

EFFECT OF *PINUS CARIBAEA* PLANTATION ON VEGETATION DIVERSITY AND DISTRIBUTION BY REFORESTATION IN LOWER HANTANA

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Introduction

During the colonial period, planting of fast-growing tree species in degraded lands was a common practice in the central highlands of Sri Lanka as a biological solution to the land degradation problem. *Pinus caribaea* is the most common type of fast-growing tree species selected for this and the total area planted exceeded 16,000 ha in 1870s (www.forestdept.gov.lk). Out of the 27,771 ha of Pine plantations, 25,091 ha are of *P. caribaea*, which was established easily on depleted soils (Ambagahaduwa *et al.*, 2009). Between 1980 and 1985 *P. caribaea* was planted by the forest department under a reforestation project of the upper Mahaweli catchment (Bandaratilake, 1988). The main objective of this study was to evaluate biodiversity of a reforestation area. This study was initiated to investigate the impact of *P. caribaea* plantations on vegetation diversity in comparison with nearby vegetation types.

Methodology

The study site is situated in the lower *Hantana* area belonging to the University of Peradeniya, Kandy district. Its coordinates are 7° 15' latitude and 80° 47' longitude. The general elevation is 480-600m above sea level, with mean annual precipitation and temperature of around 2121mm and 24 °C, respectively (Nissanka and Sakalasoorya, 2000). The site belongs to the wet-zone mid-country (WM₂) agro-ecological region. The most dominant soil group is reddish brown latosolic (Moorman and Panabokke, 1996 as cited in Ambagahaduwa, 2008). The unused grasslands of *Hantana* ridge was selected for planting *P. caribaea* in the 1980s to provide ground cover, enhance natural regeneration and to control soil erosion (Rathnayake, 2001 as cited in Ambagahaduwa, 2008). These plantations had not however been silviculturally managed since their establishment. In this area of secondary forests, Grasslands and *P. caribaea* are the dominant vegetation types at present. Three vegetation types were selected in this study. They were secondary forest

(SF; ~60 years old), restoration forest (RF; 11 years old) and mature *P. caribaea* plantation (PP; 35 years old). Restoration forest (RF) at a site formerly under *P. caribaea* plantation was initiated by the forest department as a research project in 2004. Several rows of mature *P. caribaea* trees totaling 126 trees were removed in one pine stand to establish an enrichment trial with some indigenous tree species. Those were *Artocarpusnobilis*, *Maducafulva*, *Michelicachampaka* and *Terminaliabellirica* (Ambagahaduwa *et al.*, 2009). From each vegetation type, four quadrates each of 10m² area and plants taller than one foot were counted to measure the vegetation diversity and distribution. The vegetation diversity and distribution were identified using Shannon-Weiner (H') and Shannon evenness (E) indices and 36 soil samples were collected from each vegetation type during the wet season. Fresh soils were tested for soil moisture levels using weight loss method. Air dried soils were tested for soil pH and total organic carbon using loss on ignition method. Litter samples were collected using the random sample method in each quadrate of 5m² and the Litter fall rate (g/m²/yr) and structural differences of litter fall rate were measured using oven dried samples.

Results and Discussion

Seventy two plant species were identified in the study area among which 39, 34 and 15 species were from SF, RF and PP respectively. Trees dominated all the three vegetations and 55 tree, 11 shrub and 06 vine species were found. There were 4 common plant species found in all three vegetation types. Those were *Alstoniamacrophylla*, *Neolitsea cassia*, *Panicum maximum* and *Gliricidiasepium*. When the total abundance of common species was compared, in SF the highest abundance was shown by *N. cassia* which is an endemic species. In RF it was *A. macrophylla* which is a pioneer and dominant species in RF; also it is not an enrichment trialed species. In PP it was *P. maximum* which is a shrub and pioneer species. The dominant species of SF was *Symplocoscochinensis* which is a native and pioneer species and in PP it was *Psidiumguineese* which is a shrub species. There were more than 29 new species found other than for the 04 species restored earlier in RF. Among the recognized species 03 of them were endemic and it can be identified as *Ficusfergusonii*, *Semecarpus sp.* And *Neolitsea cassia*. There were seven native species found which are *Alstoniascholaris*,

