A CRITICAL APPRAISAL OF CHANGES IN PHYTODIVERSITY IN AN ECORESTORED SITE NEAR PUDUCHERRY, SOUTH INDIA

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I, Mr. C. KRISHNAKUMAR hereby declare that the research work entitled *"A Critical Appraisal of Changes in Phytodiversity in an Ecorestored site near Puducherry, South India"* submitted for the award of the Degree of Doctor of Philosophy in Botany is my original work and has not previously formed the basis for the award of any degree, diploma, associate ship, fellowship or any other similar title.

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This is to certify that the PhD thesis entitled *"A Critical Appraisal of Changes in Phytodiversity in an Ecorestored site near Puducherry, South India"* is based on the original work done by Mr. C. KRISHNAKUMAR, Department of Botany, Kanchi Mamunivar Centre for Post-Graduate Studies, Puducherry during the period of study under my supervision and this has not previously formed the basis for the award of any degree, diploma, associateship, fellowship or any other similar title and that the thesis represents entirely an independent work on the part of the candidate.

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C. KRISHNAKUMAR, PUDUCHERRY

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CHAPTER-1

INTRODUCTION

Since the beginning of history human were depending on forests for food, shelter, clothing and medicines. They function as lungs of the earth as well as natural pharmacy in cleaning the atmosphere and curing human diseases. Socially, economically, and environmentally these forests are very important for the human wellbeing. Amongst the natural ecosystem, tropical forests are very important and occupy 7% of the geographical area of the world (Corlett and Primack 2010). These are playing an important role in regulating the local and global climate, sequestrate large amount of carbon dioxide (Gorte and Sheikh, 2010; Kohler *et al*., 2003; CBD, 2009), maintain atmospheric humidity, maintain soil moisture and provide shelter to diverse variety of flora and fauna (Lalfakawma, 2010). In particular, these tropical forests have high productive and protective natural values, housing 10-30 million of species and comprising of complex ecological communities (Sandalow, 2000).

The Tropical Dry Evergreen Forest (TDEF) is a special type of vegetation found along the Coromandel Coast of Eastern India. It constitutes only 0.01% of total geographical area of India due to rapid urbanization. This type of vegetation is adapted to survive months or sometimes years of relative drought and short periods of intense rain (Hunneyball, 2003). The TDEF have been reported from varied soil types including red ferruginous and alluvial deposits of Cuddalore sandstone formation and alluvial sandy loam (Parthasarathy and Sethi, 1997). The TDEF on the Coromandel coast of India, which occur as patches, are short-statured due to different levels of disturbance in this highly populated coastal region over the years (Venkateswaran and Parthasarathy, 2005; Mani and Parthasarathy, 2006). This forest is further threatened and fragmented into patches. Only about 4% to 5 % of the original TDEF patches exist today (Blanchflower, 2003). Most of the tropical and tropical dry evergreen forest ecosystems have been suffering on a large scale basis for many centuries due to deforestation and degradation which involves cutting, browsing, over grazing, agricultural expansion, logging, burning, fire wood collection, charcoal making, mining, new settlements developments etc (FAO 2006).

1.1. Biodiversity& Phytosociology

Biodiversity is the short form for biological diversity which is to describe the total number, variety and variability of living organism as well as the diversity of ecosystem (Noss and Cooperride, 1994; Krebs, 1999: CBD, 2009). Biodiversity plays a crucial role in ecosystem stability and productivity (Alhamad, 2006). It is one of the most important indices used for evaluating the stability and sustainability of forest communities. Information on the species composition of a forest is essential for its wise management in terms of economic value, regeneration potential and ultimately leading to conservation of biological diversity (Verma *et al*., 1999).

India is well known for significant geographical diversity which has favoured the formation of different habitats and vegetation type. It is one of the 34 mega-biodiversity hotspots of the world, having vast variety of flora and fauna and ranks 10th in the global biodiversity of flowering plants. It is a home for threatened and endemic species that have immense ecological and commercial value. Since Rio Earth Summit held in 1992, biological resources have received a priority weighting in all global discussions about biodiversity conservation. A thorough investigation of our flora has become an urgent necessity not only because of the economic and ecological importance of biodiversity but also of accelerated genetic erosion occurring as consequence of destruction of the forest and other habitat.

The term phytosociology was given by (Bran-Blanquet, 1932). It means that “an association”, in a plant community of definitive floristic composition (Flahault and Schroter, 1910). It deals with the science of plant communities or the knowledge of vegetation in the widest sense and includes all phenomena that touch upon the life of plants in social units. Phytosociological studies are important for two basic reason, namely mapping and ecological purpose (Causton, 1988). This is the study of the relationships of structure, community, composition and species diversity of forest with environmental factors which has emerged as a central issue in ecological and environmental sciences (Mataji, 2010 Sundarapandian and Subbiah, 2015). Among environmental variables, topography and soil are the most important factors affecting species and community variation as well as classification of plant communities. Though, many studies on the interaction between biodiversity and environmental variables in forest ecosystems have been recorded only few studies were conducted on composition and species diversity of forest communities of mountains and interpreted the relationships between major environmental factors and plant species (Smith, 1995).

1.2. Deforestation

Deforestation and degradation of forest land is still continuing at an alarming rate around the world, resulted in fragmentation of forest into patches and disappearance of that particular forest (Schaab *et al*., 2010), leads to serious environmental and biological consequences including loss of biodiversity (Whitmore and Sayer, 1992; Turner, 1996), and climate change at local, regional, and global levels (Myers, 1988; Lovett and Wasser, 1993; Laurance and Bierregaard, 1997; Prim and Raven, 2000). High rate of deforestation will result in loss of species, habitat and resources which is a threat of forest health (Battles and Fahey, 2000). Habitat fragmentation could be either by natural or due to anthropogenic disturbance. In which, fragmentation due to anthropogenic disturbance is more serious than that caused by natural disturbance (Laurance and Bierregaard, 1997), especially from species extinction point of view (Frankel and Soule, 1981; Prim and Raven, 2000).

1.3. Waste land

Human activities and animal disturbance are the prime cause for increasing the extent of waste land in India (Yadav, 1986). Wastelands are ecologically unstable, degraded and unutilized lands whose top soil has been nearly completely lost due to various biotic and abiotic constraints (Bhumbla and Khare, 1984; NWDB, 1986). It includes areas affected by water logging, ravine, sheet and gully erosion, riverine lands, shifting cultivation, salinity and alkalinity, shifting of sand dunes, soil erosion, extreme moisture deficiency, etc.

Naturally, the pressure on the land is often beyond its carrying capacity. Therefore, the productive lands, especially the farmlands in India are in the constant process of various degrees of degradation and are fast turning into wastelands which are nearly 68.35 million hectare (Trivedi, 2010). Land being a non-renewable resource and central to all primary production systems, it requires immediate attention.

Over the years, the country's landmass has suffered from different types of degradation caused by biotic and abiotic pressures. An ever increasing human population places enormous demand on land resources which are indispensable for a country like India with 2.4% of the world's geographical area supporting over 16% of the world's population. Further, the country has 0.5% of the worlds grazing lands but has over 18% of world's cattle population. The tremendous pressure on land has led to conversion of forest lands into urban and industrial areas (MRD, 2010). In the last 50 years, India has been deforested to the maximum. In order to restore the degraded non-forest wastelands and to maintain the ecological balance, Govt. of India had created the Department of Wasteland Development during 1992 under the Ministry of Rural Development. This is a significant development to restore such areas which are adversely affected and ecologically degraded.

1.4. Soil nutrients

Soils are composed of solids particles (minerals and organic matter) and pores which hold air and water. The "ideal" soil would hold sufficient air and water to meet the needs of plants with enough pore space for easy penetration of root, while the mineral soil particles would provide physical support and essential nutrients to plants (Chaudhari, 2013). To a large extent, soil texture determines the survival and growth rate of each species because the size of the soil particles size determines the water holding capability (Griggs, 2009). And soil organic matter which is an important indicator of soil quality plays a key role in nutrient cycling and helps to improve soil structure. It also functions as nutrient source, sinks and maintains environmental quality. A variety of soil nutrients in available form are essential for successful survival of seedlings and development of any species.

Elements such as carbon, nitrogen and hydrogen usually cycle through the organic material present in the forest, while potassium and phosphorous come from the mineral portion of the soil. Seedlings also require a variety of small quantity of nutrients such as calcium, iron, and sulfur. Each plays a role in the life cycle of the tree and must be present for survival and successful growth. In short supply, one or more nutrients can be the limiting factor to the growth and development of trees or stands.

1.5. Soil microorganism

Microorganisms are an essential part of living soil which is depending highly on the biological component of the soil ecosystem, influences plant health, environmental health, food safety and quality (Halvorson *et al*., 1997; Parr *et al*., 1992). Production of polysaccharides and other cellular debris made by microorganisms help in maintaining soil structure, as these materials function as cementing agents that stabilize soil aggregates. Thus, they affect water holding capacity, infiltration rate, crusting, erodibility, and susceptibility to compaction (Elliott *et al*., 1996). In some instances, changes in microbial populations or activity can precede detectable changes in soil physical and chemical properties, thereby providing an early sign of soil improvement or an early warning of soil degradation (Pankhurst *et al*., 1995). Soil bacteria and fungi play pivotal roles in various biogeochemical cycles (Molin and Molin, 1997; Trevors, 1998; Wall and Virginia, 1999) and they are responsible for the cycling of organic compounds. They form microbiotic crusts in intimate association with surface soil, which contribute significantly to the stabilization of soil towards erosion (Eldridge *et al*., 1994).

1.6. Leaf litter biomass

Litter fall is the most wanted waste in forest ecosystem. It plays a major role in determining the structure and function of the ecosystem. In forest ecosystem the litter fall to the floor is normally regarded as the major route through which the nutrient circulation occurs. Considerable amounts of plant nutrients absorbed from the soil are returned to it in the form of litter fall and further recycled (Egunjobi and Fasehun, 1972). It serves as source of mineral nutrients for various micro-organisms, fixing of atmospheric nitrogen, increases the water holding capacity, forms the greater part of nutrients and net production in the forest (Loria, 1999).

The integrity of an ecosystem is maintained by transfer of nutrients and energy through litter fall (Pandit *et al*., 1993). Litter fall not only increases soil fertility but also increases the infiltration and aggregation capacity of the soil. With fertile soil, the growth of protective cover vegetation is accelerated and eventually that reduces the surface runoff, erosion which further deploys soil nutrients.

Litter decomposition is controlled by three main factors viz., climate, litter quality and the nature and abundance of decomposing organism. Climate is the dominant factor in areas subjected to unfavorable weather conditions, whereas litter quality largely prevails as the regulator under favorable condition.

1.7. Eco-restoration

Eco-restoration is the process of assisting the ecosystem to recover from degraded, damaged or destroyed conditions or it is the return of a damaged ecological system to a stable, healthy, and sustainable state (Society for Ecological Restoration International Science and Policy Working Group 2004). The basic concept behind restoring any degraded land includes: having exact knowledge and monitoring about the actual condition of the problem, the causes and their impact and measures to conserve nutrients in degraded lands. There are so many approaches for the eco-restoration of degraded lands like mechanical and biological approaches, proper land use planning, soil amendments for enhancing productivity, improvement of shifting agriculture, afforestation and agroforestry.

The restoration, reclamation, and landscape management of waste land have became serious issues. Restoration has been poorly studied in tropical forest (Ewel, 1980; Kammesheidt, 1999; Kennard *et al*., 2002).The restoring capacity of any location is generally dependent on a range of factors, primarily water, topography, soil and climatic condition.

Project Ecolake situated at northeast borders of Ousteri lake, was started in 1979-80 to green about 40ha of severely eroded, pebbly, lateritic land and Cuddalore sandstone formation by Sri Aurobindo International Centre of Education. Restoration has been carried out by introduction of exotic species viz., *Acacia holosericea* (Australian wattle) and *Casuarina junghuhniana*. Later, vegetation mosaic consisting of TDEF elements and other native species were introduced with contour catchment ponds.

Various studies have been carried out in the surroundings of this area (Champion and Seth, 1968; Blasco and Legris, 1973; Meher-Homji, 1974; Parthasarathy and Karthikeyan, 1997; Ramanujam and Kadamban, 2001; Reddy MS and Parthasarathy, 2003; Ramanujam *et al*., 2007; Udayakumar and Parthasarathy, 2010; Ponnuchamy *et al*., 2013) which consists a rich and diversified vegetation, called TDEF showing high bio-resource values that were fragmented severely by anthropogenic pressures earlier. All these studies have emphasized conservation as a high priority.

Three decades of restoration effort by Sri Aurobindo International Centre of Education has produced remarkable results in the landscape and presently it consists of rich diversity of native as well as exotic plant species characteristic of TDEF. The exploration on the medicinal plants diversity (Krishnakumar *et al*., 2016) in this restored site is an evidence of rich floristic composition. The present study has been carried out in this restored landscape with the following objectives.

Objectives

The study addresses the following objectives:

- To determine the floristic diversity, floristic composition and regeneration status of the restored landscape.
- To investigate the effect of different vegetation types on the native plant diversity and species recruitment.
- To examine the differences in floristic assemblages and assess the relationship between the different plant life stages and individual vegetation types.
- To assess the relationship between each vegetation type and soil characteristics, soil microorganisms and leaf litter decomposition
- To analyze the individual relationships between soil physicochemical properties, soil microorganisms, and leaf litter decomposition with phytodiversity.

In this study, the following specific hypotheses were tested

- The diversity and structure of individual plant life-stages would differ between the different vegetation types.
- The species richness, density and basal area of the different plant life-stages would be similar among different vegetation types.
- The species richness and density of the different life-stages would be influenced by soil physicochemical properties, soil microbes and soil leaf litter decomposition.

CHAPTER-2

REVIEW OF LITERATURE

2.1. Phytodiversity

Phytodiversity is the products of dynamic interactions among different levels of integration within the living world. They are controlled by biotic and abiotic factors, such as environment, structural complexity of the landscape and habitat, ecological interactions amongst species, and past biogeographic events. This integrated approach towards biodiversity has led to new concepts such as functional ecology, biocomplexity, and ecosystem services (Gaston and Spicer, 2004; Lévêque and Mounolou, 2004).

2.2. Restoration

Restoration is one of the many types of management options that increase resilience to the effect of climate change to enhance or protect the ecosystem's natural ability and to respond to stress and change. It can provide the impact of a series of critical interventions to reduce climate change (Biringer *et. al.*, 2005). Plantations are often proposed as a means of rehabilitating or utilizing degraded lands (Pandey, 1997).

The global extent of plantation forests in 1990 is estimated at around 135 million ha (Gauthier, 1991; Pandey, 1995). About 75% of these plantation forests are in temperate regions and about 25% in the tropics and subtropics. In 1995 the global area of plantation forests was about 123.7 million hectares, approximately 3.5% percent of global forests (FAO, 1995). Asian region has the largest proportion of plantation forests, with 45 percent of the total forest area. Each of the five countries including China, United States, Russian Federation, India and Japan has established more than 10 million hectares of plantation forests. Globally, the dominant forest plantation genus is *Pinus* in subtropics. *Eucalyptus* spp are most common tropical forest plantation species in Brazil and India. Most plantation forests have been established as even-aged monoculture crops of trees with the primary purpose of wood production (Evans , 1997).

Restoration with exotics species

Acacia species are widely distributed throughout the tropical and subtropical regions of the world. They have been called the most successful survivors in arid and semi-arid region, and possess most of the features required to withstand severe climatic conditions (El-Amin, 1976; Ibrahim, 2003). *Acacia auriculiformis,* a leguminous tree native to Australia, Indonesia and Papua New Guinea, has been introduced and grown in several parts of Asia for fuel wood, erosion control and ornamental purposes. It is known to be adaptable to a wide range of soils and environmental conditions (Pinyopusarerk, 1990). In India, the species has been used extensively in afforestation programs especially in degraded wastelands for many decades. *Acacia* in pure plantations, under the Social Forestry Scheme, occupies an area of about 4,000 ha in Kerala. According to (Jayaraman and Rajan, 1991) the performance of this species (in terms of yield) in the state was exceptionally good when compared to many other parts of India or the continent but it is essential to understand the litter dynamics, primary production and nutrient cycling in plantations. *Acacia holosericea* was introduced in 'Ecolake' for first time in wasteland rehabilitation project in Pondicherry, South India and showed a profuse natural regeneration capacity from seeds (Das, 2001).

Casuarina equisetifolia subsp. *Equisetifolia* and *Casuarina junghuhniana* is a nitrogen-fixing tree of considerable social, economical and environmental importance in tropical, subtropical and littoral zones of Australia, Asia, Pacific and Africa. It is commonly used in agroforestry ecosystems for soil stabilization and reclamation work (Pinyopusarerk and House, 1993; Pinyopusarerk *et al*., 1996; Pinyopusarerk and Williams, 2000).

Restoration with native and exotic species

The Tropical Dry Evergreen Forest (TDEF) is a special type of vegetation found along the Coromandel Coast of eastern India. It constitutes only 0.01% of total geographical area of India due to rapid urbanization. This type of vegetation is adapted to survive months or sometimes years of relative drought and short periods of intense rain (Hunneyball, 2003). The TDEF have been reported from varied soil types including red ferruginous and alluvial deposits of Cuddalore sandstone formation and alluvial sandy loam (Parthasarathy and Sethi, 1997). The TDEF on the Coromandel coast of India, which occur as patches, are short-statured due to different levels of disturbance in this highly populated coastal region over the years (Venkateswaran and Parthasarathy, 2005; Mani and Parthasarathy, 2006). This forest is further threatened and fragmented into patches. Only about 4-5 % of the original TDEF patches exist today (Blanchflower, 2003). Most of the tropical dry deciduous and evergreen forest ecosystems have been suffering on a large scale basis for many centuries due to deforestration and degradation which involve cutting, browsing, over grazing, agricultural expansion, logging, burning, fire wood collection, charcoal making, mining, development of new settlements etc (FAO, 2006).

2.3. Regeneration

(Harmer, 2001) defined Natural Regeneration as the establishment of trees from seeds that fall and germinate *in situ*. Plants regenerate not only from seeds but can regenerate from vegetative part too, i.e. stumps (stools) (Evans, 1992) or root stock (Whitmore, 1982). Presence of sufficient number of seedlings, saplings and young trees in a given population indicates a successful regeneration (Saxena and Singh, 1984; Uma Shankar, 2001). Therefore understanding the patterns of regeneration enables to undertake proper management plan and in return it will help to utilize a given forest ecosystem wisely and sustainably. Several factors can influence natural regeneration, for instance, (Calegario, 1998) suggested that successional stages determine the interacting climatic as well as biotic, edaphic, physiographic and anthropogenic factors. According to (Vieira, 2006) high proportion of small seeded, wind-dispersed, plants have high ability of sprouting after disturbance, and relatively simple community diversity and structure which confer a high potential for seasonally dry tropical forests.

Various abiotic factors such as climate, season, time of canopy gap creation, shapes and sizes of disturbance patches etc. govern the dynamics of the forest, which influence the regeneration of woody species (Sukumar *et al.*, 1992). Khan *et al.* (1986, 1987) studied the interactive influence of biotic and abiotic factors on regeneration of the tree species and observed that density of larger girth class individuals were greater in undisturbed forests (sacred groves) than in disturbed ones. Survival and fine scale habitat characteristics of tree seedlings with regard to micro-environmental variations have been studied by (Augspurger, 1984) and Collins (1989). It has been observed that seedling survival rates were least during the first growing season and greater in subsequent years (Jones *et al.*, 1994; Tanaka, 1995).

Lieberman and Li (1992) observed that germination and mortality were seasonal in their distribution, and mortality was highest in dry periods in a tropical dry forest in Ghana. Whitemore (1982), Fetcher *et al.* (1983), Burton and Mueller-Dombois (1984), Connell *et al.* (1984), Canham and Marks (1985), Clark *et al.* (1996) have studied the effect of light on survival and growth of tree seedlings, while Sorensen and Ferrel (1973) have investigated the role of temperature on the growth of juveniles.

Seedling establishment and growth are influenced by soil moisture (McLead and Murphy, 1977; Lawrence and Ochel, 1983; Potvin 1993; Ashton *et al.*, 1995), soil nutrients (Campbell, 1982; Rao and Singh, 1985), thickness of the litter layer (Clark and Clark, 1989; Facelli, 1994; Molofsky and Augspurger, 1992; Seiwa, 1997), and canopy cover (Streng, *et.al.*, 1989; Titus, 1990; Harrington, 1991; Crow, 1992). Biotic factors like, herbivores (Forget, 1997; Wada, 1993; Ida and Nakagoshi, 1996), fungal infection or pathogen (Mueller-Dombois *et al.*, 1983; Khan and Tripathi, 1991; Sahashi *et al.*, 1994) and inter-species competition (Nakashizuka, 1988; Callaway, 1992) also affect the seedling demography. Disease and predation of the seeds and seedlings play a key role in seedling emergence and establishment (Schupp *et al.*, 1989). Several authors have studied the regeneration of a number of tree species in different climatic zones of the world (Matsuda *et al.*, 1989; Streng *et al.*, 1989; Leemans, 1990, 1991; Lieberman and Li, 1992; Ellison *et al.*, 1993; Lavorel *et al.*,1993; Espelta *et al.*, 1995; Hiroshi, 1995; Shibata and Nakashizuka, 1995; Boerner and Brinkman, 1996; Calabuig *et al.*, 1996).

Many studies have emphasized on natural regeneration of forests related to the spatial structure of different trees in different forest types across the world (Kigomo *et al.*, 1990; Sabogal, 1992; Annika, 1993; Hornberg *et al.*, 1995; Aun and Oshima, 1996) however, most of the studies have been carried out in temperate forests (Miles and Kinnarid, 1979). Ichikawa and Komizama (1989) studied the annual fluctuation of population density of seedlings and saplings in an evergreen coniferous forest on Mount Ontake (Japan). Kuusipalo *et al.*, (1996) studied the population dynamics of tree seedlings in a mixed *Dipterocarpus* rainforest over a period of two years in Kintap, Indonesia.

Natural regeneration in tropical forests is comparatively less studied and made less attention on it. Recently, (Forrester *et al*.2007 and Aerts and Honnay, 2011) have made attempts to evaluate regeneration status of tropical forests. In the natural forests of India, various studies were conducted by several workers on seed characteristics, seed germination, seedling growth and their population dynamics in response to various environmental conditions and disturbance (Rikhari *et al.*, 1991; Pandit *et al.*, 1998; Bhuyan, 2002, Davidar *et al*., 2007; Bouria *et al*., 2016).

2.4. Phytosociology

Phytosociology has been used as a tool in studying the vegetation over long period to show stages of development and changes in physiognomy. It is useful to assess the extent of invasion (native and exotic) of plant species, which play a very important role in biological society's classification, determining changes in vegetation, vegetation distribution, modeling potential distribution of species, communities and habitat quality (Pourbabaei *et al*., 2006). The analysis of vegetation in different communities of the world have been done by a number of workers (Lee *et al.,* 1990; Lieberman *et al.*, 1996; Killen *et al*.,1998; Bhuyan, 2002).

In India, phytosociological investigations have been carried out by many workers in different aspects (Tripath, 2002). Quantitative plant biodiversity inventories of Indian tropical forests are available from various forests of Western Ghats (Sukumar *et al.,* 1992; Ganesh *et al.,* 1996; Pascal and Pelissier, 1996;

Parthasarathy and Karthikeyan, 1997a; Ayyappan and Parthasarathy, 1999). Meanwhile the Eastern Ghats is poorly studied, except the study made by Kadavul and Parthasarathy (1999a) in the Shervarayan hills and Kadavul and Parthasarathy (1999b) in the Kalrayan hills.

Initially, phytosociology of Tropical Dry Evergreen Forest (TDEF) was investigated by Meher Homji (1973, 1974). Recent studies focused on sacred groves, with remnant patches of TDEF include: Parthasarathy and Karthikayen (1997) in Thirumanikuzhi, Parthasarathy and Sethi (1997) in Puthupet, Venkateswaran and Parthasarathy (2003) in Arasadikuppam (*Tricalysia sphaerocarpa*, *Strychnos nuxvomica* and *Dimorphocalyx glabellus*). Parathasarathy *et. al.*, (2008), Udayakumar and Parathasarathy (2010) have recorded the plant association dominant species to their studied grove. Mani and Parathasarathy (2005) recorded the association of species from coastal (*Memecylon umbellatum* and *Pterospermum canescens*) and inland groves (*Chloroxylon swetinia*, *Strychnos nux-vomica* and *Albizia amara*) from Cuddalore and Pudukkottai districts of Tamil Nadu.

The studies on sacred groves in and around Pondicherry by Kadamban (1998), Kadamban *et al*. (2004), Ramanujam and Kadamban (2001), Ramanujam and Praveen Kumar (2003), Krishnan 2004, Ramanujam *et al.* (2007), Ramanujam *et al*. (2009), Praveen Kumar (1999, 2011), Ramanujam *et al*. (2012) have recorded the dominant species such as *Memecylon umbellatum*, *Atalantia monophylla*, *Garcinia spicata*, *Borassus flabellifer*, *Glycosmis pentaphylla*, *Syzygium cumini*. Whereas Balachandran (2016) studied from 85 TDEF sites for the first time covering all the woody habit and habitat and proposed *Grewia rhamnifolia* and *Hugonia serrata* for climbers, *Memecylon umbellatum* and *Phoenix pusilla* for shrubs and *Drypetes sepiaria* and *Pterospermum suberifolium* for trees as dominant species.

2.5. Soil nutrient

Soil nutrient availability has an important relevance for understanding the processes in forest ecosystems. It depends highly on the decomposition of organic matter and subsequent release of material in the available forms by mineralization, converting organic compounds into inorganic forms. The major factors controlling decomposition in forest ecosystems are soil moisture and temperature. Thus nutrient availability in forests can be affected by forest management, as it may alter these factors (Likens, 1995). Nutrient recycling play a major role in regulating the nutrient availability. For example, Pokhriyal *et al*. (1987) had reported a positive correlation between soil nitrogen and leaf litter addition by Sal species plantation. The Syudie of Arun Prasad *et al.* (1991) and Balamurugan *et al*. (1999, 2000) indicated significant increase in the available nitrogen status in the soils under vegetative cover as compared to cultivated field and open space**.** Similar inferences were also drawn by Hosur and Dasog (1995), Contractor and Badanur (1996), Mongia *et al*. (1998), Balamurugan *et al*. (1999) and Verma and Shadangi (2004).

Evidences are available on the effect of vegetation with the availability of K due to afforestation (Balamurugan *et al*., 1999). Similar inferences were drawn by Arun Prasadsad *et al.* (1991) in the soils added with subabul leaves, *Eucalyptus* plantation by Srivastav (1993) and Mongia *et al.* (1998), *Gmelina arborea* and Teak by Chavan *et al*. (1995). However, such an increase is always observed in the surface soils due to the limited interaction of the leaf litter addition with the top soil. Geetha and Balagopalayar (2005) have reported that total nitrogen content of soil grown with Teak and *Eucalyptus* was 15 and 27 percent lower than those soils with natural forest. *Casuarina* ground cover may increase soil nitrogen and phosphorus (Richards *et al*., 2010). Aggarwal *et al*., (1990) have reported that natural forest possesses higher total

P content than the afforested area. Soil N was influenced by rain fall modality and soil texture (Yayneshet, T and Treydte, 2015). As regards to micro nutrient status of the soils under forest vegetation, there were only limited works carried out in these aspects. However, it is logical to interpret that main mechanism of micronutrients addition under forest environment must be only through the litter recycling. Hence the transformation and chemistry of micronutrients under natural vegetation or under afforested area can be linked to leaf litter addition.

Plant productivity on alkaline and calcareous soils frequently limited by the accessibility of P, Fe, Zn, Mn, Cu (White and Greenwood, 2013). Whereas Mongia *et al*. (1998) reported decrease in the zinc concentration in the soils grown with *Casuarina equiestifolia* and *Prosophis juliflora*. On the similar line, increase in the manganese and iron content was reported by Harinder *et al.* (1997) and copper by Mongia *et al*. (1998). Ambasht made a study on conservation of soil through plant cover of certain alluvial slopes in India. According to Sivaram (2006) analysis in restoration site at TDEF of Southern Coromandal Coast, *Acacia coli* and *Casuarina junghuhniana* had an impact on the spectacular improvement in the soil properties followed by natural vegetation.

2.6. Leaf litter

Litter fall is one of the most important components in soil sustainability. It serves as source of nutrients for various micro-organisms, responsible for the release of mineral nutrients and fixing of atmospheric nitrogen. It plays a major role in determining the structure and function of the ecosystem. Decayed litter fall increases the water holding capacity of the soil. Very likely, it forms the greater part of nutrients and net production in the forest (Loria, 1999). Litter decomposition is controlled by three main factors *viz.*, climate, litter quality and the nature and abundance of decomposing organisms.

An average of 65 percent of above ground production, of deciduous forests in tropical countries is transferred into litter (Lang, 1974). In tropical forest, litter decomposition is more rapid than temperate forest ecosystem so that tropical forest ecosystems are considered as vast reservoir of energy and nutrients when compared to temperate forest. Along the Coromandel Coast of India, litter productions in the tropical dry evergreen forests are higher because they are located in drier region and receive dew as a source of moisture for about six months in a year (Pragasan and Parthasarathy, 2005).

Litter enriches the soil with organic matter (Gill and Abrol, 1986) and essential nutrients (Gill, 1985). Its accumulation on the surface also checks weeds, protects the soil from the erosive impact of rain and reduces surface run-off water (Bell, 1973). A good number of works have been done on leaf litter concentration and nutrients return in plantation of *Eucalyptus* species (Sharma and Pande, 1989). The reports are also available for tropical dry evergreen forests (Viasalakshi, 1993), tropical deciduous forests (Joshi, 1993, Singh and Mishra, 1979; Pandey and Singh, 1981) and agroforestry system (Bhardwaj and Gupta, 1993).

In recent years, researchers have only specifically begun to examine potential interactions among leaves of different species during decomposition. However, these studies have not shown consistent effects of litter mixing on decomposition rates, which may be positive, negative, or neutral (Hansen, 2000; Hector *et al.*, 2000; Wardle *et al.*, 2003; Polyakova and Billor, 2007).

2.7. Soil microbes

Soil microorganisms play an important role in determining plant productivity and responsible for recycling of nutrients (Wardle, 1996). The diversity of microbes has been recognized as a biological indicator of soil quality and is related to other factors such as soil fertility enhancement (Robin *et al*., 1995), climate (Dyer *et al*., 1990), soil structure (Wright and Upadhyaya 1998; Dodd *et al*., 2000), soil texture (Wardle, 1992; Hassink, 1994; Bauhus *et al.*, 1998) soil moisture (Taylor *et al*., 1999), soil cat-ion availability (Diaz-Ravina *et al*., 1993), organic matter content (Taylor *et al*., 1989, Zak *et al*., 1990 a), available nutrients production (Moscatelli *et al*., 2001), plant productivity (Zak *et al*., 1990;Timonen *et al*., 1996) and plant health (Srivastava *et al*., 1996, Filion *et al*., 1999, Smith and Goodman 1999).

Microbial biomass represents relatively a small standing stock of nutrients compared to soil organic matter and aboveground biomass of trees, but it can act as a labile source of nutrients for plants, a pathway for incorporation of organic matter into the soil, and a temporary sink for nutrients (Zogg *et al*., 2000). Soil microbial biomass can act as a significant source or sink for soil nutrients and potentially influence how much N is retained within soil organic matter. It is important to understand the controls on microbial abundance, turnover, and nutrient sequestration.

Microbial diversity enhances soil quality by affecting soil agglomeration and increasing soil fertility. Recent studies have shown that alteration in soil microbial community alters composition of vegetation due to invasion of non-native plant species (Kourtev *et al*., 2002; Wardle *et al*., 2004; Wolfe and Klironomos, 2005; Hawkes *et al*., 2006), along with changes in soil physical properties (Ehrenfeld, 2003). Most studies on nutrient cycles in red soils have focused on the organic matter and total biomass in relation to soil fertility status (Ye *et al*., 1997: Khan *et al.*, 1998:

He *et al*., 1997), but there have been no studies on microbial community structure or ecology of red soils. Usually red soil is highly weathered, eroded due to lack of well developed top soil resulting in low fertility.

According to the reports of Sudhakaran *et al.*, 2014 in TDEF sites of southern Coromandel Coast, India the number of bacterial population was highest, followed by phosphobacteria, fungi, *Azotobacter*, *Bacillus* and *Rhizobacterium*. Consequently, the soil enzymes are very essential for maintaining soil health as they play a vital role in decomposition of organic matter, converting plant unavailable nutrient to plant liable nutrient form and nutrients (N, C, S & P) cycling in tropical dry evergreen forest. More amounts of plant litter fall and fine root biomass are the initial sources of cellulase and β–Glucosidase activities (Visalakshi, 1994; Mani and Parthasarathy, 2007). Actinomycetes population was significantly correlated with saccharase activity and positively correlated with xylanase activity. These enzymes are controlling factors of organic matter decomposition and mineralization in tropical dry evergreen forest soils (Ajwa and Tabatabai, 1994). Actinomycetes are the primary source for organic matter decomposing in forest soil. Saccarase activities in tropical dry evergreen forest soil are mainly influenced by Actinomycetes population (Wriston, 1971). Mycorrhizal colonization was the main sources of Acid and Alkaline phosphatase in the forest soil.

The present study was an attempted to record and compare the general community attributes in natural and planted forest ecology, regeneration and diversity status, nutrient recycling and microbial biomes in a restored site near Puducherry.

Moreover, due to restoration process of over three decades, several vegetation types or habitat niche were scattered within this restored site. However there was no complete information on floristic diversity, structure, regeneration and species turnover among these different vegetations. Further, there was no information available on the status of regeneration of different-life stages that includes native and exotics in relationship with soil physicochemical properties, soil microbes and leaf litter decomposition. Thus, this is the first study to understand the pattern of floristic diversity (includes native and exotics) of different life-stages in response to different vegetation types, soil physicochemical properties, soil microbes and leaf litter decomposition after three decades of restoration

CHAPTER-3
METHODOLOGY

3.1. Study area

The Coromandal coast of South India along the Bay of Bengal extends from Ramanathapurum in South Tamil Nadu to Visakapattinam in Andra Pradesh. This belt harbours several patches of tropical dry evergreen forest (TDEF) vegetation (Champion, 1936; Meher-Homji, 1974). The present study site (Project Ecolake), a part of coromandel coast vegetation, is situated 10 km west of Puducherry town near Oussuteri (11º 57’ 8.3”N, 79º 45’ 57.2” E and 40m asl) towards inland from the coastal regions (Figure,1). It spreads over 160ha of which 40ha called ‘Merville’ have been afforested through eco-restoration from a barren eroded gulley landscape with red ferralitic soil over a period of more than 30 years by the involvement of Sri Aurobindo International Centre of Education.(SAICE).

3.1.1. Geology of the soil

Geologically, the entire study area is part of the Cuddalore sand-stone formation of Miocene period (Meher-Homji, 1974, 1986). The soil in the Coromendel Coast sector under study is not uniform. It is underlain by geological formation ranging from age of Archean to Quaternary. The sediments are mainly clay, clay stone, silt, silt-stone, limestone, sand, sandstone and gravel (Meher-Homji, 1974).The soil is relatively light, ferruginous alluvium, rich in quartizite a part of Marakkanam-Pondicherry sector and is littered with pebbles; at Oussuteri and Thiruvakkarai area, it is ferruginous sand-stone. Only the top 20 cm of top soil is valuable for agriculture and the terrain is excessively impoverished in organic matter. Various stages of transitition between the coastal sand to hard ferralite and clayey alluvium are seen along the tract. Though the climate varies very little, the soil shows variations in salinity, soil texture, pH and nutrients status.(Ramanujam, 2007).

3.1.2. Climate

In the last thirty years (1982 - 2015), mean annual precipitation of 1392 ± 356 mm (max= 2043, min= 845, median= 1351) and 57 ± 10 rainy days (max= 82, min= 37, median= 56) have been recorded. The rainfall is highly seasonal, 63% of it occurrence between October and December *i.e.* retreating North-east monsoon. The monthly mean maximum and minimum temperature were 36.4 ± 1.6°C (max= 39, min= 32, median= 36.6) and 21.5 ± 0.9°C (max= 24, min= 20.1, median= 21.3) in June and January respectively. Six to eight months of the year are dry. The mean annual rainfall is 1371mm for the period 1982 and 2015.

3.1.3 Vegetation

The sites, originally with little patches of remnant plants and mostly sand-stones, have been eco-restored over a thirty-year period with a multi-pronged approach. A control plot is maintained in the first site that reflects the landscape of thirty-years ago. Eco-restoration comprised of active human intervention through the introduction of drought tolerant nitrogen fixing species and Tropical Dry Evergreen Forest (TDEF) elements found in the canyons of the original fragmented landscape. The other activities were construction of check dams along the gullies to prevent soil erosion and to improve ground water, simultaneous development of nurseries for propagating plants from various regions. As a result, the introduced TDEF species established themselves and naturally regenerated along the thickets. Lowland herbaceous species also established themselves as a green cover at ground level.

