, 496–7. DOI: 10.1126/science.aaa9204.

Opperman, J., Grill, G. and Hartmann, J. (2015). *The Power of River: Finding Balance Between Energy and Conservation in Hydropower Development.* Washington DC: The Nature Conservancy.

Plumptre, A.J., Nixon, S., Critchlow, R., *et al.* (2015). *Status of Grauer's gorilla and chimpanzees in Eastern Democratic Republic of Congo: historical and current distribution and abundance.* Report to Arcus Foundation, USAID and US Fish and Wildlife Service.

Plumptre, A.J., Nixon, S., Kujirakwinja, D.K., *et al.* (2016). Catastrophic decline of world's largest primate: 80% loss of Grauer's gorilla (*Gorilla beringei graueri*) population justifies critically endangered status. *PLoS One*, *11*, e0162697. DOI: 10.1371/journal.pone.0162697.

Poulsen, J.R., Clark, C.J., and Bolker, B.M. (2011). Decoupling the effects of logging and hunting on an Afrotropical animal community. *Ecological Applications*, *21*, 1819–36.

Poulsen, J.R., Clark, C.J., Mavah, G. and Elkan, P.W. (2009). Bushmeat supply and consumption in a tropical logging concession in northern Congo. *Conservation Biology*, *23*, 1597–608. DOI: 10.1111/j.1523–1739.2009.01251.x.

Printes, R. (1999). The Lami Biological Reserve, Rio Grande do Sul, Brazil and the danger of power lines to howlers in urban reserves. *Neotropical Primates*, *4*, 135–6.

Printes, R.C., Buss, G., Jardim, M.M. de A., *et al.* (2010). The Urban Monkeys Program: a survey of *Alouatta clamitans* in the south of Porto Alegre and its influence on land use policy between 1997 and 2007. *Primate Conservation*, *25*, 11–9. DOI: 10.1896/052.025.0103.

Quintero, J.D., Roca, R., Morgan, A.J., Mathur, A. and Xiaoxin, S. (2010). *Smart Green Infrastructure in Tiger Range Countries: A Multi-Level Approach.* Global Tiger Initiative, GTISGI Working Group, Technical Paper. Discussion Papers. Washington DC: World Bank.

Rabanal, L.I., Kuehl, H.S., Mundry, R., Robbins, M.M. and Boesch, C. (2010). Oil prospecting and its impact on large rainforest mammals in Loango National Park, Gabon. *Biological Conservation*, *143*, 1017–24. DOI: https://doi.org/10.1016/j.biocon.2010.01.017.

Reynolds, V. (2005). *The Chimpanzees of the Budongo Forest: Ecology, Behaviour, and Conservation.* Oxford, UK: Oxford University Press.

Reynolds, V., Wallis, J. and Kyamanywa, R. (2003). Fragments, sugar, and chimpanzees in Masindi District, western Uganda. In *Primates in Fragments: Ecology and Conservation*, ed. L.K. Marsh. New York, NY: Kluwer Academic/Plenum Publishers, pp. 309–20.

Ripple, W.J., Abernethy, K., Betts, M.G., *et al.* (2016). Bushmeat hunting and extinction risk to the world's mammals. *Royal Society Open Science*, *3*. DOI: 10.1098/rsos.160498.

Robinson, J.G., Redford, K.H. and Bennett, E.L. (1999). Wildlife harvest in logged tropical forests. *Science*, *284*, 595–6. DOI: 10.1126/science.284.5414.595.

Refuge for Wildlife (n.d.). *Stop the Shocks.* Guanacaste Province, Costa Rica: Refuge for Wildlife. Available at: http://refugeforwildlife.com/stop-the-shocks/.

Rodrigues, N.N. and Martinez, R.A. (2014). Wildlife in our backyard: interactions between Wied's marmoset *Callithrix kuhlii* (Primates: Callithrichidae) and residents of Ilhéus, Bahia, Brazil. *Wildlife Biology*, *20*, 91–6. DOI: 10.2981/wlb.13057.

Sandker, M., Bokoto-de Semboli, B., Roth, P., *et al.* (2011). Logging or conservation concession: exploring conservation and development outcomes in Dzanga-Sangha, Central African Republic. *Conservation and Society*, *9*, 299–310.

Sarawak Report (2014). Bakun turbines running at just 50% capacity. *Sarawak Report*, January, 2014. Available at: http://www.sarawakreport.org/2014/01/bakun-turbines-running-at-just-50-capacity-exclusive.

Sayer, J., Sunderland, T., Ghazoul, J., *et al.* (2013). Ten principles for a landscape approach to reconciling agriculture, conservation, and other competing land uses. *Proceedings of the National Academy of Sciences USA*, *110*, 8349–56.

Seneca Creek Associates, L., and Wood Resources International, L. (2004). *"Illegal" Logging and the Global Wood Markets: The Competitive Impacts on the US Wood Products Industry*. Paper prepared for American Forest and Paper Association, November 2004. Poolesville, MD, and University Place, WA: Seneca Creek Associates, LLC, and Wood Resources International, LLC.

