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Invasion of Woody Plants into the Abandoned Pineapple Fields in the Lam Phachi River Basin

Mutsuki Higo
Faculty of Regional Studies, Gifu University
Yanagido1-1, Gifu, 501-1193 Japan
Masanobu Kimura
Faculty of Agriculture, Gifu University
Yanagido1-1, Gifu, 501-1193 Japan
Tomomi Marutani
Faculty of Agriculture, Shinshu University
Minami-Minowa, Nagano, 399-4598 Japan
Nipon Tangtham*
Department of Conservation, Faculty of Forestry, Kasetsart University
Bangkok, 10900 Thailand
Kosit Lorsirirat
Office of Hydrology and Water Management, Royal Irrigation Department
Dusit, Bangkok, 10300 Thailand
Songpol Kumlungkeng
Southern Regional Center of Hydrology and Water Management, Royal Irrigation Department
A.Muang, C.Pattalung, 93000 Thailand
Hideji Maita
Institute of Agricultural and Forest Engineering, University of Tsukuba
Tsukuba, Ibaraki, 305-8572 Japan

Abstract

To clear the possibility of restoration of the pineapple field, we carried out field studies of vegetation revegetated immediately after abandonment on a pineapple field in the upper region of Lam Phachi river basin. The mean density of stems at one year after abandonment was 18.8 trees/25m^2. But the mean density of individuals regenerated was 14.0 individuals/25m^2. The total number of species recorded in 5 plots was 11 and the mean number of species was 3.8 species/25m^2. The mean density of stems at two year after abandonment was 32.8 trees/25m^2 . The mean density of individuals regenerated was 15.6/25m^2. The total number of species recorded in 9 plots was 8 and the mean number of species was 3.1 species/25m^2. *Wrightia arborea* and *Mussaenda angustisepala* dominated on the abandoned pineapple field in both years. While the density of stems increased from 18.8 trees/25m^2 to 32.8 trees/25m^2 , the density of individuals was similar between two years. Both the density of stems and the density of individuals were significantly higher in the boundary than in the interior, where only several woody plants grew. The boundary had significantly more species than in the interior both in 2001 and in 2002. The density of stem was 94.8stems/25m^2 and the number of species recorded was 11 in 5 years old *Eucalyptus* plantation. *M.angustisepala* dominated significantly (71%) and *W.arborea, Capparis micracantha, Callicarpa longifolia* , *Cleistanthus hirsutulus* occurred in comparatively higher density. The number of species was significantly larger in the boundary than in the interior. From these results obtained, it was concluded that the recovery of woody vegetation on the abandoned pineapple filed might be difficult and it might take very long time before recovery of original forest.

Key words: restoration, woody plants, distance effect, pineapple field

1. INTRODUCTION

In Thailand, the most of forested area have been destroyed to convert into agricultural lands, resulting in smaller forested area (22.8%) (FAO, 1997). Immediately after clear-cutting, the yield of crop is greater, but it become lower due to run off of nutrients from the soil. Thus recently larger area of abandoned fields have been remained in the tropical area. On the degraded land, the regeneration of woody plants and the recovery of forest is very difficult because of the soil condition, direct solar radiation, high temperature, competition with herbaceous plants, seedling predation, and smaller input of seeds (Uhl, 1987; Aide and Cavelier, 1994; Aide et al., 1995; Nepstad et al., 1996; Parrotta et al. 1997). It was suggested that graminoid species such as *Imperata* species dominated on cutover sites and inhibit the growth of trees (Otsamo, 1998). But Holl (1999) cleared that the regeneration of woody species on the abandoned pasture had inhibited at the stage of seed input and exotic herb dominated the pasture rather facilitated the emergence of seedling. In those degraded land, it have been pointed out that the plantation had catalyzing effect of the forest recovery (Lamb et al., 1997; Parrotta et al., 1997). Such a method of forest recovering are called the framework species method, and have been applied to the restoration of degraded land in the neotropical forest area (Leopold et al., 2001), the tropical forest in Australia (Lamb et al., 1997), the tropical forest of Southeast Asia (Otsamo, 1998) and also in northern Thailand (Hardwick et al., 1997). Carnevale and Montagnini (2002) cleared that the mixture of species might bring more abundant woody seedlings and higher diversity in the understory than the pure species plantations.