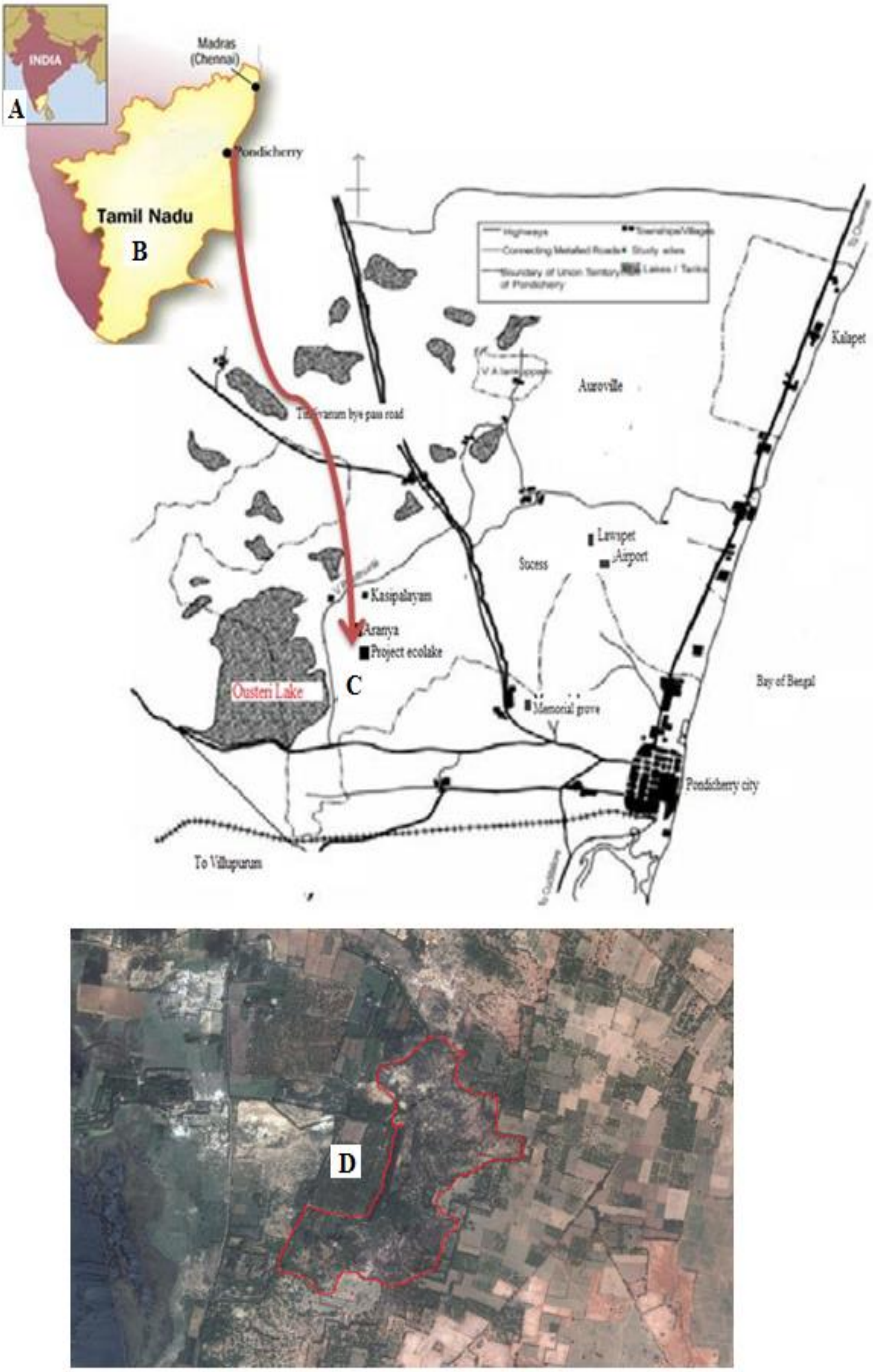


Figure-1. Location Map of the Study Site (A. India, B. South India Including Puducherry, C. The Study Site, D. Satellite View of Merville)

Figure -2. Different stages of restoration process of the study area and different habitats (a-f)

3.2. Phytodiversity

Quantitative survey was carried out from 2012 to 2015 covering the entire study area. Random samplings in all three vegetation types were made. The plot with different landscape was considered during the plot selection. Totally eighty five square quadrates of 10 m x 10 m were laid in three vegetations (*Acacia* spp, *Casuarina* spp and mixed vegetation). We assigned every individual in each census following the classification of Peters (2003) and Zhu *et al.* (2015). The categories are seedling where individuals up to 30 cm height from ground; sapling from ≥ 30.1 cm tall to ≤ 4.00 cm gbh; juvenile stage ≥ 4.1cm to ≤ 10cm gbh and adult stage ≥ 10.1 cm gbh. Herbaceous plants were identified and their abundance (number of individuals) was record separately.

Recruitment and regeneration were recorded in terms of (a) seedling count (b) sapling count (c) Juvenile count and (d) Adult individuals' count.

3.2.1. Phyto-sociology

The term plant sociology was coined by (Bran-Blanquet, 1932). It deals with the science of plant communities or the knowledge of vegetation in the widest sense and includes all phenomena that touch upon the life of plants in social units. The basic unit of plant sociology is a plant Association. "An association is a plant community of definitive floristic composition (Flahault and Schroter 1910). This can be either developmental or climax in status. The present study is to ascertain the status of plant communities at project ecolake.

3.2.2. Floristic composition

The number of species or species richness in a species assembalage is a significiant measure of biodiversity at the habitat level (Bunge and Fitzpatrick, 1993; Colwell and Coddington, 1994; Mao and Colwell, 2005).

3.2.3. Species richness

Species richness is the number of species represented in an ecological community in landscape or region. It is the simplest way to describe community and regional diversity (Magurran, 1988).

3.2.4. Diversity measure

Number of observed species, species richness, species evenness, Important Value Index (IVI), Diversity indices such as Shannon-Wiener Index ‘H’ (Shannon and Weiner, 1963), Simpson’s Index ‘D’ (Simpson, 1949) were employed.

3.2.5. Relative Diversity

Relative diversity is the number of species per family or genera found in each habitat. The relative diversity of each family reveals the dominant families and the structure of the plants community within (Keel et al. 1993)

$$\text{Relative diversity} = \frac{\text{Number of species in genus/family}}{\text{Total number of species}} \times 100$$

3.2.6. Shannon-Wiener Index

The Shannon diversity (H) and evenness (E) indices are calculated as a measure to incorporate both species richness and species evenness (Magurran, 1988). The Shannon diversity index (H) was calculated using the following equation.

$$H' = -\sum_{i=1}^{s} Pi \text{ In } Pi$$

Where S = The number of species

Pi = The proportion of individuals or the abundance of the species expressed as a proportion of total cover

Ln = Log base n

The value of Shannon diversity index is usually found to fall between 1.5 and 3.5 and only rarely surpasses 4.5 (Magurran, 1988)

3.2.7. Evenness

Evenness (E′) was calculated from the ratio of observed diversity to maximum diversity (Magurran, 1988) using the following equation.

$$E' = \frac{H}{H\,max} = \frac{H}{In\,s}$$

Where $H\,max$ is the maximum level of diversity possible within a given population, which equals in (number of species). Magurran, 1988) explained that E ranges normally between 0 and 1, where 1 representing a situation in which all species are equally abundant.

In terms of species abundance:

$$\mathrm{H} = \log N \frac{1}{\mathrm{N}} \sum_{i=1} (Pilog\ p)n$$

3.2.8 Simpson index

For species dominance, the Simpson index is calculated using the following formula

$$D=\left(\frac{ni(ni-1)}{N(N-1)}\right)$$

Where ni = the number of individuals in the species

N = the total number of individuals (Magurran, 1988)

Simpson index heavily weighted towards the most abundant species in the sample while less sensitive to species richness. As D increases, diversity decreases therefore Simpson’s Index usually is expressed as1-D or 1/D (Magurran, 1988). In this study 1-D is used.

3.2.9. Population structure

Structural analysis involves basal area, bio-volume, density, girth and height distribution among the plant species. Height and girth data of woody species and sapling were divided into classes. Structural analysis was made for all the quadrates of 10m x 10m with the woody species data (gbh≥10cm) and (gbh≥4cm to≥10cm). Diversity was analyzed separately for the woody species, sapling, and seedling. The height was measured with clinometers and girth at breast height level (GBH) with measuring tape. Phytosociological parameters (Density, frequency, basal area, relative density, relative frequency, relative basal area and Bio-volume were analysed by following the methods of Cottam and Curtis (1956).

3.2.10. Basal area

$\pi = 3.143$

radius = GBH / 2 π

Diameter = GBH / π

Area = $\pi(\text{Radius})^2$

Basal area = $(\text{GBH}^2)/\ 4\,\pi$

3.2.11. Biovolume

It is the above ground mass of a tree calculated by using d^2h

Bio volume = d^2h

Where d= diameter at breast height and H=height of the tree.

Values thus calculated for individual trees were added to get the bio-volume for the plot, which is expressed as per hectare basis (Pascal, 1988).

3.2.12. Quantitative characters

The vegetation data were tabulated for frequency, density, abundance, relative frequency, relative density, relative abundance, relative dominance, IVI.

Abundance:

It is an appreciation of the number of individuals of different species in a community per quadrate of occurrence. Since actual counting has been made, the rough scale of very rare, rare, infrequent, abundant and very abundant have been omitted. In short, abundance may be calculated as

$$\text{Abundance} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrats in which the species occured}}$$

$$\text{Relative abundance} = \frac{\text{Abundance of a species}}{\text{Total abundance of all species}} \times 100$$

Frequency:

This refers to the degree of dispersion of individual species in an area and is usually expressed in terms of percentage occurrence. This can be calculated as follows:

$$\text{Frequency (\%)} = \frac{\text{Number of quadrates of occurrence of species}}{\text{Total no. of quadrats studied}} \times 100$$

$$\text{Relative frequency} = \frac{\text{Number of occurrence of the species}}{\text{Number of occurrence of all species}} \times 100$$

Density:

Like abundance this is also an expression of numerical strength of a species. It can be calculated as:

$$\text{Density} = \frac{\text{Total number of individuals of a species in all quadrates}}{\text{Total number of quadrates studied}}$$

Both abundance and density are thus calculated by counting the number of individuals in the sample area

$$\text{Relative Density} = \frac{\text{Number of individuals of the species}}{\text{Number of individuals of all species}} \times 100$$

Dominance:

This is primarily concerned with the control over the environment involving the number of individuals or the extent the volume- covered or occupied by individuals of each species. The cover is an expression of the area covered or occupied by different species and is usually expressed in percentage. The cover can be studied both at the canopy level and at the basal. The basal cover is regarded as an index of dominance of a species. Higher the basal area greater is the dominance. The average basal area is calculated out of the average diameter of the emerging stem.

Relative dominance:

It is the coverage value of a species with respect to the sum of coverage of the rest of the species in the area.

Important value index (IVI):

Important value index (IVI) was calculated by adding the figures of relative frequency and relative basal area for that species for a maximum of 300. It gives the total picture or share of a species (SVI) in a community and can be estimated for family (FVI) too.

IVI= Relative frequency + Relative Density + Relative dominance

3.2.13. Herbarium

Periodical visits have been made to the study site and the plants were identified at species level in the field. For species that proved difficult to identify in the field were collected, prepared dried properly by following Forman and Bridson (1989) method and the sheets were deposited at AURO herbarium, Auroville. All the species were duly identified with the help of local floras (Gamble, 1915 - 1935; Matthew, 1982 - 1987) and cross checked with Herbarium-French Institute of

Pondicherry (HIFP) and AURO herbarium. For family names Bentham and Hooker system of classification was followed.

3.3. Soil analysis

The topography of the study area is highly undulating with severely eroded mostly pebbly, lateritic sandstone with gulley plugs, ravines and deep trenches. An extensive practice of restoration has been carried out in project ecolake in the last three decades. However no special attempt had been made, from inception of the project, to level the area or to disturb the topography by any means. Hence the present investigation has been carried out to quantify the changes that had occurred over a period of more than three decades in the soil properties due to afforestration programe. The selection of the soil site was based on the type of vegetation in a micro ecological environment that was introduced over years in that locality.

3.3.1. Collection of surface soil sample

The soils were dug to a dimension of one foot by one foot and to a depth of 0-40cm. The soil samples were collected from the sampled plots in different vegetation types and microhabitats viz; *Acacia* vegetation, *Casuarina* vegetation, mixed vegetation, grass vegetation, wetlands, gully plug surface soil. Ten samples were collected from each soil site. The soil samples were dried in the shade after removing plant debris, small stones and pebbles. About 300 grams of soil from each site was taken in pure polythene bag, brought to laboratory and subjected for further analysis.

3.3.2. Detailed analytical methods employed in soil analysis

The major part of physical and chemical properties of the soil was carried out at the Soil Research Laboratory of the Environment Monitoring Service (EMS) Auroville. Standard laboratory procedures were followed in the analysis for the selected physico-chemical properties in the study such as pH (at 25^{o}C) with ph digital meter; Electrical conductivity using glass electrode in the' ELICO' EC meter (Jackson 1973); Bulk Density (Cylindrical method); Water Holding capacity (Cylindric method); Particle density, Organic carbon (Chromic acid wet digestion method -Walkley and Black, 1934); Available Nitrogen (Alkaline Permanganate method- Subbiah and Asija 1956); Available Phosphorous (Colorimetric method using 0.03N NH4F and 0.02N HCL Olsen *et al.*1954); Available Potassium (Flame photometer method using neutral normal ammonium acetate of Standford and English 1949); Available Calcium, Available Magnesium, Available Sulphur ($CaCl_2$ extraction method Williams and Steinbergs (1959); Available Zinc (Atomic Absorbtion spectrophotometer method following Varian model spectra 200, Lindsay and Norvell, 1978); Available Copper, Available Iron, Available Magnesium, Available Boron, Total Nitrogen (Macrokjeldahl method, Piper, 1966); Total phosphrous (Vanadomolybdate phosphoric acid yellow colour method, Jackson 1973); Total Potassium (Perchloric nitric acid extract Jackson, 1973), Total Sodium (Perchloric nitric acid extract, Jackson, 1973); Cation exchange capacity (neutral normal NH4OAc leaching and washing with C2H5OH, Schollenberger and Dreibers, 1973); Chloride and Calcium carbonate (Spectrophotometer at 340nm).

3.4. Soil microbes analysis

3.4.1 Collection of surface soil sample

The soil samples were collected from the sampled plots in different vegetation types and microhabitats viz; *Acacia* sp, *Casuarina* sp, mixed vegetation, grass vegetation, wetlands, and gully plug surface soil. The soils were dug to a dimension of 1 foot by 1foot and to a depth of 0-40cm and ten samples were collected from each soil site. The soil samples were dried in the shade, and plant debris, small stones and pebbles were removed. About 300 grams of soil from each site was taken in pure polythene bags brought to laboratory and used for further analysis. The methodology for determining the microbial status of organic manures is described below. Several microbiological laboratory techniques have also been used as proposed by Motsara *et.al*. (1995). Apparatus: Autoclave, Hot air oven, Incubators, Inoculation chamber or laminar air flow cabinet. Sterile Petri plates, pipettes, sterile water blanks (90 ml) etc. 250 ml conical flask and 50 ml test tubes, Bacteriological filter. Colony count or magnifying lens and medium

3.4.2. Isolation of soil microbes

Media used for preparation

Different culture media have been used to isolate the microbes. Nutrient agar was used for the culture of bacteria, Martin-Rose Bengal medium for the culture of fungi, Soil extract agar for the culture of *Actinomycetes*, Yeast mannitol agar for *Rhizobium*, Nutrient broth medium for *Pseudomonas*, Jenson's N-free medium for *Azotobacter* and Pikovskaya's medium was used for the culture of Phosphorous solublizer . Specific antibiotic was added to each medium for isolation of microbes. The composition of the media used is given below.

Composition of Nutrient agar medium

Peptic digest of animal tissue	5.00 g
Sodium chloride	1.50 g
Beef Extract	1.50 g
Yeast Extract	1.50 g
Final pH (at 25C) 7.4 +0.2	

Composition of Martin-Rose Bengal medium for soil fungi

This medium consists of solutions A and B. Their method of preparation and mixing is described below.

Dextrose	10.0 g
Peptone	5.0 g
KH_2PO4	1.0 g
$MgSO_4.7H_20$	0.5 g
Distilled water	1000 ml

Preparation of medium

Solution-A. Dissolve peptone, phosphate, magnesium sulphate in 1000 ml of distilled water. Add agar, dissolve and filter at 100. Add sucrose and cool to 60C. Adjust the pH to 5-5.5 using 1NHCl, then add 33.3 mg Rose Bengal and 20.0 g agar. Sterilize the medium at 121° C at psi pressure for 30 minutes.

Solution-B. Dissolve 3 g of streptomycin sulphate in 100 ml distilled water and sterilize through membrane filter.

Cool solution A, add 1ml of solution B and shake well. This gives 30 mg streptomycin/ml.

Composition of soil extract agar medium

Soil extracts	100.0 ml
Glucose	1.0 g
K_2HPO_4	0.5 g
Agar	15.0 g
Tap water	900 ml
pH	7.0-7.2

Preparation of medium

Soil extract is prepared by heating one kg of soil sample soil 1000 ml of tap water in an autoclave for 30 minutes at 15 psi pressure. A small amount of calcium carbonate is added and the soil suspension is filtered through a double filter paper. The filtrate is bottled and sterilized in100 ml quantities.

Dissolve the phosphate in tap water, add agar, dissolve and filter at 100° C. Add glucose and cool to 60°C, adjust the pH to 7.0-7.2 and sterilize at 15 psi pressure for 30 minutes.

Composition of yeast mannitol agar

Agar	15.00gm/lit.
Yeastextract	1.00gm/lit.
Mannitol	10.00gm/lit.
K_2HPO_4	0.50gm/lit.
$MgSO_4$	0.20gm/lit.
NaCl	0.10gm/lit.
Calciumcarbonate	1.00gm/lit.
pH at 25℃	6.8±0.2
Storage	Store between 8-25℃

Preparation :

Add 27.80 gm powder to distilled water. Bring volume to 1.0 liter and mix thoroughly.Gently heat and bring to boiling. Autoclave at 15 psi pressure at 121 ℃ for 15 minutes.

Composition of nutrient broth medium

Peptone	10.00gm/lit.
Beefextract	10.00gm/lit.
NaCl	5.00gm/lit.
pH at 25 °C	7.6 ± 0.2
Storage	Store between 8-25 °C.

Preparation :

Add 25.0 gm powder to distilled/deionized water.Bring volume to 1.0 liter and mix thoroughly.Gently heat and bring to boiling. Autoclave at 15 psi pressure at 121°C for 15 minutes.

Composition of Jenson's N-free medium

Sucrose	20.0g
K_2HPO_4	1.0g
$MgSO_4.7H_2O$	0.5g
NaCl	0.5g
$FeSO_4$	0.001 g
Na_2MoO_4	0.005 g
$CaCO_3$	2.0 g
Agar	15.0 g
Distilled Water	1000 ml

Preparation:

Dissolve phosphate magnesium sulphate, sodium chloride, ferrous sulphate, sodiummolybdate, calcium carbonate and sucrose in 1000 ml distilled water. Add agar, dissolve and filter at100° C. Cool and adjust the pH to 7.0 and sterilize at 15 psi pressure for 30 minutes.

Composition of Pikovskaya's medium

Glucose	10 g
$Ca_3(PO_4)_2$	5 g
$(NH_4)2SO_4$	0.5 g
NaCl	0.2 g
$MgSO_4$. 7H20	0.5 g
KCl	0.2 g
Agar	15 g
Yeast extracts	0.5 g
MnSO4	Trace
$FeSO_4.7H_20$	Trace
Distilled water	1000 ml
pH	7.0+0.2

Preparation :

Dissolved the ingrediants except glucose and $Ca_3(PO_4)_2$ in distilled water and add agar, dissolve and filter at 100°C.Add glucose and cool to 60°C.Adjust the pH of the medium to 7.0 and sterilize at 15 psi pressure for 15 minutes.

Preparation of tricalcium phosphate Strock Suspension: of 2.5% $Ca_3(PO_4)_2$ is prepard in 0.5% gum Arabic solution and pH is adjusted to 8.4.It is sterilized at 15 psi pressure for 30 minutes. For the preparation of plates 10 ml of this stock suspension of $Ca_3(PO_4)_2$ is added aseptically to 90 ml of the sterilized medium.

For isolation of microbes, One gram soil sample was serially diluted up to 10^{-7} from each sample. 1ml of serially diluted sample of each dilution was taken from each sample and inoculated into the petriplates by pour plate method. The petriplates were sealed and were kept under room temperature (25±2ºC) for 7 to 15 days.

Microbial population count

The colonies in the isolation plates were counted using a colony counter and recorded at the end of the incubation period. The Colony Forming Unit (CFU/ml or gram) was calculated using the following formula.

$$\text{CFU/ml} = \frac{\text{(No. of colonies x Dilution factor)}}{\text{Volume of culture plate}}$$

3.5. Leaf litter analysis

3.5.1. Collection of leaf litter sample

The changes that had occurred over a period of more than three decades in the litter due to afforestration program were studied. No external manures or fertilizers were added to this area. Hence, the leaf litter that had accumulated below the plant canopy was collected without much disturbance to the soil surface. Ten leaf litter samples were collected from 1m x 1m plot within 10 m x 10 m square plot at *Acacia*, *Casuarina*, *Eucalyputus*, *Bamboo*, grasses and mixed vegetation sites. The collected litters were dried and stored in paper bags.

3.5.2 Detailed of analytical methods employed in leaf litter analysis

Total Macro and micro nutrients of litter were estimated by using Nitrogen Kjeldhal method by 1030 auto analyzer (Bremner, 1965), Phosphrous vanadomolybdate yellow colour method using triple acid extract, Potassium Flame photometer method using the neutralized tri acid extract and Micronutrients Triple acid digestion and atomic absorption spectrophotometric method (Jackson,1973).

3.6. Statistical analysis

The pooled data of species richness, density, basal area and bio-volume were calculated. Shannon diversity, Simpson and Evenness were calculated from pooled data. Abundance and natural logarithm of the total number of stems per species (N) was calculated to generate the species abundance distribution. Mean species richness and density of each life-stage were compared between different vegetation types. Percentage of species composition of each life-stage was calculated between different vegetation types. Species composition was defined as the contribution of each plant species between individual life-stage was calculated based on species richness and abundance. Species similarity was calculated based on abundance of each species was analysed by Brey-Curtis similarity analysis (UPGMA) between different vegetation types. Mean adult species richness, juvenile richness, sapling richness and seedling richness was tested by analysis of variance (ANOVA) to compare different plant life-stages among different vegetation types. Multiple comparisons of species richness, density, basal area and bio-volume of each life stage were examined on different vegetation types was analysed by LSD method. The effect of total adult species richness and density was tested in relationship with juveniles, sapling, and seedling richness and density among vegetation types. Pearson (r) Correlation Coefficients was used to examine to different soil physiochemical properties, different microbes and different leaf litter decomposition. I also tested the correlation matrix between the value of different soil variables, microbial communities and minerals of nutrients by leaf litter decomposition and different vegetation types using principal component analysis (PCA). Pearson (r) Correlation Coefficients was used to test the correlation between different soil physicochemical properties, soil microbes, soil leaf litter decomposition and different vegetation parameters of each life-stage among different vegetation types. All the statistical analyses were performed using the software SPSS version 16.

CHAPTER -4

RESULTS

4.1. Floristic diversityand Floristic Composition

4.1.1. Total species richness, density, structure and species diversity

A total of 236 plant species belongs to 189 genera and 68 families were recorded from overall plots of different vegetation of *Acacia*, *Casuarina* and Mixed. It includes 76 trees, 42 shrubs, 41 climbers and 77 herbs. In addition a total of 31956 individuals were recorded from overall plots of different vegetation. Of these *Acacia* had 86 species and 11895 individuals, whereas *Casuarina* had 72 species and 4651 individuals, while mixed vegetation had 223 species and 15410 individuals. Mixed had higher stem density than *Acacia* and *Casuarina*. The total basal area 55 m^2 ha^{-1} was recorded from all vegetation. Of these *Acacia* had 18.56 m^2 ha^{-1}, *Casuarina* had 13 m^2 ha^{-1} and mixed 23.57 m^2 ha^{-1}. Basal was higher in mixed vegetation followed by *Acacia* and *Casuarina* vegetation.

The value of Shannon diversity was 3.397, in *Acacia*, while 2.249 in *Casuarina* and 3.661 in mixed vegetation. Of these, Shannon diversity was higher in mixed vegetation followed by *Acacia* and *Casuarina*. The value of Simpson index was 0.965 in *Acacia*, while 0.89 in *Casuarina* and 0.972 in mixed vegetation. Likewise, Simpson diversity index was higher in in mixed vegetation followed by *Casuarina* and *Casuarina* vegetation. The value of evenness was 0.934 in *Acacia*, 0.948 in *Casuarina* and 0.904 in mixed vegetation. Of these, evenness was higher in *Casuarina* followed by *Acacia* and mixed vegetations.(Table1).

Table1. Floristic composition of different vegetations.

Plant variables	***Acacia***	***Casuarina***	**Mixed**
No. of species	86	72	223
No. of genera	96	79	185
No. of families	47	40	60
Density	11895	4651	15410
Basal area m2 ha-1	18.55	13.00	23.57
No of woody species	914	387	1602
Simpson_1-D	0.96	0.89	0.97
Shannon_H	3.40	2.25	3.66
Evenness_e^H/S	0.93	0.95	0.90
No. of Herbs	26	18	74
Herb density	2632	269	7363

4.1.2. Species abundance distribution

The species abundance distribution varied between life-stages and vegetation types. In *Acacia*, adult, juveniles, saplings abundance distribution did not differ significantly from a log-normal distribution (adults: χ^2 = 0.642, P = 0.422, mean = 0.423, variance = 0.41; juveniles: χ^2 = 2.112, P = 0.3478; mean = 0.588 and variance = 0.077; saplings: χ^2 = 2.388, P = 0.303, mean = 0.785, variance = 0.114). In contrast, seedlings abundance did differ significantly from a log-normal distribution (χ^2 = 4.243, P = 0.039, mean = 1.097, variance = 0.054). In *Casuarina* vegetation, adult abundance distribution did not show in relation to log-normal distribution (mean = 0.506, variance = 0.025), juveniles did not differ significantly from a log-normal distribution (χ^2 = 0.613, P = 0.433, mean = 0.673, variance = 0.109), saplings and seedlings did not show in relation to log-normal distribution (saplings mean = 0.937, variance = 0.051; seedlings: mean = 1.233, variance = 0.081). Considering the mixed vegetation, adult, juveniles, saplings, did not significantly differ from a log-normal distribution (adult: χ^2 = 1.038, P = 0.595, mean = 0.494, variance = 0.067, juveniles χ^2 = 0.461, P = 0.79, mean = 0.593, variance = 0.01; saplings: χ^2 = 5.496, P = 0.064, mean = 0.989, variance = 0.09) but seedlings did differ significantly from a log-normal distribution (χ^2 = 6.562, P = 0.038, mean = 1.168, variance = 0.059).

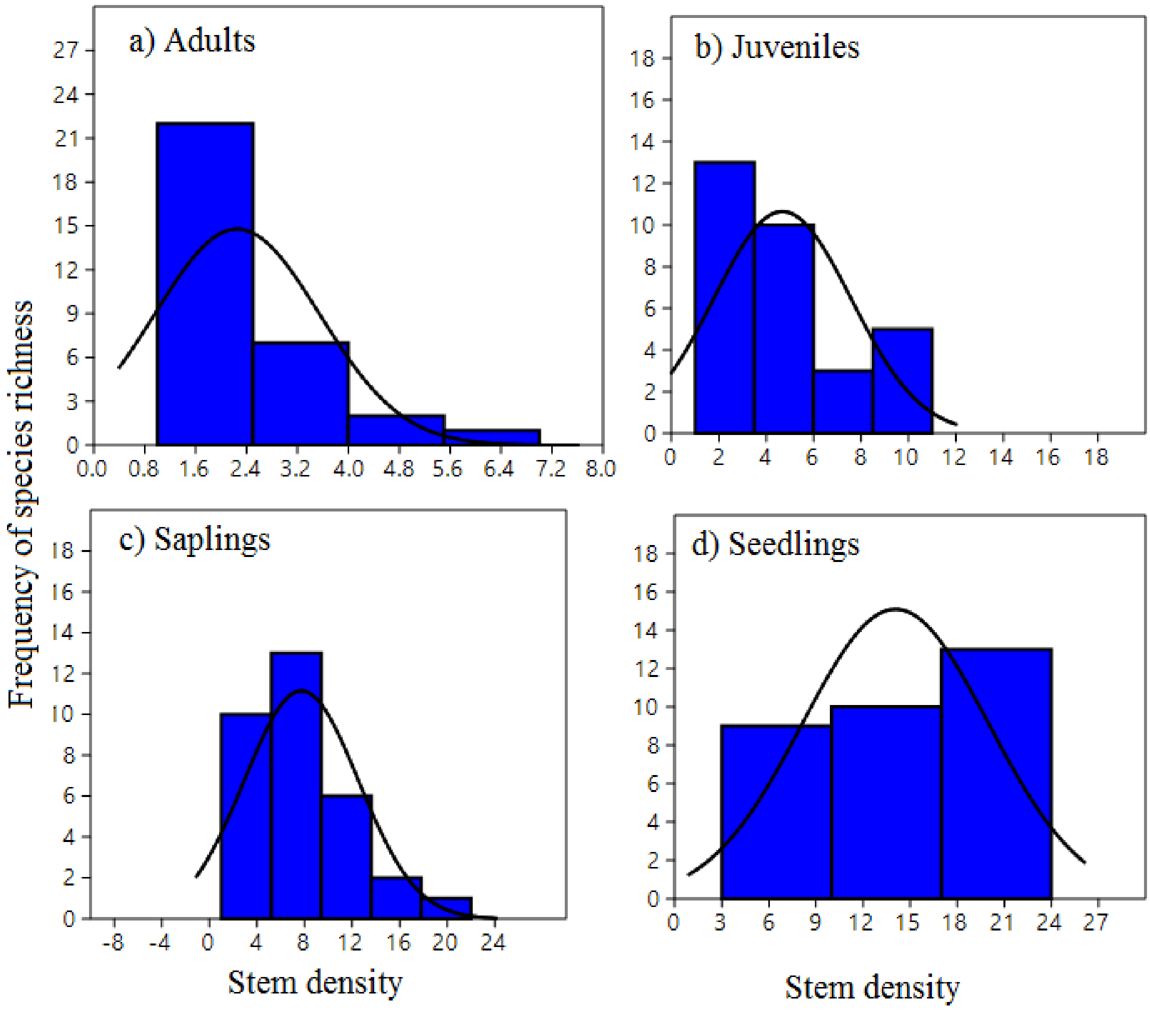


Figure 3. Frequency of species richness and stem density of various life-stages of *Acacia* vegetation that fit into normal distribution.

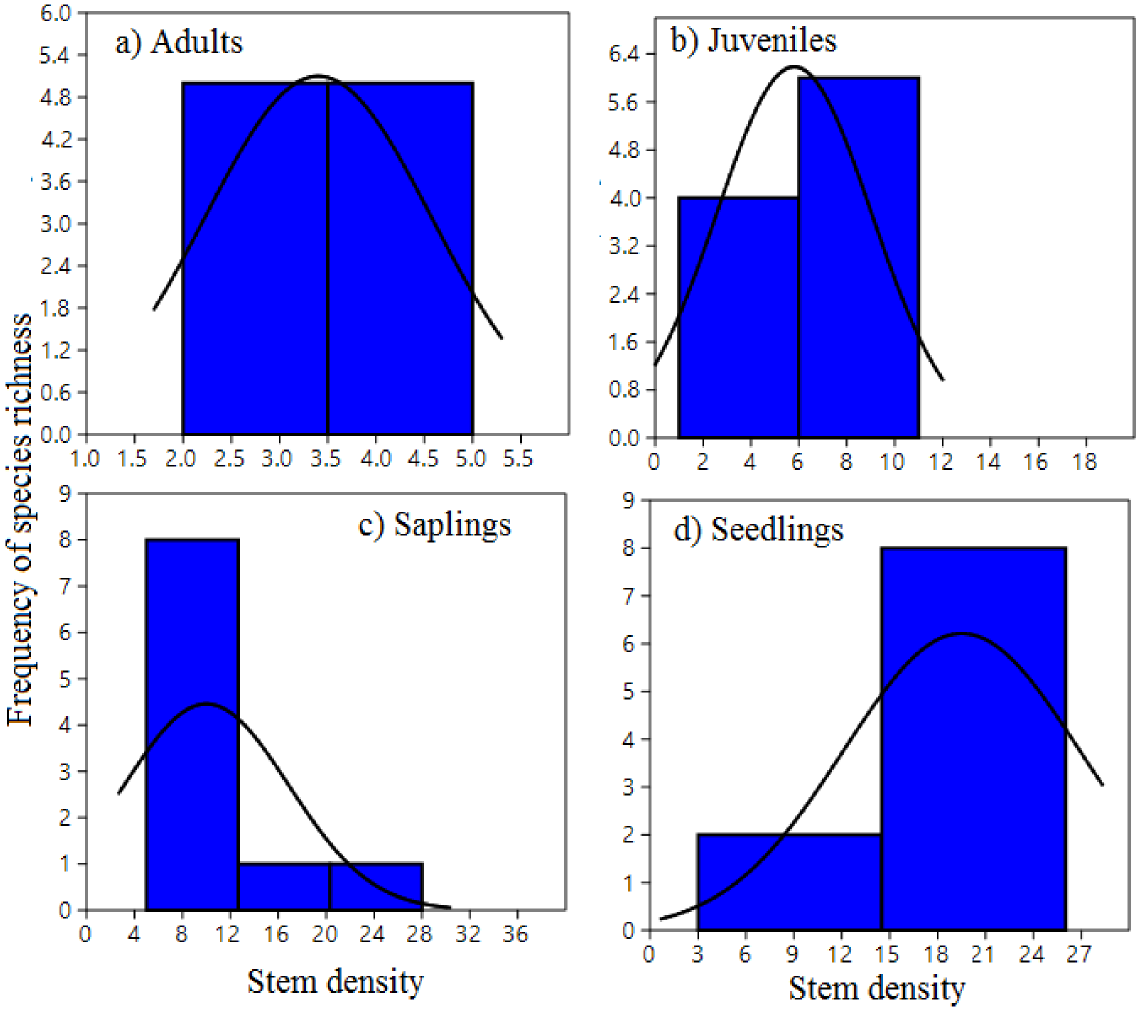


Figure 4. Frequency of species richness and stem density of various life-stages of *Casurina* vegetation that fit into normal distribution

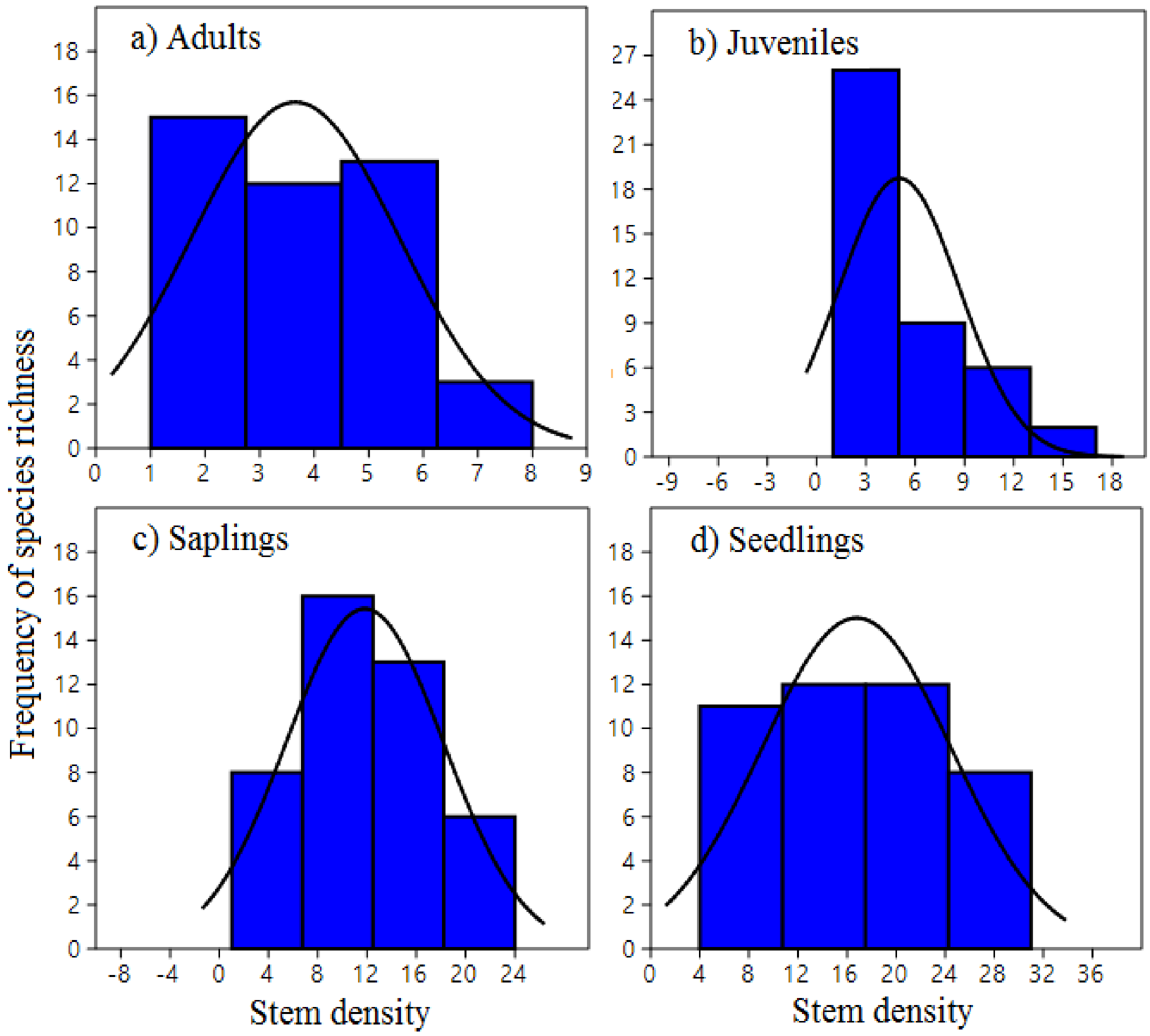


Figure 5. Frequency of species richness and stem density of various life-stages of Mixed vegetation that fit into normal distribution

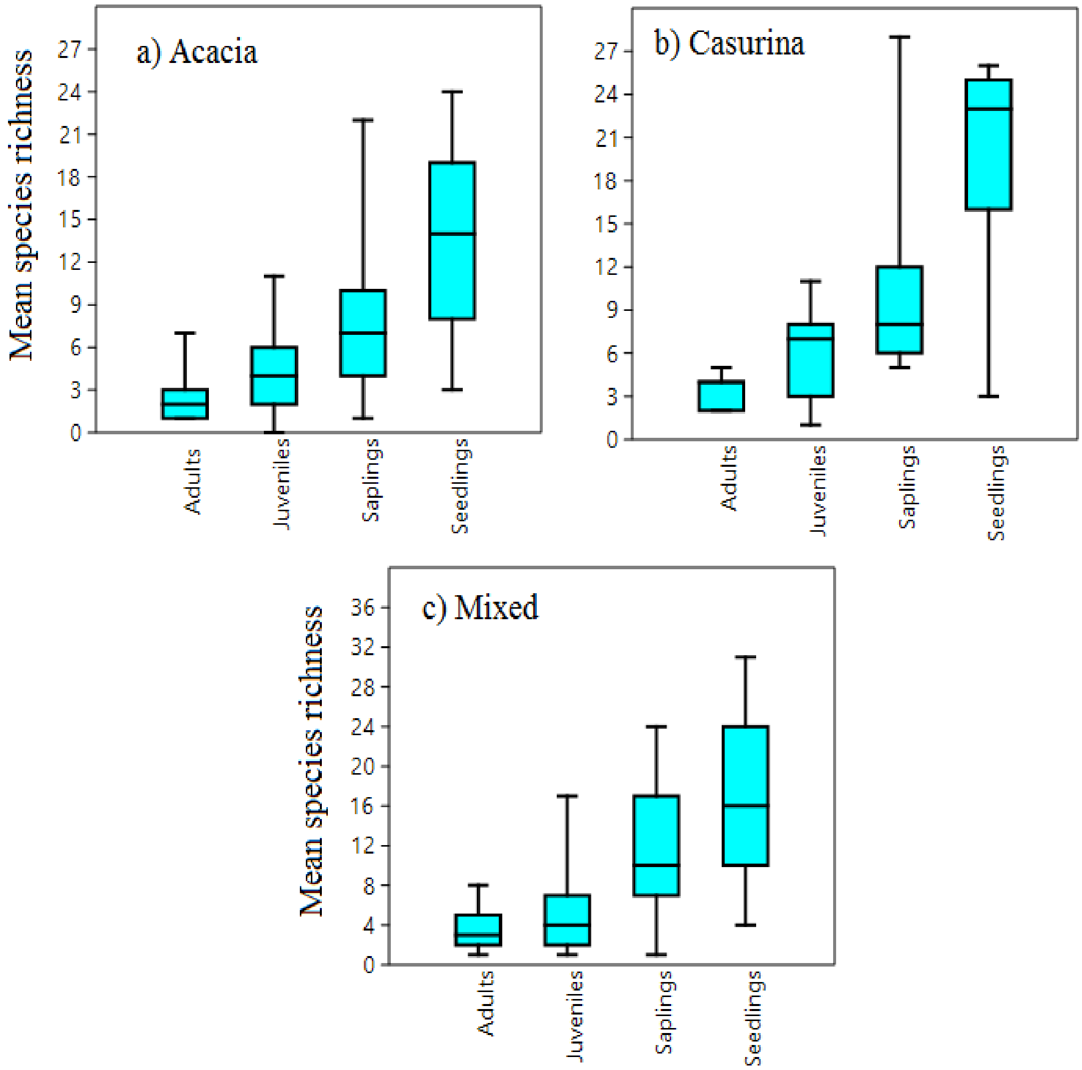


Figure 6. Mean species richness of various vegetation types (*Acacia*, *Casuarina* and Mixed vegetation)

