Regeneration dynamics during 20 years in abandoned areas of a tropical seasonal forest

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Abstract

The study on regeneration dynamics in abandoned areas of a tropical seasonal forest was carried out in Mae Klong Wateshed Research Station, western Thailand during. A 4 ha permanent plot, 100 x 400 m, was established in 1992 and all trees with girth greater than 15 cm were tagged, measured and identified. Tree monitoring was done every two year since 1992 to 2012 (20 years).

The results showed the changes on species diversity and stem density had significantly different ($P<0.001$ and $P<0.001$, respectively) between the first and second ten-year periods. The lower values were detected in the first than second period for species diversity, 70.80 ± 23.18 and 119.17 ± 5.98 species.ha^{-1}, and stem density, 332.28±55.49 and 590.31±19.43 stem.ha^{-1}, respectively). Indicating after abandonment the succession process originated by low species diversity and stem density, then, gathered more diverse during the intermediate of succession time. Tree growth in basal area (in growth and recruitment) was significantly different ($P<0.001$) among periods and rapidly increased in the second period, 26.78±8.10 and 56.46±4.76 m^2.ha^{-1}, respectively. While the recruitment and mortality rate were not significant among the periods. However, their highest rates were found in the first two years (1992-1994), 31.66 and 27.71 %.yr^{-1}, respectively, especially when the pioneer species such as *Trema orientalis* death and followed by forest fire. Indicating the occasional occurrences of forest fire strongly impeded the successful regeneration of trees after abandonment. Thus, the reforestation programs should not be concerned only the ecological niche of species but also disturbances factors such as forest fire, canopy gaps, undergrowth bamboos, etc., for their high successful.

Key words; succession, abandoned areas, forest dynamics, mixed deciduous forest, Mae Klong watershed research station

Introduction

Seasonally dry tropical forests, which occurs in the area with several months of severe drought, covers fairly large parts of tropical and subtropical ecosystems, even larger than wet-rain forests (Mooney *et al*., 1995). Their regeneration dynamics and disturbance regimes may be unique and quite different from the tropical rain forests (Murphy and Lugo 1986). In particular, they have long been affected by the frequent fire and other disturbances associated with human activities (Marod et al., 1999). However, far less attention have been given to this diversified ecosystem than the tropical rain forests and savannas (Mooney *et al*. 1995). Especially, the dynamics of these forests have not been investigated intensively (Gerhardt and Hytteborn 1992).

Despite the over-exploitations, there have been relatively few studies done on the regeneration pathways after abandonment, and especially, little is known about the link between resource use at the local community level and its effects on forest fragmentation and loss at the landscape scale (Turner and Meyer, 1991). Knowledge of these dynamic patterns may also be useful for answering questions related to the long-term sustainability of human-forest interactions and for developing management policies that protect and enhance tropical forests, especially programs aimed at forest restoration (Vieira and Scariot, 2006). Enhancing the general understanding of how the regeneration dynamics in abandoned areas influence forest regeneration and ecosystem services on the micro-scale in tropical regions is important. Thus, considering the importance of these forests to the local and global environmental issues, it needs to accumulate urgently the information about the dynamics and maintenance mechanism of them for the conservation and management.

In this paper, the long-term dynamics after abandonment from upland rice fields was investigated. The specific purpose is to make clear on the regeneration dynamics and tree diversity during 20 years in a degraded forest of the mixed deciduous forest.

