Succession following reforestation on abandoned fields in Mount Papandayan, West Java

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ABSTRACT
Mount Papandayan Nature Reserve in West Java has experienced a large-scale deforestation mainly due to illegal conversion of forests into agricultural fields during mid 1990s. Following the government's action to vacate the Nature Reserve from agriculture activities, most of farming activities have stopped and the fields were then abandoned. In some parts, the abandoned fields have been re-forested, either through government programs or community initiatives. This study aimed to investigate the extent to which succession has facilitated the entering of natural components from the forest nearby into the abandoned fields. The data were gathered through vegetation survey conducted on two abandoned-field sites having different history of reforestation, i.e. through government program and community initiative, and a site of natural forest as reference area. Shannon Wienner diversity index and Bray-Curtis similarity index were used to analyze the succession level. Based on the Bray-Curtis index, the level of similarity to the reference area for the tree component were 0.014 for the government-program site and 0.016 for the community-initiated site. This indicates that, after more than 10 years, the trees on both reforested sites were still dominated by species planted at the beginning of reforestation with very limited entering of species from the nearby natural forest. Comparison with other reforestation cases indicates that the progress of succession in these sites is relatively slow. The finding of this study provides some lessons for improving reforestation conducted in mountain ecosystem.

Keywords: Abandoned fields, reforestation, secondary succession, vegetation analysis.

1. INTRODUCTION

According to FAO (2005), Indonesia is a country with the highest deforestation rate (2 % per area wide) in the world. The vast destruction of tropical rain forest caused by deforestation has been a major problem for the world. Not only it effects the forest functions, but the most concerning impact is natural disasters that occur. Deforestation or conversion of forested areas to non-forested land can be seen as a form of disturbance that can cause forest ecosystem instability due to changes in floristic composition, vegetation structure, also faunas diversity and abundance (Williams, 2003).

Tropical rain forest ecosystem, especially vegetation component, will give adapting response naturally due to environmental changes caused by deforestation through mechanism called succession. Plant succession is a directional change in the species composition or structure of a community over time (Barbour *et al*., 1999). Succession occuring in areas near the undisturbed forest and under condition where disturbances no longer exists, could facilitate the entering of natural forest component. Eventually, this may lead the recovery of forest ecosystem which can be indicated by increase in plant diversity level until nearly the same with natural undisturbed forest (Lamb & Gilmour, 2003). This process can took different time span depending on the disturbance level and adapting level of plant components on the ecosystem where succession occurs. Commonly, natural succession happens in relatively long time span, from decades to hundreds years (Molles, 2005). However, succession can be accelarated by adding major climax component, such as trees, as commonly done in beginning of reforestation activity (Luken, 1990).

There has been many reforestation program conducted in Indonesia, either by the goverment programs or by community initiatives, such as reforestation on Cimanuk and Citarum river basin area at Mount Papandayan Nature Reserve (MPNR), West Java. MPNR area has been deforested in a large scale due to illegal conversion from forest to agricultural land. Following the government's action to vacate the Nature Reserve from agriculture activities, most of farming activities have stopped and the fields were then abandoned. In some parts, the abandoned fields have been reforested, either through government programs or community initiatives. After that, areas with different reforestation history were left and have undergone succession.

This study aimed to investigate the extent to which succession has facilitated the entering of natural components from the forest nearby into the abandoned fields with different history of reforestation. Research took place at Dayeuh Luhur, an area within MPNR which has sites with different history of reforestation. It is expected that the findings of this study provide some lessons learnt for improving reforestation methods in mountain ecosystem.