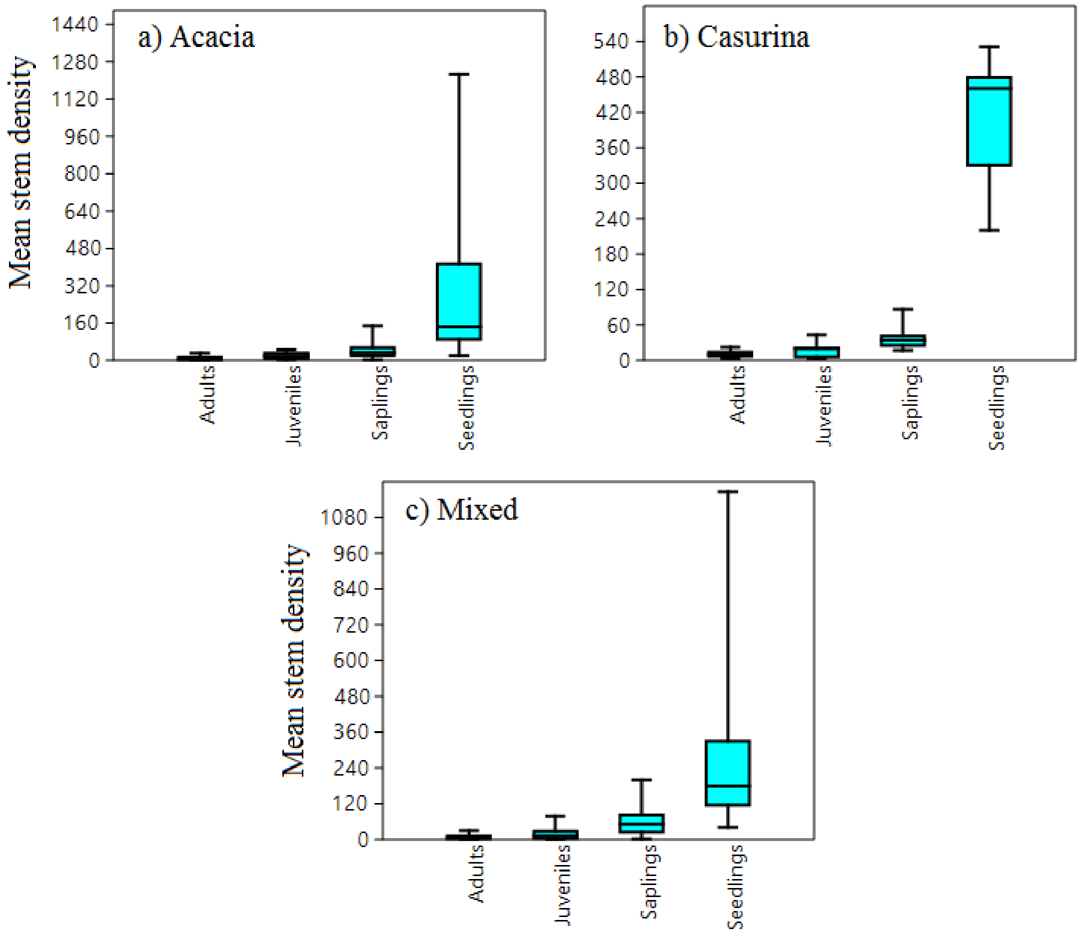


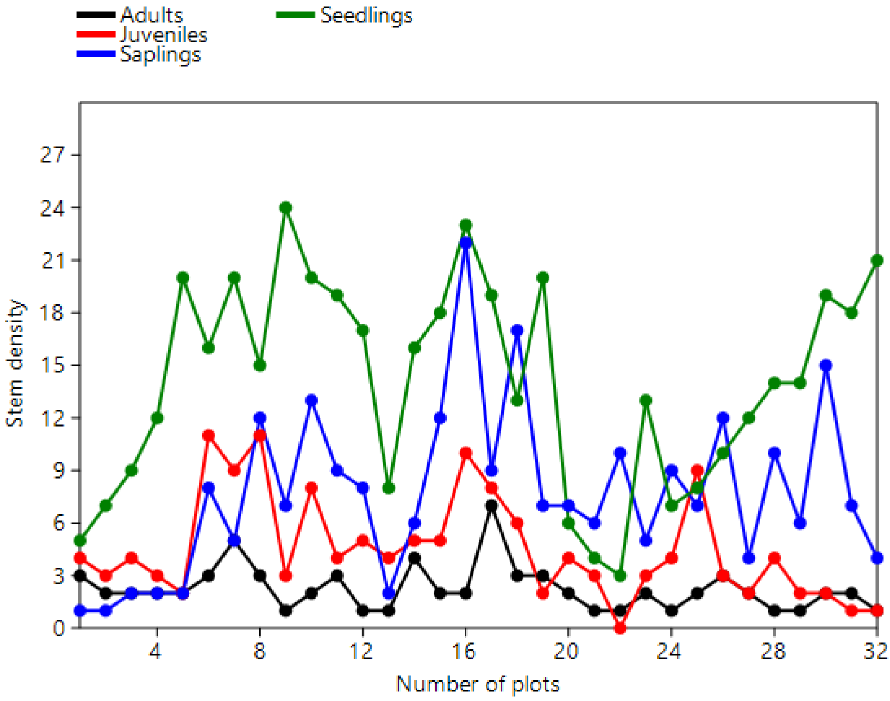
Figure 7. Mean stem density of various vegetation types (*Acacia*, *Casuarina* and Mixed vegetation)

4.1.3. Comparison of species richness and density among different vegetation

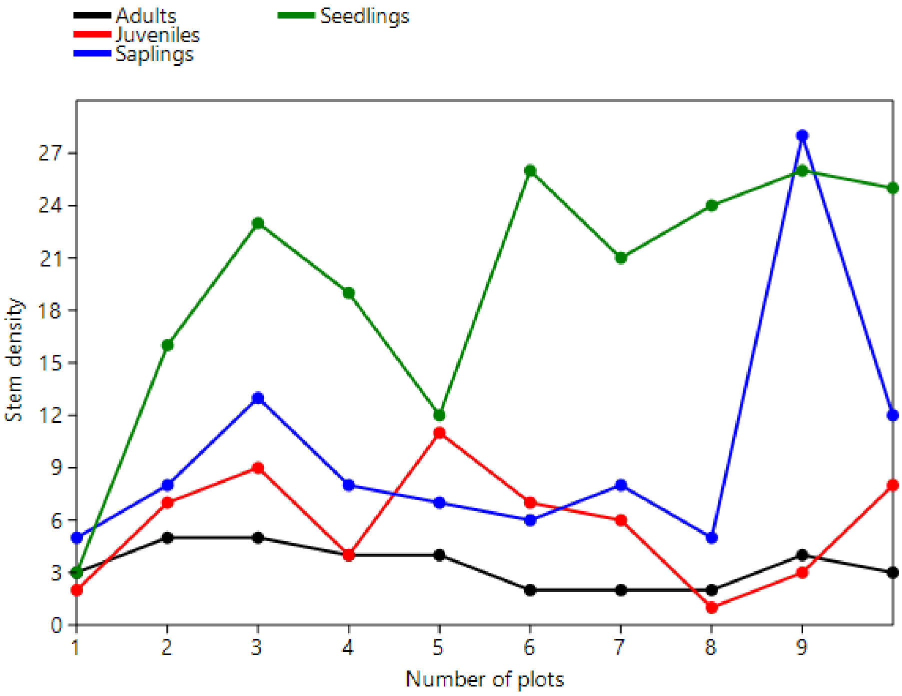
Species richness of seedlings was significantly higher, whereas species richness of adults was lower compared to other life-stages in different vegetation types. Likewise, the high density of seedlings occurred in all vegetations, while low adult density was found among different vegetation (Figure 8.).

Figure 8. Frequency of stems was recorded as different life-forms among from plot by plot (*Acacia*, *Casuarina* and Mixed vegetation)

(a) *Acacia* vegetation



(b) *Casuarina* vegetation



c) Mixed vegetation

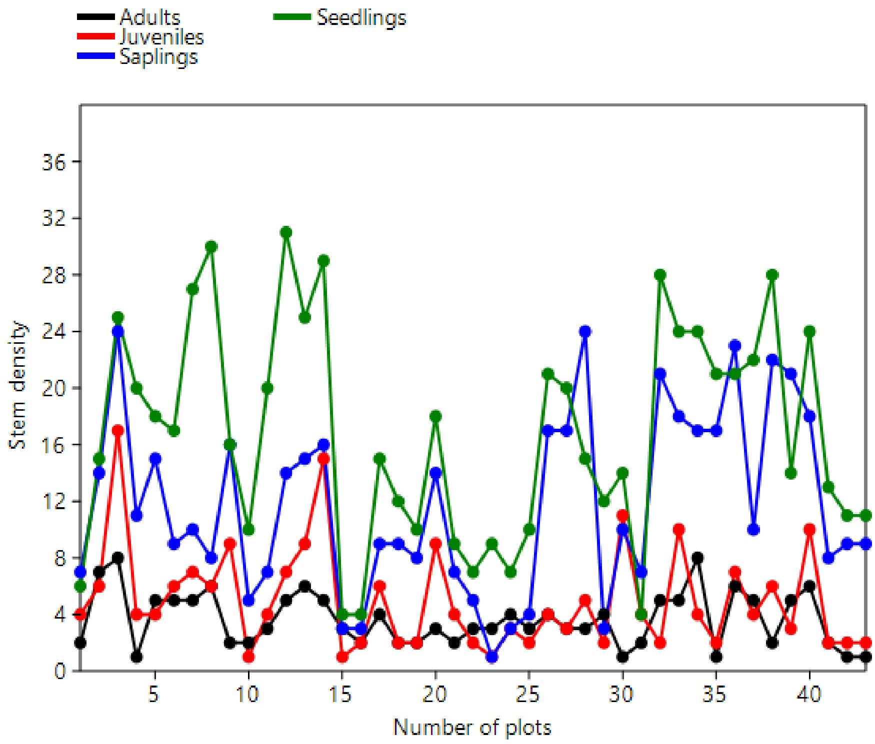
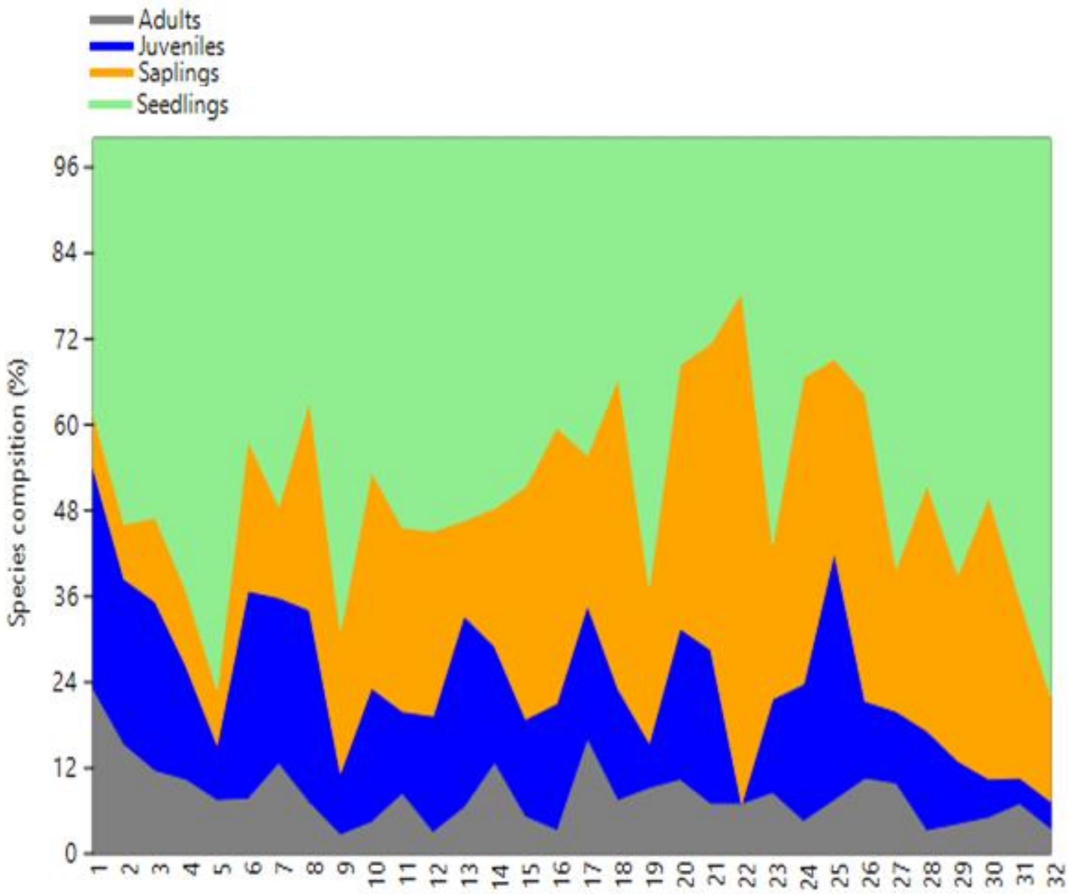
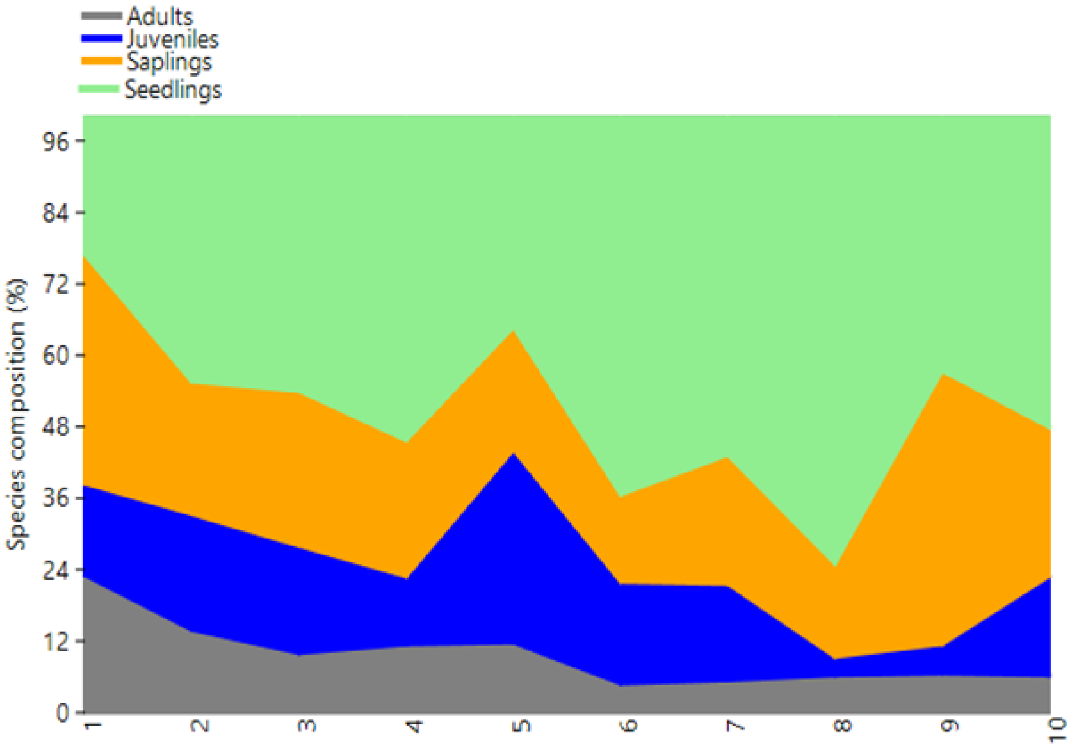


Figure 9. Percentage of species composition loaded by differetn life-forms in (*Acacia*, *Casuarina* and Mixed vegetation)

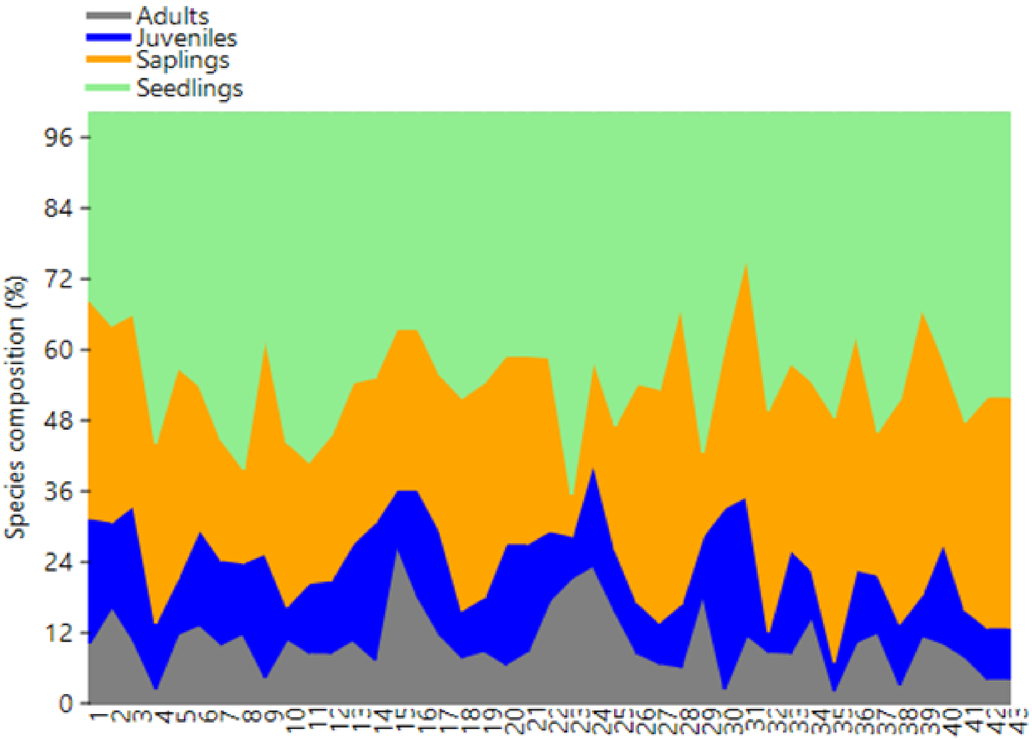
a) ***Acacia* vegetation**



b) ***Casuarina* vegetation**



c) **Mixed vegetation**



4.1.4. Frequency of stem density in plot-by plot

Stem density of adult, juveniles, saplings and seedlings were present in all sampled plots among different vegetation. However it varies in number between the plots. In *Acacia*, adult density was ranged from 1 – 7, juvenile richness ranged 1 – 11, sapling density ranged 1 – 22 and seedling density ranged 3 – 24 (Figure 8a). In *Casuarina* vegetation, adult density ranged 2 – 5, juvenile density ranged 1 – 11, sapling density ranged 5 – 28 and seedling density ranged 3 – 26. In mixed vegetation, adult density ranged 3-8, juvenile density ranged 1 – 17, sapling density ranged 1 – 24 and seedling density ranged 4 – 31 (Figure 8b). In mixed vegetation, adult density ranged 3 – 8, juvenile density ranged 1 – 17, sapling density ranged 1 – 24 and seedling density 4 – 31 (Figure 8c).

4.1.5. Percentage of different life –stages occurred in different vegetation

The percentage of highly loaded area of species compostion of seedlings increased by 24%–100% followed by 15% - 75% juveniles, 5-49% saplings and 3 – 23% adults in *Acacia* vegettion (Figure 9a). Moreover, the percentage of highly loaded area of species compostion of seedlings increased by 26%–100% followed by 11% - 75% juveniles, 4-37% saplings and 4 – 23% adults in *Acacia* vegettion (Figure 9b). In Besides, the percentage of highly loaded area of species compostion of seedlings increased by 37%–100% followed by 14% - 73% juveniles, 2-40% saplings and 2 – 25% adults in mixed vegettion (Figure 9c).

4.1.6. Species similarity composition

Sixty four (27.12 %) species were shared among three vegetation types. Of these, 31% of species shared between *Acacia* and *Casuarina*, whereas 40% shared between *Acacia* and mixed vegetation. In addition, 46% of species shared between *Casuarina* and mixed vegetation. The Bray-Curtis similarity showed similarity was higher between *Casuarina* and mixed vegetation (Figure 10).

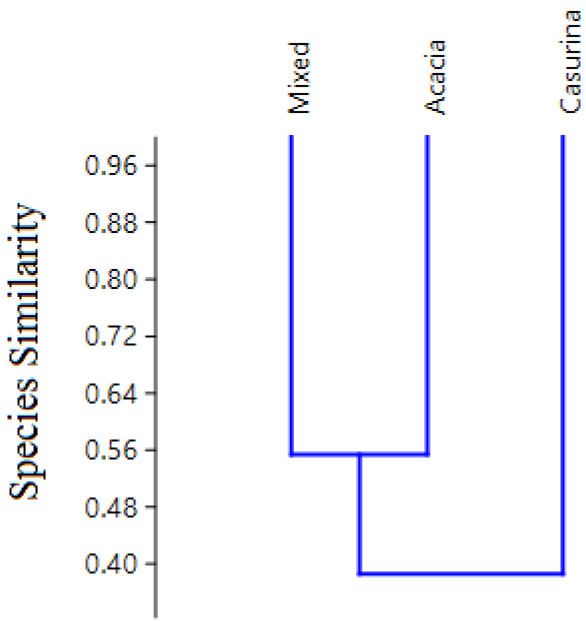


Figure 10. Dendrogram showing Brey-Curtis species similarity among different vegetation types based on abundance.

4.2. Phyto-sociology and Regeneration

At present, the study site consists of a mosaic of native species from Tropical Dry Evergreen Forest and exotics from various tropical countries. As a result of ecological study from 85 quadrates of 10 m x 10 m from *Acacia, Casuarina* and mixed vegetations a total number of 236 plants species from 189 genera and 68 families were recorded. It includes 64 dicotyledons and 4 monocotyledons. There were 77 herbs, 42 shrubs, 76 trees and 41 climbers. The scientific names, their respective families, available vernacular names and the life forms of the species observed are presented in appendix 1. The dominant families are Fabaceae (26 spp.), Euphorbiaceae (16 spp.), Rubiaceae (15 spp.), Mimosaceae (14 spp.), Acanthaceae (12 spp.) and Caesalpinaceae (12 spp). The *Acacia* vegetation had 273 adults individuals, 642 juvenile, 1313 sapling and 9667 seedling. The *Casuarina* vegetation had 100 adults, 175 juvenile, 406 saplings and 3970 seedlings. Similarly from mixed vegetation there were 348 adults, 780 juvenile, 2744 sapling and 1 1538seedling.

The description of species richness, abundance, frequency, basal area, and bio volume of different life stages (adult, juvenile, sapling and seedling) observed from three different vegetations (*Acacia*, *Casuarina* and Mixed vegetations) are presented in (Tables 2- 16).

4.2.1. *Acacia* vegetation

Adult

The total number of woody species regenerated under *Acacia* vegetation was 17 they include nine native and eight exotic species. The native species comprised 20 individuals and exotic species 253. The high number of individuals

Table -2, Phytosociology of *Acacia* Vegetation-Adult

Sl.No	Name of species (Native)	LF	I	O	BA	BV	F	A	D	RA	RF	RD	RDO	IVI	H	D
1	*Acacia chundra*	T	3	3	905.11	762.27	9.38	1.00	0.09	8.33	18.75	15.00	5.57	39.32	0.27	0.017
2	*Atalantia monophylla*	T	1	1	314.00	137.94	3.13	1.00	0.03	8.33	6.25	5.00	1.93	13.18	0.14	0.002
3	*Azadirachta indica*	T	3	2	640.76	289.75	6.25	1.50	0.09	12.50	12.50	15.00	3.94	31.44	0.24	0.011
4	*Hardwickia binata*	T	2	1	4179.93	4495.14	3.13	2.00	0.06	16.67	6.25	10.00	25.72	41.97	0.28	0.020
5	*Ixora pavetta*	T	2	1	271.61	116.69	3.13	2.00	0.06	16.67	6.25	10.00	1.67	17.92	0.17	0.004
6	*Morinda coreia*	T	4	4	9310.30	16447.33	12.50	1.00	0.13	8.33	25.00	20.00	57.30	102.30	0.37	0.116
7	*Benkara malabarica*	SH	1	1	94.99	41.73	3.13	1.00	0.03	8.33	6.25	5.00	0.58	11.83	0.13	0.002
8	*Diospyros ferrea*	SH	1	1	78.50	65.93	3.13	1.00	0.03	8.33	6.25	5.00	0.48	11.73	0.13	0.002
9	*Derris ovalifolia*	C	3	2	454.52	439.06	6.25	1.50	0.09	12.50	12.50	15.00	2.80	30.30	0.23	0.010
			20	16	16249.696	22795.83	50.00	12.00	0.63	100.00	100	100	100	300	1.94	0.183
					1.6249696	2.279583	0.005	0.001								
Sl.No	**Name of species Exotic**	**LF**	**I**	**O**	**BA**	**BV**	**F**	**A**	**D**	**RA**	**RF**	**RD**	**RDO**	**IVI**	**H**	**D**
1	*Acacia auriculiformis*	T	151	18	88501.69	79530.65	471.88	8.39	4.72	39.70	32.14	59.68	59.49	151.31	0.35	0.2544
2	*Acacia colei*	T	23	12	7524.81	4551.36	71.88	1.92	0.72	9.07	21.43	9.09	5.06	35.58	0.25	0.0141
3	*Acacia mangium*	T	1	1	5720.49	5912.82	3.13	1.00	0.03	4.73	1.79	0.40	3.84	6.03	0.08	0.0004
4	*Casuarina junghuhniana*	T	8	4	10011.11	7786.30	25.00	2.00	0.25	9.47	7.14	3.16	6.73	17.03	0.16	0.0032
5	*Leucaena leucocephala*	T	1	1	572.27	502.78	3.13	1.00	0.03	4.73	1.79	0.40	0.38	2.57	0.04	0.0001
6	*Anacardium occidentale*	T	2	2	16979.75	31800.92	6.25	1.00	0.06	4.73	3.57	0.79	11.41	15.77	0.15	0.0028
7	*Eucalyptus citriodora*	T	2	1	7669.45	15353.58	6.25	2.00	0.06	9.47	1.79	0.79	5.15	7.73	0.09	0.0007
8	*Acacia holosericea*	SH	65	17	11798.40	7049.25	203.13	3.82	2.03	18.10	30.36	25.69	7.93	63.98	0.33	0.0455
	Total		253	56	148777.95	152487.7	790.63	21.13	7.91	100.00	100	100	100	300	1.46	0.3211
	per hectare				14.877795	15.24877	0.0791	0.002								

in native species was found in *Morinda coreia* (4) followed by *Derris ovalifolia*, *Acacia chundra* and *Azadirachta indica* 3 each, whereas the high number of individuals in exotic species was recorded in *Acacia auriculiformis* (151) followed by *Acacia holosericea* (65) *and Acacia colei* (23).

The basal area of native species *Morinda coreia* was the highest (9310.30 m^2) followed by *Hardwickia binata* (4179.93 m^2), where as the basal area of *Acacia auriculiformis* (88501.69 m^2) and *Anacardium occidentale* (16979.75 m m^2) were higher among exotic species.

Similarly, the bio volume was higher among native species of *Morinda coreia* (16447.33m^3) and *Hardwickia binata* (4495.14 m^3) while that of *Acacia auriculiformis* (79530.65 m^3) and *Anacardium occidentale* (31800.92 m^3) were higher among exotic species. The frequency of native species was higher in *Morinda coreia* (12.50) followed by *Acacia chundra* (9.38), *Azadirachta indica* (6.25), *Derris ovalifolia* (6.25). Among the exotic the frequency was maximumin in *Acacia auriculiformis* (471.88) followed by *Acacia holosericea* (203.13) and *Acacia colei* (71.88).

The abundance of native species was maximum in *Morinda coreia*, (2.00) and *Ixora pavetta* (2.00) whereas it was maximum in *Acacia auriculiformis* (8.39) followed by *Acacia holosericea* (3.82) among exotics.

The density among native species was found to be higher in *Morinda coreia* (4.72), followed by *Acacia chundra*, (0.09), *Derris ovalifolia* (0.09). Among exotic species it was maximum in *Acacia auriculiformis* (4.72), followed by *Acacia holosericea* (2.03).

The important value index (IVI) was higher in *Morinda coreia* (102.30) followed by *Hardwickia binata* (41.97) *Acacia chundra* (39.32) among the native species, whereas among the exotic species, the IVI was higher in *Acacia auriculiformis* (151.31), followed by *Acacia holosericea* (63.98) and *Acacia colei* (35.58).

The Shannon value was higher for *Morinda coreia* (0.37) followed by *Hardwickia binata* (0.28) among the native species It was higher in *Acacia aurculiformis* (0.35) followed by *Acacia holosericea* (0.33) among the exotic species.

The Simpson value was higher in *Morinda coreia* (0.11) followed by *Hardwickia binata* (0.02) and it was higher in *Acacia auriculiformis* (0.25) followed by *Acacia holosericea* (0.01) among the exotic species.

Juvenilie

The total number of species regenerated under *Acacia* vegetation was 35 species that includes 25 native and 10 exotic. Moreover, the native and exotic species comprised 210 and 432 individuals respectively. The high number of individuals among native species was recorded in *Benkara malabarica* (74) followed by *Memeyclon umbelatum* (20), *Dodonea angustifolia* (3) and *Bambusa arundinacea* (16), whereas the high number of individuals among exotic species was *Acacia holosericea* (205) *followed by Acacia auriculiformis* (148) and *Acacia colei* (63).

The basal area among native species was maximum in *Benkara malabarica* (2165.03 m^2) followed by *Bambusa arundinacea* (648.42 m^2), whereas the

Table -3.Phytosociology of *Acacia* Vegetation-Juvenilie

Sl.No	Name of species (Native)	LF	I	O	BA	BV	F	A	D	RA	RF	RD	RDO	IVI	H	D
1	*Acacia chundra*	T	1	1	113.83	33.09	3.13	1.00	0.03	1.81	1.39	0.48	1.77	3.64	0.05	0.00
2	*Atalantia monophylla*	T	1	1	23.74	7.06	3.13	1.00	0.03	1.81	1.39	0.48	0.37	2.23	0.04	0.00
3	*Azadirachta indica*	T	6	5	157.20	44.61	15.63	1.20	0.19	2.17	6.94	2.86	2.44	12.25	0.13	0.00
4	*Bambusa arundinacea*	T	16	3	648.42	858.51	9.38	5.33	0.50	9.66	4.17	7.62	10.09	21.87	0.19	0.01
5	*Dalbergia paniculata*	T	3	3	48.87	20.95	9.38	1.00	0.09	1.81	4.17	1.43	0.76	6.36	0.08	0.00
6	*Ixora pavetta*	T	6	4	157.98	38.01	12.50	1.50	0.19	2.72	5.56	2.86	2.46	10.87	0.12	0.00
7	*Morinda pubescens*	T	1	1	12.56	2.92	3.13	1.00	0.03	1.81	1.39	0.48	0.20	2.06	0.03	0.00
8	*Phyllanthus polyphyllus*	T	2	1	62.21	27.56	3.13	2.00	0.06	3.62	1.39	0.95	0.97	3.31	0.05	0.00
9	*Benkara malabarica*	SH	74	7	2165.03	708.79	21.88	10.57	2.31	19.14	9.72	35.24	33.67	78.63	0.35	0.07
10	*Capparis brevispina*	SH	2	2	76.15	85.07	6.25	1.00	0.06	1.81	2.78	0.95	1.18	4.91	0.07	0.00
11	*Carrisa spinarum*	SH	5	3	116.18	60.27	9.38	1.67	0.16	3.02	4.17	2.38	1.81	8.35	0.10	0.00
12	*Dodonea angustifolia*	SH	19	5	330.09	93.69	15.63	3.80	0.59	6.88	6.94	9.05	5.13	21.13	0.19	0.00
13	*Diospyros ferrea*	SH	4	4	129.13	41.73	12.50	1.00	0.13	1.81	5.56	1.90	2.01	9.47	0.11	0.00
14	*Dichrostachys cinerea*	SH	1	1	12.56	3.25	3.13	1.00	0.03	1.81	1.39	0.48	0.20	2.06	0.03	0.00
15	*Fleuggea leucopyrus*	SH	1	1	12.56	3.16	3.13	1.00	0.03	1.81	1.39	0.48	0.20	2.06	0.03	0.00
16	*Maytenus emarginata*	SH	3	1	37.68	9.41	3.13	3.00	0.09	5.43	1.39	1.43	0.59	3.40	0.05	0.00
17	*Memeyclon umbelatum*	SH	20	6	790.29	298.87	18.75	3.33	0.63	6.03	8.33	9.52	12.29	30.15	0.23	0.01
18	*Randia dumetorum*	SH	8	3	149.14	41.23	9.38	2.67	0.25	4.83	4.17	3.81	2.32	10.30	0.12	0.00
19	*Scutia myrtina*	SH	1	1	147.38	66.65	3.13	1.00	0.03	1.81	1.39	0.48	2.29	4.16	0.06	0.00
20	*Suregada angustifolia*	SH	2	1	82.62	39.07	3.13	2.00	0.06	3.62	1.39	0.95	1.29	3.63	0.05	0.00

21	*Tarenna asiatica*	SH	7	3	103.62	28.87	9.38	2.33	0.22	4.22	4.17	3.33	1.61	9.11	0.11	0.00
22	*Derris ovalifolia*	C	12	4	503.19	422.50	12.50	3.00	0.38	5.43	5.56	5.71	7.83	19.10	0.18	0.00
23	*Hugonia mystax*	C	8	6	287.31	91.26	18.75	1.33	0.25	2.41	8.33	3.81	4.47	16.61	0.16	0.00
24	*Jasaminum angustifolium*	C	1	1	12.56	3.89	3.13	1.00	0.03	1.81	1.39	0.48	0.20	2.06	0.03	0.00
25	Ziziphus oenoplia	C	6	4	249.04	89.60	12.50	1.50	0.19	2.72	5.56	2.86	3.87	12.29	0.13	0.00
	Total		210	72	6429.32	3120.02	225.00	55.24	6.56	100	100	100	100	300	2.70	0.11
	per hectare				0.6429322	0.312002	0.0225	0.006								
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**BA**	**BV**	**F**	**A**	**D**	**RA**	**RF**	**RD**	**RDO**	**IVI**	**H**	**D**
1	*Acacia auriculiformis*	T	148	17	5325.64	2609.58	53.13	8.71	4.63	25.08	26.15	34.26	37.87	98.28	0.37	0.11
2	*Acacia colei*	T	63	18	1844.16	745.60	56.25	3.50	1.97	10.08	27.69	14.58	13.11	55.39	0.31	0.03
3	*Acacia mangium*	T	1	1	70.85	29.75	3.13	1.00	0.03	2.88	1.54	0.23	0.50	2.27	0.04	0.00
4	*Acacia tumida*	T	3	1	88.71	26.60	3.13	3.00	0.09	8.64	1.54	0.69	0.63	2.86	0.04	0.00
5	*Anacardium occidentale*	T	1	1	28.26	7.30	3.13	1.00	0.03	2.88	1.54	0.23	0.20	1.97	0.03	0.00
6	*Cassia siamea*	T	4	1	87.92	24.34	3.13	4.00	0.13	11.53	1.54	0.93	0.63	3.09	0.05	0.00
7	*Casuarina junghuhniana*	T	5	4	146.99	76.74	12.50	1.25	0.16	3.60	6.15	1.16	1.05	8.36	0.10	0.00
8	*Acacia holosericea*	SH	205	20	6444.84	2924.37	62.50	10.25	6.41	29.53	30.77	47.45	45.83	124.05	0.37	0.17
9	*Acacia mellifera*	SH	1	1	12.56	3.08	3.13	1.00	0.03	2.88	1.54	0.23	0.09	1.86	0.03	0.00
10	*Lantana camara*	SH	1	1	12.56	3.25	3.13	1.00	0.03	2.88	1.54	0.23	0.09	1.86	0.03	0.00
	Total		432	65	14062.48	6450.60	203.13	34.71	13.50	100	100	100	100	300	1.37	0.31
	per hectare				1.4062479	0.64506	0.0203	0.003								

basal area of *Acacia auriculiformis* (5325.64 m^2) and *Acacia colei* (1844.16 m^2) were higher among exotic species. Similarly, the bio volume among the native species was higher in *Bambusa arundinacea* (858.51m^3) *Benkara malabarica* (708.79 m^3) and *Derris ovalifolia* (422.50 m^3) while the bio volume of *Acacia holosericea* (2609.58 m^3) and *Acacia colei(745.60* m^3*)* were more among exotic species.

The frequency was higher in *Benkara malabarica* (21.88) followed by *Memeyclon umbelatum* (18.75), *Hugonia mystax* (18.75) among the native native species whereas among the exotics it was maximum in *Acacia holosericea* (62.5) followed by *Acacia colei* (56.25), and *Acacia auriculiformis* (53.13).

Among native species the abundance was maximum in *Benkara malabarica* (10.57) followed by *Bambusa arundinacea* (5.33) whereas *Acacia holosericea* (10.25), *and Acacia auriculiformis* (8.71) had the more abundance among exotic species.

The density of native species was maximum in *Benkara malabarica* (2.31) followed by *Memeyclon umbelatum* (0.63), *Dodonea angustifolia* (0.59) whereas among exotic species it was maximum in *Acacia holosericea* (6.41) followed by *Acacia auriculiformis* (4.63) and *Acacia colei* (1.97).

The important value index (IVI) was higher in *Benkara malabarica* (78.63) followed by *Memeyclon umbelatum* (30.15) *Bambusa arundinacea* (21.57) among the native species, whereas among the exotic species, the IVI was higher in *Acacia holosericea* (124.05) followed by *Acacia auriculiformis* (98.28) and *Acacia* colei (55.39).

The Shannon value was higher in *Benkara malabarica* (0.35) followed by *Memeyclon umbelatum* (0.23) among the native species and in exotic it was higher in *Acacia auriculiformis* (0.37), *Acacia holosericea* (0.37) and *Acacia colei* (0.31)

The Simpson value among native species was higher in *Benkara malabarica* (0.07) while it was higher in *Acacia holosericea* (0.17) followed by *Acacia auriculiformis* (0.11) among exotic species.

Sapling

The total number of regenerated species under *Acacia* vegetation was 60 species that includes 49 native and 11 exotic. The native and exotic species included 690 and 623 individual respectively. The high number of native individuals was recorded in *Dodonea angustifolia* (270) followed by *Phoneix pusilla* (58), *Memeyclon umbelatum* (53) and *Benkara malabarica* (49) whereas the high number of individuals among exotic species was recorded in *Acacia holosericea* (337), followed by *Acacia auriculiformis* (136) and *Acacia colei* (57).

