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RESEARCH ARTICLE

The early stages of vegetation succession in a recovering *Eucalyptus* plantation: A case study from Sri Lanka

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Abstract: Changes in non-herbaceous species were recorded between 2006 and 2013 to understand the secondary succession in a harvested *Eucalyptus camaldulensis* plantation near Maragamuwa, Naula in Sri Lanka. Composition, mean abundance and absolute abundance were recorded in 40 cleared, 20 × 20 m^2 quadrats placed in eight 1 ha blocks in two types of locations: harvested eucalypt plantation away from the natural forest (MP) and harvested blocks next to a natural forest (MT). A total of 77 species were recorded in 2006 in MP declining to 55 in 2013, while the 61 species recorded from MT dropped to 48. Over time the number of super-abundant species with >100 individuals decreased from 14 in MP in 2006 to 5 in 2013. In the same period, numbers declined from 13 to 3 species in MT. Changes in numbers of individuals differed significantly in both MP and MT between 2006, 2009 and 2013 years ($p<0.05$). Mean abundances did not differ significantly between plot types MP and MT ($p>0.05$). MP had lower proportions of forest species than that in MT. The proportion of forest species increased in MT, whilst remained similar in MP. As expected, both the abundance and richness decreased in MP and MT over time.

Keywords: vegetation structure, floristic composition, succession, natural forest.

INTRODUCTION

As tobacco farming developed in Sri Lanka (Reed *et al.,* 2009), the Ceylon Tobacco Company (CTC) promoted the use of fast-growing, high-calorific tree crops such as eucalypts to supply wood fuel for the furnaces used to dry tobacco after harvesting. Under suitable soil and climatic conditions, some *Eucalyptus* species can rapidly grow into stands of good quality timber, producing commercially harvestable timber within 7-8 years (Timothy *et al.,* 2004). Its capacity to regrow from multiple stems through coppicing (Little & Gardner, 2003) produces a recurrent stand of wood within 3-5 years after the first cutting, providing a good annual income (Tanvir *et al*., 2002).

Eucalyptus camaldulensis is the most commonly planted eucalypt in the semi dry areas of Sri Lanka (Vivekanandan, 1979), though not all plantations have been successful (Perera, 1998) with many suffering from limited growth due to thin soils, a relatively dry climate, and their vulnerability to periodic flash fires common in agricultural areas. Tobacco demands heavy fuel usage in the initial stages of leaf drying processes (Davis & Nielsen, 1999). As part of its farmer-support programme, CTC established a series of plantations in tobacco growing zones of Sri Lanka in the early 1980s, primarily on poor quality lands previously used by farmers for *chena* cultivation (slash and burn cultivation) regimes. Almost all plantations used *Eucalyptus camaldulensis* Dehnh to replace pre-existing cover.

Unexpectedly poor growth rates, and a subsequent switch by CTC from wood fuel to paddy rice husk for use in tobacco drying, meant that by the mid-2000s, CTC's plantations were no longer economically viable. As part of its sustainability policy, CTC decided to initiate a program of research to understand how the plantations could be returned to native forests, and to evaluate the process of ecological succession as the recovery progressed, as colonization of natural tree species in degraded habitats in the Intermediate Zone of Sri Lanka is poorly understood (Perera, 2001). As monocultural plantations, such as eucalypt, typically support poorer species assemblages than biologically diverse natural forests (Bandaratillake, 1996, Newton 2007), the program offered the chance to better understand how such areas recovered after use as plantation areas, and any lessons that might be learnt for use elsewhere by CTC or others removing poorly-performing eucalypt plantations.

The current study reports on the first seven years of monitoring the woody vegetation in plots cleared of eucalypts, and provide baseline information on the changes in biodiversity and the possible effects of distance from the adjacent native forest on the pattern of colonization in cleared plots.

