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The Effect of Selective Logging on stand structure and regeneration of Teak Bearing Forests in the Kabaung Reserved Forest, Bago Mountains, Myanmar

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မြန်မာနိုင်ငံ၊ ပဲခူးရိုးမ၊ ခပေါင်းကြိုးဝိုင်းအတွင်းရှိ သဘာဝကျွန်းတောများတွင် ရွေးချယ်ခုတ်လှဲခြင်း စနစ်၏ သစ်တောများတည်ဆောက်ပုံနှင့် ဓမ္မတာမျိုးဆက်ခြင်းအပေါ် အကျိုးသက်ရောက်မှုများကို လေ့လာခြင်း

ဒေါက်တာရိုစီနေဝင်း၊ ဦးစီးအရာရှိ
ဘီလီနေဝင်း၊ သုတေသနလက်ထောက်−၂
သစ်တောသုတေသနဌာန

စာတမ်းအကျဉ်း

ဤစာတမ်းသည် ရွေးချယ်ခုတ်လှဲခြင်းစနစ်ဖြင့် သစ်ထုတ်ထားသော ခပေါင်းကြိုးဝိုင်း အကွက် အမှတ် ၈၀ တွင် အမြဲတမ်းနမူနာကွက်ချမှတ်၍ သစ်မခုတ်မီ၊ သစ်ခုတ်ပြီး ၉ လ နှင့် သစ်ခုတ်ပြီး ၃၄ လ အခြေအနေများကို စာရင်းကောက်ယူ၍ သစ်ခုတ်ခြင်းကြောင့် သစ်တောများ တည်ဆောက်ပုံနှင့် ကျွန်းဓမ္မတာမျိုးဆက်ခြင်း အပေါ်အကျိုးသက်ရောက်မှုများကို လေ့လာဆန်းစစ် ထားပါသည်။ လေ့လာဆန်းစစ်မှုအရ သစ်ထုတ်လမ်း ဖောက်လုပ်ခြင်းနှင့် သစ်ပုံနေရာများ တည်ဆောက်ခြင်းကြောင့် သစ်ပင်များ အဓိက ဆုံးရှုံးရခြင်းဖြစ်ပြီး သစ်ပင်များခုတ်လှဲခြင်းကြောင့် ဘေးပတ်ဝန်းကျင်အပင်များ ပျက်စီးဆုံးရှုံးမှု နည်းကြောင်း တွေ့ရှိရပါသည်။ ကျွန်းဓမ္မတာမျိုးဆက် ခြင်းအနေဖြင့် သစ်ခုတ်ပြီး ၉လ နေရာတွင် ရွက်အုပ်အလင်းပွင့်မှု ၂၀% ကျော်ရှိသော သစ်ထုတ် လမ်းနှင့် သစ်ပုံနေရာ များ၌ ကျွန်းပင်ပေါက် များပြားစွာ တွေ့ရှိရပြီး ခုတ်လှဲပြီးသစ်ပင်၏ ငုတ်ရင်း တွင် ဘေးပတ်ဝန်းကျင်ရှိ သစ်ပင်နှင့် ဝါးပင် အရိပ်များကြောင့် ကျွန်းပင်ပေါက် အနည်းငယ်သာ တွေ့ရှိရပါသည်။ သစ်ခုတ်ပြီး ၃၄ လတွင် သစ်ထုတ်လမ်းနှင့် သစ်ပုံနေရာတွင် အောက်ပေါင်းများ ထူထပ်စွာ ပေါက်ရောက်လာခြင်းကြာင့် သစ်ခုတ်ပြီး ၉ လ တွင် တွေ့ရှိခဲ့သည့် ကျွန်းပင်ပေါက် တစ်ဝက်ခန့်မှာ ပျက်စီးဆုံးရှုံးသွားသည်ကို လေ့လာတွေ့ရှိခဲ့ပါသည်။ ထိုကြောင့် လက်ရှိကျင့်သုံး နေသည့် ရွေးချယ်ခုတ်လှဲခြင်းနည်းစနစ်အား ပြန်လည်သုံးသပ်၍ သစ်ခုတ်ပြီးချိန်တွင် ကျွန်းဓမ္မတာ မျိုးဆက်ခြင်း ကောင်းလာစေရန်နှင့် ချန်ပင်များ ကြီးထွားမှု ကောင်းလာစေရန်အတွက် ပြုစု ပျိုးထောင်မှုလုပ်ငန်းများ လုပ်ဆောင်သင့်ပါကြောင်း အကြံပြုတင်ပြအပ်ပါသည်။