Asparagus racemosus, *Breyniaretusa*, *Flacourtiaindica*, *Macarangapeltata*, *Osbeckiaaspera* and *Ziziphusoenoplia*. Other species were exotic and most of them were pioneer species such as *Alstoniamacrophylla* and *Gliricidiasepium*. Vegetation density was the highest in PP because understory vegetation was rapidly grown with shrub species during the wet season. However, during the dry season vegetation density had decreased due to anthropogenic fires in PP. However, the highest Shannon-Weiner diversity index was reported in SF which was 2.359, while RF and PP had indices 2.265 and 1.545 respectively. Shannon evenness (E) was the highest in SF which was 0.643, while RF and PP had indices 0.642 and 0.570 respectively. According to Shannon-Weiner and Shannon evenness indices a greater vegetation diversity and distribution as expected were recorded in SF and were lowest in PP. Nevertheless, vegetation diversity and distribution have increased remarkably in RF compared to PP in a short time period and RF is an isolated vegetation stand in the middle of a Pine plantation. RF has reached to a comparable level to that SF in a short period of 11 years. This may be due to some reasons such as a production improvement from a nitrogen-fixing species and the reduction of competition between-trees due to mixing trees with contrasting phenologies (separation in time) or the different root or canopy architectures (separation in space) (Chamshama and Nduwayexu, 2002; Lamb, 1998; Lamb and Tomlinson, 1994; Lamb and Lawrence, 1993; Binkeley, 1992).

Results of the soil study showed that soil acidity was statistically significantly higher in PP and RF than the SF ($P \leq 0.05$); nevertheless, soils of all three vegetation types were acidic (Fig.1a). Generally the variation of soil acidity under different vegetation types can be attributed to difference in uptake of bases by plants, particularly calcium and the decomposition process occurring in the forest floor and removal of bases from the surface soil by leaching (Jacobs, 2010; Muthukudaarachchi, 1987 as cited in Ambagahaduwa, 2008). However, when structural differences of litter fall rate were compared, the highest litter fall rate was recorded in PP with needle leaves which was 259.65 (g/m²/yr) and in RF it was 76.63 (g/m²/yr). According to Brady (2002) and Jacobs (2010) Pine needles, Pine sawdust and acid peat are effective at reducing pH. In the PP and RF, higher needle leave may cause increase in acidity levels in

the soil. Soil moisture was statistically significantly higher in SF and RF ($P \leq 0.05$) (Fig. 1b).