The frequency among the native species was higher in *Ixora pavetta* (21.88) followed by *Dodonea angustifolia* (18.75), *Phoneix pusilla* (18.75) *Carrisa spinarum* (37.50) whereas among the exotic species the frequency was maximum in *Acacia holosericea* (56.25) followed by *Acacia auriculiformis* (53.13) *Acacia colei* (46.88).

Dodonea angustifolia showed more abundance among native species (15.88) followed by *Benkara malabarica* (12.25). Among the exotic it was maximum in *Acacia tumida* (39.00) followed by *Acacia holosericea* (18.72).

Table 4- Phytosociology of *Acacia* Vegetation-Sapling

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Acacia chundra*	T	2	2	6.25	1.00	0.06	0.86	1.16	0.29
2	*Acacia leucophloea*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
3	*Atalantia monophylla*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
4	*Azadirachta indica*	T	5	5	15.63	1.00	0.16	0.86	2.91	0.72
5	*Borassus flabellifer*	T	9	4	12.50	2.25	0.28	1.94	2.33	1.30
6	*Casuarina equisetifolia*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
7	*Ehretia pubescens*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
8	*Ficus benghalensis*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
9	*Helicteres isora*	T	2	2	6.25	1.00	0.06	0.86	1.16	0.29
10	*Mimusops elengi*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
11	*Ixora pavetta*	T	13	7	21.88	1.86	0.41	1.60	4.07	1.88
12	*Lannea coromandelica*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
13	*Memeyclon edule*	T	5	2	6.25	2.50	0.16	2.15	1.16	0.72
14	*Morinda coreia*	T	3	3	9.38	1.00	0.09	0.86	1.74	0.43
15	*Morinda pubescens*	T	3	3	9.38	1.00	0.09	0.86	1.74	0.43
16	*Phyllanthus polyphyllus*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
17	*Pongamia pinnata*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
18	*Ziziphus xylopyrus*	T	1	1	3.13	1.00	0.03	0.86	0.58	0.14
19	*Benkara malabarica*	SH	49	4	12.50	12.25	1.53	10.55	2.33	7.10
20	*Canthium coromandelicum*	SH	10	2	6.25	5.00	0.31	4.31	1.16	1.45

21	*Capparis brevispina*	SH	3	2	6.25	1.50	0.09	1.29	1.16	0.43
22	*Carmona retusa*	SH	4	3	9.38	1.33	0.13	1.15	1.74	0.58
23	*Carrisa spinarum*	SH	22	12	37.50	1.83	0.69	1.58	6.98	3.19
24	*Cassia auriculata*	SH	1	1	3.13	1.00	0.03	0.86	0.58	0.14
25	*Clausena dentate*	SH	3	1	3.13	3.00	0.09	2.58	0.58	0.43
26	*Dichrostachys cinerea*	SH	3	2	6.25	1.50	0.09	1.29	1.16	0.43
27	*Diospyros ferrea*	SH	17	8	25.00	2.13	0.53	1.83	4.65	2.46
28	*Dodonea angustifolia*	SH	270	17	53.13	15.88	8.44	13.68	9.88	39.13
29	*Gmelina asiatica*	SH	2	2	6.25	1.00	0.06	0.86	1.16	0.29
30	*Flacourtia indica*	SH	3	1	3.13	3.00	0.09	2.58	0.58	0.43
31	*Fleuggea leucopyrus*	SH	9	2	6.25	4.50	0.28	3.88	1.16	1.30
32	*Randia dumetorum*	SH	49	9	28.13	5.44	1.53	4.69	5.23	7.10
33	*Maytenus emarginata*	SH	5	3	9.38	1.67	0.16	1.44	1.74	0.72
34	*Memeyclon umbelatum*	SH	53	8	25.00	6.63	1.66	5.71	4.65	7.68
35	*Ochna obtusata*	SH	3	1	3.13	3.00	0.09	2.58	0.58	0.43
36	*Phoneix pusilla*	SH	58	14	43.75	4.14	1.81	3.57	8.14	8.41
37	*Scutia myrtina*	SH	1	1	3.13	1.00	0.03	0.86	0.58	0.14
38	*Suregada angustifolia*	SH	13	6	18.75	2.17	0.41	1.87	3.49	1.88
39	*Toddalia asiatica*	SH	8	5	15.63	1.60	0.25	1.38	2.91	1.16
40	*Derris ovalifolia*	C	1	1	3.13	1.00	0.03	0.86	0.58	0.14
41	*Hemidesmus indicus*	C	6	5	15.63	1.20	0.19	1.03	2.91	0.87
42	*Hugonia mystax*	C	8	6	18.75	1.33	0.25	1.15	3.49	1.16
43	*Ipomoea sepiaria*	C	1	1	3.13	1.00	0.03	0.86	0.58	0.14
44	*Jasaminum angustifolium*	C	4	2	6.25	2.00	0.13	1.72	1.16	0.58

45	*Merremia tridentata*	C	1	1	3.13	1.00	0.03	0.86	0.58	0.14
46	*Reissantia indica*	C	1	1	3.13	1.00	0.03	0.86	0.58	0.14
47	*Rhynchosia minima*	C	3	1	3.13	3.00	0.09	2.58	0.58	0.43
48	*Sarcostemma intermedium*	C	1	1	3.13	1.00	0.03	0.86	0.58	0.14
49	*Ziziphus oenoplia*	C	26	11	34.38	2.36	0.81	2.04	6.40	3.77
	Total		690	172	537.50	116.0738	21.56	100	100	100
	per hectare				0.05375	0.011607	0.0022			
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Acacia auriculiformis*	T	136	17	53.13	8.00	21.83	8.22	26.56	21.83
2	*Acacia colei*	T	57	15	46.88	3.80	9.15	3.90	23.44	9.15
3	*Acacia mangium*	T	37	2	6.25	18.50	5.94	19.00	3.13	5.94
4	*Acacia tumida*	T	39	1	3.13	39.00	6.26	40.06	1.56	6.26
5	*Caesalpinia coriaria*	T	2	1	3.13	2.00	0.32	2.05	1.56	0.32
6	*Cassia siamea*	T	4	2	6.25	2.00	0.64	2.05	3.13	0.64
7	*Casuarina junghuhniana*	T	1	1	3.13	1.00	0.16	1.03	1.56	0.16
8	*Leucaena leucocephala*	T	4	3	9.38	1.33	0.64	1.37	4.69	0.64
9	*Acacia holosericea*	SH	337	18	56.25	18.72	54.09	19.23	28.13	54.09
10	*Breynia retusa*	SH	3	2	6.25	1.50	0.48	1.54	3.13	0.48
11	*Lantana camara*	SH	3	2	6.25	1.50	0.48	1.54	3.13	0.48
	Total		623	64	200.00	97.35556	100.00	100	100	100

The density among native species was higher in *Dodonea angustifolia* (8.44) followed by *Benkara malabarica* (1.53), *Randia dumetorum* (1.53) whereas *Acacia holosericea* (54.09) and *Acacia auriculiformis* (21.83) showed more density among exotic.

Seedling

The total number of seedlings regenerated under *Acacia* vegetation was 68 that include 58 native and 10 exotic. The native and exotic species included 2868 and 6799 individuals respectively. The number of native individuals was maximum in *Jasminum angustifolium* (712) followed by *Dodonea angustifolia* (406) and *Benkara malabarica* (351), whereas the high number of exotic individuals was recorded in *Acacia holosericea* (5002) and *Acacia auriculiformis* (1356).

The frequency among the native species was higher in *Azadirachta indica* (71.88), followed by *Phoneix pusilla* (71.88) and *Jasminum angustifolium* (71.88). Among the exotic species the frequency of *Acacia holosericea* (78.13) and *Acacia colei* (78.13) was higher followed by *Acacia auriculiformis* (62.50).

The abundance among native species was higher in *Benkara malabarica* (31.91) followed by *Jasminum angustifolium* (30.96) whereas the abundance of *Acacia holosericea* (200.08) and *Acacia aurculiformis* (67.80) were more among exotic species.

Density of the exotic was more than native species. Maximum density among exotic species was observed in *Acacia holosericea* (156.31), followed by *ACACIA auriculiformis* (42.38). Among native species the maximum density

Table 5. Phytosociology of *Acacia* Vegetation-Seedling

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Acacia chundra*	T	8	3	9.38	2.67	0.25	0.91	0.93	0.28
2	*Acacia leucophloea*	T	2	1	3.13	2.00	0.06	0.68	0.31	0.07
3	*Aegle marmelos*	T	1	1	3.13	1.00	0.03	0.34	0.31	0.03
4	*Atalantia monophylla*	T	9	4	12.50	2.25	0.28	0.77	1.25	0.31
5	*Azadirachta indica*	T	90	23	71.88	3.91	2.81	1.33	7.17	3.14
6	*Borassus flabellifer*	T	5	4	12.50	1.25	0.16	0.43	1.25	0.17
7	*Dalbergia latifolia*	T	2	1	3.13	2.00	0.06	0.68	0.31	0.07
8	*Ixora pavetta*	T	160	16	50.00	10.00	5.00	3.41	4.98	5.58
9	*Manilkara hexandra*	T	1	1	3.13	1.00	0.03	0.34	0.31	0.03
10	*Memeyclon edule*	T	87	14	43.75	6.21	2.72	2.12	4.36	3.03
11	*Mimusops elengi*	T	5	1	3.13	5.00	0.16	1.71	0.31	0.17
12	*Morinda coreia*	T	7	4	12.50	1.75	0.22	0.60	1.25	0.24
13	*Morinda pubescens*	T	6	6	18.75	1.00	0.19	0.34	1.87	0.21
14	*Phyllanthus polyphyllus*	T	8	1	3.13	8.00	0.25	2.73	0.31	0.28
15	*Pterocarpus santalinus*	T	1	1	3.13	1.00	0.03	0.34	0.31	0.03
16	*Syzygium cumini*	T	1	1	3.13	1.00	0.03	0.34	0.31	0.03
17	*Terminalia arjuna*	T	1	1	3.13	1.00	0.03	0.34	0.31	0.03
18	*Benkara malabarica*	SH	351	11	34.38	31.91	10.97	10.88	3.43	12.24
19	*Breynia vitis-idaea*	SH	3	3	9.38	1.00	0.09	0.34	0.93	0.10
20	*Canthium coromandelicum*	SH	5	4	12.50	1.25	0.16	0.43	1.25	0.17

21	*Capparis brevispina*	SH	7	6	18.75	1.17	0.22	0.40	1.87	0.24
22	*Carmona retusa*	SH	3	2	6.25	1.50	0.09	0.51	0.62	0.10
23	*Carrisa spinarum*	SH	117	18	56.25	6.50	3.66	2.22	5.61	4.08
24	*Cassia auriculata*	SH	7	3	9.38	2.33	0.22	0.80	0.93	0.24
25	*Clausena dentate*	SH	1	1	3.13	1.00	0.03	0.34	0.31	0.03
26	*Diospyros ferrea*	SH	46	7	21.88	6.57	1.44	2.24	2.18	1.60
27	*Dodonea angustifolia*	SH	406	18	56.25	22.56	12.69	7.69	5.61	14.16
28	*Flacourtia indica*	SH	15	5	15.63	3.00	0.47	1.02	1.56	0.52
29	*Fleuggea leucopyrus*	SH	19	3	9.38	6.33	0.59	2.16	0.93	0.66
30	*Gmelina asiatica*	SH	1	1	3.13	1.00	0.03	0.34	0.31	0.03
31	*Maytenus emarginata*	SH	8	4	12.50	2.00	0.25	0.68	1.25	0.28
32	*Memeyclon umbelatum*	SH	2	2	6.25	1.00	0.06	0.34	0.62	0.07
33	*Ochna obtusata*	SH	2	2	6.25	1.00	0.06	0.34	0.62	0.07
34	*Phoneix pusilla*	SH	171	23	71.88	7.43	5.34	2.54	7.17	5.96
35	*Psilanthus wightianus*	SH	1	1	3.13	1.00	0.03	0.34	0.31	0.03
36	*Randia dumetorum*	SH	100	9	28.13	11.11	3.13	3.79	2.80	3.49
37	*Scutia myrtina*	SH	3	1	3.13	3.00	0.09	1.02	0.31	0.10
38	*Suregada angustifolia*	SH	7	1	3.13	7.00	0.22	2.39	0.31	0.24
39	*Tarenna asiatica*	SH	53	8	25.00	6.63	1.66	2.26	2.49	1.85
40	*Toddalia asiatica*	SH	4	3	9.38	1.33	0.13	0.45	0.93	0.14
41	*Abrus precatorious*	C	2	2	6.25	1.00	0.06	0.34	0.62	0.07
42	*Aristolochia indica*	C	1	1	3.13	1.00	0.03	0.34	0.31	0.03
43	*Cassytha filiformis*	C	3	1	3.13	3.00	0.09	1.02	0.31	0.10
44	*Cissus vitiginea*	C	6	2	6.25	3.00	0.19	1.02	0.62	0.21
45	*Cocculus hirsutus*	C	1	1	3.13	1.00	0.03	0.34	0.31	0.03

46	*Derris ovalifolia*	C	57	7	21.88	8.14	1.78	2.78	2.18	1.99
47	*Galactia tenuiflora*	C	24	2	6.25	12.00	0.75	4.09	0.62	0.84
48	*Hemidesmus indicus*	C	106	18	56.25	5.89	3.31	2.01	5.61	3.70
49	*Hugonia mystax*	C	34	8	25.00	4.25	1.06	1.45	2.49	1.19
50	*Ichnocarpus frutescens*	C	12	2	6.25	6.00	0.38	2.05	0.62	0.42
51	*Ipomoea sepiaria*	C	7	3	9.38	2.33	0.22	0.80	0.93	0.24
52	*Jasaminum angustifolium*	C	712	23	71.88	30.96	22.25	10.56	7.17	24.83
53	*Passiflora foetida*	C	3	3	9.38	1.00	0.09	0.34	0.93	0.10
54	*Rhynchosia minima*	C	76	11	34.38	6.91	2.38	2.36	3.43	2.65
55	*Sarcostemma intermedium Decne*	C	20	1	3.13	20.00	0.63	6.82	0.31	0.70
56	*Strychnos minor*	C	2	1	3.13	2.00	0.06	0.68	0.31	0.07
57	*Wattakaka volubilis*	C	1	1	3.13	1.00	0.03	0.34	0.31	0.03
58	*Ziziphus oenoplia*	C	75	15	46.88	5.00	2.34	1.71	4.67	2.62
	Total		2868	321	1003.13	293.15	89.63	100	100	100
	per hectare				0.1003125	0.029315	0.009			
Sl.No	**Name of speciesExotic**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Acacia auriculiformis*	T	1356	20	62.50	67.80	42.38	21.71	23.26	19.94
2	*Acacia colei*	T	388	25	78.13	15.52	12.13	4.97	29.07	5.71
3	*Acacia mangium*	T	24	2	6.25	12.00	0.75	3.84	2.33	0.35
4	*Acacia tumida*	T	9	1	3.13	9.00	0.28	2.88	1.16	0.13
5	*Cassia siamea*	T	2	1	3.13	2.00	0.06	0.64	1.16	0.03
6	*Gliricidia sepium*	T	1	1	3.13	1.00	0.03	0.32	1.16	0.01
7	*Leucaena leucocephala*	T	4	4	12.50	1.00	0.13	0.32	4.65	0.06
8	*Acacia holosericea*	SH	5002	25	78.13	200.08	156.31	64.08	29.07	73.57

9	*Breynia retusa*	SH	6	4	12.50	1.50	0.19	0.48	4.65	0.09
10	*Lantana camara*	SH	7	3	9.38	2.33	0.22	0.75	3.49	0.10
	Total		6799	86	268.75	312.23	212.47	100	100	100
	per hectare				0.026875	0.031223	0.0212			

was recorded in *Jasminum angustifolium* (22.5) *followed by Dodonea angustifolia* (12.69) and *Benkara malabarica* (10.88).

Herbs

The total number of regenerated species of herbs under *Acacia* vegetation was 26 that include 23 native and 3 exotic. The native and exotic species under *Acacia* vegetation included 2549 and 83 individuals respectively. The highest number of individuals among native species was recorded in *Crotalaria medicaginea* (1000) followed by *Lepidagathis cristata* (525), *Oldenlandia herbacea* (277), *Waltheria indica* (199) whereas the high number of exotic individuals was recorded in Sebastiania chamaelea (65), followed by *Ageratum conyzoides* (16).

The frequency was higher in *Oldenlandia herbacea* (31.25), *Lepidagathis cristata* (25.00), *Crotalaria nana* (18.75), *Stylosanthes fruticosa* (18.75) among the native species. Whereas among the exotic the frequency of *Sebastiania chamaelea* (31.25) was higher followed by *Ageratum conyzoides* (18.75) and *Melochia corchorifolia* (6.25).

The abundance was higher among native species than exotic. It was maximum in *Crotalaria medicaginea* (250.00) followed by *Jasminum angustifolium* (30.96) *Oldenlandia herbacea* (138.50) whereas *Sebastiania chamaelea* (31.25) followed by *Ageratum conyzoides* (18.75) was more among exotic.

The density was higher in native species than exotic. Among the native species it was maximum in *Crotalaria medicaginea* (31.25) followed by *Lepidagathis cristata* (16.41) whereas *Sebastiania chamaelea* (2.03) was found in higher density among exotic species.

Table 6. Phytosociology of *Acacia* Vegetation-Herb

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Allmania nodiflora*	H	3	1	3.13	3	0.09	0.45	1.41	0.12
2	*Achyranthes aspera*	H	8	1	3.13	8	0.25	1.19	1.41	0.31
3	*Asystasia gangetica*	H	3	1	3.13	3	0.09	0.45	1.41	0.12
4	*Blepharis maderaspatensis*	H	8	2	6.25	4	0.25	0.6	2.82	0.31
5	*Blepharis molluginifolia*	H	7	2	6.25	3.5	0.22	0.52	2.82	0.27
6	*Crotalaria medicaginea*	H	1000	4	12.5	250	31.25	37.34	5.63	39.23
7	*Crotalaria nana*	H	49	6	18.75	8.17	1.53	1.22	8.45	1.92
8	*Enicostema axillare*	H	2	1	3.13	2	0.06	0.3	1.41	0.08
9	*Eulophia epidendraea*	H	6	1	3.13	6	0.19	0.9	1.41	0.24
10	*Evolvulus alsinoides*	H	73	3	9.38	24.33	2.28	3.63	4.23	2.86
11	*Hybanthus enneaspermus*	H	27	10	31.25	2.7	0.84	0.4	14.08	1.06
12	*Indiofera aspalathoides*	H	51	2	6.25	25.5	1.59	3.81	2.82	2
13	*Justicia prostrata*	H	40	2	6.25	20	1.25	2.99	2.82	1.57
14	*Lepidagathis cristata*	H	525	8	25	65.63	16.41	9.8	11.27	20.6
15	*Merremia tridentata*	H	10	3	9.38	3.33	0.31	0.5	4.23	0.39
16	*Oldenlandia herbacea*	H	277	2	6.25	138.5	8.66	20.69	2.82	10.87
17	*Phyllanthus madrespatensis*	H	12	2	6.25	6	0.38	0.9	2.82	0.47
18	*Polygala arvensis*	H	185	5	15.63	37	5.78	5.53	7.04	7.26
19	*Sansevieria roxburghiana*	H	1	1	3.13	1	0.03	0.15	1.41	0.04

20	*Stylosanthes fruticosa*	H	42	6	18.75	7	1.31	1.05	8.45	1.65
21	*Tephrosia maxima*	H	20	2	6.25	10	0.63	1.49	2.82	0.78
22	*Triumfetta rotundifolia*	H	1	1	3.13	1	0.03	0.15	1.41	0.04
23	*Waltheria indica*	H	199	5	15.63	39.8	6.22	5.95	7.04	7.81
	Total		2549	71	221.93	669.5	79.65	100	100	100
	per hectare				0.022193	0.067	0.008			

Sl.No	Name of species (Exotic)	LF	I	O	F	A	D	RA	RF	RD
1	*Ageratum conyzoides*	H	16	6	18.75	2.67	0.5	26.23	33.33	19.28
2	*Melochia corchorifolia*	H	2	2	6.25	1	0.06	9.84	11.11	2.41
3	*Sebastiania chamaelea*	H	65	10	31.25	6.5	2.03	63.93	55.56	78.31
	Total		83	18	56.25	10.17	2.59	100	100	100
	per hectare				0.005625	0.001	0.0003			

4.2.2. *Casuarina* vegetation

Adults

The total number of woody species regenerated under *Casuarina* vegetation was 18 that includes 9 native and 9 exotic. The native and exotic species included 40 and 60 individuals respectively. The high number of individuals among native was recorded in *Casuarina equisetifolia* (21), followed by *Acacia chundra* (12) and the remaining species had one individual each whereas the high number of exotic individuals was recorded in *Casuarina junghuhniana* (41) followed by *Acacia auriculiformis* (6), *Acacia holocerecia* (4), *Acacia leucoplea* (3), *Gliricidia sepium* (2) and the remaining species had one each.

The basal area of the native species *Pterocarpus santalinus* (15345.18 m^2) was higher followed by *Casuarina equisetifolia* (9442 m^2), where as the basal area of *Casuarina junghuhniana* (79271.25 m^2) and *Acacia auriculiformis* (4073.17 m^2) were higher among exotic species.

Similarly, the bio volume was higher in *Pterocarpus santalinus* (19364.44 m^3) and *Casuarina equisetifolia* (4567.95 m^3) among native species while the bio volume of *Casuarina junghuhniana* (258803.31 m^3) and *Acacia aurculiformis* (4289.95 m^3) were higher among exotic species.

Exotic species were more frequent than native species. Frequency was maximum in *Casuarina junghuhniana* (70.00) followed by *Acacia aurculiformis* (40.00) among exotics. Among native species it was

Table- 7. Phytosociology of *Casuarina* Vegetation-Adult

Sl.No	Name of species (Native)	LF	I	O	BA	BV	F	A	D	RA	RF	RD	RDO	IVI	H	D
1	*Acacia chundra*	T	12	3	7170.39	4567.95	30.00	4.00	1.20	22.22	23.08	30.00	21.51	74.59	0.346	0.062
2	*Atalantia monophylla*	T	1	1	490.63	272.58	10.00	1.00	0.10	5.56	7.69	2.50	1.47	11.66	0.1263	0.002
3	*Casuarina equisetifolia*	T	21	3	9442.18	25258.74	30.00	7.00	2.10	38.89	23.08	52.50	28.33	103.90	0.3672	0.120
4	*Ixora pavetta*	T	1	1	211.17	87.06	10.00	1.00	0.10	5.56	7.69	2.50	0.63	10.83	0.1199	0.001
5	*Pterocarpus santalinus*	T	1	1	15345.18	19364.44	10.00	1.00	0.10	5.56	7.69	2.50	46.04	56.23	0.3138	0.035
6	*Canthium coromandelicum*	SH	1	1	200.96	84.38	10.00	1.00	0.10	5.56	7.69	2.50	0.60	10.80	0.1196	0.001
7	*Capparis brevispina*	SH	1	1	176.63	75.31	10.00	1.00	0.10	5.56	7.69	2.50	0.53	10.72	0.1191	0.001
8	*Dichrostachys cinerea*	SH	1	1	200.96	90.88	10.00	1.00	0.10	5.56	7.69	2.50	0.60	10.80	0.1196	0.001
9	*Hugonia mystax*	C	1	1	94.99	52.77	10.00	1.00	0.10	5.56	7.69	2.50	0.28	10.48	0.1172	0.001
	Total		40	13	33333.063	49854.11	130.00	18.00	4.00	100.00	100	100	100	300	1.7487	0.225
	per hectare				3.3333063	4.985411	0.013	0.002								
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**BA**	**BV**	**F**	**A**	**D**	**RA**	**RF**	**RD**	**RDO**	**IVI**	**H**	**D**
1	*Acacia auriculiformis*	T	6	4	4073.17	4289.95	40.00	1.50	0.60	9.87	18.18	10.00	4.39	32.57	0.2411	0.012
2	*Acacia colei*	T	1	1	2461.76	1145.04	10.00	1.00	0.10	6.58	4.55	1.67	2.65	8.86	0.1041	0.001
3	*Acacia leucophloea*	T	3	2	2130.69	1042.76	20.00	1.50	0.30	9.87	9.09	5.00	2.30	16.39	0.1588	0.003
4	*Casuarina junghuhniana*	T	41	7	79271.25	258803.31	70.00	5.86	4.10	38.56	31.82	68.33	85.40	185.55	0.2972	0.383
5	*Eucalyptus citriodora*	T	1	1	2193.49	1726.83	10.00	1.00	0.10	6.58	4.55	1.67	2.36	8.58	0.1016	0.001
6	*Gliricidia sepium*	T	2	2	815.03	438.74	20.00	1.00	0.20	6.58	9.09	3.33	0.88	13.30	0.1382	0.002
7	*Leucaena leucocephala*	T	1	1	33.17	13.71	10.00	1.00	0.10	6.58	4.55	1.67	0.04	6.25	0.0806	0.000
8	*Peltophorum pterocarpum*	T	1	1	78.50	54.77	10.00	1.00	0.10	6.58	4.55	1.67	0.08	6.30	0.0811	0.000

9	*Acacia holosericea*	SH	4	3	1763.11	535.71	30.00	1.33	0.40	8.78	13.64	6.67	1.90	22.20	0.1927	0.005
	Total		60	22	92820.15	268050.8	220.00	15.19	6.00	100.00	100	100	100	300	1.3953	0.407
	per hectare				9.282015	26.80508	0.022	0.002								

maximum in *Acacia chundra* (30.00) *and Casuarina equisetifolia* (30.00).

The abundance of native species was higher than that of exotic species. The abundance of *Casuarina equisetifolia* (7.00) was more among native species followed by *Acacia chundra* (4.00). Among exotics it was maximum in *Casuarina junghuhniana* (5.86).

The density among native species was higher in *Casuarina equisetifolia* (2.10) followed by *Acacia chundra,* (1.20). Whereas the maximum density among the exotic was in *Casuarina junghuhniana* (4.10).

The important value index (IVI) was higher in *Casuarina equisetifolia* (103.90) followed by *Acacia chundra* (74.59) *Pterocarpus santalinus* (56.23) and lowest in *Hugonia mystax* (10.48) among the native species, whereas among the exotic species, the IVI was highest in *Casuarina junghuhniana* (185.55) and lowest in *Leucaena leucoplea* (6.25).

The Shannon value native species was higher for *Casuarina equisetifolia* (0.367) followed by *Acacia chundra* (0.346), *Pterocarpus santalinus* (0.314). Among the exotic the Shannon value was higher in *Casuarina junghuhniana* (0.297) followed by *Acacia auirculiformis* (0.241) .

The Simpson value for the individuals of native species was higher in *Casuarina equisetifolia* (0.120) followed by *Acacia chundra* (0.062) and the minimum value was 0.001 represented by 5 species. Among the exotic the Simpson value was higher in *Casuarina junghuhniana* (0.383) and minimum in *Acacia colei* and *Eucalyptus citriodora* (0.001).

Juvenile

The total number of species regenerated under *Casuarina* vegetation was 31 woody species that includes 23 native and 8 exotic. The native and exotic species under *Casuarina* vegetation included 92 and 83 individuals respectively.The high number of individuals among native species was recorded in *Memeyclon umbelatum* (17), followed by ,*Ziziphus oenoplia*(10), whereas the high number of exotic individuals was recorded in *Acacia holosericea* (50) , followed by *Acacia colei* (12) *and Acacia auriculiformis* (11).

The basal area of the native species *Memeyclon umbelatum* (363.06 m^2) was higher followed by *Ziziphus oenoplia* (336.37 m^2), whereas the basal area of *Acacia holosericea* (1002.91 m^2) and *Acacia auriculiformis* (282.80 m^2) were higher among exotic species.

Similarly, the bio volume of native species *Ziziphus oenoplia* (385.19 m^3) was maximum followed by *Hugonia mystax* (131.72 m^3) while the bio volume of *Acacia holosericea* (400.13) and *Acacia auriculiformis* (99.50 m^3) was higher among exotic species

The frequency among the native species was higher in *Dodonea angustifolia* (40.00 m^3), followed by, *Ziziphus oenoplia* (40.00 m^3) whereas among the exotic the frequency of *Acacia auriculiformis* (50.00 m^3) was higher followed by *Acacia holosericea* (40.00 m^3).

Table-8. Phytosociology of *Casuarina* Vegetation-Juvenilie

Sl.No	Name of species (Native)	LF	I	O	BA	BV	F	A	D	RA	RF	RD	RDO	IVI	H	D
1	*Atalantia monophylla*	T	5	3	73.99	24.16	30.00	1.67	0.50	3.27	7.32	5.43	3.44	16.20	0.16	0.00
2	*Casuarina equisetifolia*	T	3	1	207.24	115.22	10.00	3.00	0.30	5.89	2.44	3.26	9.65	15.35	0.15	0.00
3	*Ixora pavetta*	T	2	2	52.79	13.87	20.00	1.00	0.20	1.96	4.88	2.17	2.46	9.51	0.11	0.00
4	*Allophylus serratus*	SH	1	1	12.56	3.65	10.00	1.00	0.10	1.96	2.44	1.09	0.58	4.11	0.06	0.00
5	*Benkara malabarica*	SH	7	3	159.55	42.31	30.00	2.33	0.70	4.58	7.32	7.61	7.43	22.35	0.19	0.01
6	*Clausena dentate*	SH	1	1	12.56	2.68	10.00	1.00	0.10	1.96	2.44	1.09	0.58	4.11	0.06	0.00
7	*Canthium coromandelicum*	SH	1	1	50.24	13.63	10.00	1.00	0.10	1.96	2.44	1.09	2.34	5.86	0.08	0.00
8	*Capparis brevispina*	SH	1	1	28.26	8.03	10.00	1.00	0.10	1.96	2.44	1.09	1.32	4.84	0.07	0.00
9	*Carrisa spinarum*	SH	4	1	50.24	12.33	10.00	4.00	0.40	7.86	2.44	4.35	2.34	9.13	0.11	0.00
10	*Dichrostachys cinerea*	SH	1	1	12.56	2.76	10.00	1.00	0.10	1.96	2.44	1.09	0.58	4.11	0.06	0.00
11	*Dodonea angustifolia*	SH	7	4	94.99	21.31	40.00	1.75	0.70	3.44	9.76	7.61	4.42	21.79	0.19	0.01
12	*Diospyros ferrea*	SH	3	2	37.68	8.44	20.00	1.50	0.30	2.95	4.88	3.26	1.75	9.89	0.11	0.00
13	*Flacourtia indica*	SH	7	1	87.92	29.62	10.00	7.00	0.70	13.75	2.44	7.61	4.09	14.14	0.14	0.00
14	*Mallotus philippensis*	SH	2	2	32.19	8.14	20.00	1.00	0.20	1.96	4.88	2.17	1.50	8.55	0.10	0.00
15	*Memeyclon umbelatum*	SH	17	2	363.06	105.32	20.00	8.50	1.70	16.69	4.88	18.48	16.90	40.26	0.27	0.02
16	*Ochna obtusata*	SH	1	1	12.56	2.60	10.00	1.00	0.10	1.96	2.44	1.09	0.58	4.11	0.06	0.00
17	*Randia dumetorum*	SH	2	1	40.82	10.67	10.00	2.00	0.20	3.93	2.44	2.17	1.90	6.51	0.08	0.00
18	*Scutia myrtina*	SH	1	1	12.56	5.60	10.00	1.00	0.10	1.96	2.44	1.09	0.58	4.11	0.06	0.00
19	*Toddalia asiatica*	SH	3	2	48.87	22.28	20.00	1.50	0.30	2.95	4.88	3.26	2.27	10.41	0.12	0.00

20	*Tarenna asiatica*	SH	3	2	80.46	23.69	20.00	1.50	0.30	2.95	4.88	3.26	3.75	11.88	0.13	0.00
21	*Gymnema sylvestre*	C	2	1	47.89	32.79	10.00	2.00	0.20	3.93	2.44	2.17	2.23	6.84	0.09	0.00
22	Hugonia mystax	C	8	3	292.81	131.72	30.00	2.67	0.80	5.24	7.32	8.70	13.63	29.64	0.23	0.01
23	Ziziphus oenoplia	C	10	4	336.37	385.19	40.00	2.50	1.00	4.91	9.76	10.87	15.66	36.28	0.26	0.01
	Total		92	41	2148.15	1026.03	410.00	50.92	9.20	100	100	100	100	300	2.87	0.07
	per hectare				**0.21**	**0.10**	**0.04**	**0.01**	**0.00**							
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**BA**	**BV**	**F**	**A**	**D**	**RA**	**RF**	**RD**	**RDO**	**IVI**	**H**	**D**
1	*Acacia auriculiformis*	T	11	5	282.80	99.50	50.00	2.20	1.10	7.53	29.41	13.25	16.98	59.65	0.32	0.04
2	*Acacia colei*	T	12	2	150.72	54.12	20.00	6.00	1.20	20.55	11.76	14.46	9.05	35.27	0.25	0.01
3	*Acacia mangium*	T	3	1	37.68	10.30	10.00	3.00	0.30	10.27	5.88	3.61	2.26	11.76	0.13	0.00
4	*Cassia siamea*	T	3	2	44.75	12.27	20.00	1.50	0.30	5.14	11.76	3.61	2.69	18.07	0.17	0.00
5	*Eucalyptus citriodora*	T	2	1	121.09	67.65	10.00	2.00	0.20	6.85	5.88	2.41	7.27	15.56	0.15	0.00
6	*Peltophorum pterocarpum*	T	1	1	12.56	2.60	10.00	1.00	0.10	3.42	5.88	1.20	0.75	7.84	0.10	0.00
7	*Acacia holosericea*	SH	50	4	1002.91	400.13	40.00	12.50	5.00	42.81	23.53	60.24	60.23	144.00	0.35	0.23
8	*Lantana camara*	SH	1	1	12.56	7.06	10.00	1.00	0.10	3.42	5.88	1.20	0.75	7.84	0.10	0.00
	Total		83	17	1665.06	653.64	170.00	29.20	8.30	100	100	100	100	300	1.57	0.29
	per hectare				0.1665056	0.065364	0.017	0.003	8E-04							

Among native species *Memeyclon umbelatum* (8.50) was showing more abundance followed by *Flacourtia indica* (7.00) among exotic species *Acacia holosericea* (12.50) and *Acacia colei* (6.00) showed more abundance. Six native species and one exotic species had the minimum value of 1.00.

The density among native species was higher in *Memeyclon umbelatum* (1.70) followed by *Hugonia mystax* (0.80). Among exotic it was higher in *Acacia holosericea* (5.00) followed by *Acacia auriculiformis* (1.10) and the lowest value was 0.10 found in two exotic species.

Among the native species the important value index (IVI) was higher in *Memeyclon umbelatum* (40.26) followed by *Ziziphus oenoplia* (36.28) and *Hugonia mystax* (29.64) and the lowest IVI (4.11) was recorded in *Allophyllus serratus, Clausena dentate, Dichrostachys cinerea, Ochna obtusata* and *Scutia myrtina.* Whereas among the exotic species, it was higher in *Acacia holosericea* (144.00), *Acacia auriculiformis* (59.65), *Acacia colei* (35.27).

The Shannon value was higher in *Memeyclon umbelatum* (0.27) followed by *Ziziphus oenoplia* (0.26) among native species while in the exotic it was higher in *Acacia aurculiformis* (0.35) followed by *Acacia holosericea* (0.32).

The Simpson value among native species was higher in *Memeyclon umbelatum* (0.02) followed by *Ziziphus oenoplia* (0.01) and While the exotic the Simpson value was higher in *Acacia holosericea* (0.23) followed by *Acacia aurculiformis* (0.04).

Sapling

The total number of species regenerated under *Casuarina* vegetation was 43 woody species that includes 33 native and 10 exotic. There were 333 and 73 individuals of native and exotic species respectively. The high number of individuals among native species was *found in Atalantia monophylla* (75), followed by *Memeyclon umbelatum* (63) and *Dodonea angustifolia* (46) whereas the high number of exotic individuals was recorded in *Acacia holosericea* (34), followed by *Casuarina junghuhniana* (10) and *Cassia siamea* (9)

The frequency among the native species was higher in *Dodonea angustifolia* (60), *Ziziphus oenoplia* (60) *Benkara malabarica* (50) whereas among the exotic the frequency of *Acacia auriculiformis* (50) was higher followed by *Casuarina junghuhniana* (40) and *Acacia holosericea* (30).

The abundance among native species was found to be higher in *Memeyclon umbelatum* (31.4) followed by *Atalantia monophylla* (18.75) whereas *Acacia holosericea* (11.33), *followed by Cassia siamea* (8.71). *Casuarina junghuhniana* (2.5) had more abundance among exotic species.

The density of *Memeyclon umbelatum* (18.92) was higher followed by *Atalantia monophylla* (22.52) was higher among native species, whereas *Acacia holosericea* (3.4) was found to have more density among exotic.