2. MATERIALS & METHODS

Mount Papandayan Nature Reserve located in southern part of West Java province. The peak of Mount Papandayan is located at 7º19’42 S and 107º44’00 W. The data were gathered through vegetation survey conducted on two abandoned-field sites having different history of reforestation, i.e. reforestation through government program (GP site) and community initiative (CI site), and a site of natural forest (NF site) as reference area. Both GP and CI site were previously forest converted into agricultural field using slash and burn method. GP site has been reforested twice. Firstly was more than ten years ago with pine (*Pinus merkusii*) and kibadak (*Alnus nepalensis*) planted between horticultural crops through “Reboisasi” Program, Secondly was through “RHL” Program during 2004-2005 with several tree species, mainly salam sayur (*Syzygium polyanthum*). Meanwhile, CI site has been reforested only once (1995) through community initiative with puspa (*Schima walichii*) and anggrit (*Distylium stellare*) also planted between horticultural crops. However, the farming of horticultural crops in those reforested sites have been stopped since 2003-2004.

Parameters of the study were vegetation composition, including species diversity, similarity level, species dominance, and age structure. Vegetation measurement was conducted in four plots in each site with the plot size of 20 m x 15 m. Therefore, the total area sampled in each site was 1.2 hectares. Each plot was then divided into (5 m x 5 m) subplot, within this subplot one (2 m x 2 m) plot was randomly placed on each subplot. The vegetation analysis was stratified according to the life form, i.e. tree, shrub, and herb. Shannon-Wienner diversity index and Bray-Curtis similarity index were used to analyze succession level of the plant community.

3. RESULTS & DISCUSSION

The vegetation analysis showed that the highest species diversity in all life forms were found in Natural Forest (NF) (Table 1). Although NF site generally showed climax community characteristic, but certain minor disturbance may still have occured. This was shown by the presence of some pioneer shrubs and herbs (e.g. *Eupatorium riparium, Eupatorium inulifolium*) commonly found on disturbed areas. The minor disturbance was in the form of tree falls causing gaps and logging that may have changed small fraction of vegetation composition

Table 1

The results of vegetation analysis conducted on each sites

SITE AREA	NUMBER OF SPECIES			SHANNON WIENNER DIVERSITY INDEX		THREE SPECIES WITH HIGHEST DOMINANCE LEVEL		
GOVERNMENT PROGRAMME	TREE	13	36	TREE	1.861	TREE	*Alnus nepalensis*	104.31
							Syzygium polyanthum	69.84
							Altingia excelsa	25.16
	SHRUB	5		SHRUB	0.84	SHRUB	*Eupathorium riparium*	73.35
							Eupathorium inulifolium	22.93
							Lantana camara	1.45
	HERB	18		HERB	2.164	HERB	*Leersia hexandra*	49.95
							Digitaria argyostachya	43.65
							Eragrostis infirma	25.65
COMMUNITY INITIATED	TREE	2	22	TREE	0.279	TREE	*Schima wallichii*	273.93
							Distylium stellare	26.07
	SHRUB	5		SHRUB	0.911	SHRUB	*Eupatorium riparium*	112.23
							Eupatorium inulifolium	47.4
							Blechnum capense	36.89
	HERB	15		HERB	1.644	HERB	*Leersia hexandra*	56.99
							Digitaria argyrostachya	50.69
							Eupatorium adenophorum	30.33
NATURAL FOREST	TREE	19	57	TREE	2.099	TREE	*Cyatea latrebosa*	110.94
							Castanopsis javanica	37.88
							Helicia serrata	29.68
	SHRUB	13		SHRUB	1.297	SHRUB	*Eupathorium riparium*	55.85
							Blechnum capense	27.31
							Kadsura scandens	25.82
	HERB	25		HERB	2.178	HERB	*Carex longipes*	28.65
							Molineria capitulata	26.06
							Nephrolephis sp.	21.52

Level of plant diversity is often taken as indication of the stage of succession. Late successional stage is commonly characterized by high plant diversity, while early successional stage is characterized by low plant diversity (Odum, 1971). Therefore, the vegetation on NF site was judged to be in the late successional stage as demonstrated by its high plant diversity (Table 1). Meanwhile, both Government Programme (GP) site and Community Initiatives (CI) site were in the early successional stage. On both reforested sites, plant diversity was low and the vegetation was dominated by shrubs and herbs of pioneer species (i.e. *Eupatorium riparium, Eupatorium inulifolium, Digitaria argyostachya*). Dominant tree species on both reforested sites were those planted in the early reforestation period.

