

The need for smart road planning

by William F. Laurance¹, Mahmoud I. Mahmoud², Fritz Kleinschroth³

The tropical forests of Central Africa sustain exceptionally high biodiversity and environmental services such as forest hydrology and carbon storage. Large-scale infrastructure projects, if not planned well, pose a huge threat to important wildlife habitats, protected areas, and environmental services. William F. Laurance, Mahmoud I. Mahmoud and Fritz Kleinschroth propose smart linear infrastructure planning guided by spatial planning concepts to reduce negative environmental impacts and maximize socioeconomic benefits.

Across Africa, infrastructure projects are expanding at an unprecedented pace. These projects include a large number of industrial mining projects; over 50,000 km of proposed ‘development corridors’ that would crisscross much of the continent; the world’s largest hydropower dam complex, at Inga Falls on the Congo River; ambitious plans to increase industrial and smallholder agriculture; widespread industrial logging; and a variety of other transportation, energy, and mining ventures.

Although African infrastructure expansion is largely driven by foreign investments to exploit natural resources such as minerals, timber, and fossil fuels, major infrastructure projects are also being advocated because of concerns about Africa’s booming population, which is projected roughly to quadruple this century. This creates serious concerns about food security and human-development challenges, 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 span more than 53,000 km in length.

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

Rainforest clearing for a Chinese-operated road-construction camp in the northwest of the Republic of Congo.

PHOTO © WILLIAM LAURANCE



Development corridors could affect approximately 2,200 protected areas in Central Africa.

encroachment and poaching. 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 into the reserve itself. So, for example, a reserve with extensive logging and hunting in its surrounding lands and weak reserve management will also tend to have those same threats occurring, to some degree, within the reserve itself. A detailed analysis of the proposed and ongoing development corridors suggests that (1) many corridors as planned would occur in areas that have high environmental values and are only sparsely populated by people (Fig. 1); (2) as presently 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.

In total, the 33 development corridors could bisect or degrade about one third of all existing protected areas in

sub-Saharan Africa. Furthermore, the 23 corridors that are still in the early planning or upgrading phases would be in particular dangerous for nature. If completed, these corridors would bisect a higher proportion of high-priority reserves, such as World Heritage Sites, Ramsar Wetlands, and UNESCO Man and Biosphere Reserves, than existing development corridors. Collectively, the 23 planned corridors would slice through more than 3,600 km of protected-area habitat.

A number of the approximately 2,200 African protected areas that could be affected by development corridors are located in Central Africa. For example, two epicentres 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 – harbour vital habitats for wildlife, including great apes. There would also be considerable losses and deterioration of important habitats outside of protected areas. The World Bank projects that expanding roads and transportation infrastructure will be the biggest drivers of deforestation in Central Africa in the next 1-2 decades.



Bill Laurance with the skull of a forest elephant, slaughtered by poachers for its valuable tusks in Nouabale-Ndoki National Park in the Republic of Congo.