Shirley, R. and Kammen, D. (2015). Energy planning and development in Malaysian Borneo: assessing the benefits of distributed technologies versus large scale energy mega-projects. *Energy Strategy Reviews*, *8*, 15–29. DOI: https://doi.org/10.1016/j.esr.2015.07.001.

Shirley, R., Kammen, D. and Wynn, G. (2014). *Kampung capacity: analyzing local energy solutions in the Baram River basin, east Malaysia*. Unpublished paper.

Singleton, I., Wich, S., Husson, S., *et al.* (2004). *Orangutan Population and Habitat Viability Assessment: Final Report.* Apple Valley, MN: International Union for Conservation of Nature Species Survival Commission (IUCN SSC), Conservation Breeding Specialist Group.

Skinner, J. and Haas, L.J. (2014). *Watered Down? A review of social and environmental safeguards for large dam projects.* Geneva, Switzerland: International Institute for Sustainable Development (IISD). Available at: http://pubs.iied.org/17517IIED

Sloan, S., Bertzky, B. and Laurance, W.F. (2017). African development corridors intersect key protected areas. *African Journal of Ecology*, *55*, 731–7. DOI: 10.1111/aje.12377.

Slade, A. (2016). *Survivorship, demographics and seasonal trends among electrocuted primate species in Diani, Kenya.* Masters thesis. Bristol, UK: University of Bristol.

Sovacool, B.K. and Bulan, L.C. (2011). Behind an ambitious megaproject in Asia: the history and implications of the Bakun hydroelectric dam in Borneo. *Energy Policy*, *39*, 4842–59. DOI: https://doi.org/10.1016/j.enpol.2011.06.035.

Stokes, E.J., Strindberg, S., Bakabana, P.C., *et al.* (2010). Monitoring great ape and elephant abundance at large spatial scales: measuring effectiveness of a conservation landscape. *PLoS One*, *5*, e10294. DOI: 10.1371/journal.pone.0010294.

Tang, D. and Kelly, A.S. (2016). *Design Manual: Building a Sustainable Road to Dawei: Enhancing Ecosystem Services and Wildlife Connectivity.* Yangon, Myanmar: World Wide Fund for Nature (WWF).

TAWIRI (2017). *Tanzania national chimpanzee management plan.* Unpublished draft. Arusha, Tanzania: Tanzania Wildlife Research Institute (TAWIRI), Ministry of Natural Resources and Tourism.

Trombulak, S.C. and Frissell, C.A. (2000). Review of ecological effects of roads on terrestrial and aquatic communities. *Conservation Biology*, *14*, 18–30. DOI: 10.1046/j.1523–1739.2000.99084.x.

Tutin, C.E.G., White, L.J.T., and Mackanga-Missandzou, A. (1997). The use by rain forest mammals of natural forest fragments in an equatorial African savanna. *Conservation Biology*, *11*, 1190–203.

UNEP and McGinley, M. (2009). *Kahuzi-Biéga National Park, Democratic Republic of Congo, October 15, 2009.* Available at: http://www.seoearth.org/article/Kahuzi-Bi%C3%A9ga_National_Park,_Democratic_Republic_of_Congo.

United States Green Building Council (2016). *USGBC Statistics.* Washington, DC, USA: United States Green Building Council. Available at: https://www.usgbc.org/articles/usgbc-statistics.

USAID (2008). *Nigeria Biodiversity and Tropical Forestry Assessment. Maximizing Agricultural Revenue in Key Enterprises for Targeted Sites (Markets).* Washington DC: US Agency for International Development (USAID).

Uwaegbulam, C. (2016). Stakeholders approve $12m UN-REDD plus strategy for Nigeria. *The Guardian*, September 5, 2016. Available at: https://guardian.ng/property/stakeholders-approve-12m-un-redd-plus-strategy-for-nigeria.

Vanthomme, H., Kolowski, J., Korte, L. and Alonso, A. (2013). Distribution of a community of mammals in relation to roads and other human disturbances in Gabon, central Africa. *Conservation Biology*, *27*, 281–91. DOI: 10.1111/cobi.12017.

van Beukering, P.J.H., Cesar, H.S.J. and Janssen, M.A. (2003). Economic valuation of the Leuser National Park on Sumatra, Indonesia. *Ecological Economics*, *44*, 43–62. DOI: https://doi.org/10.1016/S0921–8009(02)00224–0.

van Vliet, N., Mertz, O., Heinimann, A., *et al*. (2012). Trends, drivers and impacts of changes in swidden cultivation in tropical forest-agriculture frontiers: a global assessment. *Global Environmental Change-Human and Policy Dimensions*, *22*, 418–29.

von Maltitz, G. and Stafford, W. (2011). *Assessing Opportunities and Constraints for Biofuel Development in Sub-Saharan Africa.* Bogor, Indonesia: Center for International Forestry Research (CIFOR).

Walsh, P.D., Abernethy, K.A., Bermejo, M., *et al.* (2003). Catastrophic ape decline in western equatorial Africa. *Nature*, *422*, 611–4.