MATERIALS AND METHODS

Study Site

The Maragamuwa Forest Regeneration Study Site (FRSS) (7^0 41' 39.16" N - 80^0 42' 31.58" E) is located near Maragamuwa village, bordering the Naula – Elahera truck road in Matale district, Sri Lanka. The FRSS was established in a 60-ha block of *E. camaldulensis* plantation, managed by CTC until 2005 to provide fuel wood. The FRSS was part of a block of land leased by CTC for a 30-year period from the Forest Department of Sri Lanka. After switching to paddy husk as an alternative fuel, CTC established the FRSS at Maragamuwa plantation in 2005,

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in order to return the eucalypt stand back to a native forest using Assisted Natural Regeneration.

The FRSS is in the intermediate climate zone at an elevation of 369 m above sea level, with a mean annual rainfall of 1,750 mm to 2,250 mm, and a mean annual temperature of 27 ^{0}C. It is part of the Kumaragala Forest reserve, a conservation forest managed by the Forest Department of Sri Lanka.

The natural forest bordering the FRSS plantation is a dry mixed evergreen forest, typical of the semi dry zone of Sri Lanka (Perera 2001). The soils are Reddish Brown Laterites (Panabokke, 1996), formed under an annual regime of two short wet periods in October to February (major wet season) and in April (minor wet season) and a long dry period. The western side of the study site borders a less-disturbed native forest (Kumaragala Forest Reserve), while the rest of the plantation is surrounded by home gardens and chena lands (slash and burn cultivation) (Figure 1).

Preparation of study sites

In order to understand the patterns of colonization, and factors influencing the development of forest and its associated biodiversity, eight 1 ha blocks were selected at different distances from the forest edge in 2005 (Figure 1). Four (labelled as Plantation Blocks, MP) were cleared and earmarked in the center of the plantation, whilst four were cleared (labelled as Transition Blocks, MT) on the border of the mature forest. Only the *Eucalyptus* trees were felled. All the woody debris was removed from area to ensure no surface obstructions that may limit colonization. Each block was subdivided into 20 m × 20 m subplots. For monitoring purposes, five subplots were randomly chosen in each block.

To control the potential effects of eucalypt regrowth, all coppice stools were killed by light exclusion (Reed *et al*., 2009), so that their regrowth would not affect plant recolonization. In addition, the blocks were protected