In the Lam Phachi river basin located in western part of Thailand, the larger part of forest have been logged and converted into sugarcane fields, cassava fields and pineapple fields (Maita et al., 1999). Especially the upper region of Lam Phachi river basin, the pineapple field have been created on the gentle slope after logging. Maita et al.(2002) cleared that the physical condition of soil in pineapple fields was quite different from those in surrounding secondary forest. The soil of pineapple field had lower permeability than the secondary forest surrounded the pineapple field (Maita et al., 2002). As a result of lower permeability, the soil erosion had developed in the pineapple field with the time elapsed after planting.

The abundance of cash crop such as pineapples planted might vary year to year depending on the economic condition, especially on the market price. Furthermore, since the continuing cultivation on the same field for more than three or four years decrease the soil fertility, the farmer applies the chemical fertilizer to enrichment the soil or abandon the field to shift another field. In some cases, after abandonment the field are planted *Eucaluptus* species. *Eucalyptus* plantations are considered to be able to manage carelessly and gain the stable income periodically.

To consider the restoration in the upper region of Lam Phachi river basin with vast area covered by pineapple field, it is necessary to study the process of revegetation both in abandoned pineapple fields and in *Eucalyptus* planted pineapple fields. In the abandoned pineapple field it hypothesized that the seed input might be primary important rate-limiting stage and the distance from the surrounding forest might affect the abundance of seeds dispersed. In the case of Eucalyptus plantation, it was predicted that the effect of Eucalyptus species on the seed input and the seedling survival might play an important role in the woody regeneration.

The purpose of this study is

(1) to clear the vegetation structure in the abandoned pineapple field at one year and two year after abandonment.

(2) to examine the distance effect on the abundance and the diversity of woody plants invaded into the pineapple field.

(3) to clear the abundance and the diversity of woody plants under the canopy of Eucalyptus trees planted.

(4) finally to consider the management to restore the pineapple field.

2. STUDY AREA AND METHOD

The study was carried out in the upper region of Lam Phachi river basin. At Kanchanaburi station about 50 Km distant from the study area. The annual mean temperature was 27.9°C, monthly mean temperature varying from 24.6°C in December and 31.2°C in April (AIT,1994). The annual precipitation was 1130mm (Maita et al., 1999). The climax community of this area was considered to be the mixed deciduous forest with bamboo (Suksawang, 1995).

The study plots were set up in the abandoned pineapple field and in *Eucaluptus* plantation near Lam Phachi river. In August 2001, when one year had elapsed after abandonment, 5 plots ($25m^2$) were set up in the abandoned pineapple field. At each 5m, 10m, 15m from the forest edge, one plot was set up, and at 20m from the forest edge two plots were set up. In 2002, when two year had elapsed after abandonment, 9 plots (25m2) were set up. At each 5m, 20m from the forest edge, one plot was set up, at each 10m, 30m from the forest edge two plots were set up and at 25m from the forest edge 3 plots were set up. In each plots set up in 2001 and in 2002, the species was recorded and height was measured for each woody plants with height over 1m. The pineapple field located on the western gentle slope.

In 2002, we studied the *Eucalyptus* plantation, where *Eucaluptusca maldulensis* trees had been planted at 1997 in a abandoned pineapple field. The *Eucaluptus* plantation located on the southern east slope and the inclination of slope was 30 degree. Two plots ($25m^2$) were set up both in the boundary (within 10m from the forest edge) and in the interior (over 30m from the forest edge). In each plots, the species was recorded and height was measured for each woody stems with height over 1m.

In this study, when multiple stems originated from the same root, we counted these stems as one individual. And to examine the effect of distance from the forest/field edge on the vegetation structure, plots set up in the pineapple field were grouped into two habitats (the boundary vs. the interior). The boundary included plots with the distance from the edge less than or equal to 10m. The interior included plots with the distance fro the edge beyond 10m.

3. RESULTS

3.1. Vegetation structure at one year after abandonment

The mean density of stems at one year after abandonment was 18.8 trees/$25m^2$ (Table 1). The highest density was 34 trees/$25m^2$ and the lowest density was 3 trees/$25m^2$. But the mean density of individuals regenerated was 14.0 individuals/$25m^2$, ranging from 3 individuals/$25m^2$ to 28 individuals/$25m^2$ (Table 2). The total number of species recorded in 5 plots was 11 and the mean number of species was 3.8 species/$25m^2$, ranging from 1 species/$25m^2$ to 7 species/$25m^2$ (Table 1).