Study Site and Methodology

The study was conducted in a seasonal tropical forest at Mae Klong Watershed Research Station, Thong Pha Phoom District (14’ 30” to 14’ 45” N, 98’ 45” to 99’ E), Kanchanaburi Province, western Thailand. The watershed is 108.9 km2 in area and ranges from 100 to 900 m above mean sea level. The climate is sub-tropical with a long wet season (May to October) alternating with a short cool dry season and the subsequent hot dry season (November to April). Mean, minimum, and maximum annual rainfall were 1,546 mm, 1,243 mm, and 1,897 mm, respectively. Mean monthly temperature is 27.5°C with a maximum of 39.1°C in April and a minimum of 14.6°C in December. The soil water content is almost saturated from May to September and the soil water tension value reaches 10 kPa. The soil is very dry during the dry season and the tension was too high for the measurement by using porous cup method (Marod *et al*. 2002). The parent materials are granite, limestone and shale. Phyllite and quartzite are also found in small patches of the watershed area (Suksawang, 1995). The prevailing forest type in this area is a mixed deciduous forest (MDF, Rundel and Boonpragob 1995, Marod *et al*. 1999), with small areas of dry dipterocarp forest (DDF) on the mountain ridges, and dry evergreen forest (DEF) along the riparian areas (Kutintara *et al*. 1995). The dominant tree species were *Shorea siamensis*, *Dillenia parviflora* var. *kerrii*, *Xylia xylocarpa* var. *kerrii*, *Pterocarpus macrocarpus*, *Vitex peduncularis*, *Canarium susbulatum*, *Mangifera caloneura*, *Schleichera oleosa* (Marod et al. 1999). In the past, the local people created the upland rice fields in the watershed areas, recently, where were abandoned and let it into natural succession process. Within the area, forest fires have probably occurred repeatedly over the past several hundred years (Rundel and Boonpragob 1995).

A 4 ha permanent plot was established in 1992 including a variety of topography (ridge, slope and valley) to monitor forest dynamics. All trees greater than 15 cm in girth, gbh, were tagged, identified, and their gbh, at 1.30 m height, was measured. Every two year until 2010, repeated tree enumeration was conducted. Survival and death of the tagged trees were checked and their gbh was measured, including, all the newly recruited trees (greater than 5 cm in gbh).

Among the parameters of forest dynamics, mortality (M) and recruitment (R) rates were calculated (Condit *et al*., 1999) as follows:

$$M\ (\%) = 100 \times (\ln (N_0) - \ln (S_t))/t$$

where N_0 = the number of population count at the beginning of the time 0
S_t = the number of population survivors at the time t
t = measurement interval between census

$$R\ (\%) = 100 \times (\ln (N_t) - \ln (S_t))/t$$

where N_t = the number of population count at the time t
S_t = the number of population survivors at the time t
t = measurement interval between census

Results and Discussion

Forest structure and dynamics

The results showed the changes on species number and stem density had significantly different ($P<0.001$ and $P<0.001$, respectively) between the first and second ten-year periods which were lower in the first than second period. The species diversity fluctuated between the period which low species number was found in the first than second period, 70.80±23.18 and 119.97±5.98 species.ha^{-1}, respectively (Figure 1 A). The stem density also showed the same trended, 332.38±55.49 and 590.31±19.43 stem.ha^{-1}, respectively (Figure 1 B). Indicating after abandonment the succession process originated by low species diversity and stem density, then, gathered more diverse during the intermediate of succesional time.