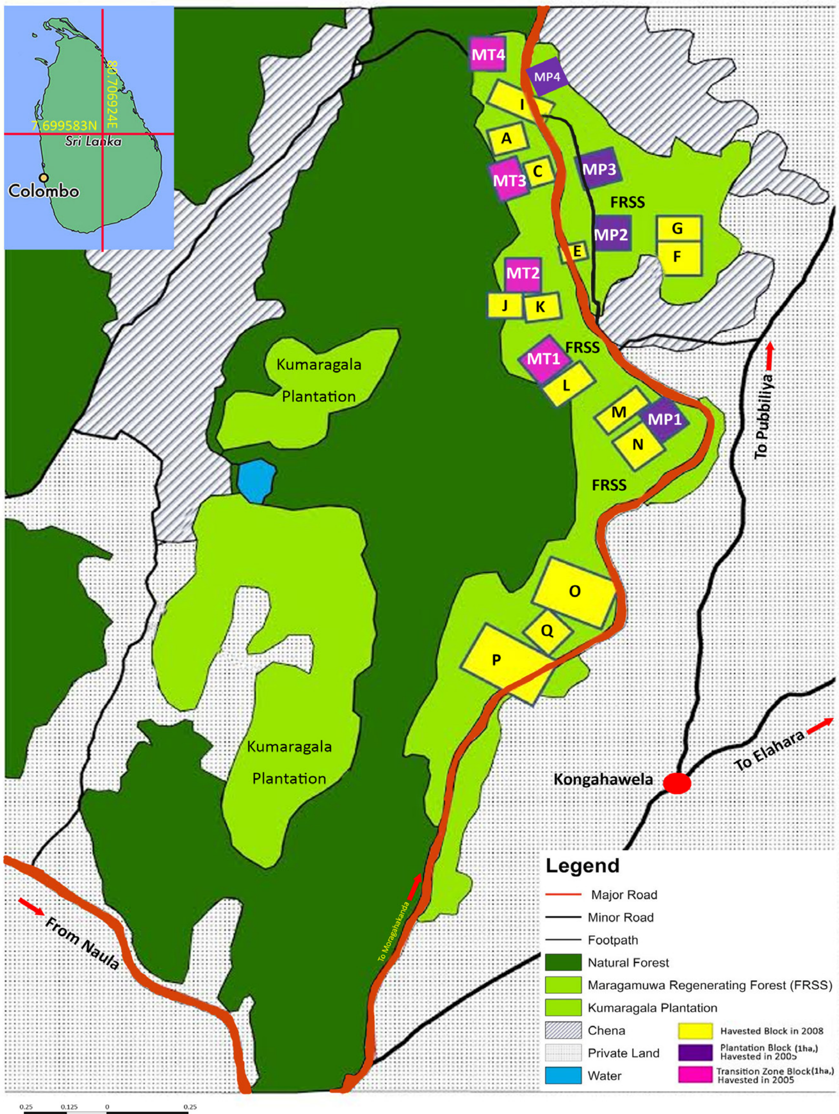

Figure 1: Map of Maragamuwa Forest Regeneration Study Site (FRSS) showing the areas cleared in the plantation and the locations of the monitored plantation blocks (MP 1-4) in the eucalypt and transition blocks (MT 1-4) adjacent to the forest reserve. Yellow blocks were not monitored for this study.

from fire by fire breaks on three sides (except the side demarcating the forest), and domestic stock were fenced out.

Establishment of experimental plots and vegetation sampling

In both plantation (MP) and transition (MT) plots, the non-herbaceous vegetation was sampled annually from 2006 to 2013.

All non-herbaceous plants were categorized as either tree, shrub or liana, and heights and abundance of all seedlings in each subplot were counted and their abundances were recorded. Each seedling was given a number, and tagged with an aluminium label. Each numbered tag was recorded with the family name, scientific name and common local name and used to track their subsequent life histories. Herbarium sheets were prepared for all recorded plant species. All specimens were identified to the species level, and the number of individuals of each was counted. Those difficult to identify were checked using herbarium sheets available in the National Herbarium, Royal Botanic Gardens, Peradeniya, Sri Lanka. Specimens were authenticated using the standard checklist of the flora of Ceylon (Senaratne, 2001). Using the ecological categorisation of Ashton *et al.,* (1997), all non-herbaceous species were divided into either scrub (scrub, scrub forest and scrub understorey) or forest (forest, forest sub-canopy and forest understorey) species.

Data analysis

The absolute numbers of individual woody plants were compared between MP and MT over time: 2006-2013 using ANOVA, and mean abundance per hectare was compared using t tests (Snedecor & Cochran 1973). Shannon Diversity Index was calculated to compare the changes in species diversity between 2006 and 2013 (Magurran, 1988).

RESULTS

Changes in the number of species and individuals over time

The number of species was reduced from 77 in MP in 2006 to 55 in 2013 (28.5%). In MT plots the decline was slightly lower *viz*., from 61 to 48 species (21.4%). In both areas, the abundance and richness declined over time. In 2006, there were 9,831 individuals in MP, and had declined to 2,831 individuals in 2013 (79%). In 2006, MT had fewer individuals than MP with 7,022 individuals, and declined to 1,078 by 2013 (85%) (Figure 2).

The abundance of woody individuals changed significantly from 2006 and 2009, and between 2006, 2009 and 2013 for both MP and MT (Table 1). Diversity measures (H') changed over the same period as the number of super-abundant species gradually reduced, resulting in fewer dominant species and a more equable spread of individuals in each species. H' decreased in MP from 2.87 in 2006 to 2.78 in 2013, whilst H' decreased in MT from 2.66 to 2.55 in the same period.

Changes in mean abundance over time

As noted before (Figure 2) the number of plants recorded changed over time. As would be expected, mean abundances also declined. In 2006, mean abundances in plots were similar (t test p> 0.05), with MT slightly higher than MP (Table 2). By 2013 mean abundances were lower, with the lowest mean abundance in MT. Due to the substantial variation between species within each category, mean abundances were overall not significantly different between MP and MT (t test p>0.05).

