



Road Expansion and the Fate of Africa's Tropical Forests

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The tropical forests of Africa are experiencing unprecedented changes as a result of a rapid proliferation of roads and other infrastructure. These projects are dramatically increasing access to relatively unexploited regions, particularly in the greater Congo Basin. We highlight some of the most important new projects and describe in detail an ongoing debate about a particular proposed development, the Cross River Superhighway in Nigeria. The scale and pace of new transportation projects, and the profound environmental changes they could bring, underscore a dire need for proactive land-use planning, capacity building, and environmental assessment in the nations of Equatorial Africa. It is no exaggeration to suggest that, unless carefully managed to ensure sustainability, the spate of planned and ongoing projects could irreparably diminish the forests and wildlife populations of Africa's most biologically diverse regions.

Keywords: deforestation, development corridors, equatorial Africa, infrastructure-tsunami, logging, wildlife

INTRODUCTION

Africa's tropical forests sustain exceptionally high biodiversity and provide valuable environmental services such as hydrological functioning and carbon storage (Abernethy et al., 2016). These forests span the greater Congo Basin as well as a narrower band across the equatorial African forests. Like much of Sub-Saharan Africa, this equatorial region is facing dramatic changes in the number, extent, and environmental impacts of large-scale infrastructure projects (Laurance et al., 2015a). A particular concern is how such projects will affect important wildlife habitats, protected areas (Figure 1), and environmental services (Wilkie et al., 2000; Laurance et al., 2009, 2015b). Here we describe an "infrastructure tsunami" in equatorial Africa and focus in particular on Nigeria's Cross River Superhighway, a proposed project that has drawn intense scrutiny and concern. The Cross River Superhighway has drawn concern as it fails to comply with Nigerian environmental laws and does not meet international standards of good practice. For instance, the project lacks justification from a cost benefit analysis perspective (Draper et al., 2016) and has other critical deficiencies including inadequate environmental baseline data, unclear project description, insufficient identification of potential environmental impacts and potential mitigation measures, and a lack of stakeholder engagement (WCS, 2016).

Across Africa, major infrastructure projects are expanding at an unprecedented pace. These projects include a large number of industrial mining projects (Edwards et al., 2014); over 53,000 km of proposed "development corridors" (see some examples in Figure 1) that would crisscross much of the continent (Weng et al., 2013; Laurance et al., 2015a); the world's largest hydropower-dam complex, at Inga Falls on the Congo River; ambitious plans to increase industrial and smallholder agriculture (African Agricultural Development Company Ltd., 2013; Laurance et al., 2014a,b); widespread industrial logging (Laporte et al., 2007; Kleinschroth et al., 2015, 2016a); and a variety of other mining ventures and energy infrastructure with accompanying roads.

The planned African infrastructure expansion also threatens ecotourism revenue. For instance, approximately 62% of African forest elephants were lost between 2002 and 2011 (Maisels et al., 2013) with roads as major contributing factor (Laurance et al., 2006). It is estimated that lost economic benefit that poached elephants (both forest and savanna) would have delivered to African countries via tourism are substantial (~USD \$25 million annually) (Naidoo et al., 2016). The expected increase in African road infrastructure and therefore access to wilderness areas will continue to threaten ecotourism income including that generated by large mammals (Joseph et al., 2017).

African infrastructure expansion is being driven largely by foreign investments, most notably from China (Foster et al., 2009; IDE-JETRO, 2009; Carey and Xiaoyun, 2016), to exploit natural resources such as minerals, timber, and

fossil fuels (Weng et al., 2013; Edwards et al., 2014). Another oft-cited justification is concerns about Africa's booming population—which is projected roughly to quadruple this century (U.N. Population Division, 2016). This is creating serious concerns about food-security and human-development challenges (African Agricultural Development Company Ltd., 2013; Weng et al., 2013), and broader anxieties about the potential for social and political instability.

AFRICAN DEVELOPMENT CORRIDORS

A true game-changer for African nature conservation is at least 33 ongoing and proposed “development corridors” that will crisscross sub-Saharan Africa. If completed in their entirety, the corridors would collectively