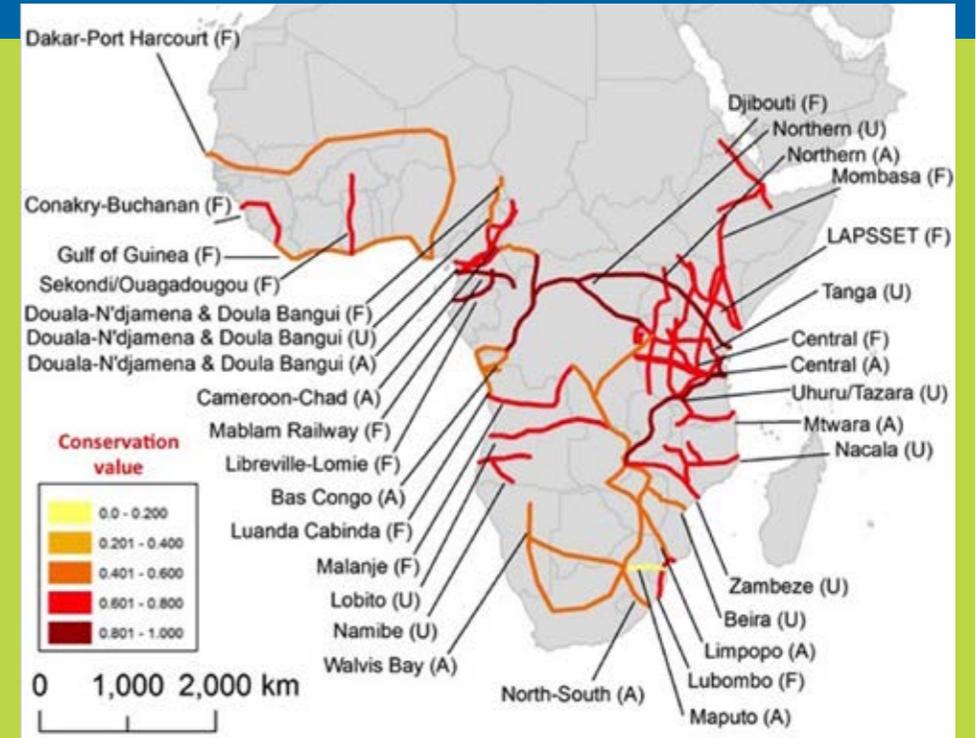
Mahmoud I. Mahmoud



Fritz Kleinschroth

FIGURE 1

Estimated conservation values (based on biodiversity, threatened species, critical ecosystems, wilderness attributes, and environmental services) of habitats within a 25 km-wide buffer zone around 33 proposed or existing development corridors in sub-Saharan Africa. © William Laurance and Sean Sloan.



THE CROSS RIVER SUPERHIGHWAY One example of the large-scale infrastructure being planned for Central Africa is the Cross River Superhighway in Nigeria. This 260 km-long highway would run from the country's far south-eastern coast to Abuja, the national capital. As planned initially and rerouted, the highway will cut through the most important forested regions in the country and skirt the border of Cross River National Park, which has, amongst others, the highest numbers of primate species in the world as well as Nigeria's greatest plant and animal biodiversity.

The superhighway project has raised widespread alarm, both nationally and internationally because Cross River National Park sustains two-thirds of Nigeria's surviving tropical rainforest – about 90 percent of which has previously been destroyed. In this context, Cross River National Park is irreplaceable. It sustains 18 species of primate, which is amongst 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. It also sustains a great plant diversity and a variety of other imperiled wildlife species, such as forest elephants and leopards.

In addition to its major environmental effects, the Cross River Superhighway would have serious social and economic consequences. Traditional land titles have been revoked within a 20 km-wide zone around the highway, affecting at least 42 forest communities within 13 Local Government Areas, especially of the Ekuri people. Leases to these traditional lands and wildlife habitats are being auctioned off by the Cross River State government, whose present governor, Ben Ayade, is a key proponent of the highway and has gone ahead to build based on the provisional approval of the revised Environmental Impact Assessment (EIA) submitted. Most leases are reportedly being sold to foreign timber and mining firms, in what have been described as abuses of Nigerian land-use laws.

If completed in their entirety, the development corridors would collectively span more than 53,000 km in length.

Already, millions of trees have been bulldozed along the proposed road route. The EIA conducted for the project has been widely derided, challenged by a lawsuit from nongovernmental groups in Nigeria, who claimed the EIA was farcical, which led to the temporary halt of the superhighway project by the then federal Minister for Environment, Amina Mohammed. Independent review revealed that the re-submitted EIA and Biodiversity Action Plan documents lacked sound scientific basis, contained significant errors and were assessed fallacious. Therefore, the chosen recommended route by the State Government still threatens critical biodiversity habitat in Cross River State and Equatorial Africa at large. Meanwhile the Federal Government of Nigeria already budgeted funding for upgrading the existing highway as suggested by authors of this article. We proposed alternative routes to the Superhighway to limit damage to rare ecosystems and wildlife based on cost-benefit analysis of building a new road as opposed to upgrading the existing highway.

We propose a smart linear infrastructure planning guided by spatial planning concepts as a plausible solution to overcome the challenge of ill planned roads in the Congo Basin. Our proposed concept is a hybrid approach that uses spatio-temporal analytics, maps and processing (STAMP) techniques in combination with cost-benefit reasoning to optimize linear infrastructure and land use planning. The suggested smart solution is the foundation needed to promote reduced negative environmental impacts and maximize socioeconomic benefits in the context of achieving Sustainable Development Goals (SDG's) through smart infrastructure provisioning and sustainable land-use management for regional conservation economy.