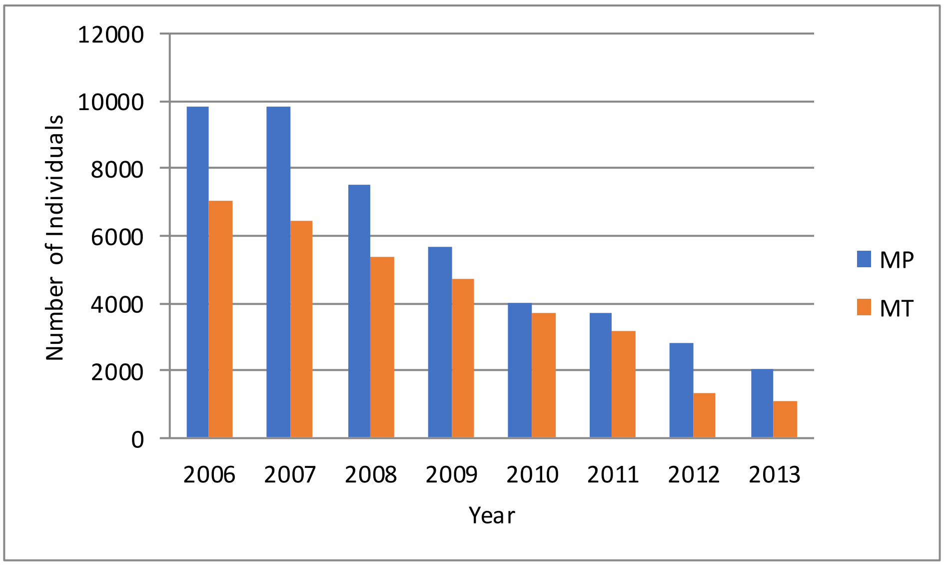

Figure 2: The number of individuals of non-herbaceous species recorded in plantation (MP) and transitional (MT) plots during the period of 2006-2013.

Table 1: Analysis of Variance (ANOVA). Comparisons of abundance between years for individual sites, and between sites between years.

Site	Comparison	p value
MP:MP	2006:2013	<0.003
MT:MT	2006:2013	<0.001
MP:MP	2006:2009:2013	<0.001
MT:MT	2006:2009:2013	<0.001

Table 2: Two sample t tests comparing mean abundance per hectare between years and sites. (n = 96).

Site	Comparison	p value
MP:MT	2006	0.92
MP:MT	2013	0.118

DISCUSSION

Any newly opened area may contain a range of colonists: some of them from outside of the plot, while others will be derived in situ from the soil seedbank (Richards, 1952; Newton, 2007). As open area species are typically more mobile and better initial colonists than forest species (Bullock et al 2002, Daniel & Aldicir 2006), it might be expected that the MP plots would initially be dominated by these early stage colonists, only slowly to be replaced by forest and secondary forest species as the forest edge expands from the Kumaragala Forest Reserve (Bierregaard *et al*., 2001).

In such circumstances, the combination of reduced light, and increased humidity on the edge of the forest would favour forest species at the expense of open area species, used to lower humidity and open sun (Bierregaard *et al*., 2001, Rondon, 2008). Over the course of the study it was noted that flash fires elsewhere in the study area burnt up to the edge of the forest, but never entered the forest; only open areas were burnt. As the forest edge moved out, so the absolute area affected by fires was reduced. Perera (2001) noted that seral succession is typically characterized by the initial dominance of a limited number of super-abundant species that act to crowd out others. Over time, these begin to decline, and become less dominant, and the first of the taller forest species begin to emerge. This occurred in the study areas over time (Appendices I-III). In the first year after clear felling, MP and MT plots were dominated by *Pterospermum suberifolium* and *Grewia damine*, both of which are early colonizing tree species in the dry zone, whilst *Mallotus eriocarpus,* a species of secondary forest, was also highly abundant in MT plots.

