Sparing forests in Central Africa: re-use old logging roads to avoid creating new ones

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Frontiers in Ecology and the Environment

DOI:
10.1002/FEEKleinscrothletter.1

Published: 02/02/2016

Publisher's PDF, also known as Version of record

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Selective logging is prevailing in tropical forests (Laurance and Edwards; *Front Ecol Environ* 2014; **12[3]**: 147), posing urgent questions of how to manage the extensive logging road networks. Bicknell *et al.* (*Front Ecol Environ* 2015; **13[2]**: 73–74) emphasized the importance of road closure after harvest operations. We agree, but logging roads should not be permanently discarded, because potentially they need to be re-used.

The presence of roads in tropical forests is often associated with negative impacts on the ecosystem through encroachment and poaching (Wilkie *et al.* 2000), and conservation scientists warn against further road expansion into high biodiversity areas (Laurance *et al.* 2014). Consequently, a motion to keep "intact forest landscapes" free from logging in certified forests has recently been passed by the Forest Stewardship Council (Rodrigues *et al.* 2014). With fewer available unlogged forests the industry will, in any case, increasingly repeat logging rotations in the same areas, despite unreliable regeneration of the most valuable, intensively harvested species. Forest management plans in Central Africa, implemented during the past 10 years, suggest a minimum of 25 years between two harvests (Karsenty *et al.* 2008). Re-using former roads in subsequent harvests reduces the overall impact on the forest and may help loggers to amortize their investment in infrastructure (Holmes *et al.* 2002). However, five decades after the start of industrial-scale logging activities in Central Africa, little is known about how and where repeated logging operations are taking place. The Sangha River catchment is representative of the whole Congo Basin in that it includes areas with both long and short logging histories (Laporte *et al.* 2007). In an area covering 61 logging concessions, we carried out remote-sensing and GIS analyses to identify where logging roads were located during the past 10 years relative to the historical network and how many of them were reopened or newly built. During field visits to 11 concessions spread over the study area, we conducted interviews with forest managers of the four operating companies.

Of all roads detectable in forest concessions during the past 30 years, only about 12% were permanent (Figure 1). Seventy-five percent of roads created between 2006 and early 2015 were built in roadless forest, likely to be previously unlogged. The remaining 25% have been built in previously logged areas located in 37 concessions within 1.5 km of a former, non-permanent road. Of these, on average 29% (range 0–74%) were reopened roads, whereas 71% (range 26–100%) were newly created. Large areas (27%) of the formerly inaccessible forest that are not protected as national parks have been penetrated by new roads since 2006. In the tradition of cut-and-run (Laurance 2000) it still seems lucrative to open new areas where the most valuable timber trees are still available, even if transport costs rise due to increasing remoteness. But why have new roads been built in close vicinity to previous ones? In our interviews, some logging operators indicated that they may simply have lacked information about where former roads were located. Abandoned logging roads have been described as potential sites for improved timber regeneration (Fredericksen and Mostacedo 2000), but interviewed forest managers said that this did not influence their decision making because the time needed for a seedling to grow to harvestable size exceeds the timescales applied in business decision making in the region. Instead, respondents stated that some former roads are intentionally not reopened because they were not sufficiently straight to guarantee the fast movement of trucks and equipment.

Concentrating logging operations on existing road networks has potential advantages and disadvantages. Arguably the biggest logging-related threat to biodiversity in the region is bushmeat hunting, which is almost impossible to regulate according to the forest managers who were interviewed. Second-growth (secondary) forests on and around abandoned roads can provide valuable habitat for species such as elephants and gorillas due to high abundance of herbaceous food plants (Matthews and Matthews 2004) while, at the same time, attracting poachers who can use former logging roads to access the forest for at least 10 years after their closure. Reopening a road can therefore have negative impacts on biodiversity (through access for hunters and loss of habitat) just as creating a new one does. On the other hand, road construction accounts for up to 40% of the costs of selective logging operations (Medjibe and Putz 2012). As compared with constructing a new road, reopening a former road is likely to cost much less, given the lower relative amounts of biomass to be removed and the soil possibly still being compacted, unless the existing road surface has been severely eroded. Carbon emissions through forest clearing could be reduced, given that the biomass accumulated on a road during the first 25 years of spontaneous revegetation is on average 30% of the biomass cleared for a new road (Kleinschroth *et al.* in review).