Table-9. Phytosociology of *Casuarina* Vegetation-Sapling

Sl.No	Name of species (Exotic)	LF	I	O	F	A	D	RA	RF	RD
1	*Acacia leucophloea*	T	2	1	10	2.00	0.60	1.65	1.33	0.60
2	*Atalantia monophylla*	T	75	4	40	18.75	22.52	15.47	5.33	22.52
3	*Azadirachta indica*	T	2	2	20	1.00	0.60	0.82	2.67	0.60
4	*Ixora pavetta*	T	13	2	20	6.50	3.90	5.36	2.67	3.90
5	*Morinda pubescens*	T	1	1	10	1.00	0.30	0.82	1.33	0.30
6	*Allophylus serratus*	SH	4	2	20	2.00	1.20	1.65	2.67	1.20
7	*Benkara malabarica*	SH	9	5	50	1.80	2.70	1.48	6.67	2.70
8	*Breynia vitis-idaea*	SH	1	1	10	1.00	0.30	0.82	1.33	0.30
9	*Canthium coromandelicum*	SH	3	2	20	1.50	0.90	1.24	2.67	0.90
10	*Capparis brevispina*	SH	8	4	40	2.00	2.40	1.65	5.33	2.40
11	*Carmona retusa*	SH	1	1	10	1.00	0.30	0.82	1.33	0.30
12	*Carrisa spinarum*	SH	8	4	40	2.00	2.40	1.65	5.33	2.40
13	*Clausena dentate*	SH	4	2	20	2.00	1.20	1.65	2.67	1.20
14	*Dichrostachys cinerea*	SH	1	1	10	1.00	0.30	0.82	1.33	0.30
15	*Diospyros ferrea*	SH	5	3	30	1.67	1.50	1.37	4.00	1.50
16	*Dodonea angustifolia*	SH	46	6	60	7.67	13.81	6.32	8.00	13.81
17	*Flacourtia indica*	SH	9	2	20	4.50	2.70	3.71	2.67	2.70
18	*Fleuggea leucopyrus*	SH	6	2	20	3.00	1.80	2.47	2.67	1.80
19	*Mallotus philippensis*	SH	1	1	10	1.00	0.30	0.82	1.33	0.30

20	*Maytenus emarginata*	SH	1	1	10	1.00	0.30	0.82	1.33	0.30
21	*Memeyclon umbelatum*	SH	63	2	20	31.50	18.92	25.99	2.67	18.92
22	*Ochna obtusata*	SH	4	2	20	2.00	1.20	1.65	2.67	1.20
23	*Phoneix pusilla*	SH	8	4	40	2.00	2.40	1.65	5.33	2.40
24	*Randia dumetorum*	SH	7	2	20	3.50	2.10	2.89	2.67	2.10
25	*Scutia myrtina*	SH	1	1	10	1.00	0.30	0.82	1.33	0.30
26	*Suregada angustifolia*	SH	1	1	10	1.00	0.30	0.82	1.33	0.30
27	*Tarenna asiatica*	SH	11	3	30	3.67	3.30	3.02	4.00	3.30
28	*Toddalia asiatica*	SH	7	3	30	2.33	2.10	1.92	4.00	2.10
29	*Hemidesmus indicus*	C	1	1	10	1.00	0.30	0.82	1.33	0.30
30	*Hugonia mystax*	C	1	1	10	1.00	0.30	0.82	1.33	0.30
31	*Merremia tridentata*	C	4	1	10	4.00	1.20	3.30	1.33	1.20
32	*Ventilago maderaspatana*	C	2	1	10	2.00	0.60	1.65	1.33	0.60
33	*Ziziphus oenoplia*	C	23	6	60	3.83	6.91	3.16	8.00	6.91
	Total		333	75	750	121.22	100.00	100	100	100
	per hectare				0.075	0.012	0.01			
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Acacia auriculiformis*	T	8	5	50	1.60	0.80	5.53	22.73	10.96
2	*Acacia mangium*	T	4	2	20	2.00	0.40	6.91	9.09	5.48
3	*Casuarina junghuhniana*	T	10	4	40	2.50	1.00	8.64	18.18	13.70
4	*Cassia siamea*	T	9	2	20	4.50	0.90	15.55	9.09	12.33
5	*Eucalyptus citriodora*	T	3	1	10	3.00	0.30	10.37	4.55	4.11
6	*Gliricidia sepium*	T	1	1	10	1.00	0.10	3.46	4.55	1.37
7	*Leucaena leucocephala*	T	1	1	10	1.00	0.10	3.46	4.55	1.37

8	*Acacia holosericea*	SH	34	3	30	11.33	3.40	39.17	13.64	46.58
9	*Breynia retusa*	SH	1	1	10	1.00	0.10	3.46	4.55	1.37
10	*Lantana camara*	SH	2	2	20	1.00	0.20	3.46	9.09	2.74
	Total		73	22	220	28.93	7.30	100	100	100
	per hectare				0.022	0.003	0.0007			

Seedling

A total number of 62 woody species were regenerated under *Casuarina* vegetation that includes 54 native and 8 exotic. The native and exotic species include 1781 and 2189 individuals under *Casuarina* vegetation. The high number of individuals among native species was recorded in *Jasminum angustifolium* (669), followed by *Atalantia monophylla* (115) and *Benkara malabarica* (88) whereas the high number of exotic individuals was recorded in *Acacia holosericea* (1723) followed by *Acacia colei* (302) and *Acacia auriculiformis* (133).

The frequency of *Azadirachta indica* (90), *Carrisa spinarum* (90), *Jasminum angustifolium* (90) was higher among the native species whereas among the exotic the frequency was higher in *Acacia auriculiformis* (70), *Acacia holosericea* (50) and *Acacia colei* (40).

The abundance of the individuals of exotic species was more than that of native species. The abundance among native species was found to be more in *Jasminum angustifolium* (66.90) followed by *Atalantia monophylla* (23.00) and *Rhynchosia minima* (23.00). Among exotic species *Acacia holosericea* recorded more values (344.60) followed by *Acacia colei* (75.50) *and Acacia auriculiformis* (19.00).

The density of *Jasminum angustifolium* (18.92) followed by *Atalantia monophylla* (11.50) was higher among native species. Among exotics *Acacia holosericea* (172.30) recorded more density, followed by *Acacia colei* (30.20) and *Acacia auriculiformis* (13.30).

Table-10. Phytosociology of *Casuarina* Vegetation-Seedling

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Acacia chundra*	T	15	2	20	7.50	1.50	1.99	1.12	0.84
2	*Acacia leucophloea*	T	17	3	30	5.67	1.70	1.50	1.69	0.95
3	*Atalantia monophylla*	T	115	5	50	23.00	11.50	6.09	2.81	6.46
4	*Azadirachta indica*	T	48	9	90	5.33	4.80	1.41	5.06	2.70
5	*Borassus flabellifer*	T	4	2	20	2.00	0.40	0.53	1.12	0.22
6	*Bridelia retusa*	T	1	1	10	1.00	0.10	0.26	0.56	0.06
7	*Casuarina equisetifolia*	T	1	1	10	1.00	0.10	0.26	0.56	0.06
8	*Ixora pavetta*	T	65	7	70	9.29	6.50	2.46	3.93	3.65
9	*Lannea coromandelica*	T	2	2	20	1.00	0.20	0.26	1.12	0.11
10	*Lepisanthes tetraphylla*	T	2	1	10	2.00	0.20	0.53	0.56	0.11
11	*Memeyclon edule*	T	45	8	80	5.63	4.50	1.49	4.49	2.53
12	*Morinda coreia*	T	3	2	20	1.50	0.30	0.40	1.12	0.17
13	*Morinda pubescens*	T	12	5	50	2.40	1.20	0.64	2.81	0.67
14	*Pterocarpus santalinus*	T	12	1	10	12.00	1.20	3.18	0.56	0.67
15	*Allophylus serratus*	SH	13	4	40	3.25	1.30	0.86	2.25	0.73
16	*Benkara malabarica*	SH	88	5	50	17.60	8.80	4.66	2.81	4.94
17	*Breynia retusa*	SH	4	3	30	1.33	0.40	0.35	1.69	0.22
18	*Canthium coromandelicum*	SH	6	4	40	1.50	0.60	0.40	2.25	0.34
19	*Capparis brevispina*	SH	10	4	40	2.50	1.00	0.66	2.25	0.56
20	*Carmona retusa*	SH	4	1	10	4.00	0.40	1.06	0.56	0.22
21	*Carrisa spinarum*	SH	80	9	90	8.89	8.00	2.35	5.06	4.49

22	*Diospyros ferrea*	SH	26	3	30	8.67	2.60	2.29	1.69	1.46
23	*Dodonea angustifolia*	SH	56	4	40	14.00	5.60	3.71	2.25	3.14
24	*Flacourtia indica*	SH	5	3	30	1.67	0.50	0.44	1.69	0.28
25	*Fleuggea leucopyrus*	SH	7	3	30	2.33	0.70	0.62	1.69	0.39
26	*Mallotus philippensis*	SH	3	2	20	1.50	0.30	0.40	1.12	0.17
27	*Memeyclon umbelatum*	SH	2	1	10	2.00	0.20	0.53	0.56	0.11
28	*Ochna obtusata*	SH	5	3	30	1.67	0.50	0.44	1.69	0.28
29	*Phoneix pusilla*	SH	36	7	70	5.14	3.60	1.36	3.93	2.02
30	*Randia dumetorum*	SH	48	4	40	12.00	4.80	3.18	2.25	2.70
31	*Scutia myrtina*	SH	2	2	20	1.00	0.20	0.26	1.12	0.11
32	*Suregada angustifolia*	SH	13	1	10	13.00	1.30	3.44	0.56	0.73
33	*Tarenna asiatica*	SH	17	3	30	5.67	1.70	1.50	1.69	0.95
34	*Toddalia asiatica*	SH	8	3	30	2.67	0.80	0.71	1.69	0.45
35	*Atylosia scarabaeoides*	C	13	1	10	13.00	1.30	3.44	0.56	0.73
36	*Cissampelos pareira*	C	5	2	20	2.50	0.50	0.66	1.12	0.28
37	*Cissus quadrangularis*	C	2	2	20	1.00	0.20	0.26	1.12	0.11
38	*Cissus vitiginea*	C	4	3	30	1.33	0.40	0.35	1.69	0.22
39	*Cocculus hirsutus*	C	1	1	10	1.00	0.10	0.26	0.56	0.06
40	*Derris ovalifolia*	C	7	3	30	2.33	0.70	0.62	1.69	0.39
41	*Diplocyclos palmatus*	C	4	1	10	4.00	0.40	1.06	0.56	0.22
42	*Gymnema sylvestre*	C	12	1	10	12.00	1.20	3.18	0.56	0.67
43	*Hemidesmus indicus*	C	59	7	70	8.43	5.90	2.23	3.93	3.31
44	*Hugonia mystax*	C	24	7	70	3.43	2.40	0.91	3.93	1.35
45	*Ichnocarpus frutescens*	C	1	1	10	1.00	0.10	0.26	0.56	0.06
46	*Jasaminum*	C	669	9	90	74.33	66.90	19.68	5.06	37.56

	angustifolium									
47	*Pachygone ovata*	C	13	2	20	6.50	1.30	1.72	1.12	0.73
48	*Passiflora foetida*	C	7	1	10	7.00	0.70	1.85	0.56	0.39
49	*Reissantia indica*	C	4	2	20	2.00	0.40	0.53	1.12	0.22
50	*Rhynchosia minima*	C	69	3	30	23.00	6.90	6.09	1.69	3.87
51	*Tragia involucrata*	C	21	3	30	7.00	2.10	1.85	1.69	1.18
52	*Ventilago maderaspatana*	C	16	2	20	8.00	1.60	2.12	1.12	0.90
53	*Wattakaka volubilis*	C	1	1	10	1.00	0.10	0.26	0.56	0.06
54	*Ziziphus oenoplia*	C	74	8	80	9.25	7.40	2.45	4.49	4.15
	Total		1781	178	1780	377.80	178.10	100	100	100
	per hectare				1.78	0.378	0.1781			
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Acacia auriculiformis*	T	133	7	70	19.00	13.30	4.17	29.17	6.08
2	*Acacia colei*	T	302	4	40	75.50	30.20	16.55	16.67	13.80
3	*Acacia mangium*	T	10	2	20	5.00	1.00	1.10	8.33	0.46
4	*Cassia siamea*	T	16	2	20	8.00	1.60	1.75	8.33	0.73
5	*Casuarina junghuhniana*	T	1	1	10	1.00	0.10	0.22	4.17	0.05
6	*Peltophorum pterocarpum*	T	2	1	10	2.00	0.20	0.44	4.17	0.09
7	*Acacia holosericea*	SH	1723	5	50	344.60	172.30	75.55	20.83	78.71
8	*Lantana camara*	SH	2	2	20	1.00	0.20	0.22	8.33	0.09
	Total		2189	24	240	456.10	218.90	100	100	100
	per hectare				0.024	0.046	0.0219			

Herb

The total number of herbaceous species regenerated under *Casuarina* vegetation was 18 that includes (15) native and (3) exotic. There were 207 and 62 individuals from native and exotic species respectively. The high number of individuals in native species was recorded in *Lepidagathis cristata* (49), *Hybanthus enneaspermus* (37), *Desmodium triflorum* (20) and other species have represented by 1-19 individuals in each. Whereas the high number of individuals among exotic species was found in *Sebastiania chamaelea* (46) followed by *Ageratum conyzoides* (15) and *Melochia corchorifolia* was represented by a lone member.

The frequency of native and exotic species ranged from 10-40. *Crotalaria medicagenia, Hybanthus enneaspermus, Ageratu conyzoides* and *Sebastina chamaelea* showed maximum frequency of 40 and five species showed minimum frequency of 10. The frequency among the native species was higher in *Hybanthus enneaspermus* (40), followed by *Crotalaria medicaginea* (40), *Justicia procumbens* (30), *Phyllanthus madrespatensis* (30). Among the exotic the frequency was more in *Ageratum conyzoides* (40) followed by *Sebastiania chamaelea* (40) *and Melochia corchorifolia* (10).

The abundance of was high in *Lepidagathis cristata* (24.50) followed by *Dipteracanthus patulus* (12.00), *Vernonia cinerea* (11.00) among native species. Among exotic species *Sebastiania chamaelea* showed maximum abundance (11.50) and *Melochia corchorifolia* (1.00) was in minimum abundance.

Table-11. Phytosociology of *Casuarina* Vegetation-Herb

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Barleria prionitis*	H	2	2	20	1.00	0.20	1.02	6.25	0.97
2	*Crotalaria medicaginea*	H	16	4	40	4.00	1.60	4.07	12.50	7.73
3	*Desmodium triflorum*	H	20	2	20	10.00	2.00	10.18	6.25	9.66
4	*Dipteracanthus patulus*	H	12	1	10	12.00	1.20	12.21	3.13	5.80
5	*Eulophia epidendraea*	H	3	1	10	3.00	0.30	3.05	3.13	1.45
6	*Hybanthus enneaspermus*	H	37	4	40	9.25	3.70	9.41	12.50	17.87
7	*Justicia procumbens*	H	19	3	30	6.33	1.90	6.45	9.38	9.18
8	*Lepidagathis cristata*	H	49	2	20	24.50	4.90	24.94	6.25	23.67
9	*Pavonia zeylanica*	H	1	1	10	1.00	0.10	1.02	3.13	0.48
10	*Phyllanthus madrespatensis*	H	14	3	30	4.67	1.40	4.75	9.38	6.76
11	*Polygala arvensis*	H	15	2	20	7.50	1.50	7.63	6.25	7.25
12	*Pseudarthria viscida*	H	3	2	20	1.50	0.30	1.53	6.25	1.45
13	*Triumfetta rotundifolia*	H	2	2	20	1.00	0.20	1.02	6.25	0.97
14	*Vernonia cinerea*	H	11	1	10	11.00	1.10	11.20	3.13	5.31
15	*Waltheria indica*	H	3	2	20	1.50	0.30	1.53	6.25	1.45
	Total		207	32	320	98.25	20.70	100	100	100
	per hectare				0.032	0.01	0.0021			
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Ageratum conyzoides*	H	15	4	40	3.75	1.50	23.08	44.44	24.19

2	*Melochia corchorifolia*	H	1	1	10	1.00	0.10	6.15	11.11	1.61
3	*Sebastiania chamaelea*	H	46	4	40	11.50	4.60	70.77	44.44	74.19
	Total		62	9	90	16.25	6.20	100	100	100
	per hectare				0.009	0.002	0.0006			

The density of *Lepidagathis cristata* (4.90) and *Hybanthus enneaspermus* (3.70) was higher among native species.Whereas *Sebastiania chamaelea* (4.60) has more *density* followed by *Ageratum conyzoides* (1.50) *and Melochia corchorifolia* (0.10) among exotic species.

4. 2.3.Mixed vegetation

Adult

The total number of regenerated species under mixed vegetation was 61 that includes 50 native and 11 exotic species. There were 238 and 110 individuals of native and exotic species respectively. The high number of individuals among native was recorded in *Syzygium cumini* (25), followed by *Suregada angustifolia* (21), *Azadirachta indica* (17) and *Benkara malabarica* (16), whereas the high number of exotic individuals was found in *Acacia auriculiformis* (58) followed by *Acacia colei* (13)and *Acacia holosericea* (10). Fifteen native species and one exotic species were represented by one individual each.

The basal area of the native species *Azadirachta indica* (38720.71 m^2) was higher followed by *Syzygium cumini* (27605.90m^2) and *Pterospermum suberifolium* (10722.71m^2), where as the basal area of *Acacia auriculiformis* (33743.42m^2), *Casuarina junghuhniana* (15321.24 m^2) and *Acacia colei* (8446.80 m^2) were higher among exotic species.

Table-12. Phytosociology of Mixed Vegetation-Adult

Sl.No	Name of species (Native)	LF	I	O	BA	BV	F	A	D	RA	RF	RD	RDO	IVI	H	D
1	*Acacia chundra*	T	1	1	785.98	238.64	2.33	1.00	0.02	0.02	0.93	0.42	0.55	1.90	0.03	0.00
2	*Acacia leucophloea*	T	2	1	1162.59	587.30	2.33	2.00	0.05	0.03	0.93	0.84	0.81	2.59	0.04	0.00
3	*Albizia lebbeck*	T	2	2	2141.87	1933.92	4.65	1.00	0.05	0.03	1.87	0.84	1.49	4.20	0.06	0.00
4	*Atalantia monophylla*	T	10	5	4171.88	2628.69	11.63	2.00	0.23	0.17	4.67	4.20	2.91	11.78	0.13	0.00
5	*Azadirachta indica*	T	17	12	38720.71	37847.64	27.91	1.42	0.40	0.29	11.21	7.14	26.99	45.35	0.29	0.02
6	*Bambusa arundinacea*	T	5	1	493.77	389.26	2.33	5.00	0.12	0.09	0.93	2.10	0.34	3.38	0.05	0.00
7	*Bauhinia racemosa*	T	1	1	706.50	410.77	2.33	1.00	0.02	0.02	0.93	0.42	0.49	1.85	0.03	0.00
8	*Borassus flabellifer*	T	2	2	5102.50	4537.71	4.65	1.00	0.05	0.03	1.87	0.84	3.56	6.27	0.08	0.00
9	*Buchanania axillaries*	T	2	2	1140.02	745.59	4.65	1.00	0.05	0.03	1.87	0.84	0.79	3.50	0.05	0.00
10	*Butea monosperma*	T	1	1	1074.67	805.33	2.33	1.00	0.02	0.02	0.93	0.42	0.75	2.10	0.03	0.00
11	*Casuarina equisetifolia*	T	3	1	1846.32	3458.96	2.33	3.00	0.07	0.05	0.93	1.26	1.29	3.48	0.05	0.00
12	*Chloroxylon swietienia*	T	1	1	433.71	222.01	2.33	1.00	0.02	0.02	0.93	0.42	0.30	1.66	0.03	0.00
13	*Dalbergia paniculata*	T	1	1	1700.11	156145.75	2.33	1.00	0.02	0.02	0.93	0.42	1.19	2.54	0.04	0.00
14	*Ficus benghalensis*	T	1	1	536.35	435.18	2.33	1.00	0.02	0.02	0.93	0.42	0.37	1.73	0.03	0.00
15	*Garcinia spicata Hook*	T	8	2	2925.11	2354.38	4.65	4.00	0.19	0.14	1.87	3.36	2.04	7.27	0.09	0.00
16	*Gyrocarpus americanus*	T	1	1	452.16	356.36	2.33	1.00	0.02	0.02	0.93	0.42	0.32	1.67	0.03	0.00
17	*Hardwickia binata*	T	2	2	2375.41	2331.19	4.65	1.00	0.05	0.03	1.87	0.84	1.66	4.37	0.06	0.00
18	*Hildegardia populifolia*	T	1	1	103.82	40.24	2.33	1.00	0.02	0.02	0.93	0.42	0.07	1.43	0.03	0.00
19	*Ixora pavetta*	T	6	6	1017.75	320.55	13.95	1.00	0.14	0.10	5.61	2.52	0.71	8.84	0.10	0.00
20	*Lannea coromandelica*	T	2	2	367.38	171.61	4.65	1.00	0.05	0.03	1.87	0.84	0.26	2.97	0.05	0.00

21	*Lepisanthes tetraphylla*	T	2	1	773.23	363.83	2.33	2.00	0.05	0.03	0.93	0.84	0.54	2.31	0.04	0.00
22	*Manilkara hexandra*	T	3	1	4753.18	3637.97	2.33	3.00	0.07	0.05	0.93	1.26	3.31	5.51	0.07	0.00
23	*Morinda coreia*	T	9	9	8748.04	15722.16	20.93	1.00	0.21	0.15	8.41	3.78	6.10	18.29	0.17	0.00
24	*Morinda pubescens*	T	2	2	691.59	328.89	4.65	1.00	0.05	0.03	1.87	0.84	0.48	3.19	0.05	0.00
25	*Narangi crenulata*	T	1	1	176.63	61.62	2.33	1.00	0.02	0.02	0.93	0.42	0.12	1.48	0.03	0.00
26	*Phyllanthus polyphyllus*	T	6	1	478.26	141.15	2.33	6.00	0.14	0.10	0.93	2.52	0.33	3.79	0.06	0.00
27	*Pterospermum suberifolium*	T	12	4	10722.71	11100.99	9.30	3.00	0.28	0.20	3.74	5.04	7.47	16.25	0.16	0.00
28	*Santalum album*	T	1	1	122.66	60.22	2.33	1.00	0.02	0.02	0.93	0.42	0.09	1.44	0.03	0.00
29	*Semecarpus anacardium*	T	5	1	2250.60	1466.52	2.33	5.00	0.12	0.09	0.93	2.10	1.57	4.60	0.06	0.00
30	*Syzygium cumini*	T	25	1	27605.90	29632.26	2.33	25.00	0.58	0.43	0.93	10.50	19.24	30.68	0.23	0.01
31	*Terminalia arjuna*	T	1	1	961.63	931.83	2.33	1.00	0.02	0.02	0.93	0.42	0.67	2.03	0.03	0.00
32	*Ziziphus xylopyrus*	T	7	3	4857.78	2150.96	6.98	2.33	0.16	0.12	2.80	2.94	3.39	9.13	0.11	0.00
33	*Benkara malabarica*	SH	16	4	1917.95	856.06	9.30	4.00	0.37	0.27	3.74	6.72	1.34	11.80	0.13	0.00
34	*Canthium coromandelicum*	SH	3	2	294.57	131.22	4.65	1.50	0.07	0.05	1.87	1.26	0.21	3.33	0.05	0.00
35	*Capparis brevispina*	SH	4	3	404.67	151.28	6.98	1.33	0.09	0.07	2.80	1.68	0.28	4.77	0.07	0.00
36	*Diospyros ferrea*	SH	4	3	358.16	137.50	6.98	1.33	0.09	0.07	2.80	1.68	0.25	4.73	0.07	0.00
37	*Dichrostachys cinerea*	SH	3	2	643.11	236.50	4.65	1.50	0.07	0.05	1.87	1.26	0.45	3.58	0.05	0.00
38	*Dodonea angustifolia*	SH	1	1	113.04	55.50	2.33	1.00	0.02	0.02	0.93	0.42	0.08	1.43	0.03	0.00
39	*Flacourtia indica*	SH	4	1	550.68	202.05	2.33	4.00	0.09	0.07	0.93	1.68	0.38	3.00	0.05	0.00
40	*Fleuggea leucopyrus*	SH	1	1	176.63	79.87	2.33	1.00	0.02	0.02	0.93	0.42	0.12	1.48	0.03	0.00
41	*Gmelina asiatica*	SH	1	1	94.99	26.39	2.33	1.00	0.02	0.02	0.93	0.42	0.07	1.42	0.03	0.00
42	*Mallotus philippensis*	SH	15	1	1606.11	829.44	2.33	15.00	0.35	0.26	0.93	6.30	1.12	8.36	0.10	0.00
43	*Memeyclon umbelatum*	SH	2	2	173.09	72.68	4.65	1.00	0.05	0.03	1.87	0.84	0.12	2.83	0.04	0.00
44	*Ochna obtusata*	SH	1	1	86.55	46.96	2.33	1.00	0.02	0.02	0.93	0.42	0.06	1.42	0.03	0.00

45	*Randia dumetorum*	SH	2	1	226.08	67.18	2.33	2.00	0.05	0.03	0.93	0.84	0.16	1.93	0.03	0.00
46	*Suregada angustifolia*	SH	21	2	3748.57	2660.97	4.65	10.50	0.49	0.36	1.87	8.82	2.61	13.31	0.14	0.00
47	*Ximenia americana*	SH	3	1	688.84	480.71	2.33	3.00	0.07	0.05	0.93	1.26	0.48	2.68	0.04	0.00
48	*Derris ovalifolia*	C	8	4	1150.81	1066.66	9.30	2.00	0.19	0.14	3.74	3.36	0.80	7.90	0.10	0.00
49	*Hugonia mystax*	C	4	3	908.64	370.00	6.98	1.33	0.09	0.07	2.80	1.68	0.63	5.12	0.07	0.00
50	*Ziziphus oenoplia*	C	2	2	916.88	1127.02	4.65	1.00	0.05	0.03	1.87	0.84	0.64	3.35	0.05	0.00
	Total		238	107	143460.12	290157.47	248.84	136.25	5.53	4.06	100	100	100	300	3.41	0.05
	per hectare				14.35	29.02	0.02	0.01	0.001							
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**BA**	**BV**	**F**	**A**	**D**	**RA**	**RF**	**RD**	**RDO**	**IVI**	**H**	**D**
1	*Acacia auriculiformis*	T	58	20	33743.42	484449.40	46.51	2.90	1.35	14.61	37.74	52.73	49.59	140.05	0.36	0.22
2	*Acacia colei*	T	13	9	8446.80	25642.14	20.93	1.44	0.30	7.28	16.98	11.82	12.41	41.21	0.27	0.02
3	*Acacia mangium*	T	4	2	2289.85	1878.45	4.65	2.00	0.09	10.08	3.77	3.64	3.37	10.78	0.12	0.00
4	*Acacia tumida*	T	3	1	296.73	119.49	2.33	3.00	0.07	15.12	1.89	2.73	0.44	5.05	0.07	0.00
5	*Casuarina junghuhniana*	T	6	4	15321.24	994316.58	9.30	1.50	0.14	7.56	7.55	5.45	22.52	35.52	0.25	0.01
6	*Delonix regia*	T	4	3	2944.54	1908.35	6.98	1.33	0.09	6.72	5.66	3.64	4.33	13.62	0.14	0.00
7	*Gliricidia sepium*	T	2	1	291.24	174.19	2.33	2.00	0.05	10.08	1.89	1.82	0.43	4.13	0.06	0.00
8	*Leucaena leucocephala*	T	5	3	1717.78	1238.42	6.98	1.67	0.12	8.40	5.66	4.55	2.52	12.73	0.13	0.00
9	*Plumeria rubra*	T	4	3	479.05	138.71	6.98	1.33	0.09	6.72	5.66	3.64	0.70	10.00	0.11	0.00
10	*Acacia holosericea*	SH	10	6	2417.41	1289.35	13.95	1.67	0.23	8.40	11.32	9.09	3.55	23.96	0.20	0.01
11	*Ipomoea carnea*	SH	1	1	94.99	26.07	2.33	1.00	0.02	5.04	1.89	0.91	0.14	2.94	0.05	0.00
	Total		110	53	68043.02	1511181.2	1.23	19.84	2.56	100.00	100	100	100	300	1.76	0.26
	per hectare				6.804302	151.11812		0.002								

Similarly, the bio volume was higher among native species of *Dalbergia paniculata* (156145.75 m^3) and *Azadirachta indica* (37847.64 m^3) and *Syzygium cumini* (29632.26 m^3) while the bio volume of *Casuarina junghuhniana* (994316.58 m^3), *Acacia aurculiformis* (484449.40 m^3) and *Acacia colei* (25642.14) were higher among exotic species

The frequency among the native species was higher in *Azadirachta indica* (27.91), *Morinda coreia* (20.93) *Ixora pavetta* (13.95) and *Atalantia monophylla* (11.63) whereas among the exotic the frequency was higher in *Acacia auriculiformis* (46.51) followed by *Acacia colei* (20.93) and *Acacia holosericea* (13.95).

The abundance among native species such as *Syzygium cumini* (25.00) was higher followed by *Mallotus philippensis* (12.00), *Suregada angustifolia* (10.50) whereas *Acacia tumida* (3.00), followed by *Acacia auriculiformis* (2.90) had more values among exotic species.

The density among native species was more in *Syzygium cumini* (0.58) followed by *Suregada angustifolia* (0.49), whereas it was more in *Acacia auriculiformis* (1.35) followed by *Acacia colei* (0.30) .

The important value index (IVI) was higher in *Azadirachta indica* (45.35) followed by *Syzygium cumini* (30.68) and *Pterospermum suberifolium* (16.25) among the native species, whereas among the exotic species, the IVI was higher in *Acacia aurculiformis* (140.05) and *Acacia colei* (41.21).

The Shannon value was higher in *Azadirachta indica* (0.29) followed by *Syzygium cumini* (0.23), *Morinda coreia* (0.17) and *Pterospermum suberifolium* (0.16) among the native while in the exotic it was higher in *Acacia auriculiformis* (0.36) followed by *Acacia colei* (0.27), *Casuarina junghuhniana*(0.25) and *Acacia holosericea* (0.20).

The Simpson value was higher in *Azadirachta indica* (0.02) followed by *Syzygium cumini* (0.01) among native and while in the exotic it and was higher in *Acacia auriculiformis* (0.22) followed by *Acacia colei* (0.02) *Casuarina junghuhniana* (0.01).

Juvenile

The total number of regenerated juvenile species under mixed vegetation was 62 that include 50 native and 12 exotic. There were 564 and 216 individuals of native and exotic species respectively. The high number of native individuals was recorded in *Benkara malabarica* (175), followed by *Memeyclon umbelatum* (47), *Hugonia mystax* (41), whereas the high number of exotic individuals was found in *Acacia holosericea* (110), followed by *Acacia colei* (42) *Acacia aurculiformis* (41). Seventeen native species and three exotic were represented by one individual each.

The basal area of native species *Benkara malabarica* (5024.82 m^2) was higher followed by *Memeyclon umbelatum* (1454.40 m^2) and *Randia dumetorum* (1232.89 m^2), where as the basal area of *Acacia*

Table -13. Phytosociology of Mixed Vegetation-Juvenilie

Sl.No	Name of species (Native)	LF	I	O	BA	BV	F	A	D	RA	RF	RD	RDO	IVI	H	D
1	*Acacia chundra*	T	5	2	284.56	80.90	4.65	2.50	0.12	2.01	1.25	0.89	1.60	3.74	0.05	0.00
2	*Albizia lebbeck*	T	1	1	78.50	40.57	2.33	1.00	0.02	0.80	0.63	0.18	0.44	1.24	0.02	0.00
3	*Atalantia monophylla*	T	7	5	668.23	292.31	11.63	1.40	0.16	1.13	3.13	1.24	3.76	8.13	0.10	0.00
4	*Azadirachta indica*	T	7	7	375.43	118.07	16.28	1.00	0.16	0.80	4.38	1.24	2.11	7.73	0.09	0.00
5	*Bambusa arundinacea*	T	5	1	354.62	281.32	2.33	5.00	0.12	4.02	0.63	0.89	2.00	3.51	0.05	0.00
6	*Bauhinia (Planted)*	T	2	1	25.12	5.60	2.33	2.00	0.05	1.61	0.63	0.35	0.14	1.12	0.02	0.00
7	*Casuarina equisetifolia*	T	1	1	12.56	4.54	2.33	1.00	0.02	0.80	0.63	0.18	0.07	0.87	0.02	0.00
8	*Drypetes sepiaria*	T	2	1	25.12	11.85	2.33	2.00	0.05	1.61	0.63	0.35	0.14	1.12	0.02	0.00
9	*Dolichandrone falcata*	T	1	1	33.17	9.64	2.33	1.00	0.02	0.80	0.63	0.18	0.19	0.99	0.02	0.00
10	*Ficus benghalensis*	T	1	1	50.24	18.50	2.33	1.00	0.02	0.80	0.63	0.18	0.28	1.09	0.02	0.00
11	*Garcinia spicata*	T	1	1	50.24	19.47	2.33	1.00	0.02	0.80	0.63	0.18	0.28	1.09	0.02	0.00
12	*Hildegardia populifolia*	T	2	2	102.05	29.67	4.65	1.00	0.05	0.80	1.25	0.35	0.57	2.18	0.04	0.00
13	*Ixora pavetta*	T	21	7	825.43	233.96	16.28	3.00	0.49	2.41	4.38	3.72	4.65	12.75	0.13	0.00
14	*Limonia acidissima*	T	1	1	38.47	10.69	2.33	1.00	0.02	0.80	0.63	0.18	0.22	1.02	0.02	0.00
15	*Memeyclon edule*	T	3	2	37.68	11.60	4.65	1.50	0.07	1.21	1.25	0.53	0.21	1.99	0.03	0.00
16	*Mitrangyna parvifolia*	T	1	1	19.63	9.13	2.33	1.00	0.02	0.80	0.63	0.18	0.11	0.91	0.02	0.00
17	*Mimusops elengi*	T	1	1	50.24	18.18	2.33	1.00	0.02	0.80	0.63	0.18	0.28	1.09	0.02	0.00
18	*Morinda coreia*	T	5	4	189.58	67.60	9.30	1.25	0.12	1.00	2.50	0.89	1.07	4.45	0.06	0.00
19	*Phyllanthus polyphyllus*	T	28	2	546.95	9995.99	4.65	14.00	0.65	11.25	1.25	4.96	3.08	9.29	0.11	0.00
20	*Strychnos nux-vomica*	T	1	1	4.91	9.51	2.33	1.00	0.02	0.80	0.63	0.18	0.03	0.83	0.02	0.00
21	*Terminalia arjuna*	T	1	1	13.20	3066.19	2.33	1.00	0.02	0.80	0.63	0.18	0.07	0.88	0.02	0.00

22	*Ziziphus xylopyrus*	T	1	1	12.56	2.76	2.33	1.00	0.02	0.80	0.63	0.18	0.07	0.87	0.02	0.00
23	*Allophylus serratus*	SH	3	2	37.68	9.82	4.65	1.50	0.07	1.21	1.25	0.53	0.21	1.99	0.03	0.00
24	*Benkara malabarica*	SH	175	12	5024.82	27774.64	27.91	14.58	4.07	11.72	7.50	31.03	28.29	66.82	0.33	0.05
25	*Canthium coromandelicum*	SH	6	4	216.66	77.86	9.30	1.50	0.14	1.21	2.50	1.06	1.22	4.78	0.07	0.00
26	*Capparis brevispina*	SH	2	1	25.12	5.92	2.33	2.00	0.05	1.61	0.63	0.35	0.14	1.12	0.02	0.00
27	*Carmona retusa*	SH	1	1	12.56	4.22	2.33	1.00	0.02	0.80	0.63	0.18	0.07	0.87	0.02	0.00
28	*Carrisa spinarum*	SH	8	3	100.48	31.00	6.98	2.67	0.19	2.14	1.88	1.42	0.57	3.86	0.06	0.00
29	*Dichrostachys cinerea*	SH	5	2	235.11	73.76	4.65	2.50	0.12	2.01	1.25	0.89	1.32	3.46	0.05	0.00
30	*Diospyros ferrea*	SH	20	12	546.41	194.84	27.91	1.67	0.47	1.34	7.50	3.55	3.08	14.12	0.14	0.00
31	*Dodonea angustifolia*	SH	35	11	821.70	507.28	25.58	3.18	0.81	2.56	6.88	6.21	4.63	17.71	0.17	0.00
32	*Fleuggea leucopyrus*	SH	2	2	69.87	23.36	4.65	1.00	0.05	0.80	1.25	0.35	0.39	2.00	0.03	0.00
33	*Mallotus philippensis*	SH	16	2	488.47	194.57	4.65	8.00	0.37	6.43	1.25	2.84	2.75	6.84	0.09	0.00
34	*Maytenus emarginata*	SH	2	2	32.19	9.17	4.65	1.00	0.05	0.80	1.25	0.35	0.18	1.79	0.03	0.00
35	*Memeyclon umbelatum*	SH	47	10	1454.40	683.96	23.26	4.70	1.09	3.78	6.25	8.33	8.19	22.77	0.20	0.01
36	*Pavetta indica*	SH	1	1	63.59	18.90	2.33	1.00	0.02	0.80	0.63	0.18	0.36	1.16	0.02	0.00
37	*Randia dumetorum*	SH	36	10	1232.89	1088.53	23.26	3.60	0.84	2.89	6.25	6.38	6.94	19.57	0.18	0.00
38	*Suregada angustifolia*	SH	5	1	285.54	154.75	2.33	5.00	0.12	4.02	0.63	0.89	1.61	3.12	0.05	0.00
39	*Tarenna asiatica*	SH	1	1	16.61	7.30	2.33	1.00	0.02	0.80	0.63	0.18	0.09	0.90	0.02	0.00
40	*Toddalia asiatica*	SH	3	1	37.68	10.06	2.33	3.00	0.07	2.41	0.63	0.53	0.21	1.37	0.02	0.00
41	*Ximenia americana*	SH	1	1	44.16	9.98	2.33	1.00	0.02	0.80	0.63	0.18	0.25	1.05	0.02	0.00
42	*Capparis zeylanica*	C	1	1	50.24	19.47	2.33	1.00	0.02	0.80	0.63	0.18	0.28	1.09	0.02	0.00
43	*Cissus vitiginea*	C	2	1	32.19	24.40	2.33	2.00	0.05	1.61	0.63	0.35	0.18	1.16	0.02	0.00
44	*Derris ovalifolia*	C	18	6	891.96	760.75	13.95	3.00	0.42	2.41	3.75	3.19	5.02	11.96	0.13	0.00
45	*Hugonia mystax L.*	C	41	11	1124.12	432.67	25.58	3.73	0.95	3.00	6.88	7.27	6.33	20.47	0.18	0.00

46	*Jasaminum angustifolium*	C	2	1	25.12	5.44	2.33	2.00	0.05	1.61	0.63	0.35	0.14	1.12	0.02	0.00
47	*Reissantia indica*	C	2	1	47.89	20.77	2.33	2.00	0.05	1.61	0.63	0.35	0.27	1.25	0.02	0.00
48	*Strychnos minor*	C	4	2	112.45	68.03	4.65	2.00	0.09	1.61	1.25	0.71	0.63	2.59	0.04	0.00
49	*Ventilago maderaspatana*	C	1	1	137.38	131.34	2.33	1.00	0.02	0.80	0.63	0.18	0.77	1.58	0.03	0.00
50	*Ziziphus oenoplia*	C	26	12	797.95	365.22	27.91	2.17	0.60	1.74	7.50	4.61	4.49	16.60	0.16	0.00
	Total		564	160	17763.67	47046.04	372.09	124.44	13.12	100.00	100	100	100	300	3.09	0.08
	per hectare				1.78	4.70	0.04	0.01	0.00							
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**BA**	**BV**	**F**	**A**	**D**	**RA**	**RF**	**RD**	**RDO**	**IVI**	**H**	**D**
1	*Acacia auriculiformis*	T	41	19	1428.06	5695.86	44.19	2.16	0.95	7.94	31.67	18.98	22.10	72.75	0.34	0.06
2	*Acacia colei*	T	42	12	1095.47	2389.16	27.91	3.50	0.98	12.88	20.00	19.44	16.96	56.40	0.31	0.04
3	*Acacia tumida*	T	1	1	23.75	8.13	2.33	1.00	0.02	3.68	1.67	0.46	0.37	2.50	0.04	0.00
4	*Adenanthera pavonina*	T	1	1	38.47	17.39	2.33	1.00	0.02	3.68	1.67	0.46	0.60	2.72	0.04	0.00
5	*Caesalpinia coriaria*	T	2	1	66.33	17.78	2.33	2.00	0.05	7.36	1.67	0.93	1.03	3.62	0.05	0.00
6	*Casuarina junghuhniana*	T	4	3	228.44	136.99	6.98	1.33	0.09	4.91	5.00	1.85	3.54	10.39	0.12	0.00
7	*Eucalyptus citriodora*	T	5	2	258.03	193.17	4.65	2.50	0.12	9.20	3.33	2.31	3.99	9.64	0.11	0.00
8	*Gliricidia sepium*	T	2	1	56.72	24.64	2.33	2.00	0.05	7.36	1.67	0.93	0.88	3.47	0.05	0.00
9	*Khaya senegalensis*	T	1	1	78.50	31.95	2.33	1.00	0.02	3.68	1.67	0.46	1.22	3.34	0.05	0.00
10	*Leucaena leucocephala*	T	4	3	89.10	35.82	6.98	1.33	0.09	4.91	5.00	1.85	1.38	8.23	0.10	0.00
11	*Acacia holosericea*	SH	110	14	3030.36	1173.43	32.56	7.86	2.56	28.91	23.33	50.93	46.90	121.16	0.37	0.16
12	*Lantana camara*	SH	3	2	67.51	35.21	4.65	1.50	0.07	5.52	3.33	1.39	1.04	5.77	0.08	0.00
	Total		216	60	6460.72	9759.54	139.53	27.18	5.02	100.00	100	100	100	300	1.66	0.26
	per hectare				0.646072	0.9759538	0.014	0.0027	5E-04							

holosericea (3030.36 m^2) *Acacia auriculiformis* (1428.06 m^2) and *Acacia colei* (1095.47 m^2) were higher among exotic species

Similarly, the bio volume was higher among native species in *Terminalia arjuna* (3066.19 m^3) while the bio volume of *Acacia auriculiformis* (5695.86 m^3), *Acacia colei* (2389.16 m^3) and *Acacia holosericea* (1173.43 m^3) were higher among exotic species.