Whilst the reduction in the number of species and individuals was expected (Newton, 2007), the increase in the relative density of forest: to non-forest species was not consistent between MT and MP plots. In the plots near the forest (MT), the proportion of individuals categorized as forest species rose from 43 to 54%, whilst it decreased from 19 to 18% in MP over the period from 2006 to 2013.

The initial and subsequent differences between MP and MT were in part due to the predominance of three species in MP plots: *Pterospermum suberifolium, Grewia damine* and *Streblus taxoides*. Relative densities of all of these changed more in MT than MP quadrats, whilst the relative density of the forest tree *Mallotus eriocarpus* in MT rose between 2006 and 2013 (Appendices II and III). This suggests that the process of seral succession and forest expansion was slowly advancing in MT plots, with a lag in the more exposed MP plots.

Overall, it appears that succession is beginning to occur in the study area: the numbers of individuals and species declined in both MT and MP plots. As they did so, the number of dominant species also dropped. In the MP plots the trend is for an increased proportion of forest category individuals, whilst the scrub species retained their initial dominance in MP. How long this will remain, with the further drop in relative densities, will be reported in further papers in this series.

For CTC, it is appears that succession will occur if areas are kept clear of eucalypts, and that this is by no means a simple linear process. Nonetheless, for large scale landholders such as CTC, and others wishing to see forest return to disturbed areas on poor soils, it is clear that native forest will expand, and that even within short distances of colonist sources there may be differences in rates and forms of recovery.

REFERENCES

Ashton, M.S., Gunatilleke, S., de Zoysa, N., Dassanayake, M. D., Gunatilleke, N. and Wijisundera, S. (1997). *A field guide to the common trees and shrubs of Sri Lanka*. WHT Colombo.

Bandaratillake, H.M. (1996). Eucalyptus Plantations in Sri Lanka: Environmental, Social, Economic and Policy Issues. In: *Reports submitted to the regional expert consultation on eucalyptus. Volume II. RAP PUBLICATION: 1996/44*. FAO Regional Office for Asia and the Pacific (RAP) Bangkok, Thailand.

Bierregaard, R.O., Gascon, C., Lovejoy, T.E., & Mesquita, R. (2001). *Lessons from Amazonia.* New Haven, Yale U.P.

Brockerhoff, E.G., Jactel, H., Parrotta, J.A., Quine, C.P., Sayer, J., and Hawksworth, D.L. (eds). *Plantation Forests and Biodiversity: Oxymoron or Opportunity?* Springer, Berlin.

Bullock, J.M., Kenward, R.E, and Hails, R.S. (eds.). (2002). *Dispersal ecology.* Blackwell, Oxford.

Daniel, I.M. and Aldicir, S. (2006). Principles of natural regeneration in tropical dry forests for restoration. *Restoration Ecology*, **14**: 11-20.

Davis, D.L. and Nielsen, M.T. eds. (1999). *Tobacco*. Blackwell, Oxford.

Little, K.M. and Gardner, R.A.W. (2003). Coppicing ability of 20 *Eucalyptus species* grown at two high-altitude sites in South Africa. *Can. J. For. Res*.**33**: 181-189.

Newton, A.C. (2007). *Forest ecology and conservation.* Blackwell, Oxford.

Magurran, A.E. (1988). Ecological Diversity and its measurement. *Croom Helm Limited*, London. 179 p.

Panabokke, C.R. (1996). *Soils and agro-ecological environment of Sri Lanka*. Natural Resource Series No.2. pp220. Natural Resource Energy& Science Authority Colombo Sri Lanka

Perera, G.A.D. (1998). Commercial viability of forest plantations in Sri Lanka. In: *Proceedings of the fourth annual forestry and environment symposium 1998.* University of Sri Jayewardenepara. Pp: 30.

Perera, G.A.D (2001). The Secondary Forest Situation in Sri Lanka. *Journal of Tropical Forest Science* **13**: 768–785.

Reed, T M., Ranawana, K.B and Nanayakkara, A. (2009). Methods tested, and their costs, to control re-growth of coppiced E*ucalyptus camaldulensis* in harvested plantations in Naula, Matale District, Sri Lanka. *Cey. J. Sci. (Bio. Sci.)* **38**: 75-82.