The frequency distribution of stem height was the unimodal distribution with the mode in 1.5-2.5 m (Fig.1). The mean value and the maximum value of stem height in 2001 was 1.6 m and 3.5m, respectively.

Wrightia arborea dominated in the density (8.8 trees/$25m^2$, 6.6 individuals/$25m^2$), and *Mussaenda angustisepala* was the next dominant (5 trees / $25m^2$, 3.4 individuals /$25m^2$, Table1,2). Other than these two species, *Callicarpa longifolia, Abelmoschus moschatus, Gmelia asiatica, Vitex* sp. and *Leucaena leucocephala* occurred in higher density (Table 1, 2).

3.2. Vegetation structure at two years after abandonment

The mean density of stems at two year after abandonment was 32.8 trees/$25m^2$ (Table 3). The highest density was 52 trees/$25m^2$ and the lowest density was 21 trees/$25m^2$. The mean density of individuals regenerated was 15.6/$25m^2$, ranging from 5 individuals/$25m^2$ to 31 individuals/$25m^2$ (Table 4). The total number of species recorded in 9 plots was 8 and the mean number of species was 3.1 species/$25m^2$, ranging from 1 species/$25m^2$ to 5 species/$25m^2$ (Table 3).

The frequency distribution of stem height in 2002 was also the unimodal distribution with the prominent peak in 2.0-2.5 m (Fig.2). The mean value and the maximum value of stem height in 2002 was 2.5 m and 7.0m, respectively.

Table 1 Density of stems regenerated in the abandoned pineapple field at 1 year after abandonment

	Number of stems/25m²					
Species / Distance from the edge	5m	10m	15m	20m	20m	Total
Wrightia arborea (Dennst.) Mabb.	15	10		19		8.8
Mussaenda angustisepala Ridl.	6	18	1			5
Callicarpa longifolia	3	1				0.8
Abelmoschus moschatus Medik.	4					0.8
Gmelia asiatica L.	3	1				0.8
Vitex sp.	3	1				0.8
Bauhinia sp.		1				0.2
Aerva sanguinolenta Blume		1				0.2
Ficus hispida L.f.			2			0.4
Litsea glutinosa (lour.) C.B. Rob.			1			0.2
Leucaena leucocephala (Lam.) de Wit			1		3	0.8
Total	34	33	5	19	3	18.8

Table 2 Density of individuals regenerated in the abandoned pineapple field at 1 year after abandonment

	Number of individuals/25m²					
Species / Distance from the edge	5m	10m	15m	20m	20m	Total
Wrightia arborea (Dennst.) Mabb.	15	6		12		6.6
Mussaenda angustisepala Ridl.	5	11	1			3.4
Callicarpa longifolia	2	1				0.6
Abelmoschus moschatus Medik.	3					0.6
Gmelia asiatica L.	1	1				0.4
Vitex sp.	2	1				0.6
Bauhinia sp.		1				0.2
Aerva sanguinolenta Blume		1				0.2
Ficus hispida L.f.			2			0.4
Litsea glutinosa (lour.) C.B. Rob.			1			0.2
Leucaena leucocephala (Lam.) de Wit			1		3	0.8
Total	28	22	5	12	3	14

M. angustisepala dominated in the density of stems (16.8 trees/25m^2), and *W. arborea* was the next dominant (11.4 trees / 25m^2, Table3,4). However, for the density of individuals, *W. arborea* had the most abundant individuals (7.1 individuals/25m^2) and *M. angustisepala* had fewer individuals (5.9 individuals/25m^2) than *W.arborea*. Other than these two species, only *G. asiatica*, occurred in higher density.

Table 3 Density of stems regenerated in the abandoned pineapple field at 2 year after abandonment

Species/	Number of stems/25m²									
Distance from the edge	5m	10m	10m	20m	25m	25m	25m	30m	30m	Total
Callicarpa longifolia	2		2							0.44
Gmelia asiatica	12	10	1							2.56
Litsea glutinosa	1								1	0.22
Mussaenda angustisepala	5	11	17	6	18	13	30	21	30	16.78
Wrightia arborea	21	12	31	8	11	15			5	11.44
Diospyros rhodocalyx				4						0.44
Mimosa pigra				2	1		4			0.78
Unidentified			1							0.11
Total	41	33	52	20	30	28	34	21	36	32.78