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Abstract

This study analyses the stand structure and *Tectona grandis* (Teak) seedlings in logged and unlogged stands by setting up permanent sample plot (60m x 100m) in compartment no. 80 of the Kabaung Reserved Forest. This study shows the logging road (LR) and log landings (LL) construction had high impact on tree stands while the impact of tree felling on stand damage is low. The establishment of teak seedlings increased in LR and LL sites with increasing soil disturbance caused by logging machinery, as well as the increased light from removal of canopy and understory vegetation. However, plant competitors (especially bamboo seedlings) are occupied in LR and LL sites at 34 months after logging (L34) and restrict the growth of teak seedlings recruited in 9 months after logging (L09) site. But, the seedlings released from the shade of competing vegetation reached to the height of 1.3 m. Therefore, current selective logging should be evaluated and included the post-harvesting silvicultural treatments to control competing vegetation.

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1. Introduction

In Myanmar, the Bago Mountains is one of the places covered with various species of trees. Evergreen forests, deciduous and mixed forests are thriving densely on the Bago Mountains. According to Kermode (1964), the Bago Mountains is one of the forested regions with best teak growth and highest density of stocking of teak of any forest in Myanmar. Forested area of the Bago Mountains is 11.3 % of the total teak bearing forests of the country (Aung Thant Zin, 2000). The natural teak bearing forests are the country's primary source of forest products. The extraction of teak and other commercial hardwood species is a major source of foreign exchange earning for the country's economy.

For sustainable timber production in forest management, it is important to fully understand the dynamics of stand structure and regeneration in the management forest. Recruitment of tree regeneration is a critical step in securing sustained wood production in naturally managed tropical forests (Pariona and Fredericksen, 2003). Because of its importance to forest management, the dynamics of regeneration after exploitation has received particular attention (Bazzaz, 1991). If tree regeneration increases in response to selective logging, then sustained use is at least possible. However, if the removal of woody vegetation results in little tree regeneration, or a change to a different woodland structure, the heavy exploitation of timber resources could have adverse effects on species composition and possibly on the animal species living there (Campbell et al., 1996). A number of studies relating to regeneration following selective logging and conventionally executed logging have been conducted (Magnusson et al, 1999; Nagaike et al, 1999; Dekker and Graaf, 2003; Lobo et al, 2007).

Because selective logging is one of the main silvicultural practices of forest management in Myanmar, a detailed understanding of regeneration following selective logging is important. However, there is a clear absence of empirical studies delineating logging effects on damage to unlogged stands and tree regeneration in the Kabaung Reserved Forest. This study made an effort to fill this gap.

The objective of this study was to determine the forest damage and status of commercial tree regeneration after selective logging and to evaluate the efficacy of selective logging on tree regeneration.

2. Objectives

(1) To determine the stand damage caused by selective logging
(2) To evaluate the effect of selective logging on young tree regeneration

3. Study area

The Bago Mountain area is located in the southern part of the central basin of Myanmar. The study area, Kabaung Reserved Forest, is one of the reserved forests in the Bago Mountains. It has moist deciduous forests and is located at approximately 18°50′–19°09′N, 95°50′–96°12′E and situated in Taungoo and Oktwin townships of the Taungoo District. Natural teak-bearing forests in the Bago Mountains have been managed under the Myanmar Selection System (MSS) since 1856 (Ko Ko Gyi and Kyaw Tint 1995), and the MSS is still the main regime used to manage natural teak-bearing forests. Under the MSS, the felling cycle is 30 years, and the minimum limits of exploitable diameter at breast height (DBH) are 73 cm in moist teak forests and 63 cm in dry teak forests. Various tending operations are carried out to help restore the forests prior to the start of the next harvest cycle. The idea of this system is to sustainably harvest teak-bearing forests every 30 years. Marketable trees, meeting exploitable DBH limits are felled, creating a single or multiple felling gaps dependent on the density and proximity of selected trees. Harvested trees are cut into logs and dragged by elephants to the log landings, where they are piled up. These piled logs are transported by trucks along logging road to timber depot. As a result of this process, different disturbances are created in the forests, each affecting the canopy cover, understory vegetation and soil.