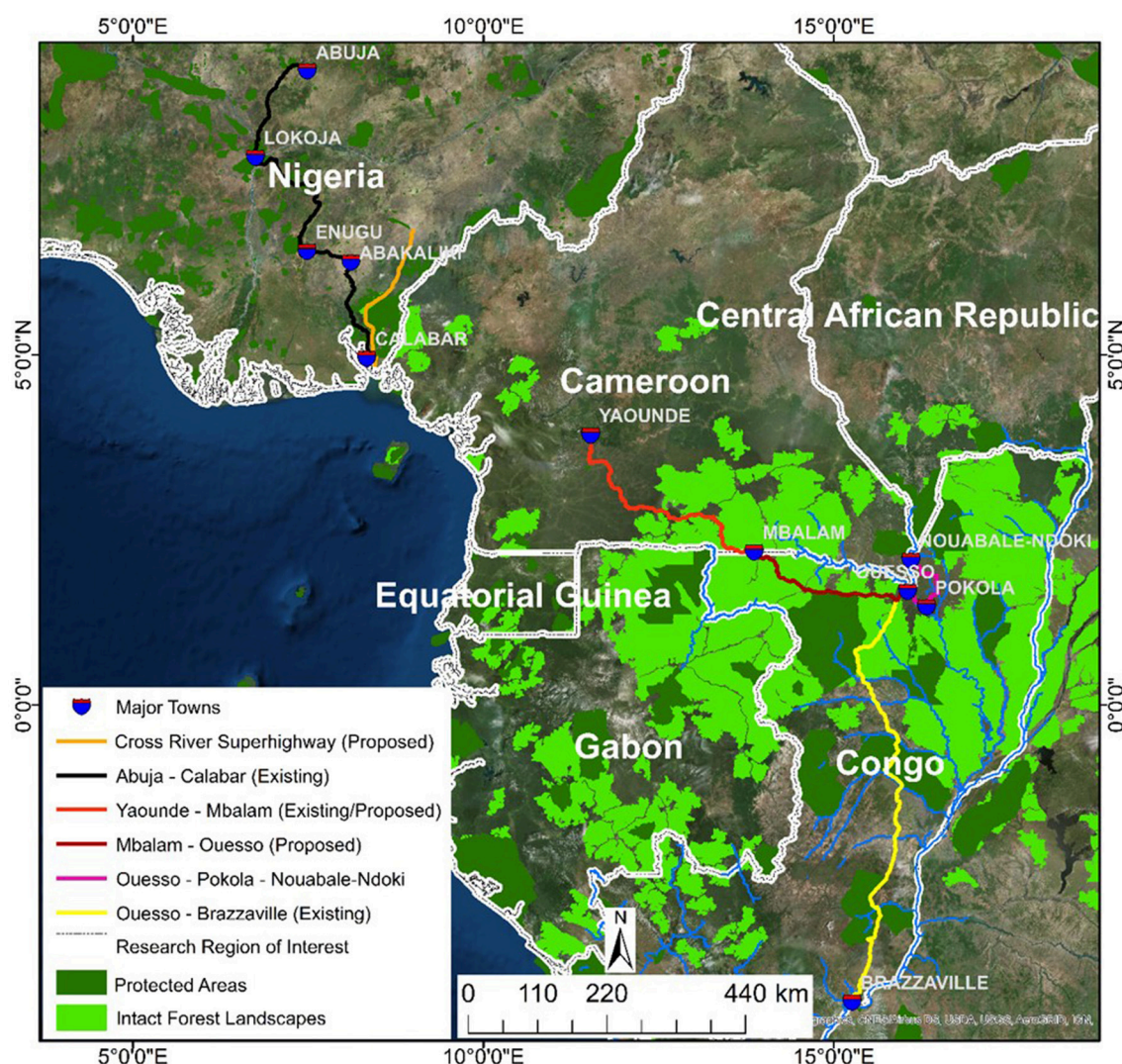


FIGURE 1 | Some of the proposed and existing highway routes in Equatorial Africa. The Cross River Superhighway in Nigeria (proposed). Yaounde-Mbalam (partly existing and proposed) Mbalam-Ouessou (proposed) and Ouessou-Brazzaville (existing). The protected areas layer was downloaded from the World Database on Protected Areas 2017 and Intact Forest Landscapes 2000 layer was acquired from the Global Forest Watch website.

