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A history of hubris – Cautionary lessons in ecologically sustainable forest management

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ABSTRACT

Logging is one of the most important forms of native-forest exploitation and can have substantial impacts on biodiversity and key ecosystem services. Here we briefly contrast logging operations in temperate and tropical forests and then highlight several challenges for understanding the ecological impacts of logging. We argue that many logging studies are conducted at small spatial scales or over inadequate time periods, and are biased against finding significant negative impacts. This is because of confounding environmental differences between logged and unlogged forests as well as the prolonged nature of forest stand development. Human perceptions of logging also can be biased by the 'shifting baseline' phenomenon, and by an incorrect perception that logging operations approximate natural disturbance regimes. We argue that the ecological impacts of logging can be more challenging to detect than is often appreciated, and that forest managers and decision-makers should be cautious when weighing the arguments of pro-logging lobbies.

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1. Introduction

Around the world, forest management for timber production has long been one of the most controversial, and sometimes divisive, natural resource issues (e.g. Yaffee, 1994; Puettmann et al., 2008). Many debates have arisen over the impacts of timber harvesting on other forest values, particularly the conservation of biodiversity (Lindenmayer and Franklin, 2002; Gibson et al., 2011) (for instance, see the contrasting views of Paillet et al. (2009) vs. Halme et al. (2010)).

Here we briefly examine several aspects of the debate over logging impacts on biodiversity, based on our combined 60 years of experience in working in temperate forests (e.g. Lindenmayer et al., 1999, 2009; Lindenmayer, 2009) and tropical forests (e.g. Laurance, 1991; Laurance et al., 1997, 2000, 2007). This exercise is important, we believe, because aspects of these recurring arguments are either flawed or often misunderstood, meaning that

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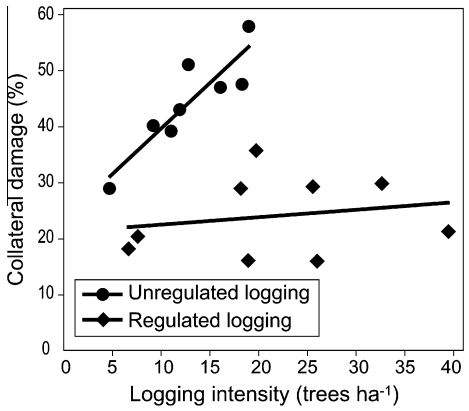

Fig. 1. Reduced-impact logging methods can markedly reduce forest damage. Shown are data from different logging studies in Southeast Asia (unregulated logging) and north Queensland (regulated logging). Collateral damage is the percentage of non-harvested trees ($\geqslant$10 cm diameter) that were killed during logging operations (data from Crome et al., 1992).

forest managers and decision-makers should be cautious when weighing the arguments of pro-logging lobbies or interpreting logging-impact research.

2. Temperate vs. tropical logging

At the outset, it is important to emphasize that logging typically differs between temperate and tropical regions. Forest stands in temperate regions are often dominated by a small number of tree species, and in many cases stands are clearcut in a mosaic pattern (Puettmann et al., 2008). In some harvesting operations, living and dead trees that provide hollows for wildlife as well as strips of vegetation along watercourses are retained (e.g. Carey, 2007; Bunnell and Dunsworth, 2009). Logging of temperate and boreal moist forests can make them more fire prone (Odion et al., 2004; Thompson et al., 2007; Lindenmayer et al., 2009) and this may even result in regime shifts as a result of significant alterations in fire frequency and/or severity (Lindenmayer et al., 2011a).

In the tropics, tree species richness is far higher than in temperate forests and only a limited number of larger trees are harvested – typically from 1–20 trees per hectare (Crome et al., 1992; Felton et al., 2008). Unharvested species are generally those that have undesirable wood properties, are too small, or are too rare or poorly known to be exploited by wood-products industries. Although cutting is selective, logging operations in the tropics can cause a substantial (10–80%) loss of forest canopy-cover and heavy collateral mortality of non-harvested trees (Fimbel et al., 2001). As we discuss further below, such damage can be considerably diminished via reduced-impact logging methods (Putz et al., 2008) (Fig. 1).

Fig. 2. Logging operations often create large amounts of dry, fine fuels that can promote forest fires, as shown here in the Congo Basin (photo by W.F. Laurance).

In a separate paper in this issue, highlight many challenges involved in the sustainable logging of native forests in the tropics. For tropical wildlife, impacts on populations can arise not only from the logging operation itself but also from important secondary effects. In particular, forest roads created by logging operations tend to facilitate a sharp increase in hunting, slash-and-burn farming and human colonization of forests (Redford, 1992; Laurance, 2001; Asner et al., 2006), whereas the dry, fine debris created by logging operations (Fig. 2) in concert with increased human ignition sources can lead to a major increase in destructive wildfires (Uhl and Kauffman, 1990; Malhi et al., 2009). Fires can be particularly harmful to tropical rainforests because few plant species are adapted to survive even low-intensity fires (Cochrane, 2003; Cochrane and Laurance, 2008).

3. Key lessons

3.1. Many factors can confound studies of logging impacts

Numerous studies have sought to assess the effects of logging on biodiversity by contrasting the biota of logged and unlogged sites (see reviews by Lindenmayer and Franklin, 2002; Paillet et al., 2009). Non-significant results are sometimes interpreted as a lack of impact or only benign effects of logging on biodiversity and ecosystem processes. However, robust logging-impact studies are far from straightforward for a range of reasons, including the three considered briefly below.

First, site productivity can confound comparisons of logged and unlogged sites (Chazdon et al., 2009; Gardner et al., 2009) (see Kavanagh and Bamkin (1995) for an example of this). Logging is often concentrated in flatter, lower-elevation areas that tend to occur on richer alluvial or basaltic soils, whereas unlogged sites are often in steep, rocky, higher-elevation sites that generally have lower soil fertility and forest productivity. Such differences can substantially influence the structure, floristic composition, and faunal communities of sites independently of logging, and may reduce the likelihood of finding significant logging impacts on disturbance-sensitive fauna because they are naturally more abundant in the more productive, lower-elevation sites (Huggett and Cheeseman, 2002; Lindenmayer and Franklin, 2002).

Second, detecting long-term impacts of logging on biodiversity can be extremely difficult because forest trees can be very long-lived (Chambers et al., 1998; Laurance et al., 2004) and forest-stand development can span centuries (Johnson and Miyanishi, 2008). Many investigations have substituted space for time in an attempt to overcome this (Lindenmayer and Likens, 2010). However, such retrospective studies can fail to account for the important influence of site history on biodiversity (Gustavsson et al., 2007), sometimes leading to erroneous conclusions (Pickett, 1989; Lindenmayer et al., 2011b).

Finally, some of the most significant impacts of logging on biodiversity are cumulative over space (Lindenmayer et al., 2011a), over time, or both. For example, logging – especially low-intensity selective logging or shelterwood-silvicultural systems – can have relatively limited effects after a single cutting cycle (Grieser Johns and Grieser Johns, 1995; Greiser Johns, 1997). However, repeated cutting events can substantially alter stand structure (Kellas and Hateley, 1991; Linder and Östlund, 1998), leading to significant negative effects on particular elements of the biota (Lindenmayer and Franklin, 2002). Cumulative effects on forest biodiversity can be extremely difficult to quantify (Cocklin et al., 1992) (but see