Based on Bray-Curtis similarity index, among the three sites compared, two sites with highest similarity for each life form were GP and CI sites (tree : 0,067; shrub : 0,712; herb : 0,661). The low similarity for the trees was due to difference in the species planted for reforestation. The relatively high similarity for shrubs and herbs indicates that similar shrubs and herbs naturally entering the site after disturbance occur.

Indication of the successional stage on reforested sites can be assessed by comparing the reforested site and the undisturbed forest. If the main purpose of reforestation was to restore the previous forest condition (climax community), then reforestation will be considered successful when plant community between the natural forest used as reference area and reforested site showed high level of similarity index (nearby 1). In this study, the level of similarity to the reference area based on Bray-Curtis similarity index, for the tree component were 0,014 for the GP site and 0,016 for the CI site. For shrub component, the level of similarity to the reference area was 0,391 for the GP site and 0,443 for the CI site. While for the herb component the level of similarity to the reference area was 0,022 for the GP site and 0,003 for the CI site. These results indicate that vegetation composition on both reforested sites were significantly different with those of natural forest site.

As mentioned by Luken (1990), the recovery of forest ecosystem marked by changes in microclimate condition that will provide favourable condition to facilitate the entering of species from natural forest nearby. The results from this study showed that both reforested sites had low level of similarity to the natural forest, therefore it can be concluded that succession occuring on both reforested sites has not been able to facilitate the entering of late successional species of natural forest yet.

The forest recovering and maturity process were also shown by the ability of forest to regenerate. One characteristic of mature or climax forest is ability to maintain its stability by tree regeneration mechanism (Richards, 1996). Therefore, successional stage can also be shown from the age structure of the trees. Lortz *et al.* (1997) and Bender (1999) mentioned that mature, climax stage forest showed age structure pattern approaching a "reverse J" distribution. While forest maturity process is marked with changes in age distribution frequency pattern toward approaching a "reverse J" distribution pattern. In this study, the age structure of the tree component was gathered through diameter distribution analysis (Richards, 1996) as shown in Figure 1. On NF site, the graph showed a pattern approaching a "reverse J" distribution which indicates an uneven aged structure. This pattern is commonly found in climax stage of mixed forest, e.g. mixed forest at Sepunggur, Jambi, Sumatra (Ketterings *et al.*, 2001). The largest proportion of trees on this site was found on the smallest Diameter at Breast Height (DBH) class consisting of treelets. The species of treelets found in this site were from the dominant species. The frequency of trees in each age class tends to be lower as the diameter class increases.