Table 4 Density of individuals regenerated in the abandoned pineapple field at 2 year after abandonment

Species/	Number of individuals/25m²									
Distance from the edge	5m	10m	10m	20m	25m	25m	25m	30m	30m	Total
Callicarpa longifolia	1		1							0.22
Gmelia asiatica	5	4	1							1.11
Litsea glutinosa	1								1	0.22
Mussaenda angustisepala	2	6	6	2	10	6	5	5	11	5.89
Wrightia arborea	15	7	22	2	9	8			1	7.11
Diospyros rhodocalyx				2						0.22
Mimosa pigra				2	1		3			0.67
Unidentified			1							0.11
										0.00
Total	24	17	31	8	20	14	8	5	13	15.56

3.3. Change of vegetation during two years

While the density of stems increased from 18.8 trees/25m² to 32.8 trees/25m² (Table 1, 3), the density of individuals was similar between two years (14.0 individuals/25m² in 2001, 15.6 individudas/25m² in 2002, Table 3,4).

The dominant species, *W.arborea* and *M.angustisepala*, had higher density than other species in both years (Table 1,2,3,4). By two censuses 14 species were totally recorded, and five species occurred in both years. Six species and 3 species occurred only in 2001 and 2002, respectively.

For *M.angustisepala*, the density of stems increased drastically from 5 stems/25m² to 16.8 stems/25m², and the density of individuals increased from 3.4 individuals/25m² to 5.9individuals/25m². But other species showed little increase or decrease both of the density of stems and of the density of individuals (Table 1,2,3,4). *M.sngustisepala* had higher value of the number of stems per individual than other species in 2002 (Table 5).

There was significant difference in the mean height of stems between 2001 and 2002 (2001;mean H=1.64m, 2002;mean H=2.14, F=41.34, p<0.001). Although *W.arborea* had significantly different mean

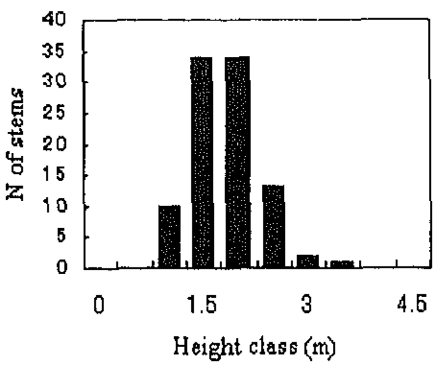

Fig. 1. Frequency distribution of height in the abandoned pine apple field at 1 year after abandonment.

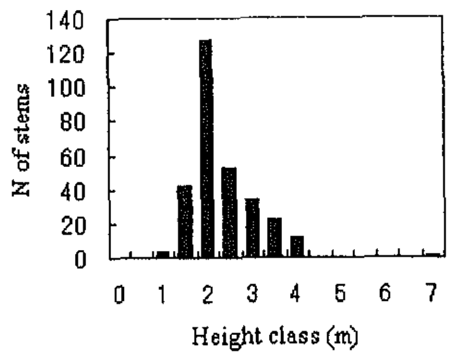

Fig.2. Frequency distribution of height in the abandoned pine apple field at 2 year after abandonment.

Table 5 Number of stems per individual in 2001 and in 2002

	N of stems/individual	
Species	2001	2002
Wrightia arborea	1.33	1.61
Mussaenda angustisepala	1.47	2.85
Callicarpa longifolia	1.33	2.00
Abelmoschus moschatus	1.33	
Gmelia asiatica	2.00	2.30
Vitex sp.	1.33	
Bauhinia sp.	1.00	
Aerva sanguinolenta	1.00	
Ficus hispida	1.00	
Litsea glutinosa	1.00	1.00
Leucaena leucocephala	1.00	
Diospyros rhodocalyx		2.00
Mimosa pigra		1.17
Unidentified		1.00
All species	1.34	2.11

height between 2001 and 2002 (2001;mean H=1.60m, 2002;mean H=2.51, F=59.122, $p<0.001$), *M.angustisepala* had the almost the similar mean height between 2001 and 2002 (2001;mean H=1.74m, 2002;mean H=1.85, F=1.87, p=0.173).