4. Materials and Methods

In November 2008 (prior to logging), one permanent sample plot (60 m x 100 m) was established in the Kabaung Reserved Forest and divided into 20 m x 20 m sub-plots. In each sub-plot, all living trees with height ≥ 1.3 m were measured, a bamboo census was also conducted, and regeneration of teak was monitored. Trees with height ≥ 1.3 m were tagged and identified, and the stem diameters at breast height (DBH) were measured. For the bamboo census, maximum and minimum culms diameters were measured and the number of culms per clump was recorded. Shoots (<1.3 m height) of the two tree species were counted and tagged, and their diameter and height were measured in each sub-plot. The direction and distance of every tree, bamboo, teak and seedlings were measured from the center point of each sub-plot by using Ushikata Tracon surveying compass LS-25 and Vertex compass (Vertex III) in order to know their exact locations. Four canopy photos were taken with a fisheye lens (Nikon FC-E8) at 1 m height in the interior locations of each sub-plot.

Logging was conducted in March 2009 by timber companies. In December 2009, nine months after logging (L09), and in January 2012, 34 months after logging (L34), the plot was revisited and resurveyed. Damaged trees, bamboos, dead seedlings and surviving seedlings were enumerated. New seedlings that sprouted since the November 2008 survey were counted and tagged, and their height and diameter were measured. The exact location of each recruited seedling was measured using the same method mentioned above. In each sub-plot, canopy photos were again taken at the same locations as in 2008. The images were analyzed using Gap Light Analyzer (Simon Fraser University, Institute of Ecosystem Studies).

Significance of differences in density and height of shoots in sub-plots among disturbance types was tested by one-way ANOVA. A *post hoc* Tukey test was used to compare disturbance categories. Statistical analyses were carried out with SPSS 16.0.

5. Results

(1) Damage caused by selective logging

The level of stand damage was classified into four classes, no damage, minimal, moderate and severe. The stand was regarded as “no damage” when there was no visible sign of injury on it. The term “minimal” was applied when there was a slight injury on the tree and < 50% of the total number of bamboo culms was broken while “moderate” was used when the branch of the tree was broken and ≥ 50 % of the total number of bamboo culms was broken and “severe” was used when the tree or bamboo was uprooted or killed.

During the logging operation, 25 trees ha^{-1} (12.3 % of the total basal area of trees) were found to cause severe damage while 2 trees ha^{-1} (0.4% of the total basal area of trees) and 10 trees ha^{-1} (2.5 % of the total basal area of trees) were caused moderate and minimal damages respectively. 102 trees ha^{-1} (57.2 % of the total basal area of trees) remained undamaged after the logging operation (Figure 1). Among the 25 trees with severe damage, 8 trees were teak, 5 trees were pyinkado and 12 were other trees.

Table 1 showed that the ratio of trees and bamboos with severe damage was significantly higher in areas with logging road (LR) and log landings (LL) than that in areas with felling gaps (FG) and no logging disturbance (NLD).

Table 1 χ^2 test for the impact of logging road and log landings construction on stands damage

	severe damage	no damage	$\chi2$	df	*p*-value
	No. of trees and bamboos per ha				
areas with logging road and log landings	65 (71%)	27 (29%)	59.281	1	0.000
areas with felling gaps and no logging disturbance	13 (9%)	135 (91%)			

Table 1 showed the ratio of trees and bamboos with severe damage was significantly higher in areas with logging road and log landings than that in areas with felling gaps and no logging disturbance.

(2) Average canopy openness in each disturbance category

Figure 1 shows the average canopy openness at post-logging in each disturbance category. LL sites had the highest canopy openness, followed by LR sites. Canopy openness values for LL and LR sites were significantly higher than those for FG and NLD sites ($P < 0.01$).

