Saving logged tropical forests: closing roads will bring immediate benefits

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There is growing recognition that selectively logged tropical forests are of high conservation value (Gibson *et al.* 2011). In their recent editorial on this subject, Laurance & Edwards (*Front Ecol Environ* 2014; **12:** 147) draw attention to the vulnerability of forests following logging and propose a number of highly pertinent strategies to minimize subsequent biodiversity loss. One of these, the closure of logging roads, warrants closer scrutiny. To date it has been under-acknowledged in the context of selectively logged forests, but this single action could pay immediate dividends to tropical biodiversity. To illustrate using Kalimantan, Indonesian Borneo, we show that rates of forest loss during 2000-2012 were nearly two times higher in areas where logging roads were present pre-2000 (Fig. 1a).

Across the tropics, forestry authorities lease production forests to companies, for the harvest of timber via selective logging. During the lease period, corporations are responsible for management of their concessions, and other land-uses (e.g. agriculture) are typically prohibited or heavily restricted. For companies invested in the long-term fate of the timber through involvement in forest certification schemes, road closure after harvesting is recommended in order to maintain forest cover (FSC 2010). Indeed, we find that rates of forest loss across Kalimantan were higher in uncertified concessions compared to those that were certified (Fig. 1b).

Across Kalimantan, 25% of the land allocated for timber production in 2000 later had its status changed for conversion to industrial plantation (Gaveau *et al.* 2013). This most frequently happens under the "cut and run" scenario emphasised by Laurance & Edwards, whereby logging concessions are abandoned after harvest and, consequently, face exploitation for illegal timber extraction, agriculture and mining, all of which are facilitated by the logging roads (Wilkie *et al.* 2000; Laurance *et al.* 2001; Meijaard *et al.* 2005). In such

43 instances, logging estates are classified as ‘degraded’, making the likelihood of the land being
44 re-allocated for conversion much greater.
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46 Logging concessions therefore follow one of two broad destinies: (1) companies ensure high
47 production for the next harvest through responsible management and restricted access; or (2)
48 timber corporations having little incentive to protect the forest, resulting in eventual land-use
49 change. Under these two scenarios, biodiversity follows much the same fate as the forest
50 (Fig. 2) (Edwards *et al.* 2014).
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52 Spatial determinants of tropical deforestation, other than roads and linear transport routes
53 (e.g. rivers, train lines), include additional factors associated with accessibility (e.g. slope,
54 topography, distance to settlements) and the suitability of the land for conversion to
55 alternative uses (Laurance *et al.* 2002; Gaveau *et al.* 2009). While the relationship between
56 deforestation, logging roads and certification highlighted here could thus potentially be
57 confounded by a number of additional variables, roads into tropical forests are a well-known
58 precursor to much more high-impact forms of disturbance. For example, in the Brazilian
59 Amazon, 95% of deforestation is within 5 km of roads (Barber *et al.* 2014).
60
61 Given that more than 4 million km^2 of the world’s tropical forests are officially designated
62 for future timber production, it has never been more critical to consider the fate and
63 biodiversity value of logged forests. Road closure between harvests is fundamental, and can
64 be easily and inexpensively achieved by deconstructing bridges and installing physical
65 barriers (Applegate *et al.* 2004). However, ensuring roads stay closed requires investment,
66 monitoring and enforcement to prevent illegal behaviour. To incentivise the logging industry,
67 forestry authorities should lease concessions over multiple cutting cycles, thus placing more

responsibility on companies to safeguard the future timber stocks, even those that do not seek certification. The ability of forestry authorities to achieve these moderate changes to management and regulations may be constrained by local contexts, and could even require governments to sanction timber corporations that do not adequately protect forest cover in their concessions. In many forests, closing roads is an important step in protecting timber stocks, and consequently, this action could make a significant contribution to protecting the long-term sustainability of forestry, as well as biodiversity within managed tropical landscapes.