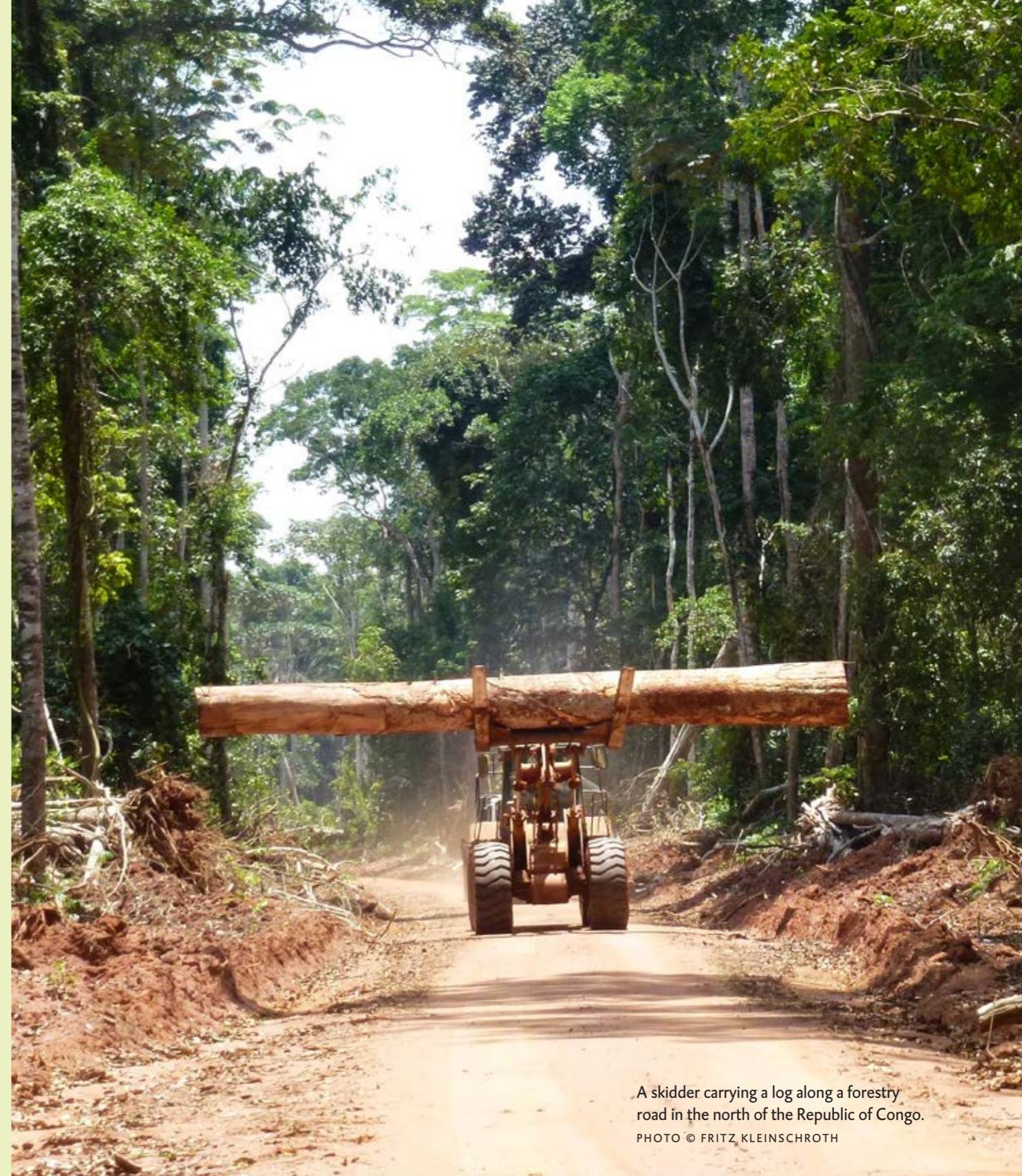
EXPANSION OF CONGO LOGGING An expanding network of large-scale African development corridors, such as the Ouesso-Bangui-N'Djamena, Libreville-Lomie, Cameroon-Chad, and Northern Upgrade, will soon traverse large areas of Central Africa. These development corridors will span parts of Cameroon, Gabon, Republic of Congo, the Democratic Republic of Congo and

Central African Republic. At present, many forests in these nations are still remote and only partially accessible through logging roads and existing timber concessions. 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 and deforestation for agriculture. A key 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 cleared or depleted of wildlife by commercial and subsistence hunting and ivory poaching.

In temperate forests, a permanently accessible and maintained road network is usually considered an essential part of sustainable forestry to enable timber harvesting, ecological monitoring, hunting, and recreation. In the tropics, however, road networks built for selective logging are considered a high risk for native forests by opening the door for uncontrolled land use, forest degradation and wildlife exploitation.