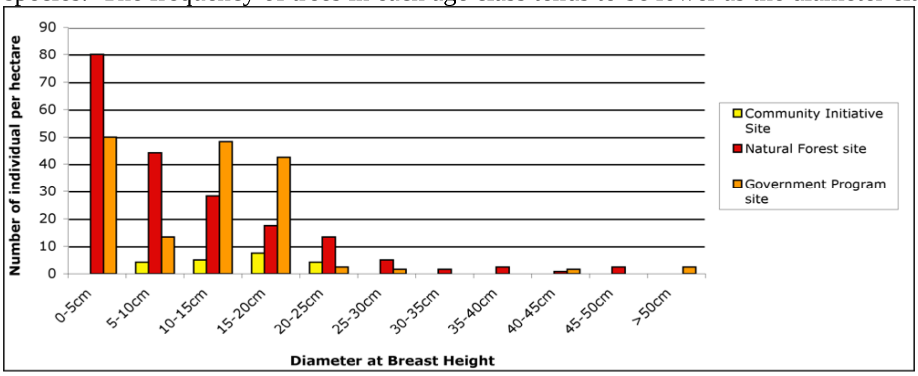

Figure 1 Tree diameter distribution on each sites

Meanwhile, there was no clear pattern of age structure for GP site. However, there was a sudden jump from 25-30 cm DBH class until 40-45 cm DBH class. This indirectly shows the reforestation history in this site, i.e. two different period of tree planting. The large proportion of trees with DBH below 30 cm represented those recently planted, i.e. 3-4 years ago. Meanwhile, few large trees found (DBH >40 cm) in this site represents the trees that have survived from the early planting period (more than 10 years ago). The graph from CI site shows an approaching "plateau" pattern which is commonly occurred on young forest with uniform age of trees (Lortz *et al.*, 1997). This also describe the reforestation history that only consist of one period of planting, unlike in the GP site. Each DBH class on this site consist of uniform tree species.

At this stage, the age distribution pattern on both reforested sites were not approaching "reverse J" pattern. Therefore, it can be concluded that regeneration level on both reforested sites were still low. Based on the regeneration characteristic, the NF site was in the late successional stage, while GP and CI stage were in the early successional stage. The facts that treelets only occured at the Natural Forest site and none were found at both reforested sites also explained that succession occuring on both sites has no been able to facilitate the entering of tree seedlings yet.

Although the GP site and CI site have been reforested in different times and with different tree species, both were showing early successional stage characteristics. Compared with other succession cases, e.g. succession on silviculture-based management area at Kathmandu, Nepal (Gilmour *et al.*, 1990) and succession on reclamated ex-mined bauxite at Amazon, Brazil (Parotta & Knowles, 2001), directional changes that happen along the successional process on both reforested site occured relatively slow. In Nepal case, for example, land rehabilitation with planting chir pine (*Pinus roxburghii*) showed accelarated succession. Three waves of regeneration followed planting with chir pine. The first developed as coppice from stumps which were remnants of the original forest. The second wave consisted of seedling regeneration which germinated about five years after plantation establishment. Dominant species in the first and second wave was *Schima wallichii*. Within 12 years, the canopy closes, the third wave of regeneration occurred at this time, and included a large number of species from nearby forest. It regenerated at high densities and by plantation age 14 years it covered the forest floor at a density of about 1,600 per ha with a mean height of 22 cm (Gilmour *et al.*, 1990).

Lamb & Gilmour (2003) offered a perspective that can be used to explain the relatively slow successional process in the reforested sites in this study. According to them, in order to accelerate the successional process, it is necesarry to eliminate disturbance that caused succession. Succession on both reforested sites at Mount Papandayan Nature Reserve happened because conversion of forest areas into horticultural areas. As mentioned before, reforestation period started more than ten years ago, while horticultural farming activity stopped by year 2003-2004 (5-6 years ago). Therefore, disturbance caused by farming activity in the form such as removal of tree seedling was in fact still occuring during the early reforestation period. We suspect, during farming period, farmers remove tree seedling and other undergrowth plant in order to enhance crop growth rate. This may reduce the tree probability to establish and regenerate, causing slow directional movement of succession. Besides that, Luken (1990) also offered an alternative way to accelerate successional movement. According to him, succession management may include controlled species performance method, or by performing methods used to decrease or enhance growth and reproduction of spesific plant species (i.e. weeding method of certain herbs or shrubs that may decrease tree growth rate). On both reforested areas, species covered the area were mainly pioneer herbs and shrub. Existence of these group of species could decrease tree growth rate through nutrient competition, that is why weeding method is considered necessary to be done in order to enhance growth of tree species.

4. CONCLUSION

Based on vegetation composition (species diversity, similarity level, species dominance, and age structure) characteristics, it can be concluded that Natural Forest site showed late successional stage characteristics while Government Program and Community Initiative site showed early successional stage characteristics. This indicates that, after more than 10 years, the trees on both reforested sites were still dominated by species planted at the beginning of reforestation with very limited entering of species from the nearby natural forest. Comparison with other reforestation cases indicates that the progress of succession in these sites is relatively slow.

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