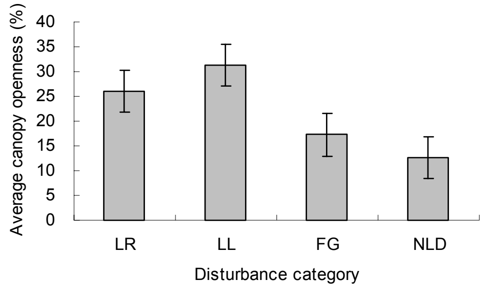

Figure 1. Canopy openness in different categories

Relationship between the canopy openness and regeneration

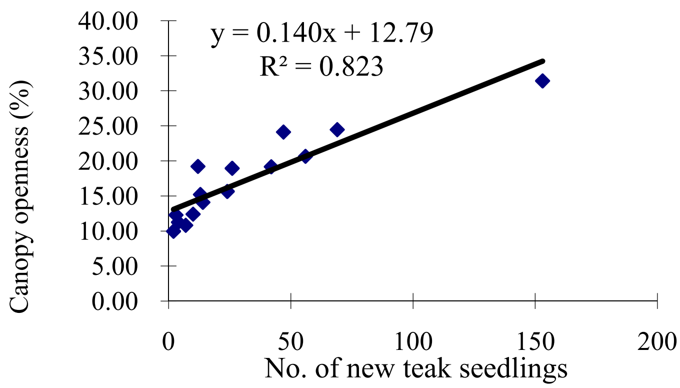

Figure 2. Relationship between canopy openness and regeneration

Figure 2 shows the canopy openness is positively correlated with the number of teak seedlings as teak is the light demanding species.

(3) Young tree regeneration caused by selective logging

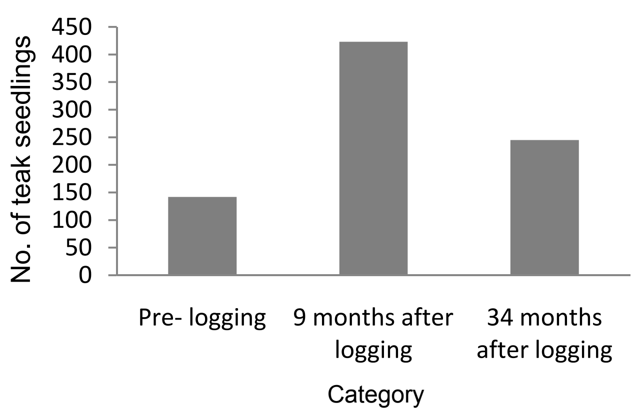

Figure 3. Teak seedling density in each category

Figure 3 shows the number of teak seedlings in different logged areas. Comparison of pre-logging and L09 sites shows that the number of teak seedlings at L09 is much higher than that at pre-logging site. Most of teak seedlings at L09 can be found in LR and LL sites where canopy openness was greater than 20%. However, at L34 site, competing vegetation was appeared at LR and LL sites and suppressed the teak seedlings at those sites. (Field survey, 2012). Therefore, the number of teak seedlings at L34 is less than that at L09.

(4) Mortality, survival and recruitment of teak seedlings in logged and unlogged areas

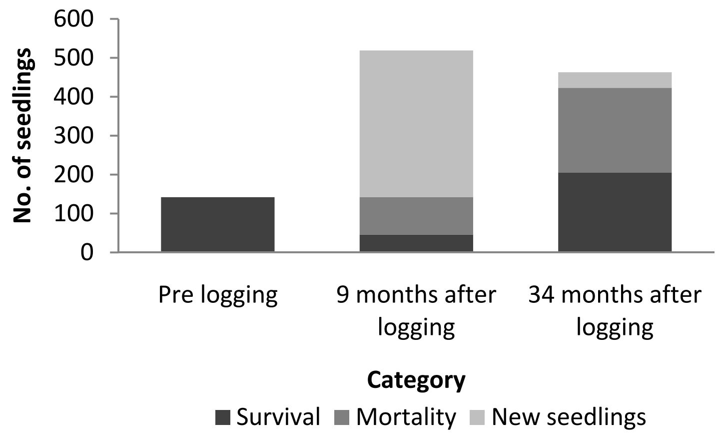

Figure 4. Mortality, survival and recruitment of teak seedlings in each category

In pre-logging area, there were 142 seedlings. In L09 site, among 142 seedlings, 46 seedlings were survived, 96 seedlings were died due to the logging operation and 377 seedlings were newly sprouted, therefore, total 423 seedlings existed. In L34 site, 218 seedlings (about half) out of 423 were died, 205 seedlings out of 423 were survived, and 40 seedlings were newly sprouted. Therefore, total 245 seedlings were remained at L34 site.

(5) Mean height of teak seedlings in different logged areas

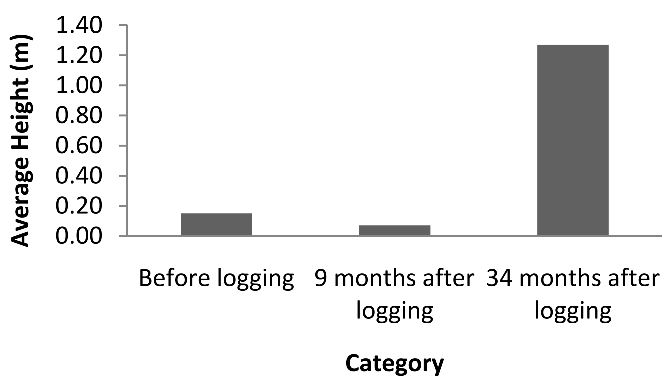

Figure5. Mean height of teak seedlings in different categories

Comparison of mean height in different logged areas showed the mean height in L34 was the highest among three categories although the number of seedlings was lower than that in L09 site.