ACCESS Human encroachment into unexploited rainforests generally follows a trajectory of land uses. Logging companies are often the first to build new frontier roads into continuous blocks of intact forests to access commercial timber. After abandonment, former logging roads – at least in Cameroon and the Republic of Congo – are frequently used by hunters to access an extensive network of footpaths and motorcycle routes. Such access allows market-oriented hunting, leading to severely reduced wildlife populations, even to the extent of depleting the forest of many species. Motorcycle paths required for commercial hunting activities can only be found on logging roads abandoned less than 10 years ago. That means rapid forest recovery impedes access after a while and hunters move on to more recently logged areas.

Some of the hunting camps may serve as nuclei for more permanent settlements, predominantly using slash-and-burn agriculture. This shifting cultivation on a small scale



A skidder carrying a log along a forestry road in the north of the Republic of Congo.
PHOTO © FRITZ KLEINSCHROTH



PHOTO © WILLIAM LAURANCE

A pangolin for sale as bushmeat along a highway in south-central Cameroon.

facilitate can be highly detrimental to forest ecosystems and wildlife. Limiting the number and spatial footprint of permanent forest roads constructed for timber-harvest operations, and closing roads after harvests are completed, are vital priorities.

CONCLUSIONS Clearly, those seeking to manage the forests of Central Africa sustainably must grapple with serious and immediate challenges regarding (1) effectively designing, assessing, and mitigating new infrastructure projects to limit their environmental and social impacts, (2) providing good governance 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”.

An array of solutions is needed to meet these serious challenges, ranging from an increased focus on proactive land-use planning, sustainable agriculture, and forest management; to improving environmental impact assessments for new infrastructure projects, to better managing protected areas, and finally to addressing deficiencies in forest governance and law enforcement. None of these goals will be easy to advance, but the fate of Central Africa’s forests and societies will suffer even more if we fail to try.

ACKNOWLEDGEMENTS Support was provided by the Arcus Foundation, James Cook University, ETH-Zürich, and the European Union.

For more information, contact:

- Dr Mahmoud Ibrahim Mahmoud
National Oil Spill Detection and Response Agency (NOSDRA),
Abuja, Nigeria
Email: salammahmoudiii@gmail.com
- Alliance of Leading Environmental Researchers & Thinkers (ALERT)
www.ALERT-conservation.org

has taken place in tropical forests for millennia without causing permanent damage. However, once connections are established from these settlements to main roads and markets, they can sustain growing human populations, potentially exhausting timber supplies and other forest values. As such areas become increasingly accessible and their forests depleted of economic value, decision makers often find it increasingly difficult to resist the allure of foreign and domestic investors or land speculators. Such changes can drive large-scale forest clearing for intensive uses such as oil palm and rubber plantations.

Not all of the immense number of logging roads in Central Africa follow this same fate. In the northern Congo Basin, less than 20 percent of all logging roads actually remain permanently open. However, if local population pressures or lax law enforcement permit the commercial bushmeat trade to thrive, then logging roads and the poaching they

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 and deforestation for agriculture.