Richards, P.W. (1952). *Tropical Rain Forests*. Cambridge University press, London.

Rondon, X.J. (2008). *Assessing the sustainability of strip clear-cutting in the Peruvian Amazon.* Botany Department, Oxford, OH, Miami University.

Senaratne, L.K. (2001). *A check list of the flowering plants of Sri Lanka*. National Science Foundation, Colombo 7, Sri Lanka.

Snedecor, G.W. and Cochran, W.G. (1973). *Statistical methods.* Iowa State Press, Ames.

Tanvir, M.A., Siddiqui, M.T. and Shah, A.H. (2002). Growth and Price Trend of *Eucalyptus camaldulensis i*n Central Punjab. *International Journal of Agriculture Biology* **4**: 344-346.

Timothy, A.V., Verwijst, T., Pradeep J., Tharakan, A., Lawrence, P., Abrahamson K, and White, E.H. (2004). Growing fuel: a sustainability assessment of willow biomass crops. *Frontiers in Ecology and the Environment* **2**: 411-418.

Vivekanadan, K. (1979). Performance of provenances of *Eucalyptus* in Sri Lanka. *Sri Lanka Forester* **14**: 49-54.

Appendix I: The changes in relative density of lianas and shrubs in plantation plots (MP) and transitional plots (MT) during 2006-2009- 2013.

Family	Species	Life Form	Relative Density (%)					
			2006 MP	2009 MP	2013 MP	2006 MT	MT 2009	2013 MT
Rhamnaceae	*Ziziphus oenoplia*	Liana	1.3	2.45	1.2	2.18	2.07	0.56
Hippocrateaceae	*Salacia reticulata*	Liana	2.65	2.71	1.64	2.48	2.53	1.31
Fabaceae	*Derris trifoliata*	Liana	13.94	10.86	1.33	14.3	6.67	1.31
Tiliaceae	*Grewia orientalis*	Liana	6.16	4.17	1.4	3.03	1.36	0.47
Vitaceae	*Cayratia pedata*	Liana	-	-	-	0.2	0.06	-
Apocynaceae	*Aganosma cymosa*	Liana	0.14	-	-	0.17	-	0.09
Capparidaceae	*Capparis sp*	Liana	0.19	0.03	-	0.4	0.28	-
Rhamnaceae	*Ventilago madraspatana*	Liana	0.03	-	-	-	-	-
Rubiaceae	*Mussaenda frondosa*	Shrub	0.02	-	-	-	-	-
Rubiaceae	*Psilanthus wightianus*	Shrub	0.18	0.14	0.51	2.75	1.87	1.12
Apocynaceae	*Carissa spinarum*	Shrub	0.01	-	-	-	-	0
Rubiaceae	*Catunaregam spinosa*	Shrub	6.06	5	8.55	2.74	3.32	4.12
Euphorbiaceae	*Phyllanthus polyphyllus*	Shrub	0.01	-	-	-	-	-
Myrsinaceae	*Maesa indica*	Shrub	1.63	1.67	0.89	0.03	0.06	-
Flacourtiaceae	*Casearia tomentosa*	Shrub	0.01	0.02	-	-	-	-
Rutaceae	*Atalantia ceylanica*	Shrub	0.13	0.12	0.21	0.07	-	-

Appendix II: The changes in relative density of small trees in plantation plots (MP) and transitional plots (MT) during 2006- 2009-2013.