3.4. Effect of distance on the vegetation structure

In 2001, there was a significant difference both in the density of woody stems and in the density of individuals between the boundary of pineapple field and the interior (density of stems;F=14.17, p=0.033, density of individuals; F=19.31, p=0.022, Table 6). Both the density of stems and the density of individuals was higher in the boundary than in the interior. The same results was obtained in 2002 as in 2001 (Table 6).

Table 6 Comparison of density of stems, density of individuals and number of species between between the boundaru and the interior. The boundary and the interior of 2001 include plots set up at 0m, 10m from the edge and plots set up at 15m,20m from the edge, respectively. The boundary and the interior of 2002 include plots set up at 5m, 10m from the edge and plots set up at 20m,25m,30m from the edge, respectively.

	2001		2002	
	Boundary	Interior	Boundary	Interior
Density of stems (/25m^2)	33.5	9	42	32.8
Density of individuals (/25m^2)	25	6.7	24	11.3
Number of species (/25m^2)	6.5	2	4.3	2.5

Table 7 Comparison of mean height between the boundary and the interior. The boundary and the interior of 2001 include plots set up at 0m, 10m from the edge and plots set up at 15m,20m from the edge, respectively. The boundary and the interior of 2002 include plots set up at 5m, 10m from the edge and plots set up at 20m,25m,30m from the edge, respectively. In 2001, because M.angustisepala had only one stem in the interior, no comparison was carried out.

	Mean height (m)			
	2001		2002	
	Boundary	Interior	Boundary	Interior
All species	1.52	1.95	2.17	2.13
Wrightia arborea	1.44	1.81	2.36	2.75
Mussaenda angustisepala	1.71	2.5	1.95	1.83

For the number of species, there was a significant difference between the boundary of pineapple field and the interior in 2001 and in 2002 (2001; F=11.22, p=0.044, 2002; F=5.76, p=0.047, Table 6). The boundary had more species than in the interior both in 2001 and in 2002. And also the dominance of *W.arborea* and *M.angustisepala* was higher in the interior than in the boundary both in 2001 and in 2002. *Leucaena leucocephala* in 2001 and *Mimosa pigra* in 2002 occurred only in the interior part.

When all species were included, the average height was higher in interior than in the boundary for 2001(boundary; 1.52m, interior; 1.95, F=17.816, p<0.001, Table 7), but no significant difference was detected for 2002 (boundary; 2.17m, interior; 2.13, F=0.2315, p=0.631, Table 7). Stems of *W. arborea* were higher in the interior than in the boundary both for 2001 and for 2002 (2001; F=18.174, p<0.001, 2002; F=6.845, p=0.01, Table 7). But *M.angustisepala* in 2002 showed no difference of mean height between the boundary and the interior (F=3.636, p=0.059, Table 7).

3.5. Vegetation under the Eucalyptus plantation

The density of stem was 94.8stems/25m^2 and the number of species recorded was 11 in 5 years old *Eucalyptus* plantation(Table 8). Without *E. camaldulensis*, the density of stems was 81.8 stems/25m^2 and *M.angustisepala* dominated significantly (71%). *W.arborea*, *Capparis micracantha*, *Callicarpa longifolia* and *Cleistanthus hirsutulus* occurred in comparatively higher density (>2.0 stems/25m^2).

The density of individuals was 33.3 individuals/25m^2 and *M.angustisepala* dominated significantly (70%) (Table 9). Also *E. camaldulensis*, *W.arborea* and *Capparis micracantha* occurred in comparatively higher density (>1.0 individuals/25m^2).

The frequency distribution of height was the unimodal distribution with the prominent mode in 2-3 m

Table 8 Density of stems in the Eucalyptus plantationon the the abandoned pineapple field

	Number of stems (/25m2)				
	PL-1	PL-2	PL-3	PL-4	Total
Broussonetia papyrifera	1			1	0.5
Eucalyptus camaldulensis	19	16	5	12	13
Mussaenda angustisepala	69	80	23	97	67.25
Wrightia arborea	6	6			3
Capparis micracantha		9	2	2	3.25
Callicarpa longifolia			8		2
Cleistanthus hirsutulus			12	1	3.25
Dalbergra volubilis			4		1
Quercus sp			4		1
Syzygium megacarpam			1		0.25
Leucaena leucocephala				1	0.25
Total	95	111	59	114	94.75

Table 9 Density of individuals in the Eucalyptus plantationon the the abandoned pineapple field