6. Discussion

(1) Stands damage due to the selective logging

The construction of logging roads and log landings had high impact on stands damage by seeing the higher ratio of severely damaged trees in logging road and log landings areas (Table 1). The effect of tree felling on stands damage was low and perhaps it was due to the planned felling direction and climber cutting before logging in MSS (Khin Zaw, 2004). Most of the moderately damaged bamboos were found in the tree felling areas and it can be realized that bamboo was the main damaged stand due to the tree felling.

(2) Seedling recruitment caused by selective logging

In 9 months post-logging area, the seedling recruitment was 377 which was four times higher than the mortality due to the logging operation. This recruitment was mainly occurred in logging road and log landing where light availability was increased due to logging. Some studies have shown that soil compaction can delay the establishment of seedlings (Malmer and Grip 1990; Guariguata and Dupuy 1997; Whitman et al. 1997; Pinard et al. 2000), while other studies have reported that greater canopy openness and soil disturbance favor tree regeneration (Denslow 1995; Dickinson and Whigham 1999). In this study, the recruitment of teak seedlings was enhanced in LR and LL sites where light availability was increased due to logging and disturbance of soils by logging machines. These findings concur with those of other studies in which improved seedling and sapling recruitment were observed in areas where soil had been scarified by logging equipment (Fredericksen and Mostacedo 2000; Fredericksen and Pariona 2002). Fredericksen et al. (1999) observed that the regeneration of free-standing fig tree species harvested for timber was enhanced in areas with logging-induced soil disturbance.

The compaction of wet soil by logging machines can impede regeneration on skid trails (Malmer and Grip 1990, Pinard et al. 1996), but if the soils are dry during logging, commercial tree species can regenerate abundantly on skid trails (Dickinson and Whigham 1999; Dickinson et al. 2000). The soils at the present study site were sandy loams (FRI soil laboratory, Myanmar), and forest road construction began at the end of the rainy season, around November, when forest soils harden (Khin Zaw 2004). Dry soils are much more resistant to compaction than moist or wet soil. Therefore, soil compaction from logging machines should be limited during logging.

Competing vegetation at ground level can result in tree regeneration failure (Kermode 1964). In L09 site, low competing plant volume due to the initial removal of vegetation from LR and LL by logging machines may be one of the factors to explain the successful early recruitment of teak seedlings.

Some studies have reported that logging gaps in the tropics are quickly filled with a dense cover of competing plants (Buschbacher 1990; Webb 1997). In moist deciduous forest, the undergrowth is very variable and if the canopy has been opened, the undergrowth become very dense and effectively prevent regeneration of trees (Kermode 1964). Despite removal of vegetation by logging machinery on logging road and log landings, these areas were rapidly being recognized by plant competitors that may restrict the future growth of commercial tree regeneration initially established on these sites. The result of this study follows their findings. In 34 months post-logging area, most of the recruited seedlings at LR and LL in L09 site was lost due to the growth of competing vegetation. In L09, the impact of undergrowth vegetation on teak regeneration is not serious by observing many seedlings at LR and LL sites, however, in L34, the height of competing vegetation was higher than that of tree seedlings and suppressed them (Field observation, 2012).

By seeing figure 5, height of the seedlings in L34 site reached to the pole-sized trees although the number of seedlings is much lower than that in L09 site.

7. Conclusion

This study shows the logging road and log landings construction had high impact on tree stands while the impact of tree felling on stand damage is low. The establishment of teak seedlings increased in LR and LL sites with increasing soil disturbance caused by logging machinery, as well as the increased light from removal of canopy and understory vegetation. However, plant competitors (especially bamboo seedlings) are occupied in LR and LL sites and restrict the growth of teak seedlings recruited in L09 site. But, the seedlings released from the shade of competing vegetation reached to the height of 1.3 m. Therefore, current selective logging should be evaluated and included the post-harvesting silvicultural treatments to control competing vegetation.

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