Family	Species	Life form	Relative Density (%)					
			2006 MP	2009 MP	2013 MP	2006 MT	MT 2009	2013 MT
Alangiaceae	*Alangium salviifolium*	Small tree	0.18	0.24	0.27	0.26	0.26	0.56
Annonaceae	*Polyalthia korinti*	Small tree	0.16	0.21	0.03	0.77	0.88	0.84
Boraginaceae	*Carmona retusa*	Small tree	0.11	0.17	0.17	1.23	0.57	0.28
Capparidaceae	*Capparis brevispina*	Small tree	0.39	0.31	0.38	0.74	0.54	0.19
Capparidaceae	*Capparis zeylanica*	Small tree	-	-	-	-	0.03	-
Ebenaceae	*Diospyros ovalifolia*	Small tree	0.01	0.02	-	-	-	-
Euphorbiaceae	*Sapium insigne*	Small tree	-	-	-	-	-	0.09
Euphorbiaceae	*Dimorphocalyx glabellus*	Small tree	1.39	1.72	1.54	0.94	1.36	1.69
Fabaceae	*Cassia fistula*	Small tree	0.01	-	0.07	-	-	-
Fabaceae	*Leucaena leucocephala*	Small tree	0.07	0.09	-	-	-	-
Fabaceae	*Pongamia pinnata*	Small tree	0.03	0.03	0.1	-	-	-
Flacourtiaceae	*Scolopia acuminata*	Small tree	-	-	-	0.03	0.03	0.09
Leeaceae	*Leea indica*	Small tree	0.01	-	0.03	-	-	-
Melastomataceae	*Memecylon umbellatum*	Small tree	0.23	0.24	1.13	0.19	-	-
Meliaceae	*Cipadessa baccifera*	Small tree	0.91	1.11	1.54	6.74	7.53	6.28
Moraceae	*Streblus taxoides*	Small tree	7.02	8.79	6.67	0.19	0.09	0.09
Moraceae	*Streblus asper*	Small tree	5.64	4.95	5.23	1.57	1.16	0.94
Myrtaceae	*Eugenia bracteata*	Small tree	0.36	0.1	1.03	0.71	1.05	1.03
Myrtaceae	*Psidium guajava*	Small tree	-	-	-	-	0.03	-
Rubiaceae	*Canthium coromandelicum*	Small tree	0.25	0.24	0.48	0.14	0.14	0.09
Rubiaceae	*Ixora coccinea*	Small tree	0.07	0.03	-	0.09	0.06	-
Rutaceae	*Glycosmis angustifolia*	Small tree	4.56	0.03	-	0.1	0.17	0.09
Rutaceae	*Glycosmis pentaphylla*	Small tree	9.45	11.99	6.91	5.34	3.29	1.22
Rutaceae	*Pleiospermium alatum*	Small tree	0.07	0.09	0.14	0.2	0.45	0.56
Sabiaceae	*Zanthoxylum rhetsa*	Small tree	0.01	-	-	-	-	-
Sapindaceae	*Allophylus cobbe*	Small tree	0.37	0.3	0.17	0.1	0.11	0.09
Verbenaceae	*Gmelina asiatica*	Small tree	0.94	1.18	1.61	0.07	0.09	-
Verbenaceae	*Premna latifolia*	Small tree	0.01	-	-	-	-	0.19

Appendix III: The changes in relative density of trees in plantation plots (MP) and transitional plots (MT) during 2006- 2009- 2013.