The frequency was higher among the native species in *Benkara malabarica* (27.91), *Diospyros ferrea* (27.91) and *Ziziphus oenoplia* (27.91) whereas among the exotic it was more in *Acacia auriculiformis* (44.19) followed by *Acacia holosericea* (32.56) and *Acacia colei* (27.91).

The abundance among native species was higher in *Benkara malabarica* (14.58) followed by *Phyllanthus polyphyllus* (14.00) *Mallotus philippensis* (8.00) whereas it was more in *Acacia colei* (3.50) followed by *Acacia holosericea* (2.56), *Acacia auriculiformis* (2.16) among exotic.

The density of the native species was higher in *Benkara malabarica* (4.07) whereas it was more in *Acacia holosericea* (2.56) among exotic species studied. The lowest density of 0.02 was recorded in sixteen native species and in four exotic species.

The important value index (IVI) was higher in *Benkara malabarica* (66.82) followed by *Memeyclon umbelatum* (8.19) *Hugonia mystax* (6.94) among the native species, whereas among the exotic species it was higher in *Acacia holosericea* (121.16) followed by, *Acacia auriculiformis* (72.75) and *Acacia colei* (56.40).

The Shannon value of the native species was higher in *Benkara malabarica* (0.33) followed by *Memeyclon umbelatum* (0.20), *Randia dumetorum* (0.18) and *Dodonea angustifolia* (0.17) and in the exotic the Shannon value was higher in *Acacia holosericea* (0.37) followed by *Acacia auriculiformis* (0.34) and *Acacia colei* (0.31).

Of the native species observed, the Simpson value was higher in *Benkara malabarica* (0.05) followed by *Memeyclon umbelatum* (0.01) and in the exotic the Simpson value was higher in *Acacia holosericea* (0.06), *Acacia auriculiformis* (0.06) and (0.04)

Sapling

The total number of regenerated species under mixed vegetation was 101 that include 81native and 20 exotic. The native species included 2134 individuals and all the exotic species included 610 individuals. The high number of individuals in native species was in *Dodonea angustifolia* (394) followed by *Benkara malabarica* (203), *Memeyclon umbelatum* (125) whereas the high number of individuals of the exotics species was observed in *Acacia holosericea* (270) followed by *Acacia aurculiformis* (95) and *Acacia colei* (91).Twenty native species and eight exotic species were represented by one individual each.

Among the native species the frequency was higher in *Dodonea angustifolia* (58.14), *Carrisa spinarum* (53.58) *Ziziphus oenoplia* (48.84) and *Phoneix pusilla* (48.54) whereas among the exotic the frequency was higher in *Acacia auriculiformis* (53.49), *Acacia holosericea* (39.53) and *Acacia colei* (37.21). The lowest frequency of 2.33 was observed in 32 native species and in 13 exotic species.

Table-14. Phytosociology of Mixed Vegetation-Sapling

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Acacia chundra*	T	7	3	6.98	2.33	0.16	0.80	0.65	0.33
2	*Acacia leucophloea*	T	2	1	2.33	2.00	0.05	0.68	0.22	0.09
3	*Albizia lebbeck*	T	6	3	6.98	2.00	0.14	0.68	0.65	0.28
4	*Atalantia monophylla*	T	34	6	13.95	5.67	0.79	1.94	1.29	1.59
5	*Azadirachta indica*	T	42	11	25.58	3.82	0.98	1.30	2.37	1.97
6	*Bambusa arundinacea*	T	2	2	4.65	1.00	0.05	0.34	0.43	0.09
7	*Cordia dichotoma*	T	3	1	2.33	3.00	0.07	1.03	0.22	0.14
8	*Drypetes sepiaria*	T	1	1	2.33	1.00	0.02	0.34	0.22	0.05
9	*Ixora pavetta*	T	106	21	48.84	5.05	2.47	1.72	4.53	4.97
10	*Lannea coromandelica*	T	5	2	4.65	2.50	0.12	0.85	0.43	0.23
11	*Mangifera indica*	T	1	1	2.33	1.00	0.02	0.34	0.22	0.05
12	*Memeyclon edule*	T	23	2	4.65	11.50	0.53	3.93	0.43	1.08
13	*Morinda coreia*	T	5	4	9.30	1.25	0.12	0.43	0.86	0.23
14	*Morinda pubescens*	T	10	9	20.93	1.11	0.23	0.38	1.94	0.47
15	*Phyllanthus polyphyllus*	T	12	3	6.98	4.00	0.28	1.37	0.65	0.56
16	*Polyalthia longifolia*	T	5	1	2.33	5.00	0.12	1.71	0.22	0.23
17	*Pterocarpus santalinus*	T	1	1	2.33	1.00	0.02	0.34	0.22	0.05
18	*Pterospermum suberifolium*	T	7	1	2.33	7.00	0.16	2.39	0.22	0.33
19	*Syzygium cumini*	T	2	2	4.65	1.00	0.05	0.34	0.43	0.09
20	*Ziziphus xylopyrus*	T	1	1	2.33	1.00	0.02	0.34	0.22	0.05

21	*Allophylus serratus*	SH	46	5	11.63	9.20	1.07	3.14	1.08	2.16
22	*Benkara malabarica*	SH	203	21	48.84	9.67	4.72	3.30	4.53	9.51
23	*Breynia vitis-idaea*	SH	19	7	16.28	2.71	0.44	0.93	1.51	0.89
24	*Cadaba fruiticosa*	SH	1	1	2.33	1.00	0.02	0.34	0.22	0.05
25	*Canthium coromandelicum*	SH	14	7	16.28	2.00	0.33	0.68	1.51	0.66
26	*Capparis brevispina*	SH	31	16	37.21	1.94	0.72	0.66	3.45	1.45
27	*Carmona retusa*	SH	30	7	16.28	4.29	0.70	1.46	1.51	1.41
28	*Carrisa spinarum*	SH	85	23	53.49	3.70	1.98	1.26	4.96	3.98
29	*Clausena dentate*	SH	4	3	6.98	1.33	0.09	0.46	0.65	0.19
30	*Dichrostachys cinerea*	SH	7	4	9.30	1.75	0.16	0.60	0.86	0.33
31	*Diospyros ferrea*	SH	61	20	46.51	3.05	1.42	1.04	4.31	2.86
32	*Dodonea angustifolia*	SH	394	25	58.14	15.76	9.16	5.39	5.39	18.46
33	*Flacourtia indica*	SH	23	12	27.91	1.92	0.53	0.65	2.59	1.08
34	*Fleuggea leucopyrus*	SH	36	8	18.60	4.50	0.84	1.54	1.72	1.69
35	*Glycosmis mauritiana*	SH	2	1	2.33	2.00	0.05	0.68	0.22	0.09
36	*Gmelina asiatica*	SH	3	2	4.65	1.50	0.07	0.51	0.43	0.14
37	*Ixora finlaysoniana*	SH	1	1	2.33	1.00	0.02	0.34	0.22	0.05
38	*Jatropha gossypiifolia*	SH	1	1	2.33	1.00	0.02	0.34	0.22	0.05
39	*Mallotus philippensis*	SH	11	1	2.33	11.00	0.26	3.76	0.22	0.52
40	*Maytenus emarginata*	SH	35	14	32.56	2.50	0.81	0.85	3.02	1.64
41	*Memeyclon umbelatum*	SH	125	20	46.51	6.25	2.91	2.14	4.31	5.86
42	*Ochna obtusata*	SH	12	8	18.60	1.50	0.28	0.51	1.72	0.56
43	*Phoneix pusilla*	SH	88	21	48.84	4.19	2.05	1.43	4.53	4.12
44	*Psilanthus wightianus*	SH	5	2	4.65	2.50	0.12	0.85	0.43	0.23
45	*Randia dumetorum*	SH	103	18	41.86	5.72	2.40	1.96	3.88	4.83

46	*Scutia myrtina*	SH	3	3	6.98	1.00	0.07	0.34	0.65	0.14
47	*Stenosiphonium parviflorum*	SH	7	1	2.33	7.00	0.16	2.39	0.22	0.33
48	*Suregada angustifolia*	SH	1	1	2.33	1.00	0.02	0.34	0.22	0.05
49	*Tarenna asiatica*	SH	6	5	11.63	1.20	0.14	0.41	1.08	0.28
50	*Toddalia asiatica*	SH	27	11	25.58	2.45	0.63	0.84	2.37	1.27
51	*Ximenia americana*	SH	24	1	2.33	24.00	0.56	8.20	0.22	1.12
52	*Abrus precatorious*	C	29	6	13.95	4.83	0.67	1.65	1.29	1.36
53	*Aristolochia indica*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
54	*Asparagus racemous*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
55	*Capparis zeylanica*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
56	*Cissampelos pareira*	C	3	1	2.33	3.00	0.07	1.03	0.22	0.14
57	*Cissus quadrangularis*	C	7	5	11.63	1.40	0.16	0.48	1.08	0.33
58	*Cissus vitiginea*	C	6	4	9.30	1.50	0.14	0.51	0.86	0.28
59	*Cocculus hirsutus*	C	2	2	4.65	1.00	0.05	0.34	0.43	0.09
60	*Coccinia indica*	C	2	1	2.33	2.00	0.05	0.68	0.22	0.09
61	*Cucumis melo*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
62	*Derris ovalifolia*	C	6	4	9.30	1.50	0.14	0.51	0.86	0.28
63	*Derris scandens*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
64	*Diplocyclos palmatus*	C	4	1	2.33	4.00	0.09	1.37	0.22	0.19
65	*Grewia rhamnifolia*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
66	*Gymnema sylvestre*	C	4	2	4.65	2.00	0.09	0.68	0.43	0.19
67	*Hemidesmus indicus*	C	17	9	20.93	1.89	0.40	0.65	1.94	0.80
68	*Hugonia mystax*	C	51	17	39.53	3.00	1.19	1.03	3.66	2.39
69	*Ichnocarpus frutescens*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
70	*Jasaminum angustifolium*	C	106	16	37.21	6.63	2.47	2.26	3.45	4.97

71	*Merremia tridentata*	C	67	7	16.28	9.57	1.56	3.27	1.51	3.14
72	*Pachygone ovata*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
73	*Passiflora foetida*	C	6	4	9.30	1.50	0.14	0.51	0.86	0.28
74	*Pergularia daemia*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
75	*Pentatropis capensis*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
76	*Reissantia indica*	C	2	1	2.33	2.00	0.05	0.68	0.22	0.09
77	*Rhynchosia minima*	C	1	1	2.33	1.00	0.02	0.34	0.22	0.05
78	*Sarcostemma intermedium*	C	5	3	6.98	1.67	0.12	0.57	0.65	0.23
79	*Strychnos minor*	C	48	2	4.65	24.00	1.12	8.20	0.43	2.25
80	*Tinospora cordifolia*	C	6	1	2.33	6.00	0.14	2.05	0.22	0.28
81	*Ziziphus oenoplia*	C	69	21	48.84	3.29	1.60	1.12	4.53	3.23
	Total		2134	464	1079.07	292.63	49.63	100	100	100
	per hectare				0.108	0.029	0.005			
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Acacia ampliceps*	T	1	1	2.33	1.00	0.02	1.52	1.02	0.16
2	*Acacia auriculiformis*	T	95	23	53.49	4.13	2.21	6.29	23.47	15.57
3	*Acacia colei*	T	91	16	37.21	5.69	2.12	8.66	16.33	14.92
4	*Acacia mangium*	T	2	1	2.33	2.00	0.05	3.04	1.02	0.33
5	*Acacia tumida*	T	7	2	4.65	3.50	0.16	5.33	2.04	1.15
6	*Anacardium occidentale*	T	1	1	2.33	1.00	0.02	1.52	1.02	0.16
7	*Annona squamosa*	T	2	1	2.33	2.00	0.05	3.04	1.02	0.33
8	*Caesalpinia coriaria*	T	2	1	2.33	2.00	0.05	3.04	1.02	0.33
9	*Cassia javanica*	T	1	1	2.33	1.00	0.02	1.52	1.02	0.16
10	*Gliricidia sepium*	T	5	1	2.33	5.00	0.12	7.61	1.02	0.82

11	*Guazuma ulmifolia*	T	1	1	2.33	1.00	0.02	1.52	1.02	0.16
12	*Leucaena leucocephala*	T	78	7	16.28	11.14	1.81	16.96	7.14	12.79
13	*Kleinhovia hospita*	T	1	1	2.33	1.00	0.02	1.52	1.02	0.16
14	*Pithecellobium dulce*	T	1	1	2.33	1.00	0.02	1.52	1.02	0.16
15	*Plumeria rubra*	T	1	1	2.33	1.00	0.02	1.52	1.02	0.16
16	*Acacia holosericea*	SH	270	17	39.53	15.88	6.28	24.18	17.35	44.26
17	*Breynia retusa*	SH	10	7	16.28	1.43	0.23	2.17	7.14	1.64
18	*Cassia biflora*	SH	2	1	2.33	2.00	0.05	3.04	1.02	0.33
19	*Lantana camara*	SH	38	13	30.23	2.92	0.88	4.45	13.27	6.23
20	*Rauvolfia tetraphylla*	SH	1	1	2.33	1.00	0.02	1.52	1.02	0.16
	Total		610	98	227.91	65.69	14.19	100	100	100
	per hectare				0.023	0.007	0.001			

Of the native species studied *Benkara malabarica* was more abundant (14.58) followed by *Phyllanthus polyphyllus* (14.00) *Mallotus philippensis* (8.00). The exotic species *Acacia holosericea* (15.88), *Leucaena leucocephala* (11.14) *Acacia colei* (5.69) were found in more abundance.

The density among native species was higher in *Dodonea angustifolia* (9.16) followed by *Benkara malabarica (*4.72), whereas *Acacia holosericea* (6.28), *Acacia auriculiformis* (2.21)**,** *and Acacia colei* (2.12) were found in more density among exotic species.The lowest density of (0.02) was observed in 17 native and eight exotic species.

Seedling

The total number of species regenerated under mixed vegetation was 94 that include 85 native and 9 exotic species. All the native species included 7177 individuals and exotic species included 4361 in this vegetation.The high number of individuals in native species was observed in *Jasminum angustifolium* (1623) followed by *Pterospermum suberifolium* (772), *Randia dumetorum* (511) whereas the high number of individuals of exotic species was in *Acacia holosericea* (3074), followed by *Acacia auriculiformis* (999) and *Leucaena leucocephala* (163).Eleven native and two exotic species were represented by one individual each.

The frequency among the native species was higher in *Jasminum angustifolium* (93.02) followed by *Azadirachta indica* (69.77) *Ixora pavetta* (69.77) and *Carrisa spinarum* (69.77) whereas among the exotic the frequency was higher in *Acacia holosericea* (55.81) followed by *Acacia auriculiformis*

Table-15. Phytosociology of Mixed Vegetation-Seedling

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Acacia chundra*	T	36	8	18.60	4.50	0.84	0.55	1.29	0.50
2	*Acacia leucophloea*	T	6	3	6.98	2.00	0.14	0.24	0.48	0.08
3	*Albizia lebbeck*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
4	*Atalantia monophylla*	T	43	11	25.58	3.91	1.00	0.48	1.77	0.60
5	*Azadirachta indica*	T	250	30	69.77	8.33	5.81	1.01	4.82	3.48
6	*Bauhinia racemosa*	T	5	1	2.33	5.00	0.12	0.61	0.16	0.07
7	*Borassus flabellifer*	T	12	4	9.30	3.00	0.28	0.36	0.64	0.17
8	*Bridelia retusa*	T	5	4	9.30	1.25	0.12	0.15	0.64	0.07
9	*Buchanania axillaries*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
10	*Cassine glauca*	T	2	1	2.33	2.00	0.05	0.24	0.16	0.03
11	*Dalbergia latifolia*	T	3	1	2.33	3.00	0.07	0.36	0.16	0.04
12	*Dalbergia paniculata*	T	18	2	4.65	9.00	0.42	1.09	0.32	0.25
13	*Delonix regia*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
14	*Dolichandrone falcata*	T	3	1	2.33	3.00	0.07	0.36	0.16	0.04
15	*Ixora pavetta*	T	231	30	69.77	7.70	5.37	0.94	4.82	3.22
16	*Lannea coromandelica*	T	4	4	9.30	1.00	0.09	0.12	0.64	0.06
17	*Lepisanthes tetraphylla*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
18	*Memeyclon edule*	T	286	26	60.47	11.00	6.65	1.34	4.18	3.98
19	*Morinda coreia*	T	4	2	4.65	2.00	0.09	0.24	0.32	0.06
20	*Morinda pubescens*	T	24	10	23.26	2.40	0.56	0.29	1.61	0.33
21	*Phyllanthus polyphyllus*	T	58	5	11.63	11.60	1.35	1.41	0.80	0.81

22	*Pterocarpus santalinus*	T	2	1	2.33	2.00	0.05	0.24	0.16	0.03
23	*Pterospermum suberifolium*	T	772	3	6.98	257.33	17.95	31.30	0.48	10.76
24	*Sapindus emargiata*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
25	*Syzygium cumini*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
26	*Terminalia cattapa*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
27	*Walsura trifoliata*	T	1	1	2.33	1.00	0.02	0.12	0.16	0.01
28	*Ziziphus xylopyrus*	T	15	4	9.30	3.75	0.35	0.46	0.64	0.21
29	*Agave sisalana*	SH	7	3	6.98	2.33	0.16	0.28	0.48	0.10
30	*Allophylus serratus*	SH	62	8	18.60	7.75	1.44	0.94	1.29	0.86
31	*Benkara malabarica*	SH	355	21	48.84	16.90	8.26	2.06	3.38	4.95
32	*Breynia vitis-idaea*	SH	4	2	4.65	2.00	0.09	0.24	0.32	0.06
33	*Cadaba fruiticosa*	SH	5	2	4.65	2.50	0.12	0.30	0.32	0.07
34	*Canthium coromandelicum*	SH	30	9	20.93	3.33	0.70	0.41	1.45	0.42
35	*Capparis brevispina*	SH	33	15	34.88	2.20	0.77	0.27	2.41	0.46
36	*Capparis sepiaria*	SH	2	1	2.33	2.00	0.05	0.24	0.16	0.03
37	*Carmona retusa*	SH	14	7	16.28	2.00	0.33	0.24	1.13	0.20
38	*Carrisa spinarum*	SH	411	30	69.77	13.70	9.56	1.67	4.82	5.73
39	*Clausena dentate*	SH	2	2	4.65	1.00	0.05	0.12	0.32	0.03
40	*Dichrostachys cinerea*	SH	42	2	4.65	21.00	0.98	2.55	0.32	0.59
41	*Diospyros ferrea*	SH	146	18	41.86	8.11	3.40	0.99	2.89	2.03
42	*Dodonea angustifolia*	SH	304	19	44.19	16.00	7.07	1.95	3.05	4.24
43	*Flacourtia indica*	SH	23	10	23.26	2.30	0.53	0.28	1.61	0.32
44	*Fleuggea leucopyrus*	SH	55	13	30.23	4.23	1.28	0.51	2.09	0.77
45	*Gmelina asiatica*	SH	23	2	4.65	11.50	0.53	1.40	0.32	0.32
46	*Mallotus philippensis*	SH	64	3	6.98	21.33	1.49	2.60	0.48	0.89

47	*Maytenus emarginata*	SH	18	12	27.91	1.50	0.42	0.18	1.93	0.25
48	*Memeyclon umbelatum*	SH	1	1	2.33	1.00	0.02	0.12	0.16	0.01
49	*Ochna obtusata*	SH	42	6	13.95	7.00	0.98	0.85	0.96	0.59
50	*Phoneix pusilla*	SH	182	27	62.79	6.74	4.23	0.82	4.34	2.54
51	*Psilanthus wightianus*	SH	3	1	2.33	3.00	0.07	0.36	0.16	0.04
52	*Randia dumetorum*	SH	511	22	51.16	23.23	11.88	2.83	3.54	7.12
53	*Scutia myrtina*	SH	6	2	4.65	3.00	0.14	0.36	0.32	0.08
54	*Stenosiphonium parviflorum*	SH	5	1	2.33	5.00	0.12	0.61	0.16	0.07
55	*Suregada angustifolia*	SH	187	2	4.65	93.50	4.35	11.37	0.32	2.61
56	*Tarenna asiatica*	SH	37	8	18.60	4.63	0.86	0.56	1.29	0.52
57	*Toddalia asiatica*	SH	40	10	23.26	4.00	0.93	0.49	1.61	0.56
58	*Ximenia americana*	SH	4	1	2.33	4.00	0.09	0.49	0.16	0.06
59	*Abrus precatorious*	C	103	5	11.63	20.60	2.40	2.51	0.80	1.44
60	*Aristolochia indica*	C	2	2	4.65	1.00	0.05	0.12	0.32	0.03
61	*Atylosia scarabaeoides*	C	4	1	2.33	4.00	0.09	0.49	0.16	0.06
62	*Canavalia virosa*	C	1	1	2.33	1.00	0.02	0.12	0.16	0.01
63	*Cassytha filiformis*	C	3	1	2.33	3.00	0.07	0.36	0.16	0.04
64	*Cissampelos pareira*	C	17	5	11.63	3.40	0.40	0.41	0.80	0.24
65	*Cissus quadrangularis*	C	12	6	13.95	2.00	0.28	0.24	0.96	0.17
66	*Cissus vitiginea*	C	136	12	27.91	11.33	3.16	1.38	1.93	1.89
67	*Cocculus hirsutus*	C	2	1	2.33	2.00	0.05	0.24	0.16	0.03
68	*Derris ovalifolia*	C	50	7	16.28	7.14	1.16	0.87	1.13	0.70
69	*Diplocyclos palmatus*	C	6	2	4.65	3.00	0.14	0.36	0.32	0.08
70	*Galactia tenuiflora*	C	67	6	13.95	11.17	1.56	1.36	0.96	0.93
71	*Gymnema sylvestre*	C	6	5	11.63	1.20	0.14	0.15	0.80	0.08

72	*Hemidesmus indicus*	C	219	21	48.84	10.43	5.09	1.27	3.38	3.05
73	*Hugonia mystax*	C	78	24	55.81	3.25	1.81	0.40	3.86	1.09
74	*Ichnocarpus frutescens*	C	4	3	6.98	1.33	0.09	0.16	0.48	0.06
75	*Jasaminum angustifolium*	C	1623	40	93.02	40.58	37.74	4.94	6.43	22.61
76	*Jasaminum angustifolium var. sessiliflorum*	C	2	1	2.33	2.00	0.05	0.24	0.16	0.03
77	*Kedrostis foetidissima*	C	10	1	2.33	10.00	0.23	1.22	0.16	0.14
78	*Mukia maderaspatana*	C	3	3	6.98	1.00	0.07	0.12	0.48	0.04
79	*Passiflora foetida*	C	8	5	11.63	1.60	0.19	0.19	0.80	0.11
80	*Rhynchosia minima*	C	172	13	30.23	13.23	4.00	1.61	2.09	2.40
81	*Strychnos minor*	C	30	5	11.63	6.00	0.70	0.73	0.80	0.42
82	*Tinospora cordifolia*	C	4	2	4.65	2.00	0.09	0.24	0.32	0.06
83	*Ventilago maderaspatana*	C	6	2	4.65	3.00	0.14	0.36	0.32	0.08
84	*Wattakaka volubilis*	C	1	1	2.33	1.00	0.02	0.12	0.16	0.01
85	*Ziziphus oenoplia*	C	203	28	65.12	7.25	4.72	0.88	4.50	2.83
	Total		7177	622	1446.51	822.08	166.91	100	100	100
	per hectare				0.145	0.082	0.017			
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Acacia auriculiformis*	T	999	22	51.16	45.41	23.23	16.20	30.56	22.91
2	*Acacia mangium*	T	1	1	2.33	1.00	0.02	0.36	1.39	0.02
3	*Acacia tumida*	T	2	1	2.33	2.00	0.05	0.71	1.39	0.05
4	*Acacia holosericea*	SH	3074	24	55.81	128.08	71.49	45.71	33.33	70.49
5	*Caesalpinia coriaria*	T	40	1	2.33	40.00	0.93	14.27	1.39	0.92
6	*Casuarina junghuhniana*	T	1	1	2.33	1.00	0.02	0.36	1.39	0.02
7	*Leucaena leucocephala*	T	163	3	6.98	54.33	3.79	19.39	4.17	3.74

8	*Breynia retusa*	SH	28	9	20.93	3.11	0.65	1.11	12.50	0.64
9	*Lantana camara*	SH	53	10	23.26	5.30	1.23	1.89	13.89	1.22
	Total		4361	72	167.44	280.24	101.42	100	100	100
	per hectare				0.017	0.028	0.010			

(51.16) and *Lantana camara* (23.26). The lowest frequency of 2.33 was observed in 25 native and 14 exotic species.

The abundance of *Pterospermum suberifolium* (257.33) was more among the native species followed by *Suregada angustifolia* (93.50) and *Jasminum angustifolium* (40.58) whereas *Acacia holosericea* (128.08), *Leucaena leucocephala* (54.33) *and Acacia aurculiformis* (45.41) were more abundant among the exotic species. The lowest abundance of 1.00 was observed in 15 native and two exotic species.

The density of *Jasminum angustifolium* (37.74) was higher among native species followed by *Pterospermum suberifolium* (17.95) and *Randia dumetorum* (11.88) whereas it was more in *Acacia holosericea* (71.49) and *Acacia auriculiformis* (23.23) among exotic species

Herb

The total number of regenerated herbaceous species under mixed vegetation was 74 that includes 62 native and 12 exotic. Moreover, 62 and 12 individuals were native and exotic species under mixed vegetation. .The high number of individuals in native species was observed in *Mollugo pentaphylla* (1818), followed by *Crotalaria medicaginea* (756), *Indiofera aspalathoides* (546) *Mollugo disticia* (381) whereas the high number of individuals among exotic species was in *Sebastiania chamaelea* (775) followed by *Ageratum conyzoides* (22) and *Melochia corchorifolia* (9). Six native species and one exotic (*Martynia annua*) were represented by one individual each.

Table -17. Phytosociology of Mixed Vegetation-Herb

Sl.No	Name of species (Native)	LF	I	O	F	A	D	RA	RF	RD
1	*Aeschynomene indica*	H	2	1	2.33	2.00	0.05	0.15	0.40	0.03
2	*Achyranthes aspera*	H	40	4	9.30	10.00	0.93	0.74	1.62	0.61
3	*Allmania nodiflora*	H	4	4	9.30	1.00	0.09	0.07	1.62	0.06
4	*Alysicarpus monilifer*	H	25	2	4.65	12.50	0.58	0.92	0.81	0.38
5	*Amaranthus spinosa*	H	1	1	2.33	1.00	0.02	0.07	0.40	0.02
6	*Asystasia gangetica*	H	165	5	11.63	33.00	3.84	2.43	2.02	2.53
7	*Andrographis alata*	H	3	1	2.33	3.00	0.07	0.22	0.40	0.05
8	*Barleria prionitis*	H	28	2	4.65	14.00	0.65	1.03	0.81	0.43
9	*Blepharis maderaspatensis*	H	78	2	4.65	39.00	1.81	2.87	0.81	1.20
10	*Boerhavia diffusa*	H	44	2	4.65	22.00	1.02	1.62	0.81	0.68
11	*Borreria hispida*	H	200	6	13.95	33.33	4.65	2.45	2.43	3.07
12	*Borreria ozhymodies*	H	84	2	4.65	42.00	1.95	3.09	0.81	1.29
13	*Cassia mimosoides*	H	9	2	4.65	4.50	0.21	0.33	0.81	0.14
14	*Cassia tora*	H	5	1	2.33	5.00	0.12	0.37	0.40	0.08
15	*Cleome aspera*	H	3	4	9.30	0.75	0.07	0.06	1.62	0.05
16	*Commelina benghalensis*	H	253	2	4.65	126.50	5.88	9.31	0.81	3.88
17	*Crotalaria medicaginea*	H	756	9	20.93	84.00	17.58	6.18	3.64	11.60
18	*Crotalaria nana*	H	30	7	16.28	4.29	0.70	0.32	2.83	0.46
19	*Corchorus aestuanus*	H	2	1	2.33	2.00	0.05	0.15	0.40	0.03
20	*Crotolaria montana*	H	17	5	11.63	3.40	0.40	0.25	2.02	0.26

21	*Cyanotis tuberosa*	H	79	2	4.65	39.50	1.84	2.91	0.81	1.21
22	*Desmodium triflorum*	H	12	4	9.30	3.00	0.28	0.22	1.62	0.18
23	*Dipteracanthus patulus*	H	138	3	6.98	46.00	3.21	3.38	1.21	2.12
24	*Dyschoriste depresea*	H	2	1	2.33	2.00	0.05	0.15	0.40	0.03
25	*Ecbolium viridae*	H	15	1	2.33	15.00	0.35	1.10	0.40	0.23
26	*Eulophia epidendraea*	H	2	2	4.65	1.00	0.05	0.07	0.81	0.03
27	*Evolvulus alsinoides*	H	133	8	18.60	16.63	3.09	1.22	3.24	2.04
28	*Hybanthus enneaspermus*	H	120	21	48.84	5.71	2.79	0.42	8.50	1.84
29	*Hyptis suaveolens*	H	5	3	6.98	1.67	0.12	0.12	1.21	0.08
30	*Indigofera astragalina*	H	4	2	4.65	2.00	0.09	0.15	0.81	0.06
31	*Indiofera aspalathoides*	H	546	12	27.91	45.50	12.70	3.35	4.86	8.38
32	*Indigofera trifoliata*	H	2	1	2.33	2.00	0.05	0.15	0.40	0.03
33	*Indigofera trita*	H	1	1	2.33	1.00	0.02	0.07	0.40	0.02
34	*Justicia procumbens*	H	90	8	18.60	11.25	2.09	0.83	3.24	1.38
35	*Justicia prostrata*	H	62	5	11.63	12.40	1.44	0.91	2.02	0.95
36	*Kalanchoe pinnata*	H	1	1	2.33	1.00	0.02	0.07	0.40	0.02
37	*Lepidagathis cristata*	H	79	8	18.60	9.88	1.84	0.73	3.24	1.21
38	*Leucas aspera*	H	2	2	4.65	1.00	0.05	0.07	0.81	0.03
39	*Mollugo pentaphylla*	H	1818	6	13.95	303.00	42.28	22.30	2.43	27.89
40	*Mollugo disticia*	H	381	3	6.98	127.00	8.86	9.35	1.21	5.85
41	*Ocimum canum*	H	1	1	2.33	1.00	0.02	0.07	0.40	0.02
42	*Oldenlandia herbacea*	H	240	3	6.98	80.00	5.58	5.89	1.21	3.68
43	*Oldenlandia umbellata*	H	83	3	6.98	27.67	1.93	2.04	1.21	1.27
44	*Orthosiphon thymiflorus*	H	11	1	2.33	11.00	0.26	0.81	0.40	0.17
45	*Pavonia zeylanica*	H	1	1	2.33	1.00	0.02	0.07	0.40	0.02

46	*Plumbago zeylanica*	H	1	1	2.33	1.00	0.02	0.07	0.40	0.02
47	*Polycarpaea corymbosa*	H	3	2	4.65	1.50	0.07	0.11	0.81	0.05
48	*Phyllanthus debilis*	H	81	7	16.28	11.57	1.88	0.85	2.83	1.24
49	*Phyllanthus urinaria*	H	6	2	4.65	3.00	0.14	0.22	0.81	0.09
50	*Polygala arvensis*	H	82	8	18.60	10.25	1.91	0.75	3.24	1.26
51	*Pseudarthria viscida*	H	4	3	6.98	1.33	0.09	0.10	1.21	0.06
52	*Psilotrichum nudum*	H	6	4	9.30	1.50	0.14	0.11	1.62	0.09
53	*Sansevieria roxburghiana*	H	139	3	6.98	46.33	3.23	3.41	1.21	2.13
54	*Sida acuta*	H	15	3	6.98	5.00	0.35	0.37	1.21	0.23
55	*Sida cordata*	H	4	2	4.65	2.00	0.09	0.15	0.81	0.06
56	*Sida rhombifolia*	H	6	3	6.98	2.00	0.14	0.15	1.21	0.09
57	*Striga angustifolia*	H	6	1	2.33	6.00	0.14	0.44	0.40	0.09
58	*Stylosanthes fruticosa*	H	48	12	27.91	4.00	1.12	0.29	4.86	0.74
59	*Tephrosia maxima*	H	61	5	11.63	12.20	1.42	0.90	2.02	0.94
60	*Triumfetta rotundifolia*	H	2	2	4.65	1.00	0.05	0.07	0.81	0.03
61	*Vernonia cinerea*	H	134	10	23.26	13.40	3.12	0.99	4.05	2.06
62	*Waltheria indica*	H	343	13	30.23	26.38	7.98	1.94	5.26	5.26
	Total		6518	247	574.42	1358.94	151.58	100	100	100
	per hectare				0.057	0.136	0.015			
Sl.No	**Name of species (Exotic)**	**LF**	**I**	**O**	**F**	**A**	**D**	**RA**	**RF**	**RD**
1	*Ageratum conyzoides*	H	22	7	16.28	3.14	0.51	6.18	11.48	2.60
2	*Alternanthera ficoidea*	H	4	2	4.65	2.00	0.09	3.93	3.28	0.47
3	*Celosia argentea*	H	8	3	6.98	2.67	0.19	5.24	4.92	0.95
4	*Cleome viscosa*	H	2	3	6.98	0.67	0.05	1.31	4.92	0.24
5	*Croton bonplaindonus*	H	6	2	4.65	3.00	0.14	5.89	3.28	0.71

6	*Euphorbia cyathophora*	H	6	1	2.33	6.00	0.14	11.79	1.64	0.71
7	*Martynia annua*	H	1	1	2.33	1.00	0.02	1.96	1.64	0.12
8	*Melochia corchorifolia*	H	9	4	9.30	2.25	0.21	4.42	6.56	1.07
9	*Sebastiania chamaelea*	H	775	31	72.09	25.00	18.02	49.12	50.82	91.72
10	*Scutalaria violacea*	H	4	2	4.65	2.00	0.09	3.93	3.28	0.47
11	*Turnera ulmifolia*	H	3	2	4.65	1.50	0.07	2.95	3.28	0.36
12	*Stachytarpheta jamaicensis*	H	5	3	6.98	1.67	0.12	3.27	4.92	0.59
	Total		845	61	141.86	50.89	19.65			
	per hectare				0.014	0.005	0.002			

Note:

Name of plant species with Native and Exotic status, Life Forms (LF), Individuals (I), Occurance (O), Basal Area (BA), Bio-volume (BV), Frequency (F), Abundance(A), Density (D), Relative Abundance(RA), Relative frequency (RF), Relative Density (RD) , Relative Dominance (RD), Importance Value Index (IVI), Shannon index (H) and Simpson index (D) of three vegetation types were provided from restored site of Outseri lake, Pondicherry, India

The frequency among the native species was higher in *Hybanthus enneaspermus* (48.84) followed by *Waltheria indica* (30.23) *Indiofera aspalathoides* (27.91) and *Crotalaria medicaginea* (20.93) whereas among the exotic the frequency was more in *Sebastiania chamaelea* (72.09) followed by *Ageratum conyzoides* (16.28) *Melochia corchorifolia* (9.30).

Mollugo pentaphylla was more abundant (303.00) among the native species studied followed by *Mollugo disticia* (127.00) *Commelina benghalensis* (126.50). Of the exotic species *Sebastiania chamaelea* was more abundant (25.00), followed by *Euphorbia cyathophora* (6.00) and *Ageratum conyzoides* (3.14)

The density among native species was higher in *Mollugo pentaphylla* (42.28) followed by *Crotalaria medicaginea* (17.58) and *Indiofera aspalathoides* (12.20). Among exotics *Sebastiania chamaelea* (18.02) had more density than all other exotic species.

4.3. Relationship between different plant life stages and individual vegetation types.

Among the three vegetation types, adult species richness differed significantly ($F = 6.968$, $P = 0.002$), while the juvenile species richness did not differ significantly ($F = 0.574$, $P = 0.565$). In contrast the sapling species richness varied significantly ($F = 4.42$, $P = 0.015$). On the contrary, density of adults, juveniles, saplings and seedlings did not differ significantly among the three vegetation types (Table 17). However, adult basal area showed significant differences on different vegetation types, whereas the basal area of juveniles did not differ significantly and eventually adult bio-volume and juvenile bio-volume did not show any significant differences among the different vegetation types.

Table 17. Effect of different vegetation types on floristic species richness, density, basal area and bio-volume with different life-stages of the restored site

Dependent variables	Df	F-value	P
Adult species richness	2, 84	6.968	**0.002**
Juvenile species richness	2, 84	0.574	0.565
Sapling species richness	2, 84	4.416	**0.015**
Seedling species richness	2, 84	2.692	0.074
Adult density	2, 84	0.317	0.73
Juvenile density	2, 84	0.302	0.74
Sapling density	2, 84	2.926	0.059
Seedling density	2, 84	0.88	0.419
Adult basal area	2, 84	8.87	**0.0001**
Juvenile basal area	2, 84	0.341	0.712
Adult bio-volume	2, 84	0.593	0.555
Juvenile bio-volume	2, 84	0.402	0.67

$P < 0.01$, $P < 0.0001$

Table 18. Multiple comparisons on species richness among different vegetations (LSD method).

Dependent Variable	(I) Vegetation	(J) Vegetation	Mean Difference (I-J)	Std. Error	P-value
Adult species richness	*Acacia*	*Casuarina*	-1.15	0.591	0.054
		Mixed	-1.40*	0.381	0.0001
	Casuarina	*Acacia*	1.15	0.591	0.054
		Mixed	-0.25	0.573	0.662
	Mixed	*Acacia*	1.40*	0.381	0.0001
		Casuarina	0.25	0.573	0.662
Juvenile	*Acacia*	*Casuarina*	-1.27	1.22	0.302

species richness					
		Mixed	-0.49	0.786	0.533
	Casuarina	*Acacia*	1.27	1.22	0.302
		Mixed	0.78	1.183	0.513
	Mixed	*Acacia*	0.49	0.786	0.533
		Casuarina	-0.78	1.183	0.513
Sapling species richness	*Acacia*	*Casuarina*	-2.28	2.138	0.289
		Mixed	-4.10*	1.378	0.004
	Casuarina	*Acacia*	2.28	2.138	0.289
		Mixed	-1.81	2.072	0.384
	Mixed	*Acacia*	4.10*	1.378	0.004
		Casuarina	1.81	2.072	0.384
Seedling species richness	*Acacia*	*Casuarina*	-5.44*	2.554	0.036
		Mixed	-2.7	1.646	0.104
	Casuarina	*Acacia*	5.44*	2.554	0.036
		Mixed	2.73	2.475	0.273
	Mixed	*Acacia*	2.7	1.646	0.104
		Casuarina	-2.73	2.475	0.273

Considering the different vegetation types, the adult species richness in *Acacia* plantation differed significantly as compared to *Casuarina* (P = 0.054) and mixed vegetation (P = 0.0001). On the contrary, the adult species richness in *Casuarina* plantation did not differ compared to mixed vegetation (P = 0.662), while the adult species richness in mixed vegetation differed significantly compared to *Acacia* vegetation and did not differ significantly compared to *Casuarina* vegetation (Table 2). On the contrary, the juvenile species richness in *Acacia* vegetation did not show significant differences compared to either in *Casuarina* and mixed vegetation. Besides, the sapling species richness in *Acacia* vegetation showed significant differences when compared to mixed vegetation (P = 0.004) and did not show any significant differences when compared to *Casuarina* vegetation (P = 0.289). Moreover, the seedling species richness in *Acacia* vegetation differed significantly (P

= 0.036) compared to *Casuarina* vegetation and did not differ significantly (P = 0.104) when compared to mixed vegetation (Table 18).