	Number of individuals (/25m2)				
	PL-1	PL-2	PL-3	PL-4	Total
Broussonetia papyrifera	1			1	0.5
Eucalyptus camaldulensis	5	4	2	5	4
Mussaenda angustisepala	25	33	9	26	23.25
Wrightia arborea	1	6			1.75
Capparis micracantha		2	1	2	1.25
Callicarpa longifolia			2		0.5
Cleistanthus hirsutulus			2	1	0.75
Dalbergra volubilis			2		0.5
Quercus sp			1		0.25
Syzygium megacarpam			1		0.25
Lэucaena leucocephala				1	0.25
Total	32	45	20	36	33.25

(Fig.3). Each plot had the same height structure. In the overstory (over 5m) of this plantation *E. camaldulensis* shared dominance with *W.arborea*, *C. micracantha* and *D. volubilis* .In the understory (<3m), *M.angustisepala* strongly dominated.

The density of stems was not significantly different between plots in the boundary (PL-3. PL-4) and

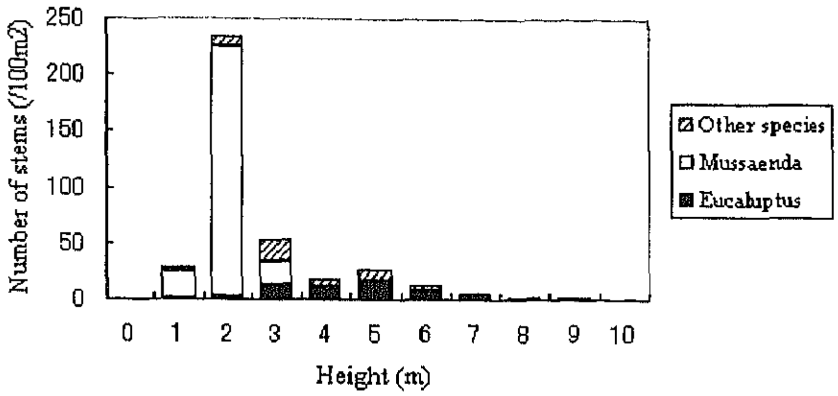

Fig.3. Frequency distribution of height in *Eucalyptus* plantation on the abandoned pineapple field.

plots in the interior (PL-1,PL-2). But the number of species was larger in the boundary (6 species, 8 species) than in the interior (4 species in both plots) (Table 8). *E. camaldulensis* and *M.angustisepala* occurred in all plots with varying density of stems. While *W.arborea* occurred in the interior plots, *C. longifolia* and *C. hirsutulus* occurred in the boundary plots.

4. DISCUSSION

4.1. Abandoned pineapple field

The density of woody plants established on abandoned pineapple field seemed to be higher than the density of woody plants established on the abandoned pasture (Aide et al., 1995), on the abandoned crop land (Chinea, 2002) and on the abandoned orchard (Milton et al., 1997). Aide et al (1995) reported that during first 7 years after abandonment no woody vegetation had developed and the density of woody plants had increased rapidly during 10 –15 years after abandonment. On the abandoned pineapple field, woody plants established even at first year after abandonment. Many authors indicated that the competition with herbaceous plants might inhibit establishment of woody plants on the degraded land in the tropical area (Sun and Dickson, 1996; Parrotta et al., 1997; Holl,1998; Otsamo,1998). On this pineapple field, the intensive management such as weeding by hand had been practiced immediately before abandonment. It was considered that the intensive management might inhibit the growth of herbaceous plants and facilitate the establishment of woody plants after abandonment.

Within species occurred in the abandoned pineapple field, *G.asiatica, C.longifolia* and *W.arborea* were observed to grow in the secondary stand surrounding the pineapple field. Thus these woody species established in the plot were considered to be dispersed from the surrounding secondary stand. But in this study, we could not determine dispersal agents of these species. It had been pointed out that the most of species in tropical forest tended to depend their dispersal on animals (Howe, 1984) and it was very difficult for seeds of woody species to be dispersed into pastures without woody vegetation because animal tended to avoid the open environment (Cardoso da Silva et al., 1996). Because pineapples had the shape similar to the shrub species, these pineapples might function as the attractive center and facilitate the seed dispersal by birds. Residual trees on the abandoned pasture were considered to attract bird species and abundant seeds were deposited under the canopy of these trees with comparing to the open grassland (Guevara et al., 1992). It is necessary to clear the mechanism of seed input into the abandoned pineapple field.