Family	Species	Life form	Relative Density (%)					
			2006 MP	2009 MP	2013MP	2006 MT	2009 MT	2013 MT
Anacardiaceae	*Nothopegia beddomei*	Tree	-	-	-	0.1	0.06	-
Annonaceae	*Annona cherimola*	Tree	-	-	-	0.01	0.03	-
Bignoniaceae	*Stereospermum colais*	Tree	0.03	0.03	-	0.01	0.03	0.19
Euphorbiaceae	*Mallotus eriocarpus*	Tree	0.19	0.21	0.17	28.25	34	38.43
Lauraceae	*Litsea glutinosa*	Tree	0.02	0.03	0.03	0.07	0.06	0.09
Moraceae	*Broussonetia zeylanica*	Tree	0.02	-	-	0.06	0.03	-
Myrtaceae	*Syzygium gardneri*	Tree	-	0.09	-	0.06	0.03	0.09
Rubiaceae	*Ixora pavetta*	Tree	0.06	0.12	0.07	0.1	0.11	-
Rutaceae	*Chloroxylon swietenia*	Tree	1.47	1.74	3.25	2.37	3.15	3.37
Sapindaceae	*Lepisanthes tettraphylla*	Tree	0.38	0.47	0.85	0.2	0.37	0.56
Tiliaceae	*Grewia helicterifolia*	Tree	0.03	0.05	-	0.04	0.03	0.09
Tiliaceae	*Grewia damine*	Tree	8.87	12.35	25.68	4.93	7.04	13.78
Ulmaceae	*Trema orientalis*	Tree	0.01	0.02	0.03	-	-	-
Annonaceae	*Miliusa indica*	Tree	-	-	-	0.03	0.06	0.09
Boraginaceae	*Cordia dichotoma*	Tree	0.07	0.09	0.17	0.06	0.06	0.19
Clusiaceae	*Garcinia spicata*	Tree	0.01	-	-	-	-	-
Ebenaceae	*Diospyros ebenoides*	Tree	0.06	0.07	-	-	-	-
Ebenaceae	*Diospyros ebenum*	Tree	0.06	0.09	0.14	0.17	0.14	0.19
Euphorbiaceae	*Blachia umbellata*	Tree	0.03	0.02	0.03	-	-	-
Euphorbiaceae	*Macaranga peltata*	Tree	0.21	0.05	0.03	0.14	0.23	0.47
Euphorbiaceae	*Croton laccifer*	Tree	0.07	0.12	0.44	-	-	-
Euphorbiaceae	*Bridelia retusa*	Tree	0.89	1.3	1.78	0.28	0.71	0.75
Fabaceae	*Cassia spectabilis*	Tree	0.02	0.02	0.03	-	-	-
Fabaceae	*Bauhinia racemosa*	Tree	0.14	0.19	0.31	0.03	0.03	-
Fabaceae	*Cassia siamea*	Tree	1.72	2.12	2.77	0.36	0.51	1.03
Flacourtiaceae	*Flacourtia indica*	Tree	1.59	1.53	0.75	0.24	0.14	0.09
Lecythidaceae	*Careya arborea*	Tree	-	-	-	-	-	0.09
Meliaceae	*Chukrasia tabularis*	Tree	0.02	0.03	0.03	0.01	0.03	-
Meliaceae	*Walsura trifoliolata*	Tree	0.08	0.03	0.27	0.09	0.06	-
Meliaceae	*Azadirachta indica*	Tree	0.01	-	-	-	-	-
Meliaceae	*Melia azedarach*	Tree	0.06	0.05	0.21	-	0.06	-
Olacaceae	*Olax imbricata*	Tree	0.01	0.02	-	0.01	-	-
Rubiaceae	*Haldina cordifolia*	Tree	0.04	0.02	0.07	0.03	0.03	0.09
Rutaceae	*Pamburus missionis*	Tree	0	0.02	0.03	0.41	0.2	-
Sapindaceae	*Sapindus trifoliata*	Tree	0.39	0.57	1.09	0.26	0.43	0.66
Sapindaceae	*Schleichera oleosa*	Tree	0.56	0.59	0.48	0.31	0.45	0.66
Sapindaceae	*Dimocarpus longan*	Tree	0.68	0.47	0.38	1.11	1.53	0.94
Sapotaceae	*Madhuca longifolia*	Tree	-	0.02	0.03	-	-	-
Sterculiaceae	*Helicteres isora*	Tree	0.02	0.03	0.03	-	-	-
Sterculiaceae	*Pterospermum suberifolium*	Tree	16.73	17.53	16.65	11.43	13.15	12.93
Vahliaceae	*Callicarpa tomentosa*	Tree	0.01	-	-	0.36	0.17	0.28
Verbenaceae	*Vitex altissima*	Tree	0.11	0.23	0.1	0.13	0.4	0.47
Verbenaceae	*Premna tomentosa*	Tree	0.26	0.3	0.44	0.26	0.48	1.12
Verbenaceae	*Tectona grandis*	Tree	0.32	0.35	0.41	-	-	-
Verbenaceae	*Clerodendrum phlomidis*	Tree	-	-	-	0.34	0.14	-