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Original research article

Stand structure, composition and illegal logging in selectively logged production forests of Myanmar: Comparison of two compartments subject to different cutting frequency

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HIGHLIGHTS

- Forest degradation and illegal logging are revealed in the production forest in Myanmar.
- Inadequately shorter intervals of logging can strongly degrade stands and facilitate more illegal logging.
- Size and species of illegal logged trees depend on stand condition.

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ABSTRACT

Appropriate cutting cycles and annual allowable cuts are crucial to ensure sustainability of tropical selective logging, but there have been limited field data to verify long-term effects of different cutting cycles. This study reveals some evidence of forest degradation in selectively logged production forests of Myanmar, which are subject to inappropriate cutting frequency. We compared stand structure, commercial species composition, and incidence of illegal logging between two compartments with low (LCF; 1 time) and high (HCF; 5 times) cutting frequency over a recent 18 years. Prior to the latest cutting, LCF had 176 trees ha^{-1} with an inverted-J shape distribution of diameter at breast height (DBH), including a substantial amount of teak (*Tectona grandis*) and other commercially important species in each DBH class. HCF prior to the latest cut had only 41 trees ha^{-1} without many commercially important species. At HCF, nearly half the standing trees of various species and size were illegally cut following legal operations; this was for charcoal making in nearby kilns. At LCF, two species, teak and *Xylia xylocarpa*, were cut illegally and sawn for timber on the spot. More extensive and systematic surveys are needed to generalize the findings of forest degradation and illegal logging. However, our study calls for urgent reconsideration of logging practices with high cutting frequency, which can greatly degrade forests with accompanying illegal logging, and for rehabilitating strongly degraded, bamboo-dominated forests. To reduce illegal logging, it would be important to pay more attention on a MSS regulation stating that logging roads should be destroyed after logging operations.

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1. Introduction

Selective logging is a common practice for timber production in tropical natural forests. There have been increasing global concerns about sustainability of tropical selective logging in terms of timber production (Kammesheidt et al., 2001; Sist and Ferreira, 2007), biodiversity conservation (Edwards et al., 2012; Putz et al., 2012; Burivalova et al., 2014; Edwards et al., 2014a), and carbon and/or energy exchange (Miller et al., 2011; Zimmerman and Kormos, 2012; Sasaki et al., 2012; Medjibe et al., 2013; Sist et al., 2014; Griscom et al., 2014; Pearson et al., 2014). The determination of appropriate cutting cycle or frequency and annual allowable cut (AAC) is crucial to ensure the sustainability of tropical selective logging (Kammesheidt et al., 2001). Many growth and yield models have already been developed and widely used for improving cutting cycles to ensure sustainable yield and stand structure (Kammesheidt et al., 2001; Sist et al., 2003b; van Gardingen et al., 2006). It is doubtless that such models are necessary to predict the future of forest stands under different management options. There have also been numerous studies using field surveys to examine effects of selective logging on stand structure and species composition (e.g. Brown and Gurevitch, 2004; Putz et al., 2012; Gourlet-Fleury et al., 2013; Burivalova et al., 2014; Edwards et al., 2014b). However, such field studies mostly evaluated effects of a one-time logging operation (Panfil and Gullison, 1998; Kammesheidt, 1998; Parrotta et al., 2002; Okuda et al., 2003; Villela et al., 2006; Kao and Iida, 2006; Rutten et al., 2015), and so there are still limited field data showing the results of repeated logging under different cutting cycles.

Myanmar has a long history since 1856 of the forest management system known as the Myanmar Selection System (MSS). The dominant forest type under MSS is tropical mixed deciduous forest, with teak and a few commercially important hardwood species selectively harvested (Dah, 2004). The principle rules of MSS are a cutting cycle of 30 years, minimum diameter cut for each commercial species, and AAC calculated from forest inventory data. MSS has been using elephants for most skidding operations, which is considered to have less impact than the heavy machines commonly used in other countries (Brunner et al., 1998). With more than one hundred years of experience in continuous timber extraction, the MSS can be considered a sustainable practice and suitable for maintaining multi-species, natural teak-bearing forests (Dah, 2004). However, studies using remote sensing have revealed that forest degradation, defined as a reduction of canopy cover, has been increasing in selectively logged forests in Myanmar during recent decades (Mon et al., 2010, 2012a,b). One of the reasons for degradation in the production forest may be a shorter felling cycle with production exceeding AAC for some compartments (Mon et al., 2012b). This deficient practice is carried out because Myanmar's forests have been facing high pressure from increased resource utilization associated with population growth and high demand from neighboring countries, and the country had been heavily reliant on earnings from export of timber, particularly between 1990 and 2000 (Mon et al., 2012b). Another reason may be illegal logging in those forests (Mon et al., 2012b). However, there has been very limited field evidence to verify how stand structure and species composition are degraded, and which species and tree size are illegally cut after repeated logging operations.

The objective of this study was to show field evidence of forest degradation in a selectively logged production forest of Myanmar. We compared stand structure, commercial species composition, and incidence of illegal logging between two stands subject to different cutting frequencies during a recent 18 years. In addition to woody species, bamboos were measured since their dominance in tropical deciduous forests can be a form of degraded forest (Larpkern et al., 2009). A specific point of the study was to evaluate stumps for quantifying the amount and pattern of illegal cutting, as distinct from legal cutting.

2. Methods

2.1. Study site

The study sites are located in Bago Yoma, which has the longest history of MSS. We selected two compartments 93 (17 °50′48″N, 96 °7′19″E) and 29 (17 °13′22″N, 96 °22′54″E) in the South Zamaye Reserved Forest (RF) within Bago Township (Fig. 1). This RF has 119 compartments with total area 79,613 ha. The areas of compartments 93 and 29 are 740 ha and 1238 ha, respectively (Fig. 1). Our criteria to select two compartments 93 and 29 to be compared were that (1) the cutting frequencies were largely different, (2) the locations were relatively close within the same RF and (3) the timings of the latest legal logging operations were close in recent years. Here, there is a typical tropical monsoon climate with two distinct seasons, a wet period from the end of May through October and dry period from November through May. Mean annual rainfall is 3360 mm with average humidity 82.9%, and mean annual temperature is 26.7 °C in the Bago District.

Timber extraction with shorter cutting cycles than the 30-year MSS standard has been done in many compartments of South Zamaye RF in recent decades, separately for teak (*Tectona grandis*) and other hardwood species. In compartment 93, timber harvesting during 2012 was the first instance of hardwood extraction after 1995. In compartment 29, there were two teak extractions in 2000 and 2009 and three other hardwood extractions in 1999, 2004 and 2011. Although there was no documentation available for timber extraction prior to 1995 in either compartment, old stumps indicated that timber was harvested at least twice before that year. In this study, we refer to compartments 93 and 29 with low and high cutting frequencies as LCF and HCF sites, respectively.