Table 19. Multiple comparisons on species density among different vegetations (LSD method).

Dependent Variable	(I) Vegetation	(J) Vegetation	Mean Difference (I-J)	Std. Error	Sig.
Adult density	*Acacia*	*Casuarina*	-1.46875	2.47841	0.555
		Mixed	0.43823	1.59714	0.784
	Casuarina	*Acacia*	1.46875	2.47841	0.555
		Mixed	1.90698	2.40174	0.429
	Mixed	*Acacia*	-0.43823	1.59714	0.784
		Casuarina	-1.90698	2.40174	0.429
Juvenile density	*Acacia*	*Casuarina*	3.20968	5.62966	0.57
		Mixed	2.57014	3.6473	0.483
	Casuarina	*Acacia*	-3.20968	5.62966	0.57
		Mixed	-0.63953	5.43469	0.907
	Mixed	*Acacia*	-2.57014	3.6473	0.483
		Casuarina	0.63953	5.43469	0.907
Sapling density	*Acacia*	*Casuarina*	0.43125	15.79921	0.978
		Mixed	-22.78270*	10.18139	0.028
	Casuarina	*Acacia*	-0.43125	15.79921	0.978
		Mixed	-23.214	15.3105	0.133
	Mixed	*Acacia*	22.78270*	10.18139	0.028
		Casuarina	23.21395	15.3105	0.133
Seedling density	*Acacia*	*Casuarina*	-94.9063	1.01E+02	0.349
		Mixed	33.76817	64.9191	0.604
	Casuarina	*Acacia*	94.90625	1.01E+02	0.349
		Mixed	128.6744	97.623	0.191
	Mixed	*Acacia*	-33.7682	64.9191	0.604
		Casuarina	-128.674	97.623	0.191

Adult species richness varied, sapling richness varied significantly, adult basal area showed significant differences by the effect of vegetation types. While comparing the density of adults, juveniles, saplings and seedlings did not differ significantly among the different vegetation types such as *Acacia*, *Casuarina* and mixed (Table 19).

Table 20. Multiple comparisons on species basal area among different vegetations (LSD method).

Dependent Variable	(I) Habitat	(J) Habitat	Mean Difference (I-J)	Std. Error	Sig.
Adult basal area	*Acacia*	*Casuarina*	-18652.90*	4719.52	0.0001
		Mixed	-634.63	3168.48	0.842
	Casuarina	*Acacia*	18652.90*	4719.52	0.0001
		Mixed	18018.27*	4543.77	0.0001
	Mixed	*Acacia*	634.63	3168.48	0.842
		Casuarina	-18018.27*	4543.77	0.0001
Juvenile basal area	*Acacia*	*Casuarina*	-32.2847	211.61	0.879
		Mixed	97.6678	142.07	0.494
	Casuarina	*Acacia*	32.2847	211.61	0.879
		Mixed	129.9526	203.73	0.525
	Mixed	*Acacia*	-97.6678	142.07	0.494
		Casuarina	-129.953	203.73	0.525

Considering the adult basal area of the different vegetation showed significant differences between *Acacia* and *Casuarina* (P = 0.0001), whereas the adult basal area did not show significant differences between *Acacia* and mixed vegetation (P = 0.842). However, the adult basal area of *Casuarina* vegetation showed significant differences between *Acacia* (P = 0.0001) and mixed vegetation (P = 0.0001). The basal area of juveniles did not show any significant differences between *Acacia* and *Casuarina* and *Acacia* and mixed vegetation (Table 20).

Table 21. Multiple comparisons on species bio-volume among different vegetations (LSD method).

Dependent Variable	(I) Habitat	(J) Habitat	Mean Difference (I-J)	Std. Error	P-value
Adult bio-volume	*Acacia*	*Casuaria*	-59551.5	65467.4	0.366
		Mixed	-38082.7	42414.5	0.372
	Casuaria	*Acacia*	59551.53	65467.4	0.366
		Mixed	21468.82	63200.1	0.735
	Mixed	*Acacia*	38082.72	42414.5	0.372
		Casuaria	-21468.8	63200.1	0.735
Juvenile bio-volume	*Acacia*	*Casuaria*	-14.5455	1874.92	0.994
		Mixed	-1012.33	1214.71	0.407
	Casuaria	*Acacia*	14.5455	1874.92	0.994
		Mixed	-997.785	1809.98	0.583
	Mixed	*Acacia*	1012.33	1214.71	0.407
		Casuaria	997.7848	1809.98	0.583

Considering the bio-volume of adult among different vegetation did not show any significant differences when compared between different vegetation (*Acacia* & *Casuarina*, *Acacia* & mixed). Similarly the bio-volume of juveniles also did not show any significant differences on between the different vegetation (see Table 21).

Table 22. Different life stages of mean species richness among different habitats.

Habitat	Adult richness	Juvenile richness	Sapling richness	Seedling richness
Acacia	2.25 ± 0.23	4.53 ± 0.53	7.72 ± 0.85	14.06 ± 1.05
Casuarina	3.40 ± 0.37	5.80 ± 1.02	10.0 ± 2.17	19.5 ± 2.33
Mixed	**3.65** ± 0.29	5.02 ± 0.56	11.81 ± 0.97	16.77 ± 1.18

The mean adult species richness tends to be higher in mixed vegetation followed by *Casuarina* and *Acacia*, whereas the mean juvenile species richness was greater in *Casuarina* vegetation followed by mixed and *Acacia*. But the mean sapling species richness was in mixed vegetation and the mean seedling species richness was greater in *Casuarina* vegetation (Table 22).

Table 23. Different life stages on mean density among different habitats.

Vegetation types	**Adult density**	**Juvenile density**	**Sapling density**	**Seedling density**
Acacia	8.53 ± 1.33	20.71 ± 2.46	41.03 ± 5.15	302.09 ± 60.56
Casuarina	10.00 ± 1.80	17.5 ± 3.71	40.6 ± 7.62	397.0 ± 32.93
Mixed	8.09 ± 1.00	18.14 ± 2.64	63.81 ± 8.30	268.33 ± 37.98

On the contrary, the mean adult density was higher in *Casuarina* vegetation compared to *Acacia* and mixed vegetation. In contrast, the mean juvenile density was higher in *Acacia* vegetation compared to *Casuarina* and mixed, but the mean sapling density was higher in mixed vegetation followed by *Acacia* and *Casuarina* density. Moreover, the mean seedling density was higher in *Casuarina* vegetation followed by *Acacia* and mixed vegetation (Table 23).

Table 24. Different life stages on mean basal area among different vegetations.

Habitat	Adult Basal Area	Juvenile Basal area
Acacia	5157.1 ± 1177.5	661.0 ± 95.6
Casuarina	12615.5 ± 3745.08	381.32 ± 72.08
Mixed	4918.7 ± 824.6	563.4 ± 75.0

The mean adult basal area of *Casuarina* vegetation was higher followed by *Acacia* and mixed vegetation. Besides, the mean juvenile basal area of *Acacia* vegetation was higher followed by mixed and *Casuarina* vegetation (Table 24).

Table 25. Different stages of mean bio-volume among different vegetations.

	Adult bio-volume	Juvenile bio-volume
	Mean	Mean
Acacia	5477.61 ± 1850.63	308.73 ± 51.07
Casuarina	31790 ± 1263	167.967 ± 33.42
Mixed	42627.8 ± 3839	1345.64 ± 1116

Similarly, the mean adult bio-volume was higher in mixed vegetation followed by *Casuarina* and *Acacia* vegetation. However the mean juvenile bio-volume tends to be higher in mixed vegetation followed by *Acacia* vegetation and lower in *Casuarina* vegetation (Table 25).

In *Acacia* vegetation, the relationship between adult species richness and juvenile species richness was significant (R^2 = 0.218, P = 0.007), however the relationship was not significant between the adult species richness and sapling richness (R^2 = 0.005, P = 0.688) and seedling richness (R^2 = 0.065, P = 0.160).

Besides, while examine in *Casuarina* vegetation, the relationship between adult species richness, juvenile richness, sapling richness and seedling richness was not significantly related to each other. Considering the mixed vegetation, the relationship between adult species richness and juvenile species richness was significant (R^2 = 0.165, P = 0.007), in addition the adult species richness and seedling species richness was also significant (R^2 = 0.185, P = 0.004). In contrast the relationship was not significant between adult species richness and sapling species richness (R^2 = 0.062, P = 0.108) in mixed vegetation.

Besides, the relationship between adult and juvenile density was significant in *Acacia* vegetation, whereas the adult and sapling density was not significantly related; similarly the adult and seedling density was not showed significant relationship in *Acacia* vegetation. Likewise in *Casuarina* vegetation, the relationship between adult and juvenile density was significant (R^2 = 0.453, P = 0.033). However, there was not significant relationship showed between the adult and sapling and seedling density. On the contrary, to examine the mixed vegetation, there was not any significant relationship found between the densities of different life stages parameters (Table 26).

Table .26. Relationship between species richness and density of different life stages among different vegetations.

Habitat			Slope	Error	Intercept	Error	R^2	P
Acacia	Adult species richness	Juvenile richness	1.072	0.371	2.119	0.958	0.218	**0.007**
		Sapling species richness	0.274	0.676	7.102	1.748	0.005	0.688
		Seedling species richness	1.164	0.807	11.445	2.086	0.065	0.160
Casuarina	Adult species richness	Juvenile richness	0.794	0.671	0.273	0.355	0.149	0.271
		Sapling species richness	0.677	0.441	0.594	0.233	0.228	0.163
		Seedling species richness	-0.184	0.630	1.326	0.333	0.011	0.777
Mixed	Adult species richness	Juvenile richness	0.490	0.172	0.353	0.096	0.165	**0.007**
		Sapling richness	0.292	0.178	0.845	0.099	0.062	0.108
		Seedling richness	0.405	0.133	0.967	0.074	0.185	**0.004**
Acacia	Adult density	Juvenile density	0.612	0.114	0.726	0.099	0.498	**0.000**
		Sapling density	-0.070	0.144	1.564	0.124	0.008	0.629
		Seedling density	0.033	0.210	2.211	0.181	0.001	0.877
Casuarina	Adult density	Juvenile density	-0.929	0.361	1.999	0.349	0.453	**0.033**
		Sapling species density	0.081	0.308	1.474	0.298	0.009	0.798
		Seedling density	0.029	0.171	2.557	0.165	0.004	0.870
Mixed	Adult density	Juvenile density	0.366	0.200	0.753	0.171	0.075	0.075
		Sapling density richness	-0.104	0.186	1.713	0.159	0.008	0.580
		Seedling density	0.206	0.149	2.123	0.127	0.045	0.174

4.4. Soil nutrients, soil microbes and leaf litter

4.4.1.Soil physicochemical properties

The soil pH and moisture content was higher in *Acacia* plantation followed by control and lower in gully pugs. Considering the electrical conductivity (EC), control site had higher EC, whereas lower in gully plugs. Bulk density was higher in *Casuarina* plantation and least in gully plugs, whereas the water holding capacity was maximum in *Casuarina* and minimum in grass vegetation. Besides, the PD was higher in mixed and lower in gully plugs. The organic carbon and organic matter was higher in control, whereas lower in mixed vegetation. In addition, the nitrogen and phosphorus was higher in control and lower in *Casuarina* and mixed vegetation respectively. On the contrary, potassium was higher in *Acacia* plantation and least in mixed. The calcium (Ca), magnesium (Mg), sulphur was higher in control, whereas lower in *Casuarina* and gully plugs. In addition, the zinc (Zn) was highly found in *Acacia* and lower amoun recorded in gully plugs, whereas the copper (Cu) highly found in *Casuarina* and lower in *Acacia*. Interestingly, the iron highly found in wetlands and the lower rate of iron found in grass vegetation. Manganese highly found in grass and the low rate found in control, whereas boron was higher in *Casuarina* and lower in control (Table. 27).

Similarly, the total NPK also differed between different vegetation. Of these, the total was N highly found in *Acacia* and the lower rate found in wetlands. Moreover, the total phosphorus, total potassium and total sulphur were highly found in control, whereas lower in grass, *Casuarina* and gully plugs. The total CEC was higher in control and lower in grass vegetation. Similarly, the chloride was higher in mixed and lower in wetlands. Eventually, the CC highly found in mixed and the least in *Casuarina* vegetation (Table 27).

Table 27. Soil physicochemical properties of different vegetation types.

Variables	Units	Control	*Acacia*	*Casuarina*	Mixed	Grass	Wet lands	Gully plugs
pH		7.3	7.8	6.8	6.7	6.5	6.6	5.4
EC		70	53	50	58	50	66	47
Moisture	%	5.6	6.2	4.6	5.3	4.1	5.6	3.9
BD		1.55	1.6	1.62	1.53	1.54	1.6	1.5
WHC	%	25	30	35	30	24	33	30
PD		2.66	2.65	2.64	2.67	2.66	2.62	2.67
OC	%	0.23	0.32	0.38	0.4	0.36	0.32	0.28
OM	%	0.46	0.64	0.76	0.80	0.72	0.64	0.56
Nitrogen	kg/ha	154	291	459	448	347	336	308
Phosphorus	kg/ha	12	16	38	42	28	21	31
Potassium	kg/ha	24	19	121	67	35	48	53
Calcium	mg/kg	132	159	172	162	162	142	183
Magnesium	mg/kg	68	98	111	112	108	89	133
Sulphur	mg/kg	56	83	106	96	101	92	88
Zinc	mg/kg	1.8	1	1.3	1.62	1.5	1.42	1.64
Copper	mg/kg	0.06	0.05	1.1	0.5	0.28	0.26	0.18
Iron	mg/kg	6.52	13.5	18.7	12.5	6.02	22.1	14.3
Manganese	mg/kg	0.68	1.6	0.84	6.6	7.52	5.2	2.14
Boron	mg/kg	0.21	0.33	0.52	0.42	0.33	0.46	0.26
TN	%	0.015	0.025	0.006	0.0063	0.0048	0.0047	0.0052
TP	%	0.004	0.0052	0.0016	0.0019	0.0016	0.0021	0.0021
TK	%	0.008	0.0074	0.002	0.0021	0.0021	0.0029	0.0029
TS	%	0.002	0.0022	0.0004	0.0011	0.0009	0.0006	0.0004
CE C	Meq/100 g	5.3	7.9	6.6	10	28	24	8.2
Chloride	mg/kg	0.045	0.06	0.053	0.062	0.057	0.036	0.046
CC	mg/kg	56	62	42	63	51	58	56

4.4.2. Soil microbes

A total of eight microbial communities were recorded from the restored site namely Bacterial sp., Fungal sp., *Actinomycetes* sp., *Azospirillum* sp., Phosphate solubiliser sp., *Pseudomonas* sp., *Rhizobium* sp., *Azotobacter* sp., (Figure 12). Considering the soil microbes, the total bacterial was highly counted in *Casuarina* and the lower numbers were counted in mixed. Similarly, the total fungal highly counted in *Casuarina vegetation* and least amount present in gully plugs. Besides, the *Actinomycetes* were higher in mixed vegetation and the lower in wetland. In addition, azospirillum was lower in gully plugs and higher in wetlands. The phosphate solubiliser sp. and the *Pseudomonas* sp. highly found in grass and the lower amount was recorded in *Casuarina* and mixed respectively. While the *Rhizobium* sp. and azotobacter sp. had higher count in *Casuarina* and lower count in mixed and grass vegetations.

Table 28. Enumeration of soil microbes from different vegetation types.

Parameter	Control	*Acacia*	*Casuarina*	Mixed	G & H	Wetland	Gully
Total bacterial count	28×10^5	$35x10^4$	$60x10^4$	$31x10^5$	$20x10^5$	$25x10^5$	$25x10^5$
Total fungal count	2×10^4	$5x10^3$	$20x10^3$	$15x10^3$	$7x10^4$	$2x10^3$	$12x10^4$
Actinomycetes sp	14×10^4	$40x10^4$	$16x10^5$	$63x10^4$	$5x10^5$	$20x10^5$	$19x10^5$
Azospirillum sp	Absent	Absent	Absent	$6x10^2$	Absent	$4x10^2$	$11x10^2$
Phosphate solubiliser sp	2×10^4	$2x10^4$	$12x10^4$	$5x10^4$	$5x10^3$	$12x10^4$	$5x10^4$
Pseudomonas sp	$28x\ 10^3$	$29x\ 10^3$	$21x10^3$	$15x10^4$	$93x10^3$	$93x10^3$	$23x10^3$
Rhizobium sp	5×10^5	$6x10^5$	$4x10^4$	$16x10^5$	$12x10^5$	$10x10^5$	$13x10^5$
Azotobacter sp	$20x10^4$	$15x10^4$	$24x10^3$	$14x10^4$	$16x10^5$	$20x10^4$	$16x10^4$

Table 29. Macro and Micro nutrients values from different vegetation types by leaf litter decomposition

Vegetation	Macronutrients			Micronutrients			
	N	**P**	**K**	**Zn**	**Cu**	**Fe**	**Mn**
Acacia	1.33	0.04	0.92	128	2	600	393
Casuarina	1.92	0.053	0.66	137	11	1210	332
Mixed	**2.1**	0.6	0.87	173	3	520	269
Eucalyptus	1.33	0.03	0.53	164	55	1210	237
Bamboo	1.72	0.05	0.73	185	3	705	349
Grasses & Herbs	1.23	0.07	0.79	143	5	255	370

4.4.3.Leaf litter decomposition

Leaf litter composition of macronutrients under different vegetation also varied in numbers. It showed mixed had higher nitrogen and grass had lower rate of nitrogen macronutrients in litter composition. While the mixed had higher phosphorus and eucalyptus had lower phosphorus. Besides, the potassium highly found in *Acacia* plantation and less amount present in *Casuarina* plantation (Table 29).

Considering the micronutrients under different vegetation differed in numbers. Bamboo had high zinc micronutrients, whereas *Acacia* had less zinc. The copper was lesser in *Acacia* plantation and higher in eucalyptus plantation. Similarly the iron was higher in *Casuarina* and *Eucalyptus* and lower in grass vegetation. But the *Acacia* had high manganese and low manganese found in eucalyptus vegetation (Table 29).

The PCA on soil factors and different vegetation showed significant correlation. The eigenvalues for the first and second axes were 6.81and 0.15 respectively. The cumulative percentage variance of soil factors data showed that the first two PCA axes explain 99.37 % of the variability in soil data. The component 1 and 2 explains 97.23% and 2.14% of the variance in the soil characteristics among different vegetation (fig 11). Component 1 was highly positively correlated with electrical conductivity, available nitrogen, available potassium, calcium, magnesium and calcium carbonate. Component 2 was highly correlated with calcium, magnesium and calcium carbonate (Table 30).

Table 30. Principal Component Analysis of different soil physicochemical properties (PCA).

Sl.no	Soil variables	PC 1	PC 2	PC 3	PC 4
1	pH (at 25˚C)	-1.082	-0.017	-0.020	0.019
2	Electrical Conductivity (at 25˚C)	**0.870**	**0.774**	0.133	0.415
3	Moisture	-1.146	-0.035	-0.023	0.019
4	Bulk Density	-1.283	-0.087	-0.023	-0.011
5	Water Holding Capacity	-0.231	0.118	0.035	0.056
6	Particle Density	-1.241	-0.074	-0.021	-0.009
7	Organic Carbon (as OC)	-1.330	-0.103	-0.025	-0.015
8	Organic Matter (as OM)	-1.318	-0.101	-0.025	-0.014
9	Available Nitrogen (as N)	**10.530**	-0.913	-0.103	0.112
10	Available phosphorous (as P)	-0.404	-0.197	0.045	-0.099
11	Available Potassium (as K)	**0.442**	-0.462	0.622	-0.035
12	Available Calcium (as Ca)	**4.633**	**1.176**	0.092	-0.173
13	Available Magnesium (as Mg)	**2.450**	**0.388**	-0.047	-0.409
14	Available Sulphur (as S)	**1.913**	0.132	-0.108	0.010
15	Available Zinc (as Zn)	-1.285	-0.081	-0.018	-0.011
16	Available Copper (as Cu)	-1.332	-0.110	-0.019	-0.015
17	Available Iron (as Fe)	-0.857	-0.110	0.001	0.028

18	Available Manganese (as Mn)	-1.220	-0.132	-0.079	0.001
19	Available Boron (as B)	-1.329	-0.104	-0.024	-0.014
20	Total Nitrogen (as N)	-1.342	-0.103	-0.024	-0.016
21	Total Phosphorous (as P)	-1.342	-0.104	-0.024	-0.016
22	Total Potassium (as K)	-1.342	-0.104	-0.024	-0.016
23	Total Sodium(as Na)	-1.342	-0.104	-0.024	-0.016
24	Cation Exchange Capacity	-0.869	-0.124	-0.196	0.064
25	Chloride	-1.341	-0.103	-0.024	-0.016
26	Calcium Carbonate	**0.799**	**0.579**	-0.075	0.162

Figure. 11 Relationship between soil characteristics and vegetation types by PCA analysis

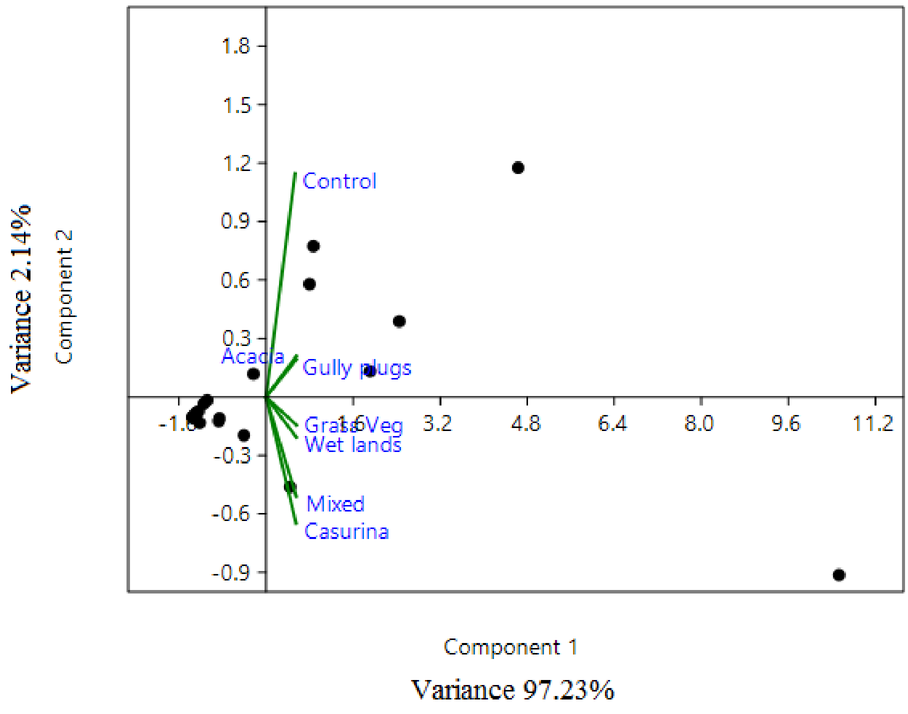
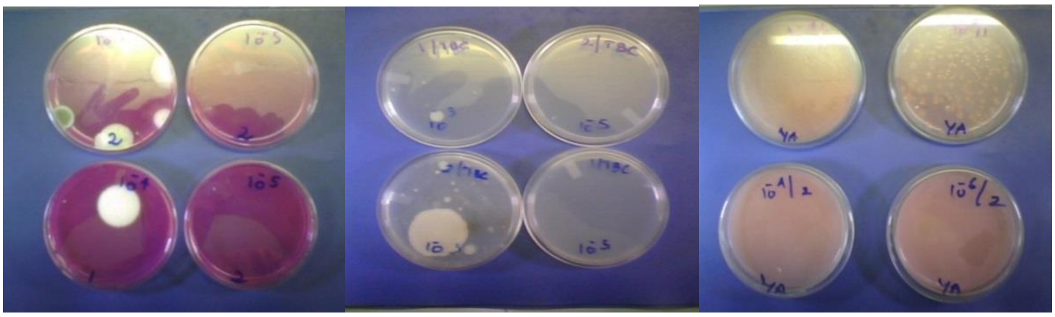
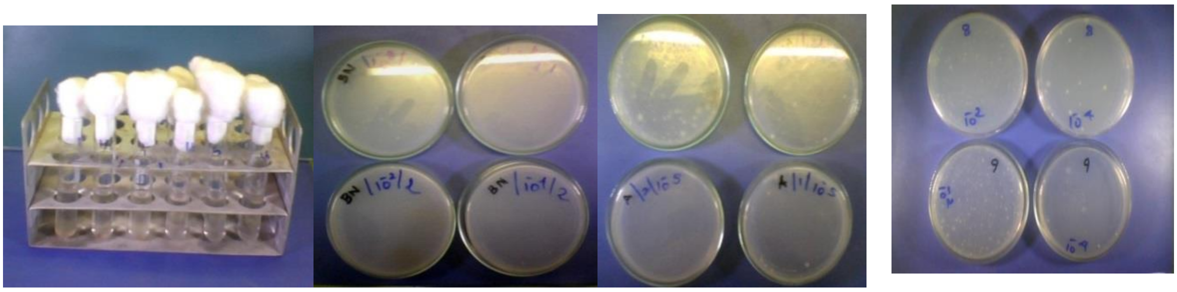


Figure.12 Colonies of different soil microorganisms



a) Total fungal count **b) Total bacteria count** **c) *Rhizobium* sp**

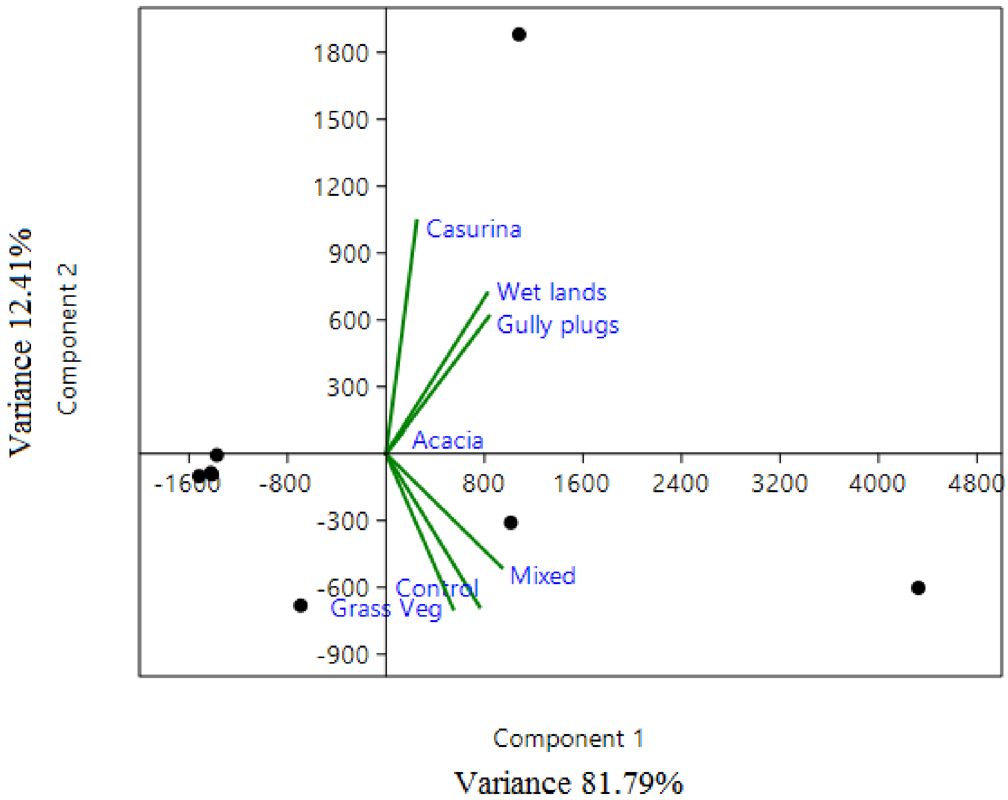


(d) Pseudomonas **(e) *Azotobacter* sp** **(f) *Actinomycetes*** **(g) *Azospirillum***

Table 31. Principal Component Analysis of different soil microbial diversity among different vegetation types (PCA).

SL.No	**Microbial diversity**	**PC 1**	**PC 2**	**PC 3**	**PC 4**
1	Total bacterial sp	**4.274**	-1.023	-0.925	-0.028
2	Total fungal sp	-1.715	-0.075	-0.311	-0.170
3	*Actinomycetes* sp	1.723	**2.492**	0.075	0.231
4	*Azospirillum* sp	-1.828	-0.076	-0.326	-0.221
5	Phosphate solubiliser sp	-1.621	0.077	-0.321	-0.149
6	*Pseudomonas* sp	-1.667	-0.074	-0.235	-0.164
7	*Rhizobium* sp	**1.434**	-0.477	1.481	-0.582
8	*Azotobacter* sp	-0.602	-0.841	0.561	1.0824

The PCA on soil microbial community and different vegetation types showed significant correlation. The eigenvalues for the first and second axes were 5.05 and 1.17 respectively. The cumulative percentage variance of soil factors data showed that the first two PCA axes explain 94.2% of the variability in soil data. The component 1 and 2 explains 81.79% and 12.41% of the variance on soil microbial community among different vegetation types (fig 3). Component 1 was highly correlated with total bacterial sp and rhizobium sp. Component 2 was highly correlated with actinomycetes (Table 31).

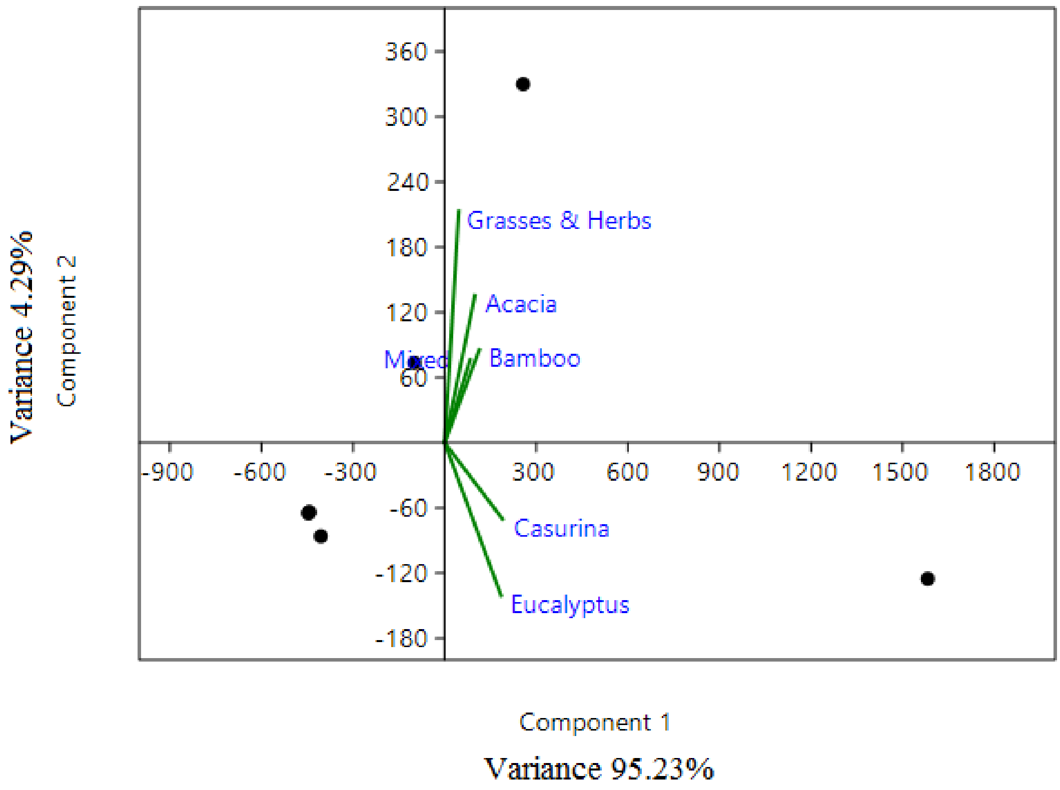


Figures.13. Relationship between soil microbes and different vegetation types by PCA analysis

Table 32. Principal Component Analysis of correlation matrix between leaf litter decomposition and vegetation types

Variables	PC 1	PC 2	PC 3	PC 4
N	-1.547	-0.218	0.038	-0.024
P	-1.561	-0.222	0.040	-0.023
K	-1.555	-0.218	0.041	-0.023
Zn	-0.062	0.316	-0.275	0.001
Cu	-1.476	-0.262	0.043	0.070
Fe	**4.554**	-0.821	0.016	-0.002
Mn	**1.648**	**1.425**	0.097	0.001

The PCA on soil factors and different vegetation showed significant correlation. The eigenvalues for the first and second axes were 5.481 and 0.502 respectively. The cumulative percentage variance of soil factors data showed that the first two PCA axes explain 99.52% of the variability in soil data. The component 1 and 2 explains 95.23% and 4.29% of the variance in the soil characteristics among different vegetation (fig 14). Component 1 was highly correlated with Fe and Mn. Component 2 was highly correlated with Mn (Table 32)



Figures. 14. Relationship between leaf litter and different vegetation types PCA analysis

4.5. Relationship between soil physiochemical properties and vegetation parameters

Considering the relationship between soil physico-chemical characteristics and vegetation parameters showed that the electrical conductivity significantly positively correlated with adult basal area ($r = 0.996$, $P = 0.029$) sapling richness ($r = 0.996$, $P = 0.029$) and herb density ($r = 1.00$, $P = 0.003$). Bulk density significantly negatively correlated with juvenile species richness ($r = -0.996$, $P = 0.03$), sapling species richness ($r = -0.997$, $P = 0.024$), seedling richness ($r = -0.999$, $P = 0.011$) and herb richness ($r = -0.997$, $P = 0.026$). Particle density significantly positively correlated with adult basal area ($r = -0.990$, $P = 0.044$), sapling richness ($r = -0.999$, $P = 0.014$), seedling richness ($r = -0.988$, $P = 0.05$) and herb density ($r = -0.998$, $P = 0.018$). In addition, the adult density significantly positively correlated to iron ($r = 0.998$, $P = 0.022$), whereas negative correlation found between juvenile basal area and iron ($r = -1.00$, $P = 0.007$). In addition, the available iron significantly positively correlated with seedling density ($r = 0.994$, $P = 0.033$). The manganese significantly positively correlated with adult species richness ($r = -0.990$, $P = 0.045$), juvenile species richness ($r = -1.00$, $P = 0.001$), sapling density ($r = 0.994$, $P = 0.034$), seedling richness ($r = 0.998$, $P = 0.018$) and herb species richness ($r = 1.000$, $P = 0.003$). Total sodium significantly correlated with juvenile density ($r = -0.988$, $P = 0.04$), whereas the cation exchange capacity significantly correlated with adult basal area ($r = 0.997$, $P = 0.026$), sapling richness ($r = 0.995$, $P = 0.032$) and herb density ($r = 1.000$, $P = 0.001$). Besides, the chloride significantly negatively correlated with adult density ($r = -1.000$, $P = 0.003$) and seedling density ($r = -0.999$, $P = 0.014$), whereas positively correlated with juvenile basal area (r = 0.999, P = 0.013). Finally, considering the calcium carbonate significantly positively correlated with juvenile basal area (r = 0.992, P = 0.041).

Table. 33. Analysis of relationship between soil characteristics and phytodiversity of different life-stages

Soil variables	Adult species richness	Adult density	Adult basal area	Juvenile species richness	Juvenile density	Juvenile basal area	Sapling richness	Sapling density	Seedling richness	Seedling density	Herb richness	Herb density
pH (at 25˚C)	-0.586	-0.218	-0.133	-0.468	0.948	0.266	-0.312	-0.556	-0.416	-0.184	-0.456	-0.214
Electrical Conductivity (at 25˚C)	0.921	-0.902	**.996***	0.966	0.099	0.88	**.996***	0.934	0.979	-0.917	0.969	**1.000****
Moisture	-0.092	-0.685	0.39	0.047	0.978	0.719	0.215	-0.056	0.105	-0.659	0.06	0.312
Bulk Density	-0.973	0.818	-0.967	**-.996***	0.068	-0.789	**-.997***	-0.981	**-.999***	0.837	**-.997***	-0.984
Water Holding Capacity	-0.483	0.976	-0.839	-0.599	-0.693	-0.985	-0.726	-0.514	-0.645	0.967	-0.61	-0.792
Particle Density	0.938	-0.881	**.990***	0.977	0.052	0.857	**.999***	0.95	**.988***	-0.897	0.98	**.998***
Organic Carbon (as OC)	0.708	0.06	0.29	0.603	-0.885	-0.108	0.459	0.682	0.555	0.025	0.592	0.367
Organic Matter (as OM)	0.708	0.06	0.29	0.603	-0.885	-0.108	0.459	0.682	0.555	0.025	0.592	0.367
Available Nitrogen (as	0.466	0.353	-0.00	0.339	-0.98	-0.39	0.175	0.434	0.284	0.321	0.326	0.075

N)			7		3	8						
Available phosphorous (as P)	0.634	0.158	0.193	0.521	-0.927	-0.206	0.369	0.606	0.47	0.124	0.509	0.274
Available Potassium (as K)	-0.014	0.758	-0.485	-0.152	-0.951	-0.789	-0.317	-0.05	-0.21	0.735	-0.166	-0.411
Available Calcium (as Ca)	-0.278	0.903	-0.699	-0.408	-0.835	-0.923	-0.557	-0.312	-0.461	0.888	-0.42	-0.638
Available Magnesium (as Mg)	0.571	0.236	0.115	0.452	-0.953	-0.283	0.294	0.541	0.399	0.202	0.44	0.197
Available Sulphur (as S)	0.095	0.682	-0.387	-0.044	-0.979	-0.717	-0.212	0.059	-0.102	0.656	-0.057	-0.31
Available Zinc (as Zn)	0.885	-0.238	0.559	0.812	-0.708	0.19	0.701	0.867	0.776	-0.271	0.804	0.626
Available Copper (as Cu)	-0.062	0.788	-0.527	-0.2	-0.935	-0.817	-0.363	-0.098	-0.257	0.767	-0.213	-0.455
Available Iron (as Fe)	-0.609	**.998***	-0.911	-0.713	-0.577	**-1.000****	-0.821	-0.637	-0.752	**.994***	-0.722	-0.874
Available Manganese (as Mn)	**.990***	-0.762	0.939	**1.000****	-0.159	0.73	0.986	**.994***	.998*	-0.784	**1.000****	0.964
Available Boron (as B)	-0.01	0.755	-0.482	-0.149	-0.952	-0.786	-0.314	-0.047	-0.206	0.732	-0.162	-0.408
Total Nitrogen (as N)	-0.505	-0.311	-0.038	-0.381	0.974	0.357	-0.219	-0.474	-0.326	-0.278	-0.368	-0.12
Total Phosphorous (as P)	-0.505	-0.311	-0.038	-0.381	0.974	0.357	-0.219	-0.474	-0.326	-0.278	-0.368	-0.12
Total Potassium (as	-0.50	-0.31	-0.03	-0.37	0.975	0.359	-0.21	-0.47	-0.32	-0.28	-0.36	-0.11

K)	3	3	5	9			7	2	4		6	7
Total Sodium(as Na)	-0.147	-0.643	0.338	-0.009	**.988***	0.679	0.161	-0.111	0.05	-0.616	0.005	0.259
Cation Exchange Capacity	0.918	-0.906	.997*	0.964	0.107	0.883	**.995***	0.931	0.978	-0.92	0.967	**1.000****
Chloride	0.657	**-1.000****	0.935	0.755	0.525	.999*	0.855	0.684	0.792	**-.999***	0.764	0.903
Calcium Carbonate	0.519	-0.984	0.861	0.632	0.662	**.992***	0.755	0.55	0.677	-0.977	0.643	0.817

*P < 0.05, ** P < 0.001, ns = not significant (without *)

The PCA on soil factors and different vegetation parameters showed significant correlation. The eigenvalues for the first and second axes were 20.6 and 17.39 respectively. The cumulative percentage variance of soil factors data showed that the first two PCA axes explain 100% of the variability in soil data. The component 1 and 2 explains 54.21% and 45.79% of the variance in the soil characteristics among different vegetation (fig 15). Component 1 was highly correlated to different soil phyisco-chemical properties such as soil pH, electrical conductivity, PD, Mn, total nitrogen, total phosphorus, total potassium, CEC, Chloride and Carbonate chloride. Among the vegetation parameter, the component 1 was highly correlated with adult species richness, adult basal area, juvenile species richness, juvenile density, juvenile basal area, sapling richness, sapling density, seedling richness, herb richness and herb density. Component 2 was highly correlated with electrical conductivity, particle density, organic carbon, organic matter, nitrogen, phosphorus, potassium, calcium, magnesium, sulphur, zinc, Cn, Mn, B, CEC (Table 8). In addition, the Component 2 also showed significant correlation with adult species richness, adult basal area, juvenile species richness, sapling richness, sapling density, seedling species richness, herb species richness and herb density.