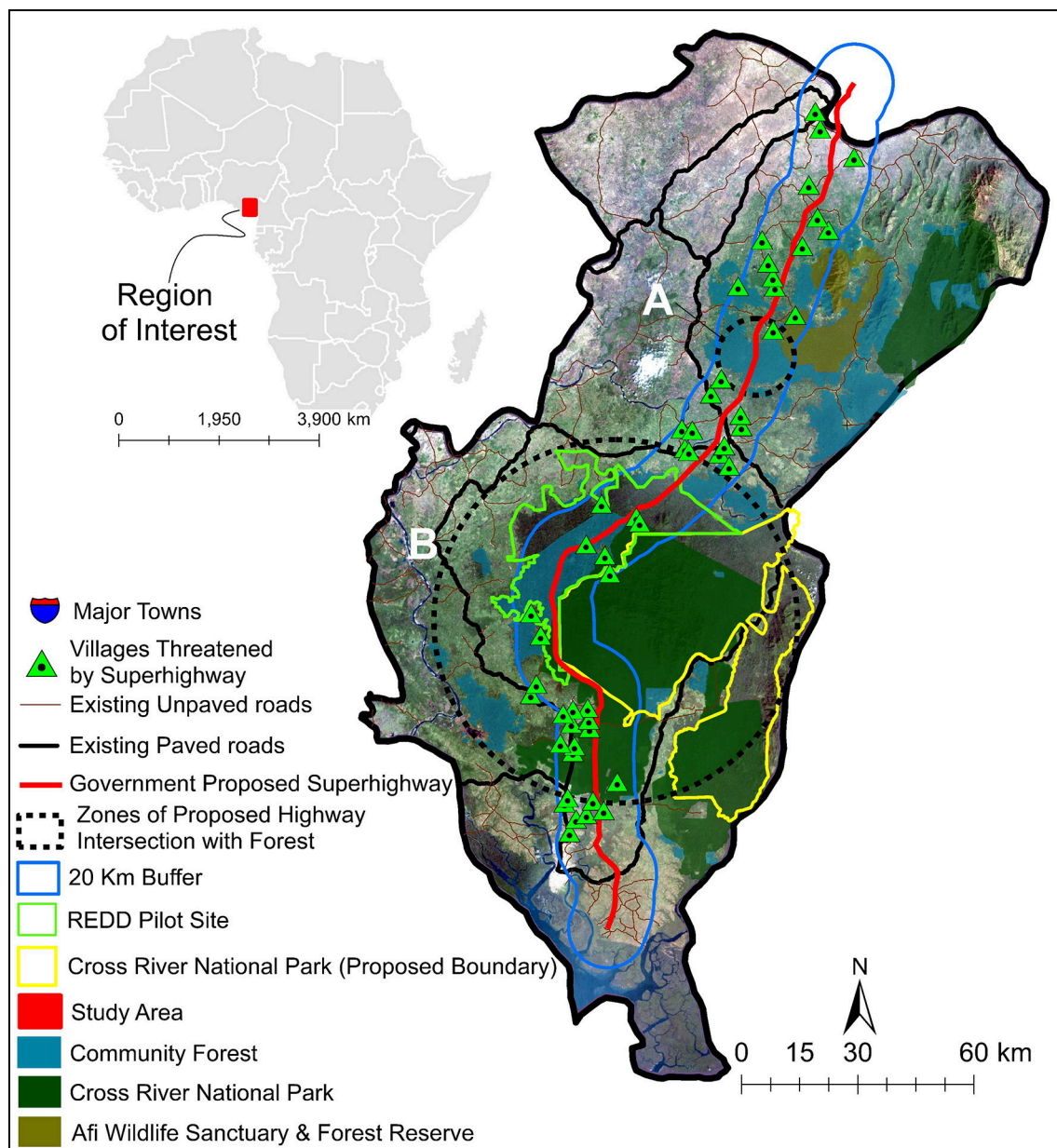


FIGURE 2 | (Top left) An inset of Africa depicting the study region. **(Right)** The proposed 260 km-long Cross River Superhighway route with its originally proposed 20 km-wide buffer zone in Cross River State, Nigeria. Circles A and B depict areas of intersection between the proposed superhighway, the Cross River national park and community forest.

span more than 53,000 km in length (Laurance et al., 2015a).

The development corridors would have a range of environmental effects, including major impacts on existing protected areas. First, they could bisect reserves, fragmenting them and opening them up to illegal encroachment, logging, mining, poaching (Jeusset et al., 2016; Sloan et al., 2016), and contagious development (Selva et al., 2015). Second, by promoting colonization, habitat loss, and intensified land uses around reserves, they could decrease the ecological connectivity

of the reserves to other nearby habitats. Finally, environmental changes in the lands immediately surrounding a nature reserve tend to infiltrate inside the reserve itself (Findlay and Bourdages, 2000; Seiler, 2001; Laurance et al., 2012). So, for example, a reserve with extensive logging and hunting in its surrounding lands and weak reserve management will also tend to experience those same threats, to some degree, inside the reserve (Caro et al., 2014).