Watts, D.P., Muller, M., Amsler, S.J., Mbabazi, G. and Mitani, J.C. (2006). Lethal intergroup aggression by chimpanzees in Kibale National Park, Uganda. *American Journal of Primatology*, *68*, 161–80. DOI: 10.1002/ajp.20214.

WCD (2000). *Dams and Development: A New Framework for Decision-making.* World Commission on Dams (WCD). London, UK: Earthscan Publications. Available at: https://www.internationalrivers.org/sites/default/files/attached-files/world_commission_on_dams_final_report.pdf.

WCS (2015). *Projet pour la Protection des Populations de Gorilles et de Chimpanzés, et Conservation de la Biodiversité dans la Forêt de Deng - Deng Région de l'Est Cameroun. RAPPORT FINAL.* Yaoundé, Cameroon: Wildlife Conservation Society (WCS). Available at: https://programs.wcs.org/cameroon.

Weng, L., Boedhihartono, A.K., Dirks, P.H.G.M., *et al.* (2013). Mineral industries, growth corridors and agricultural development in Africa. *Global Food Security*, *2*, 195–202. DOI: https://doi.org/10.1016/j.gfs.2013.07.003.

White, A. and Fa, J.E. (2014). The bigger picture: indirect impacts of extractive industries on apes and ape habitat. In *State of the Apes: Extractive Industries and Ape Conservation*, ed. Arcus Foundation. Cambridge, UK: Cambridge University Press, pp. 197–225.

Wich, S.A., Gaveau, D., Abram, N., *et al.* (2012). Understanding the impacts of land-use policies on a threatened species: is there a future for the Bornean orang-utan? *PLoS One*, *7*, e49142.

Wich, S.A., Meijaard, E., Marshall, A.J., *et al.* (2008). Distribution and conservation status of the orang-utan (*Pongo spp.*) on Borneo and Sumatra: how many remain? *Oryx, 42*, 329–39.

Wich, S., Riswan, J.J., Refish, J. and Nelleman, C. (2011). *Orangutans and the Economics of Sustainable Forest Management in Sumatra.* Norway: UNEP, GRASP, PanEco, YEL, ICRAF, GRID-Arendal, Birkeland Trykkeri AS. Available at: www.grida.no/search?query=Orangutans+and+the+Economics+of+Sustainable+Forest+Management+in+Sumatra.

Wilkie, D.S. and Carpenter, J.F. (1999). Bushmeat hunting in the Congo Basin: an assessment of impacts and options for mitigation. *Biodiversity and Conservation*, *8*, 927–55.

Wilkie, D., Shaw, E., Rotberg, F., Morelli, G. and Auzel, P. (2000). Roads, development and conservation in the Congo basin. *Conservation Biology*, *14*, 1614–22.

Wilkie, D.S., Sidle, J.G., Boundzanga, G.C., Auzel, P., and Blake, S. (2001). Defaunation, not deforestation: commercial logging and market hunting in northern Congo. In *The Cutting Edge: Conserving Wildlife in Logged Tropical Forests*, ed. R. Fimbel, A. Grajal, and J.G. Robinson. New York, NY: Columbia University Press, pp. 375–99.

World Bank (2012). *Project Appraisal Document on a Proposed Credit in the Amount of SDR 85.2 Million (US$132 Million Equivalent) to the Republic of Cameroon for a Lom Pangar Hydropower Project.* Washington DC: World Bank. Available at: http://siteresources.worldbank.org/INTCAMEROON/Resources/LPHP-PAD-Mar2012.pdf.

WWF (2015). *A Global Assessment of Extractive Activity within World Heritage Sites.* Gland, Switzerland: World Wide Fund for Nature (WWF)-International.

Zarfl, C., Lumsdon, A.E., Berlekamp, J., Tydecks, L. and Tockner, K. (2015). A global boom in hydropower dam construction. *Aquatic Sciences*, *77*, 161–70. DOI: 10.1007/s00027–014–0377–0.

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Infrastructure development in Africa and Asia is expanding at breakneck speed, largely in biodiversity-rich developing nations. The trend reflects governments' efforts to promote economic growth in response to increasing populations, rising consumption rates and persistent inequalities. Large-scale infrastructure development is regularly touted as a way to meet the growing demand for energy, transport and food—and as a key to poverty alleviation. In practice, however, road networks, hydropower dams and "development corridors" tend to have adverse effects on local populations, natural habitats and biodiversity. Such projects typically weaken the capacity of ecosystems to maintain ecological functions on which wildlife and human communities depend, particularly in the face of climate change.

This volume—*State of the Apes: Infrastructure Development and Ape Conservation*—presents original research and analysis, topical case studies and emerging tools and methods to inform debate, practice and policy with the aim of preventing and mitigating the harmful impacts of infrastructure projects on biodiversity. Using apes as a proxy for wildlife and ecosystems themselves, it identifies opportunities for reconciling economic and social development with environmental stewardship.

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>
> **Matthew V. Cassetta**
> Facilitator, Congo Basin Forest Partnership
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