While the density of stems increased considerably from 2001 to 2002, the density of individuals did not change from 2001 to 2002. *M. angustisepala* contributed mostly to the increase of stem density from 2001 to 2002. *M.angustisepala* had abundant stems per one individual in 2002. Thus it was considered that higher ability of vegetative propagation of *M. angustisepala* brought about the considerable increase of stem number. Because no significant change of individual number could be observed, it was suggested that the recruitment of woody plants might be suppressed at 2 years after abandonment. At 2 years after abandonment, the abandoned pineapple field was covered densely by vigorously growing herbaceous plants in addition to woody plants. It was considered that the recruitment of woody plants had successfully occurred only within 1 year after abandonment and the recruitment had failed at 2 years after abandonment because of densely growing vegetation.

Both the density of woody plants and the number of species were significantly higher in the boundary than in the interior of the abandoned pineapple field. Lamb et al (1997) had already reported that there was a significant negative relation between seedling density and distance from the nearest seed source in plantations. Holl (1999) cleared that the number of seeds, especially animal dispersed seeds, decreased sharply on the pasture side of the forest/pasture edge and few seeds were recorded beyond 5m of the forest/pasture edge. Also Holl and Lulow (1997) indicated that in open areas seeds were subjected to high rate of predation. Thus it was suggested that low density and small number of species of woody plants beyond 10m from the forest/field edge might be caused by few seed input and high seed or seedling predation. And also it was considered that harsh environmental condition such as direct solar radiation, higher temperature and lower soil moisture negatively affected the recruitment of woody plants in the pineapple field.

4.2. *Eucalyptus* plantation

The density of woody plants in 5 year old *Eucalyptus* stand planted in the abandoned pineapple field was higher than in the abandoned pineapple field. But without *M.angustisepala* and *E.camaldulensi*, there was no significant difference of the stem density between the plantation and the pineapple field. Although there was no difference of total number of species recorded between the plantation and the pineapple field, the mean number of species per plots was higher in the plantation. *Eucalyptus* species had been reported to deplete the soil fertility and suppress the development of understory vegetation (Malik and Sharma 1990, Lisanework and Michelsen 1993, 1994). But Michelsen et al (1996) cleared that there was no significant difference of density and diversity of herbaceous plants between *Eucalyptus* plantation and natural forests. Also in this study, no significant difference of the density and the diversity of woody plants could be detected between *Eucalyptus* plantation and the pineapple field. Thus it was concluded that the planting of *Eucalyptus* species did not affect the restoration of plant diversity in the abandoned pineapple field.

In this plantation, the most of woody species other than *M.angustisepala* had grew from midstory to the overstory, but in the understory only *M.angustisepala* dominated. Such height structure might suggest the regeneration failure in the understory of these woody species. It seemed that the dense coverage of *M.angustisepala* might inhibit the emergence and growth of woody species in the understory.

4.3. Conclusion

In the upper region of Lam Phachi river basin, woody species had invaded both into the abandoned pineapple field and into the *Eucalyptus* planted pineapple field. But it seemed that the density of woody plants was lower and the establishment was restricted to shorter period (only 1 years) immediately after abandonment. Furthermore, in the abandoned pineapple field, the establishment of woody plants mainly occurred in the boundary within 10m from the edge and woody plants were difficult to regenerate successfully in the interior beyond 10m from the edge. From these results obtained, it was concluded that the recovery of woody vegetation on the abandoned pineapple filed might be difficult and it might take very long time before recovery of original forest.

Recently, in tropical area the framework species method have been applied to restore the degraded land where various factors suppress the establishment of woody plants (Hardwick et al., 1997; Lamb et al., 1997; Otsamo, 1998; Leopold et al., 2001). In the framework species method, initially planted trees are of native woody species that may grow rapidly, produce fleshy fruits to attract seed dispersal agents such as birds, bats, and create the physical environment suitable for establishment of indigenous woody species (Elliott at al., 1997). Many authors reported that plantation of framework species catalyze the invasion of woody plants and multiply the abundance and the diversity of the stand (Hardwick et al., 1997; Lamb et al., 1997; Otsamo, 1998; Leopold et al., 2001). Because it became evident that the establishment of woody species was difficult on abandoned pineapple fields, it will be necessary to plant framework tree species when we try to restore the degraded land produced by cultivation and abandonment in Lam Phachi river basin.

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