A detailed analysis of the proposed and ongoing development corridors (Laurance et al., 2015a) suggests that (1) many

corridors as planned would occur in areas that have high environmental values and are only sparsely populated by people; (2) as planned, the corridors would bisect over 400 existing nature reserves; and (3) assuming that land-use changes intensify only within a 25 km-wide zone around each corridor, more than 1,800 additional reserves could experience deterioration in their ecological integrity and connectivity as well as increased human encroachment (Barber et al., 2014).

In total, the 33 development corridors could bisect or degrade about one-third of all existing protected areas in sub-Saharan Africa (Laurance et al., 2015a). Further, 23 of the corridors are still in the early planning or upgrading phases and these would be especially dangerous for nature, bisecting a larger proportion of high-priority reserves, such as World Heritage Sites, Ramsar Wetlands, and UNESCO Man and Biosphere Reserves. Collectively, the 23 planned corridors would slice through more than 3,600 km of protected-area habitat (Sloan et al., 2016).

Of the approximately 2,200 African protected areas that could be affected by planned or existing development corridors, a number are located in Central Africa. For example, two epicenters of bisected reserves—located in the mineral-rich belt spanning southern Cameroon and the northern Republic of Congo, and the Great Lakes region of East Africa—harbor vital habitats for wildlife, including great apes (Sloan et al., 2016). Considerable losses and deterioration of important habitats would also occur outside of protected areas, as human populations, agriculture, hunting, and other activities proliferate around the development corridors (Laurance et al., 2012, 2015a). The World Bank projects that, in coming decades, expanding roads and transportation infrastructure will be the biggest drivers of deforestation in the Congo Basin (Megevand, 2013).

The substantial investment in road infrastructure development planned in equatorial Africa will also significantly contribute to other underlying threats facing African tropical forests. These threats include habitat degradation and fragmentation, over-exploitation, exotic species invasion and future climate change impacts (Morris, 2010; Malhi et al., 2013, 2014). The magnitude of these impacts is not clearly known as the ecology of African tropical forests is less understood than that of the Americas and Asia (Malhi et al., 2013). This is largely due to limited scientific capacity, absence of funding for research, short-lived environmental governance plan and management regimes (Owusu et al., 2017).

THE CROSS RIVER SUPERHIGHWAY

One example of the large-scale infrastructure being planned for Central Africa is the Cross River Superhighway in Nigeria. This six lane 260 km-long highway would run from the country's far southeastern coast to Abuja, the national capital (Figure 2). The highway is expected to cost an estimated US\$ 2.5 billion (Anonymous, 2016) and will be funded through both a Public Private Partnership and an Israeli-British firm who will contribute an estimated 500 million Euros (Akpan, 2016). As currently planned, the highway will cut through the most important forested regions in the country, a REDD pilot site and skirt the border of Cross River National Park,

a proposed world heritage area (Figure 2). Notably, the Cross River National Park harbors the highest numbers of primate species in the world as well as Nigeria's greatest plant and animal biodiversity (Mittermeier et al., 2006; IUCN, 2010; ALERT, 2016).

Road infrastructure development such as the proposed superhighway contribute to urbanization by attracting land speculators and settlers (Anderson, 2017; Haines, 2017) which in conjunction with the highway would have devastating impacts on ecosystem functioning and threaten biodiversity (Riley et al., 2005; Pauchard et al., 2006; McKinney, 2008; Heinrichs and Pauchard, 2015). For instance, the Cross River National Park harbors roughly 20% of the planet's butterfly species which if constructed the superhighway would threaten. The superhighway would also threaten endemic species (Fahrig, 2001; Dicks et al., 2015), and contribute to the extraction of the remains of hardwood trees including the highly priced local mahogany (*Khaya snegalensis*, *Khaya grandifolia*, and *Khaya puchii*) (Thompson, 1908; Lukumbuzya and Sianga, 2017). If the highway is built along its proposed route, it would penetrate a previously roadless area of forest, allowing its exploitation and contributing to a country wide net-loss of forest (Ibisch et al., 2016).

The superhighway project has raised widespread alarm both nationally and internationally because about 90% of Nigeria's tropical rainforest has previously been destroyed and Cross River National Park sustains two-thirds of the country's remaining tropical rainforest. In this context, Cross River National Park is irreplaceable. It sustains 18 species of primates—among the highest primate diversity in the world. Among these is the critically endangered and locally endemic Cross River Gorilla (*Gorilla gorilla diehli*), which like other primates in the region is highly sensitive to hunting (Effiom et al., 2013). It also sustains high plant diversity and a variety of other imperiled wildlife species, such as forest elephants and leopards (ALERT, 2016; Ingle, 2016).