Edwards *et al.* (2014) advocated land sparing over land sharing for logging activities. We argue that, while presenting some drawbacks, re-using logging roads can spare forests in two ways: (1) within the same area by avoiding new forest clearing in the vicinity of forest previously disturbed by former roads and (2) at a larger scale by sparing unlogged forests from new logging disturbance, by intensifying operations on previously logged forests. To achieve greater concentration of logging activities in formerly logged areas without completely depleting timber resources

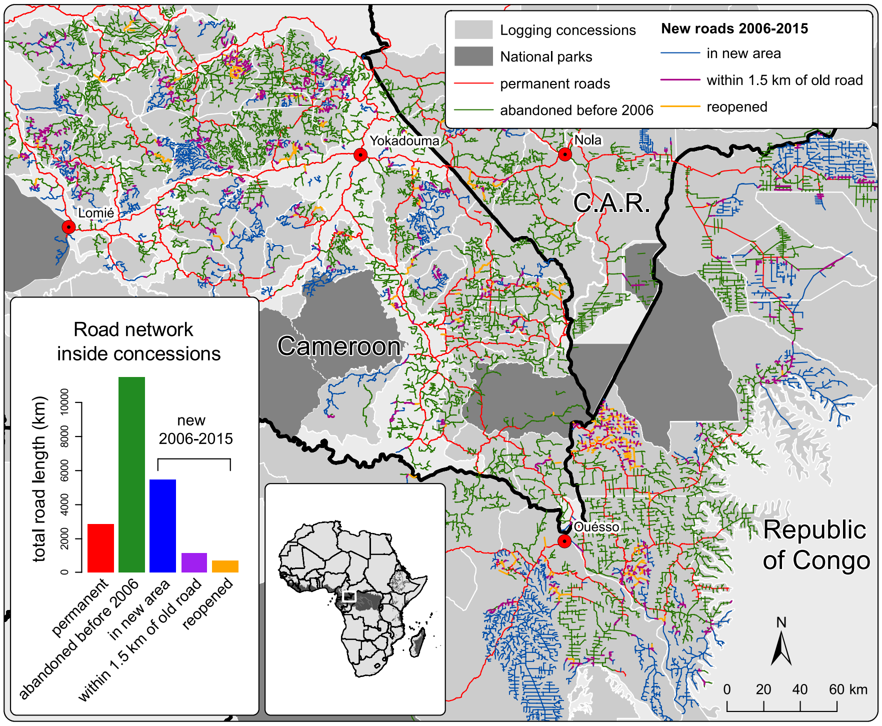

Figure 1. *Logging road network in a 108 000-km² forested area within central Africa. On the basis of 222 LANDSAT images taken between 1985 and 2015, we delineated roads and determined how long they were open and when they became revegetated due to abandonment and/or closure (Kleinschroth* et al. *2015). We grouped roads into three intervals depending on openness: (1) 1985–2001, (2) 2002–2005, or (3) 2006–2015. We then determined which roads were permanent [open in intervals (1), (2), AND (3), or open in (2) AND (3), red lines], were abandoned before 2006 [(1) AND/OR (2), green], have been reopened during 2006–2015 [(1) AND (3), orange], or were newly built during 2006–2015 [only (3)]. We then identified which newly built roads were located in "intact" (blue) and in previously logged (purple) areas – those within a 1.5-km buffer on each side of all former, non-permanent roads (based on maximum skidding [log yarding] distance). Ground truthing was performed while driving along ~2000 km of the road network and conducting vegetation inventories on abandoned roads. Underlying logging concessions (http://www.wri.org/tags/forest-atlas) and national parks (www.protectedplanet.net) are shown in gray scales. Insets: total road length for each category and location of the study area in Africa and the moist tropical ecoregion (http://maps.tnc.org). CAR = Central African Republic.*

therein, we advocate the diversification of target species and the implementation of post-logging silviculture to make repeated logging rotations sustainable. We suggest that loggers identify former road networks based on historical satellite images such as freely available LANDSAT data (http://landsat.gsfc.nasa.gov/?page_id=2367) and plan their road network so that the major part of the forest remains inaccessible. To secure completely road-free corridors, we support landscape planning at a larger scale.

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Acknowledgements

FK was funded by the European Commission under the Erasmus Mundus Joint Doctorate Programme FONASO. We thank E Forni for his support in the field.

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doi:10.1002/FEEKleinschroth letter.1