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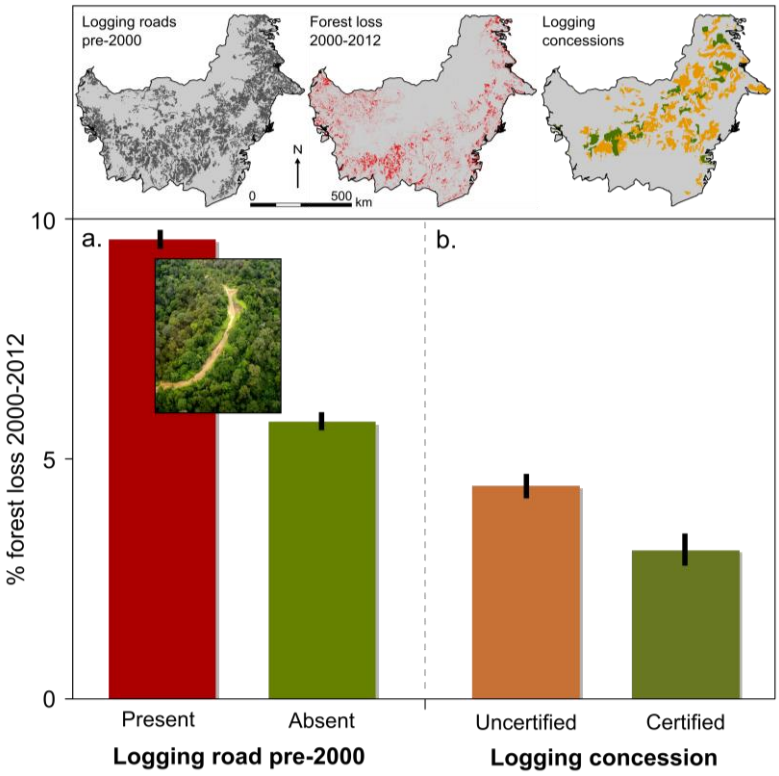

Fig. 1. Mean (± SE) % forest loss in 10 x 10 km grid cells during 2000-2012: (A) where primary logging roads were present (red) or absent (green) pre-2000 - photo shows a typical primary logging road through Borneo's timber production forests; (B) in certified (green) and uncertified (orange) logging concessions. Maps show primary logging roads pre-2000, forest loss 2000-2012 and certified and uncertified logging concessions in Kalimantan. Concession data was acquired from the Ministry of Forestry of Indonesia. Forest loss was measured using high-resolution global maps of 21st century forest cover change (Hansen *et al.* 2013). Primary logging roads were mapped using LANDSAT images classified in Gaveau *et al*. (2014) and do not include secondary logging roads that infrequently open the canopy. Primary roads are typically unsurfaced and are designed for use by heavy machinery to extract and transport timber. To account for misclassification or possible regeneration, small patches of forest loss were first removed using the generalisation tool in ArcGIS. Strictly protected areas were excluded from the analysis and, to account for access provided by rivers, a 1 km river buffer was also excluded.

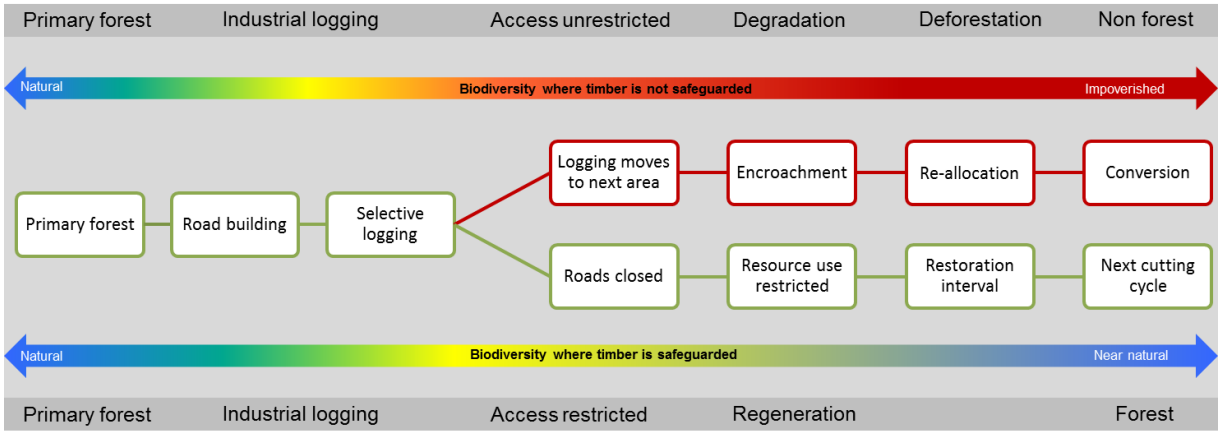

Fig. 2. The consequences for biodiversity of two logging concession scenarios: (Top) forests that are unmanaged with unrestricted access; and, (Bottom) forests that are managed, including access restriction.