The Cross River Superhighway is in a state of flux and heated debate. Until recently, the land titles of traditional landowners were revoked by the Cross River State government within a 20 km-wide zone around the highway route, affecting at least 42 forest communities within 13 Local Government Areas, especially the Ekuri people and current REDD pilot sites. Leases to these traditional lands and wildlife habitats were reportedly going to be auctioned off by the Cross River State government, whose present governor, Ben Ayade, is a key proponent of the highway. The leases would reportedly be sold to foreign timber and mining firms, in what have been described as an abuse of Nigerian land-use laws (ALERT, 2016).

Scientists and conservationists (e.g., Abutu, 2016; ALERT, 2016; Okeke, 2016a,b; Ingle, 2016; Laurance et al., 2017) have vigorously decried the Cross River Superhighway because of its high potential to damage Nigeria's most important forest ecosystems. Already, millions of trees have been bulldozed along the proposed road route. The environmental impact assessment (EIA) conducted for the project has been widely derided, with construction of the superhighway temporarily halted by the then federal Minister for the Environment, Amina Mohammed, because of concerns about the EIA. The project is also being

challenged by a lawsuit brought by nongovernmental groups in Nigeria, who claim its EIA is farcical (ALERT, 2016).

After concerted international and national pressure, the Cross River State government announced in February 2017 that it would proceed with the Superhighway, but would forego its scheme to revoke land titles and exploit lands within the 20-km wide zone along the highway route. Instead, the government claims it will appropriate lands only along the highway itself plus a forest-free zone of 70 m width along either side (totaling about 200 m width overall, including the road surface and its verges). This is clearly a positive development, but many remain concerned that the present routing of the Superhighway—running along the margin of Nigeria's most important national park and bisecting the nation's last extensive tract of tropical forest—is extremely risky from an environmental perspective. Re-routing the highway to avoid these critical habitats is a key priority.

TIP OF THE ICEBERG

The Cross River Superhighway is but one of an expanding network of large-scale development corridors in equatorial Africa. In the Congo Basin alone, the Ouesso-Bangui-N'Djamena, Libreville-Lomie, Cameroon-Chad, and Northern Upgrade Corridors will span parts of Cameroon, Gabon, Republic of Congo, Democratic Republic of Congo, and Central African Republic (Laurance et al., 2015a). At present, many forests in these nations are still remote and only partially accessible via logging roads and existing timber concessions (Laporte et al., 2007; Kleinschroth et al., 2015). Unless environmental safeguards are rapidly implemented, the spate of new infrastructure projects will open up large tracts of Central Africa to further pressures, such as mining, hunting, logging, and deforestation for agriculture (Laurance et al., 2006, 2015a; Blake et al., 2007; Poulsen et al., 2009). An urgent priority is retaining the large areas of the region affected by selective logging as native forests for biodiversity and ecosystem services, rather than seeing them being deforested or depleted of wildlife by commercial hunters and poaching (Laurance and Edwards, 2014).

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Clearly, those seeking to manage the forests of equatorial Africa sustainably must grapple with serious and immediate challenges revolving around (1) effectively designing, assessing, and mitigating new infrastructure projects to limit their environmental and social impacts, (2) improving governance capacity for nations experiencing unprecedented foreign investments for infrastructure and natural-resource extraction, and (3) managing the economic and social instabilities that can plague nations largely reliant on just a few natural resources or commodities for export income—avoiding the so-called “natural-resource curse” or “Dutch Disease” (Edwards et al., 2014).

An array of solutions is needed to meet the serious challenges road developments pose with solutions varying upon the stage of road development. Prior to road construction an increased focus on proactive land-use planning (Laurance et al., 2014a, 2015a) ensuring that infrastructure locations effectively integrate sustainable agriculture (Laurance et al., 2014b) with forest conservation (Kleinschroth et al., 2016a,b) should occur. Before the commencement of an individual project, landscape level, detailed environmental and social impact assessments should be undertaken by road proponents and the resultant constraints rigorously enforced by governmental bodies (Laurance et al., 2015b). This would also allay the need for rerouting of poorly designed road projects (Mahmoud et al., 2017). Finally, the impacts of existing roads on forests could be lessened through effective forest management and law enforcement (Edwards et al., 2014; Abernethy et al., 2016). These solutions are not easily attained, but they are nonetheless urgent and essential for the future of Africa's tropical forests.

AUTHOR CONTRIBUTIONS

WL wrote the manuscript and MM, MC, and MA provided ideas, critical feedback and assisted with the revision of the manuscript.

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