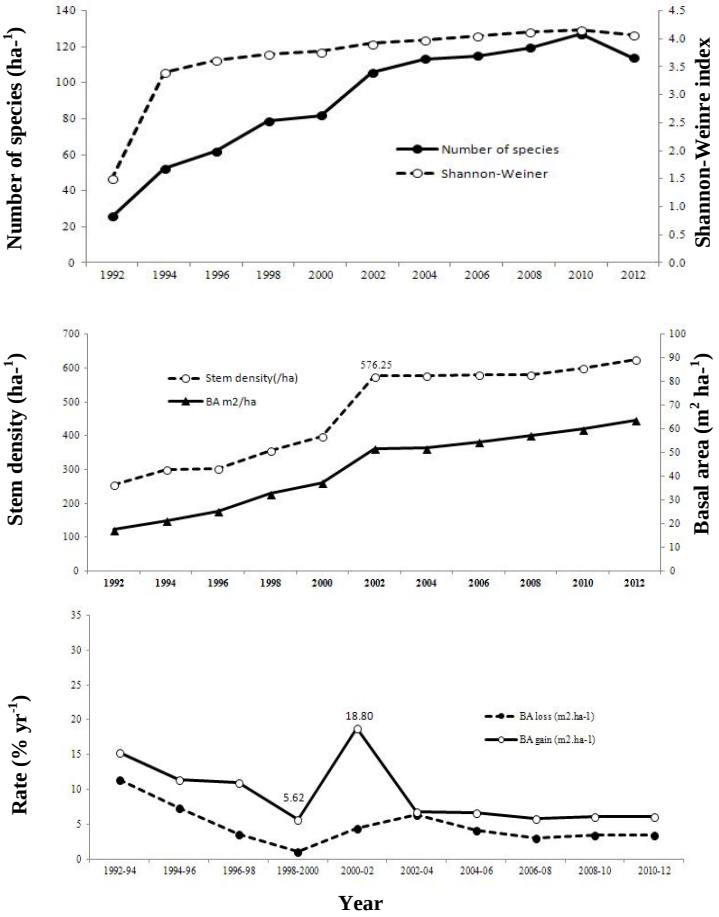

Figure 1 The changes on species diversity (A), basal area and stem density (B) and rate of basal area, BA, loss and gain (B) during 1992 to 2012.

Tree growth in basal area, BA, (in growth and recruitment) was significantly different ($P<0.001$) among periods and rapidly increased in the second period, 26.78±8.10 and 55.00±3.55 $m^2.ha^{-1}$, respectively. Gain rate in BA had higher than loss rate through the study period, especially during 2000-02 (Figure 1 C). It increased about three times, 5.62 to 18.80 m^2ha^{-1}, when tree density was highest value, 576.25 $stem.ha^{-1}$ (Figure 1 B). Indicating it changing well correlated to the stem density.

Recruitment and Mortality patterns

The recruitment and mortality rate were not significant among the periods. The balance between recruitment and mortality slightly fluctuated, 8.710 $\pm$ 9.08 and 5.88 $\pm$ 8.26 $\%.yr^{-1}$, respectively. However, their highest rates were found in the first two years (1992-1994), 31.66 and 27.71 $\%.yr^{-1}$, respectively. There were decreased by death of abundance pioneer species and followed by forest fire in 1994. However, the recruitment rate in 2000-02 increased almost four times compared to 1998-2000 (Figure 2).

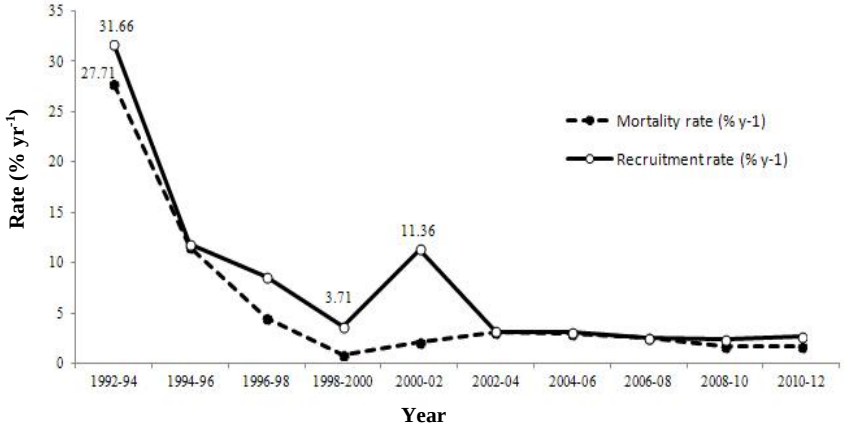

Figure 2 Mortality and recruitment rate in abandoned area during 1992 to 2012

Recruitment and Mortality patterns of tree populations

According to the colonization and local extinction, species number appeared at each census fluctuated through the study period, 90.4 ± 32.7 $species.ha^{-1}$. The relationship between mean recruitment and mortality of tree populations over 10 stems varied between species and year (Figure 3).