REFERENCES

- Abernethy, K., Maisels, F. and White, L. J. T. (2016) Environmental issues in central Africa. *Annual Review of Environment and Resources* 41:1-33.
- African Agricultural Development Company Ltd. (2013). *Developing Sustainable Agriculture in Africa* (http://www.agdevco.com/about_us.php).
- ALERT (2016) Mega-highway imperils 'biological jewel' of Nigeria. Press release, Alliance of Leading Environmental Researchers and Thinkers (<http://www.alert-conservation.org/issues-research-highlights/2016/9/22/alert-joins-battle-to-halt-nigerias-highway-to-hell>), 22 September 2016.
- Blake, S., Strindberg, S., Boudjan, P., Makombo, C., Bila-Isia, I., Ilambu, O., Grossmann, F., Bene-Bene, L., de Semboli, B., Mbenzo, V., et al. (2007) Forest elephant crisis in the Congo Basin. *PLoS Biology* 5, e111.
- Caro, T., Dobson, A., Marshall, A. J. and Peres, C. A. (2014). Compromise solutions between conservation and road building in the tropics. *Current Biology* 24:R722-R725.
- Edwards, D. P., Sloan, S., Weng, L., Sayer, J., Dirks, P. and Laurance, W. F. (2014) Mining and the African environment. *Conservation Letters* 7:302-311.
- Effiom, E. O., Nuñez-Iturri, G., Smith, H. G., Ottosson, U. and Olsson, O. (2013). Bushmeat hunting changes regeneration of African rainforests. *Proceedings of the Royal Society B* 280:20130246; <http://dx.doi.org/10.1098/rspb.2013.0246>.
- Feintrenie, L. (2014) Agro-industrial plantations in Central Africa, risks and opportunities. *Biodiversity and Conservation* 23:1577-1589.
- Ingle, N. (2016) Will the ax fall on Nigeria's national parks? Editorial, *The New York Times* (http://www.nytimes.com/2016/11/04/opinion/willtheaxfallonnigeriasnationalparks.html?_r=1/5), 3 November 2016.
- Kleinschroth, F., Goulet-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* 15:64; DOI:10.1890/ES14-00488.1.
- Kleinschroth, F., Healey, J. R., Sist, P., Mortier, F., & Goulet-Fleury, S. (2016). How persistent are the impacts of logging roads on Central African forest vegetation? *Journal of Applied Ecology*, 53, 1127–1137.
- Kleinschroth, F., Healey, J. R. and Goulet-Fleury, S. (2016a) Sparing forests in Central Africa: Re-use old logging roads to avoid creating new ones. *Frontiers in Ecology and the Environment* 14:9-10.
- Kleinschroth, F., Healey, J. R., Mortier, F., Goulet-Fleury, and Stoica, R. (2016b) Effects of logging on roadless space in intact forest landscapes of the Congo Basin. *Conservation Biology*, DOI:10.1111/COBI.12815.
- 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. 2001. Tropical logging and human invasions. *Conservation Biology* 15:4-5.
- Laurance, W. F. and Edwards, D. P. (2014) Saving logged tropical forests. *Frontiers in Ecology and the Environment* 12:147.
- Laurance, W. F., Croes, B. M., Tchignoumba, L., Lahm, S. A., Alonso, A., Lee, M., Campbell, P. and Ondzeano, C. (2006) Impacts of roads and hunting on central-African rainforest mammals. *Conservation Biology* 20:1251-1261.
- Laurance, W. F., Goosem, M. and Laurance, S. G. (2009) Impacts of roads and linear clearings on tropical forests. *Trends in Ecology and Evolution* 24:659-669.
- Laurance, W. F., Useche, D. C., Rendeiro, J. et al. (2012) Averting biodiversity collapse in tropical forest protected areas. *Nature* 489:290-294.
- Laurance, W. F., Clements, G. R., Sloan, S. P., O'Connell, C. S., Mueller, N. D., Goosem, M., O. Venter, O., Edwards, D. P., Phalan, P., Balmford, A., Van Der Ree, R. and Arrea, I. B. (2014a) A global strategy for road building. *Nature* 513:229-232.
- Laurance, W. F., Sayer, J. and Cassman, K. G. (2014b) Agricultural expansion and its impacts on tropical nature. *Trends in Ecology and Evolution* 29:107-116.
- Laurance, W. F., Sloan, S. P., Weng, L. and Sayer, J. A. (2015a) Estimating the environmental costs of Africa's massive "development corridors". *Current Biology* 25:3202-3208.
- Laurance, W. F., Peletier-Jellema, A., Geenen, B., Koster, H., Verweij, P., Van Dijk, P., Lovejoy, T. E., Schleicher, J. and Van Kuijk, M. (2015b) Reducing the global environmental impacts of rapid infrastructure expansion. *Current Biology* 25:R259-R262.
- Megevan, C. (2013). *Deforestation Trends in the Congo Basin: Reconciling Economic Growth and Forest Protection*. Washington, D.C.: World Bank.
- 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* 23:1597-1608.
- 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* 21:1819-1836.
- Redford, K. 1992. The empty forest. *BioScience* 42:412-422.
- Sloan, S., Bertzky, B. and Laurance, W. F. (2016) African development corridors intersect key protected areas. *African Journal of Ecology*, DOI: 10.1111/aje.12377.
- U.N. Population Division (2016) *World Population Prospects*. New York: United Nations Population Division.
- van Gernerden, B. S., Olff, H., Parren, M. P. E. and Bongers, F. (2003) The pristine rain forest? Remnants of historical human impacts on current tree species composition and diversity. *Journal of Biogeography* 30:1381-1390.
- Weng, L., Boedihartono, A., Dirks, P. G. M., Dixon, P., Lubis, M. I. and Sayer, J. A. (2013) Mineral industries, growth corridors and agricultural development in Africa. *Global Food Security* 3:195-202.
- Wilkie, D., Shaw, E., Rotberg, F., Morelli, G., and Auzel, P. (2000) Roads, development, and conservation in the Congo Basin. *Conservation Biology* 14:1614-1622.