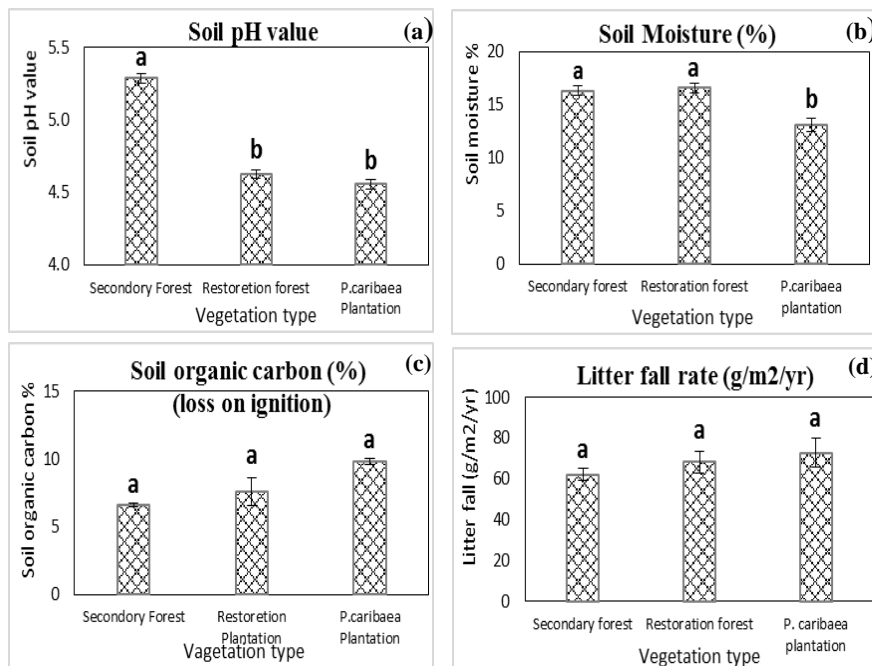


Figure 1: Result of soil study; (a) Soil pH value, (b) Soil moisture, (C) Soil organic carbon (loss on ignition) and (d) Litter fall rate. Means with the same letter are not significant different at $P \leq 0.05$

Higher soil moisture content in SF may be attributable to the fact that SF is a mature forest compared to the other two. Transpiration rates of mature forest are usually lower than young forest stands. Although RF was not a mature forest, soil moisture level had increased within the area. This may have resulted from some conditions other than the maturity of the forest. According to Gunasena (1988) one of the most critical issues with regard to reforestation with Pine is the excessive water consumption due to its rapid growth. The limiting factor which determines evapotranspiration from Pine plantation in the upper elevations is not moisture availability, but the energy for evapotranspiration. At lower elevation, for example in Kandy the percentage of water loss through evapotranspiration is more than one half of the rainfall, consequently

there was a substantial reduction of water yield compared to that in the Pine plantations at high elevations (Gunawardena, 1988). This factor may have contributed to the loss of soil moisture under the surface of Pine plantation compared to both SF and RF.

According to Fisher and Binkley (2000) soil organic carbon is a crucial factor for plant growth. In this study there was no statistically significant difference with respect to total organic carbon and litter fall rate among three vegetation types ($P \leq 0.05$) (Fig.1c & 1d). But the total organic carbon is higher in PP and it may be from charcoal due to anthropogenic fires. Research by Abeywickrama and Ranasinghe (1994), and Lilenfein *et.al.* (2001) also found that Pine forests improve total organic carbon and supply for plants in subsequent cultures. When considering litter fall rate, litter layer and humus layer, litter fall rate (Fig.1d) and depth of litter layer were higher in PP (PP: 3.63cm, SF: 1.38cm, RF: 2.13cm), but depth of humus layer was lowest in PP (PP: 0.4cm, SF: 3.38cm, RF: 3.38cm). This may lead to a higher fire risk and it means less multi-year accumulations. According to Rupasinghe (1988) as a result of needle leave of pine being unable to touch the earth surface with fine mineral is covered for seeds and also infiltration of water and air is reduced. Therefore, higher litter cover with needle leave also negatively affects vegetation growth. On the other hand, soil erosion is highly reduced due to thick litter cover in the pine site.

In Pine plantations, human activities such as anthropogenic fires and destruction of forest cover leads to reduction of litter layer, increasing soil erosion and loss of nutrients. Subsequently plant diversity and distribution are also reduced. People who are living around the area use forest products for several purposes, such as, collecting fuel wood and feed cattle and goats. However, the low levels of biomass production due to pine forest fires does not fulfill their demand. Therefore, replanting with Pine has been abandoned later due to growing concern among the general public and environmentalists on negative issues related to Pine, such as ground water extraction, natural regeneration, forest fire, soil erosion, wildlife habitats etc.

Conclusion

The results indicate that restoration with native plant species of mixed restoration in enriched Pine plantation have positively affected vegetation diversity, plant biomass and soils within a short time period of eleven years. *P. caribaea* plantation negatively affected the vegetation diversity and distribution. All objectives of establishing *P. caribaea* were therefore not satisfied, but due to Pines forest cover and thick litter layer soil erosion and runoff are controlled. With careful species selection and management practices based on an understanding of natural succession and nutrient cycling processes, forest plantations are a promising tool for rehabilitation of degradation land. Therefore, the results suggest that the mixed plant restoration with native plant species is the most applicable and eco-friendly practice to maintain the biodiversity in Central highlands of Sri Lanka.

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