Many species increased their recruitment rate during 1992-94 and rapidly decreased in the next two years, 1994-96. In contrast, *Trema orientalis* showed the highest mortality, 53.25 $\%.yr^{-1}$. It was damaged by climbers on the crown canopy and followed by forest fire in 1993. In 2000-02, the dominant species such as *Garuga pinnata*, *Lagerstroemia tomentosa* and *Xylia xylocarpa* increased their recruitments even though forest fire occurred. Because those recruited trees were larger enough to resist on forest fire. However, the pioneer species such as *Croton oblongifolius* and *Trema orientalis* was highly damaged by fire. Indicating the occasional occurrences of forest fire strongly impeded the successful of tree regeneration after abandonment.

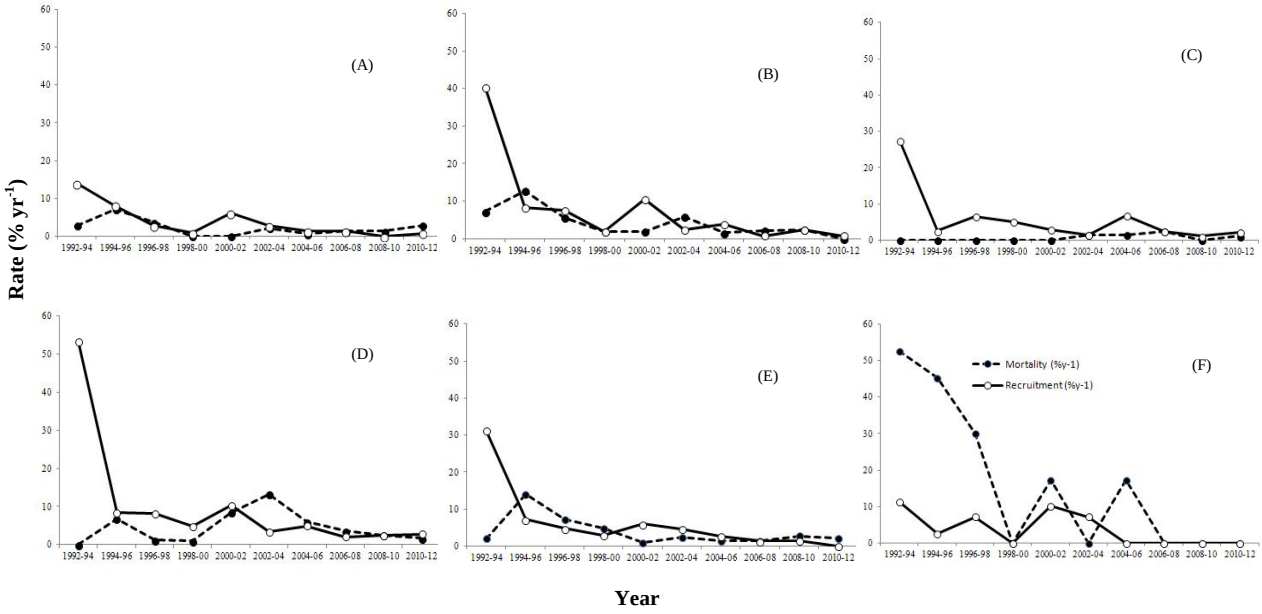

Figure 3 Stem recruitment and mortality rate of some species which had over 10 stems; (A) *Garuga pinnata*, (B) *Lagerstroemia tomentosa*, (C) *Xylia xylocarpa*, (D) *Croton oblongifolius*, (E) *Ficus hispida* and (F) *Trema orientalis*. The opened and closed symbols indicated the recruitment and mortality rate, respectively.

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