Figure.15. PCA analysis of relationship between soil physiochemical properties and vegetative parameters

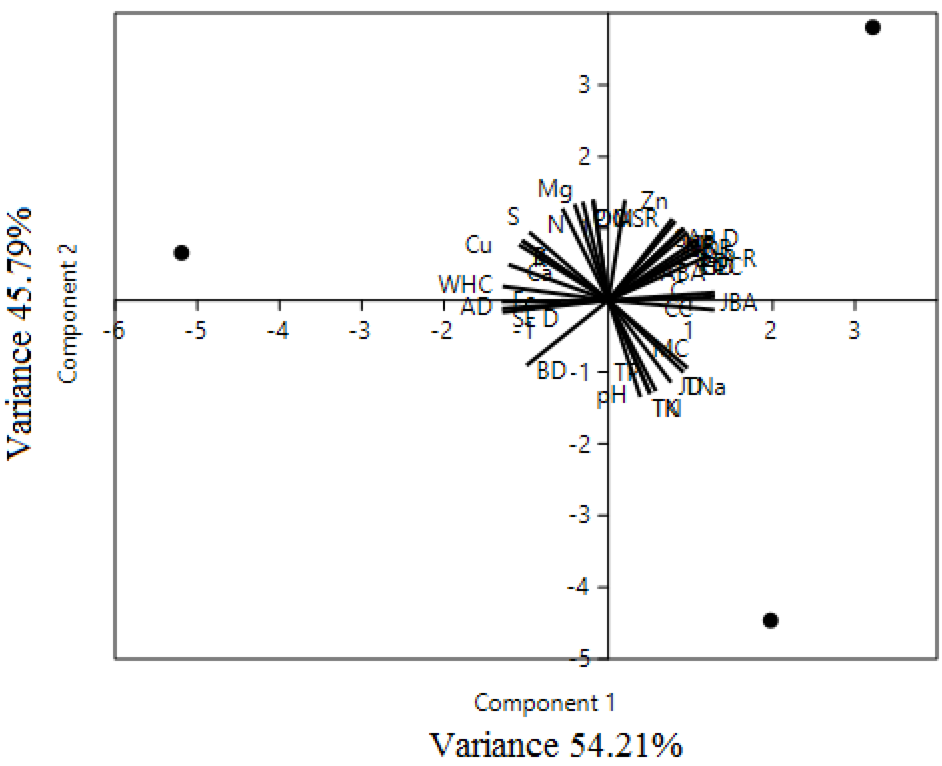


Table. 34. Correlation matrix analysis between soil physicochemical properties and different vegetation parameters (PCA).

Soil Variables	PC 1	PC 2
pH	**0.299**	-0.954
EC	**0.863**	**0.505**
MC	**0.743**	-0.669

BD	-0.767	-0.642
WHC	-0.991	0.137
PD	**0.838**	**0.545**
OC	-0.143	**0.990**
OM	-0.143	**0.990**
N	-0.430	**0.903**
P	-0.240	**0.971**
K	-0.810	**0.587**
Ca	-0.936	**0.352**
Mg	-0.317	**0.949**
S	-0.741	**0.671**
Zn	0.155	**0.988**
Cu	-0.837	**0.547**
Fe	-1.000	-0.013
Mn	**0.705**	**0.709**
B	-0.808	**0.590**
TN	**0.389**	-0.921
TP	**0.445**	-0.895
TK	**0.392**	-0.920
TNa	**0.705**	-0.709
CEC	**0.867**	**0.498**
C	**0.997**	0.076

CC	**0.995**	-0.095
ASR	**0.598**	**0.801**
AD	-0.997	-0.084
ABA	**0.906**	**0.424**
JSR	**0.703**	**0.711**
JD	**0.588**	-0.809
JBA	**0.999**	0.035
SAP R	**0.813**	**0.582**
SAP D	**0.627**	**0.779**
SE R	**0.744**	**0.669**
SE D	-0.993	-0.118
HR	**0.713**	**0.701**
HD	**0.868**	**0.497**

Relationship between soil microbes and different life-stages of vegetation parameters

Total bacterial sp significantly positively correlated to adult species richness (r = 0.998, P = 0.02) and sapling density (0.995, P = 0.031), whereas the total fungal sp significantly negatively correlated to juvenile density (r = – 0.996, P = 0.029). In addition, the *Azospirillum* sp significantly positively correlated to adult species richness (r = 1.000, P = 0.006), juvenile species richness (r = – 0.993, P = 0.038), sapling density (r = – 1.000, P = 0.005) and herb density (r = – 0.991, P = 0.042). Besides, the adult basal area positively significantly correlated with adult basal area (r = –0.994, P = 0.035) and herb density (r = – 1.000, P = 0.009). However, the phosphate solubiliser sp and *Azotobacter* sp did not correlated significantly with any of the vegetation parameter in the examined restored site.

Table 35. Relationship between soil microbes and different life-stages of vegetation parameters

Variables	Adult Species richness	Adult Density	Adult Basal area	Juvenile Species richness	Juvenile Density	Juvenile Basal area	Sapling	Sapling density	Seedling	Seedling density	Herbs	Herb density
Total bacterial sp	**.998***	-0.615	0.85	0.98	-0.356	0.576	0.932	**.995***	0.966	-0.642	0.977	0.891
	0.02	0.289	0.177	0.064	0.384	0.305	0.118	**0.031**	0.083	0.278	0.068	0.15
Total fungal sp	0.208	0.594	-0.278	0.071	**-.996***	-0.632	-0.099	0.173	0.013	0.566	0.058	-0.198
	0.433	0.298	0.41	0.477	**0.029**	0.282	0.468	0.445	0.496	0.309	0.482	0.436
Actinomycetes sp	-0.317	0.92	-0.727	-0.445	-0.812	-0.938	-0.59	-0.351	-0.496	0.906	-0.457	-0.668
	0.397	0.128	0.241	0.353	0.198	0.113	0.299	0.386	0.335	0.139	0.349	0.267
Azospirillum sp	**1.000****	-0.678	0.891	**.993***	-0.278	0.641	0.959	**1.000****	0.984	-0.703	**.991***	0.925
	0.006	0.263	0.15	**0.038**	0.41	0.278	0.092	**0.005**	0.056	0.252	**0.042**	0.124
Phosphate solubiliser sp	-0.206	0.869	-0.644	-0.339	-0.873	-0.892	-0.493	-0.241	-0.393	0.851	-0.352	-0.578
	0.434	0.165	0.277	0.39	0.162	0.149	0.336	0.423	0.371	0.176	0.386	0.304
Pseudomonas sp	-0.833	0.138	-0.473	-0.749	0.775	-0.09	-0.626	-0.813	-0.709	0.173	-0.74	-0.544
	0.187	0.456	0.343	0.231	0.218	0.471	0.285	0.198	0.249	0.445	0.235	0.317
Rhizobium sp	0.928	-0.894	**.994***	0.971	0.081	0.872	.997*	0.941	0.983	-0.909	0.974	**1.000****
	0.122	0.148	**0.035**	0.077	0.474	0.163	0.023	0.11	0.059	0.137	0.073	**0.009**
Azotobacter sp	0.419	-0.957	0.798	0.541	0.743	0.97	0.675	0.451	0.589	-0.947	0.552	0.746
	0.362	0.093	0.206	0.318	0.234	0.078	0.264	0.351	0.3	0.104	0.314	0.232

Table. 36. Principal component analysis of different leaf litter decomposition of macro and micro nutrients and different life stages of vegetation parameters

Variables	PC 1	PC 2
Total bacterial count	**0.877**	**0.480**
Total fungal Count	-0.227	**0.974**
Actinomycetes sp	-0.690	**0.724**
Azospirillum sp	**0.914**	**0.407**
Phosphate solubiliser sp	-0.602	**0.799**
Pseudomonas sp	-0.519	-0.855
Rhizobium sp	**0.998**	0.057
Azotobacter sp	**0.765**	-0.644
Adult species richness	**0.905**	**0.425**
Adult density	-0.918	**0.396**
Adult basal area	**0.999**	-0.053
Juvenile species richness	**0.955**	0.295
Juvenile density	0.137	-0.991
Juvenile basal area	**0.898**	-0.440
Sapling species richness	**0.992**	0.129
Sapling density	**0.920**	**0.392**
Seedling species richness	**0.971**	0.239
Seedling density	-0.931	**0.364**
Herb species richness	**0.959**	0.282
Herb density	**1.000**	0.029

The PCA on soil microbial community and different vegetation parameters exhibited significant correlation. The eigenvalues for the first and second axes were 14.3 and 5.70 respectively. The cumulative percentage variance of soil microbial community data showed that the first two PCA axes explain 100% of the variability in soil data. The component 1 and 2 explains 71.51% and 28.49% of the variance in the soil microbial community in relation with different vegetation parameters (fig 8). Component 1 was highly correlated to different soil microbial community total bacterial sp., *Rhizobium*, *Azotobacter*. Among the vegetation parameters, the Component 1 significantly correlated to adult species richness, adult basal area, juvenile species richness, juvenile basal area, sapling species richness, sapling density, seedling species richness, herb species richness and herb density. While we observed in Component 2 highly correlated to total bacterial sp., total fungal sp., *Actinomycetes*, *Azospirillum*, while I examined on vegetation parameters, Component 2 showed significant correlation with adult species richness, adult density, sapling density and seedling density (Table 36).

Figure . 16. Correlation relationship between nutrients of leaf litter decomposition and different vegetation parameters

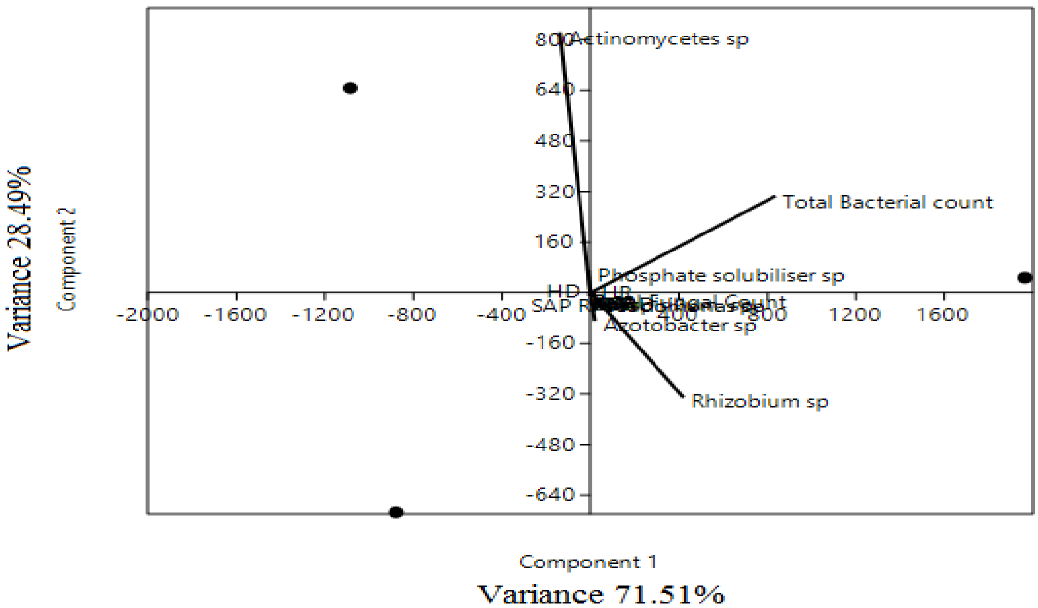


Table 37. Relationship between leaf litter and different life-stages of vegetation parameters.

Variables	Adult Species richness	Adult density	Adult basal area	Juvenile species richness	Juvenile density	Juvenile basal area	Sapling richness	Sapling density	Seedling richness	Seedling density	Herb richness	Herb density
N	0.695	0.077	0.273	0.589	-0.893	-0.125	0.444	0.669	0.541	0.042	0.578	0.351
P	1.000**	-0.663	0.881	.990*	-0.297	0.626	0.953	.999*	0.981	-0.688	.988*	0.917
K	0.316	-0.92	0.727	0.444	0.812	0.938	0.59	0.35	0.496	-0.906	0.456	0.668
Zn	0.986	-0.527	0.789	0.953	-0.454	0.485	0.887	0.979	0.933	-0.556	0.948	0.836
Cu	-0.391	0.948	-0.78	-0.515	-0.763	-0.963	-0.653	-0.424	-0.564	0.937	-0.527	-0.726
Fe	-0.573	.993*	-0.892	-0.681	-0.613	-.998*	-0.795	-0.602	-0.722	.989*	-0.691	-0.852
Mn	-0.88	0.228	-0.552	-0.806	0.714	-0.181	-0.694	-0.863	-0.77	0.262	-0.798	-0.618

Significant level : *P < 0.05, without * = not significant

Leaf litter decomposition of P significantly positively correlated to adult species richness, juvenile species richness, sapling density, herb species richness. In addition, micronutrients of Fe showed significant correlation with adult density and seedling density. In contrast, there was significant negative correlation found between leaf litter decomposition of copper and juvenile basal area (Table 37).

Table 38. Principal component analysis of different nutrients by leaf litter decomposition and different vegetation parameters (correlation matrix).

Variables	PC 1	PC 2
N	0.106	**0.401**
P	**0.252**	0.156
K	0.171	-0.337
Zn%	**0.232**	0.223
Cu	-0.188	**0.313**
Fe%	-0.224	0.244
Mn	-0.176	-0.330
ASR	**0.252**	0.156
AD	-0.239	0.201
ABA	**0.268**	-0.055
JSR	**0.263**	0.098
JD	0.017	-0.435
JBA	0.233	-0.220
SAP R	**0.269**	0.025
SAP D	**0.255**	0.141
SE R	**0.266**	0.073
SE D	-0.244	0.188
HR	**0.264**	0.093
HD	0.270	-0.019

Finally, there was significant correlation observed between leaf litter decomposition and different vegetation parameters by principal component analysis.

The eigenvalues for the first and second axes were 13.73 and 5.27 respectively. The cumulative percentage variance of soil factors data showed that the first two PCA axes explain 100% of the variability in soil data. The component 1 and 2 explains 72.29% and 27.71% of the variance in the leaf litter decomposition in relation with different vegetation parameters (fig 17). Component 1 was correlated to leaf litter decomposition of phosphorus and Zinc and examined on vegetation parameters; it was correlated with adult species richness, adult basal area, juvenile species richness, sapling richness, sapling density, seedling species richness and herb species richness. The Component 2 highly correlated to nitrogen and copper, there was no significant correlation on vegetation parameters. (Table 38).

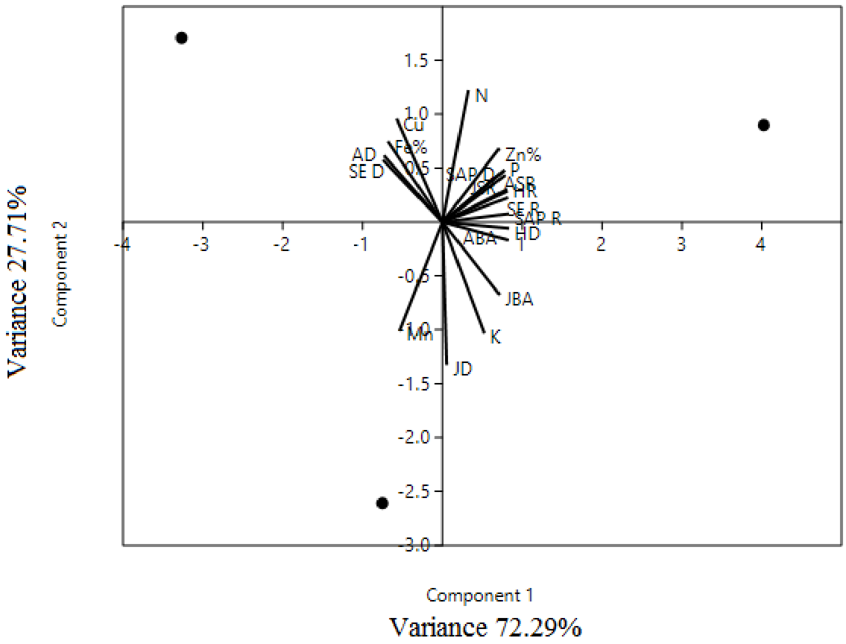


Figure. 17. PCA analysis of the relationship between nutrients of leaf litter decomposition and different vegetation parameters

CHAPTER -5

DISCUSSION

5.1. Floristic inventory of different life-stages in different vegetation types

Restoration and long-term management of tropical dry evergreen forest (TDEF) ecosystem is one of the challenging tasks for conservation of plant diversity and their ecosystem plays a significant role on forest structure and forest functional dynamics (Blanchflower 2005; Davidar *et al*., 2007). Besides, TDEF is one of the richest and complex terrestrial ecosystems that support various plant life-forms and biodiversity (Selywn and Parthasarathy, 2006; Parthasarathy *et al*., 2008).

In this study, species richness and density are high and composed of variety of species and increased number of adult individuals and regeneration success among the three vegetation types were recorded (*Acacia*, *Casuarina* and mixed). This is due to different sources of ecological niches from the forest floor to the canopy which facilitate rich plant diversity. Moreover, the species diversity and basal area were higher when compared to other restored sites (Davidar *et al*., 2007), thus indicates the availability of soil nutrients, precipitation, long warm temperatures and light (radiation) which might have influenced higher plant productivity in this restored site.

However, the species richness, density, basal area and diversity showed variation in number among different vegetations. Of these, mixed vegetation had higher species diversity than *Acacia* and *Casuarina.* This indicates that the vegetation is diverse in species composition which influences higher species diversity by the availability of fleshy fruits that are highly dispersed by vertebrates (Davidar *et al*., 2007). Moreover, mixed vegetation may facilitate greater availability of ecological niches that may have various natural resources such as soil moisture content, temperature, and the availability of light. In addition, basal area was higher in mixed vegetation which indicates the presence of large number of big trees when compared to *Acacia* and *Casuarina* vegetations. It also reveals that mixed vegetation enhanced plant growth by the age of plantation and continuous resource availability. The study results also showed that evenness was higher in *Casuarina* vegetation that exhibits more similar number of species and density occurred in all plots. However species-specific are highly influenced under *Casuarina* vegetation. Interestingly, species abundance distribution of various life-stages among different vegetation did not differ from normal distribution. This pattern is similar to the natural tropical evergreen forest of the Western Ghats (Mohandass and Davidar 2009; Mohandass *et al*., 2016).

Seedling abundance distribution differs from normal distribution thus suggests regeneration of seedlings might be greater than natural tropical evergreen forest of the Western Ghats. Moreover, the study results showed that seedlings are highly successful in all vegetation types compared to other life-stages. This indicates the lake estate restored site has younger forest formation produces with relatively higher proportion of sapling and seedling regeneration compared to mature forest (Chauhan *et al*., 2008; Jayakumar and Nair, 2013). Besides, the study also found that species similarity was higher between the vegetations; therefore vegetation types are potential tool to restore and increase plant diversity and forest regeneration. In addition, these similarities in species diversity suggest that species colonized and survived under this stressful soil compaction conditions. However the results suggest that saplings and seedlings recruitment are abundant in all vegetation types which indicates colonization dynamics might have played a vital role in increasing plant diversity and structure in the studied restored site. Further permanent inventory study on saplings and seedlings is inevitable to understand the functional traits of TDEF species that would bring significant insights for forest succession and restoration program. In summary, floristic diversity is consistent between different life stages in all vegetations examined.

5.2. Native and exotic natural regeneration of different life-stages under different vegetation types

Natural regeneration of native woody species under different vegetation demonstrates that the present restored site has been adapted to support native forest species through natural colonization process. Besides the monoculture vegetations of *Acacia* and *Casuarina* have increased native woody species diversity and this is in conformity with several previous studies of *Eucalyptus* plantation and tea plantation (Lemenih *et al*., 2004; Selwyn and Ganesan, 2006; Alem *et al*., 2012; Mohandass *et al*., 2016). This evidences the potential role of *Acacia* and *Casuarina* plantations in restoring the native woody plants. The number of native woody species in *Acacia* and *Casuarina* vegetations and the species richness and density of the present study are comparable to native tropical dry evergreen forest of Coromandel Coast (Parthasarathy and Karthikeyan, 2002; Venkateswaran and Parthasarathy, 2003). This facilitation of high recovery of native woody plants under *Acacia* and *Casuarina* vegetations may be attributed to natural pollinators and seed dispersal mechanisms prevailing in the vegetations. This may also be attributed to the suitable environmental conditions available in these vegetations for seed germination, seedling growth and establishment of the species (Hopkins and Graham, 1984; Bellairs and Bell, 1993; Mohandass *et al*., 2014; Mohandass *et al*., 2016). In addition, *Acacia* and *Casuarina* vegetations increased soil nutrients by leaf litter decomposition and nutrient recycling for success of natural regeneration of native woody plants (Prescott, 1997).

In this study, the average number of saplings and seedlings of native species recorded from *Acacia* and *Casuarina* vegetations may be attributed to pioneer species dispersal by biotic vectors (Mohandass *et al*., 2016). Moreover, the initial stages of species recruitment under these vegetations showed that the degree of species similarity was parallel, but it tends to influence low diversity and species composition under *Acacia* and *Casuarina* vegetations than mixed vegetation due to dispersal limitations (Davidar *et al*., 2007). In addition, during early stage of colonization, saplings in different vegetations may exhibit random distribution because pioneer species may be found in gaps where more light favours for survival (Queenborough *et al*., 2007). Interestingly, birds play key role in seed dispersal in this restored site (Davidar *et al*. 2007) which might have influenced greater tree diversity and stem density in adult and sapling stages under mixed vegetation.

The most important process of vegetation dynamics in the restored site is influenced by plantation age of exotic and native trees. In the restored site, *Acacia* and *Casuarina* were introduced as pioneer plantation to improve soil nutrient that enhanced nutrient cycling by the processes of biogeochemical cycles. Therefore in this study it is found that introduced exotics vegetation such as *Acacia* and *Casuarina* increased native tree regeneration due to nutrient enrichment, seed dispersal which might have enhanced natural colonization of native stems in the past successive 10 to 20 years. Similar pattern was reported stating that density of adult was increased by the population of sapling and seedlings from 25 to 40years under exotic plantation of *Eucalyptus* (Senbeta *et al*., 2002; Selwyn and Ganesan, 2006).

5.3. Comparison and relationship on floristic composition of different life-stages and different vegetation types

Long-term restoration and recovery of tropical forests regeneration leads to changes in the ecosystem functions (Aerts and Honnay, 2011). Restoration of tropical forest in terms of ecological relationship may increase the ranks of plant communities from human-disturbed ecosystems (Brudvig, 2011) that may reduce the impact of climate change (Harris, 2009). The present study reveals that the species richness, density, basal area and bio-volume of different life stages of the vegetation types studied responded variedly.

The species richness of adult and sapling greatly varied among different vegetation types. This indicates that the mature trees of different species are diverse that might have influenced the regeneration of a variety of saplings in different vegetation types. Moreover, the results showed that mean species richness of adult and sapling was higher in mixed vegetation. This might be due to the presence of a variety of species that might have facilitated diverse natural regeneration and influenced more species richness. This might also be due to natural seed dispersal which might have played significant role in regeneration of species in mixed vegetation. In most of the plant species of this restored site, the seed dispersal is by vertebrates and natural mechanical methods which might have greatly influenced the natural regeneration and species recruitment (Davidar *et al*., 2007). However the local environmental conditions prevailed due to progress of regeneration might also have influenced variedly the species richness of juvenile and seedling at different life stages of different vegetation. In addition, the mean juvenile and seedling species richness was higher in *Casuarina* vegetation which may be due to large amount of litter biomass production under ground cover of *Casuarina* vegetation.

Uma *et al*. (2014) and Uriarte *et al.* (2015) are of the opinion that the available soil nutrients directly influence the plant species recruitment. The leaf litter under 3-year old *Casuarina* plantation was found to have more soil nutrients when compared to temperate and subtropical forests in Australia (Clark and Allaway, 1996). The consistent amount of species richness of the life stages, juveniles and seedlings was found among different vegetation types. This is in conformity with the studies of Bhadouria *et al.* (2016) who have stated that natural regeneration of different vegetations was steady in the tropical forests. The adult basal area also significantly varied among different vegetation types. It was found to be more in the *Casuarina* vegetation than in *Acacia* and mixed vegetations. The large trees present in *Casuarina* vegetation might have enriched the ground cover with more leaf litter and ultimately with soil nutrients. This is in conformity with the studies of Dutta and Aggarwal (2002) and Richards *et al*. (2010) who have reported an increase in soil nitrogen and phosphorus under adult tree species of *Casuarina* vegetation. They have also attributed the increase in soil nutrients to suitable air temperature available under *Casuarina* vegetation. However, other vegetation parameters did not show significant differences on different vegetation types. This could be the due to local environmental variations on available soil nutrients, temperature and soil moisture which enhance natural regeneration (Richards *et al*., 2010).

Density of different life stages of adult, juvenile and seedlings was found to be higher in *Casuarina* and *Acacia* vegetations. It suggests that these vegetations have highly facilitated natural regeneration of seedlings due to more shade adaptation and high nutrient recycling under them. Because the trees in these vegetations shed more leaves and facilitate recycling of nutrients and enrich the soil. The studies of Uma *et al.* (2014) is in conformity with this. This process can enable to maintain the higher density of adults, juveniles and seedlings recruitment in the *Casuarina* and *Acacia* plantations. Considering the basal area of different life stages, the mean adult and juvenile basal area were enhanced in the *Casuarina* and *Acacia* vegetations. This may also be due to nutrient enrichment by leaf litter fall and increase of organic matter in soil cover of *Casuarina* and *Acacia* vegetations that might have increased the growth of adult trees and juvenile plants. The increase in growth and mean bio-volume of adult and juvenile individuals of different species in mixed vegetation may also be attributed to the enhanced nutrients and organic matter added to the soil by leaf litter fall. Previous studies were also found to be similar to the present study which revealed that the mixed plantation had higher rates of carbon sequestration and above ground biomass production compared to monocultures (De Bell *et al*., 1989; Kelty, 1992; Erskine *et al*., 2006; Forrester *et al*., 2004; Piotto, 2008; Pretzsch and Schütze, 2009).

Moreover, plantations are primary strategies to protect biodiversity that leads to management of ecosystem through erosion control, carbon sequestration, land rehabilitation, water table stabilization and habitat provision; however they must be more resistant to disturbances (Bauhus *et al*., 2010). Thus to maintain and understand the composition of vegetation, it is necessary to manage the relationship between vegetation and their parameters.

In the present study, I found that there was significant positive relationship between species richness of adult and juvenile in *Acacia* and mixed vegetations. In addition, there was a significant positive relationship found between adult and juvenile density in *Acacia* and *Casuarina* vegetations. This suggests that the vegetation types ensure enrichment of available nutrients and successful regeneration under rain fed conditions. For instance, *Acacia* vegetation had dominant species of *Acacia auriculiformis* which increases nitrogen fixation in the soil through leaf litter fall that may facilitate the regeneration of species. However, the study did not find significant relationship between adult and either saplings or seedlings richness and density regeneration among the three vegetations. This may be due to long-term survival of *A. auriculiformis* with old mixtures of *Eucalyptus* (May and Attiwill, 2003; Forrester *et al*., 2007) which may fix less nitrogen resulting in competition between *Acacia* and *Eucalyptus* where soil nitrogen is poor (Pfautsch *et al.,* 2009) that may inhibit the significant relationship between adult and seedlings richness. In *Acacia* vegetation nitrogen content is greater due to long-term recycling, however local environmental conditions such as soil erosion and drought may reduce uptake of N and P (Oliveira *et al*., 2009; Rouphael *et al*., 2012) which may affect plant growth resulting negative impact on seedling richness and density. Overall, the study suggests that the species richness, density, basal area and bio-volume varied between the different vegetation types. However, mixed vegetation highly adopted a variety of species and stem individuals due to increased availability of soil nutrients and the influence of dispersal agents. The study reveals that the long-term survival of *Acacia*, *Casuarina* and *mixed* vegetations has significant positive relationship to natural regeneration. This confirms that the restored site maintains sustainable management on plant diversity and vegetation dynamics.

5.4. Influence of soil physicochemical properties, soil microbes, leaf litter decomposition on different plant life-stages

Many studies demonstrate the relationship between soil physico-chemical properties and different vegetation parameters resulting either positive or negative for plant diversity and regeneration success in the tropical forests (Mandal and Joshi, 2014; Nadeau and Sullivan, 2015). In the present study the relationship between soil physicochemical properties and vegetation parameters observed in the restored site were analysed.

To my knowledge, this is the first study to find out the relationship among the soil physio-chemical, soil microbes and leaf litters decomposition in the restored site of the tropical dry land of Southern India. Hence, it would be interesting to bring out important insights to evaluate the relationship in responses of soil and vegetation parameter among this kind of harsh environmental condition, so that it would be helpful to create an idea for future restoration plan for conservation of the native tropical forests. In the present study the results showed that pH varied between different vegetation types (pH ranged between 5.4 and 7.8) that forms acidic and slightly alkaline (basic) in nature however it did not show any significant relationship to vegetation parameter. On the contrary, the soil electrical conductivity showed significant positive relationship to adult basal area, sapling richness and herb density suggesting that soil chemistry was associated to topographic characteristics such as soil texture, cation exchange capacity, organic matter level and drainage conditions (Caroll and Oliver, 2005). These factors might have influenced positively adult basal area, saplings richness and herb density.

However, the soil electrical conductivity may possibly act as secondary gradient because it may influence indirectly water holding capacity and soil moisture content (Gaitan *et al.*, 2011). In addition, the bulk density showed significant negative relationship to juveniles, sapling, seedling and herb species richness thus indicates that the bulk density drives soil compaction which might be the reason for negative relationship with species regeneration (Sharma *et al*., 2010). Besides the study results showed that the particle density significantly positively correlated to adult basal area, sapling richness, seedling richness and herb density suggesting the solid part of the soil texture that may consist of heavy metal which may positively influences the natural regeneration of woody plants including herbs.

Moreover, the results showed positive correlation of iron to adult and seedling density. This might have helped to increase the adult growth and number of individuals under different vegetation that ensure the processes of plant functional dynamics. It also plays major role in seed germination, function of tree respiration, nitrogen fixation and energy transfer through various metabolic activities. The study results also found negative relationship between juvenile basal area and soil iron. This may be due to ecological niche with less iron which might have influenced negatively the tree growth. The micro nutrient manganese (Mn) positively influenced the adult, juvenile, seedling and herb species richness as well as sapling density thus involved to aid as structural ecosystem functions by the combination of soil iron by accelerating seed germination under different stress condition. In addition total sodium, cations exchange capacity, chloride and calcium positively correlated to juvenile density, juvenile basal area, adult basal area, sapling richness and herb density. This might be due to the presence of calcareous soil which might have accumulated these kinds of micro nutrients with other elements that supported species regeneration. This in turn facilitated the increased of number of trees and herbs and in addition accelerated plant growth to increase tree basal area. Overall, these evidences showed that soil chemistry highly positively increased different plant life stages under different vegetations leading to the success of plant regeneration.

Soil microbes form a precarious connection between the plant and the soil by stimulating nutrition cycling and soil functions (Korb *et al.,* 2003). Soil microbial communities play a significant role in mutual association with plant communities for nutrient and water uptake, defense against pathogens, increased resistance to drought and high temperature, tolerance capacity to heavy metals and increased plant diversity and plant growth development in the terrestrial ecosystems (Smith and Read, 1997).

Results of the present study showed that total bacterial sp including *Azospirillum* significantly positively correlated to different vegetation parameters (Table 35). The increase in adult and sapling diversity and basal area must be due to the activity of soil bacterial communities which might have stimulated the uptake of nutrient and water by plants. In addition, *Rhizobium* species increases nitrogen fixation through leguminous plants that may enhance the plant diversity, plant growth and regeneration success. However, fungal species and other micro organisms did not play significant role on plant diversity in this study site. This may be probably due to the local environmental stress such as soil compaction and leaching .

The present study also showed that the macro nutrient, P and the micronutrient, Fe accumulated through leaf litter decomposition, positively influenced the adults, juveniles, herb species richness and adult density, sapling density and seedling density. This confirms that the leaf litter decomposition is positively associated to plant diversity and regeneration success under different vegetation types in the restored site. During seed germination stage, litter composition may interrupt light that will hinder germination by changes of red/far-red light ratio (Vázquez-Yánes *et al.*, 1990) and also it may act as a physical barrier to seedling development (Molofsky and Augspurger, 1992). In particular it can be subjected to small-seeded plants which may not have a large stock of resources (Metcalfe and Turner, 1998) and that may prevent the germinated radicals of fresh seeds while reaching the soil (Brearley *et al*., 2003). The study also found that leaf litter negatively correlated to sapling and seedling regeneration and this might be due to available fungal pathogen that may kill seedlings due to higher soil moisture content in the litter composition by indirect effects (Garcia- Guzman and Benitez-Malvido, 2003). In the present restored site, litter fall is relatively high due to *Acacia*, *Casuarina* and mixed vegetations that contributes important nutrient cycling and this may influence plant diversity and regeneration success of native and exotics. However the litter fall may vary due to decomposition of leaves of diverse species which may facilitate to create suitable regeneration niche on the forest floor (Grubb, 1977) and thus help to increase high species diversity.

5.5. Effect of vegetation types on soil-physicochemical properties, soil microbes and leaf litter decomposition

5.5.1. Physicochemical properties of soil

In the present study the nutrients availability of seven different vegetation types including *Acacia*, *Casuarina*, mixed, grassland, wetlands, gully pugs and control was analysed and discussed. The study results were also examined to ascertain the significant correlation between vegetation types and soil physicochemical characteristics. The availability of nutrient content was mostly higher in *Acacia* and *Casuarina* vegetations followed by mixed vegetation and lower in gully plugs. The soil pH was higher in *Acacia* and control plots which may be due to higher rate of interaction between soil microbes and organic matter that enhanced the production of more amounts of organic acids to influence soil pH. However the slight variation in the soil characteristics at different vegetation may be attributed to the alterations in the species composition of the vegetations (Singh and Totey, 1985; Vadiraj and Rudrappa, 1990; Rathod and Devar, 2003). But the gully pugs had lower pH and EC compared to other vegetation and this may be due to higher leaching of salts due to seasonal soil erosion by rainfall (Rathod and Devar, 2003).

In the present study the bulk density was found to be not higher than 1.6 g/cm^3 in all vegetation types. This might have facilitated the growth of the roots to the deeper region of soil in all vegetation types (Twum and Nii-Annang, 2015). In addition water holding capacity was higher in *Casuarina* vegetation. This may be due to conducive microclimate underneath the tree canopy that increased the water holding capacity of the soil which in turn increased the available nutrients to the optimum and enhanced the stem growth and plant bio-volume. The organic carbon and organic matter were higher in control plot which is in proximity to the *Acacia* and *Casuarina* vegetations. Interestingly, nitrogen was found to be higher in *Casuarina* vegetation followed by mixed vegetation which may be due to the increased turnover rate of nitrogen in top soil of this vegetation. Similar findings were reported by Voigtlaender *et al*. (2012). Moreover, in mixed vegetation there is large number of trees like *Acacia* sp, *Casuarina* sp and wild trees which might have helped to increase soil nitrogen that might have been utilised by *Eucalyptus* also (Baker *et al.,* 1994). The studies of Baker *et al*. (1994) and Voigtlaender *et al.* (2012) showed that 6-year rotation of monoculture plantation of *Acacia mangium* managed to increase carbon and nitrogen fixation in the forest floor.

The natural turnover rates of nitrogen and phosphorus released essential soil nutrients into terrestrial ecosystem to manage composition of plant community

(Vitousek, 1994; Vitousek *et al*., 1997; Carpenter *et al*., 1998). In the present study phosphorus was higher in mixed vegetation compared to monoculture. This may be probably due to increased production of forest biomass in response to high atmospheric nitrogen input that might have increased phosphorus nutrition by climate change effects in the ground floor of mixed vegetation (Medlyn *et al*., 2011). The processes of biogeochemical cycles influence the K availability in the forest ecosystems and it was higher in *Acacia* plantation which was strongly influenced by biotic processes such as seasonal dynamics in plant tissues, soil organic matter and surface waters. Moreover the availability of K may be influenced by natural regeneration of saplings and seedlings under different vegetation types that may alter the land use pattern (Johnson *et al*., 1985; Bock and Van Rees, 2002). Therefore the study suggests that greater macronutrients availability and turnover rate may be due to long term nutrient recycling of monoculture plantation like *Acacia* and *Casuarina*. It further states that mixed vegetation influenced the sustainability of plant diversity and dynamics in the restored site.

In addition, the micronutrients might have also played a vital role for the sustainable management of plant diversity in the restored site of the present study. Plant productivity on alkaline and calcareous soils is frequently limited by the accessibility of P, Fe, Zn, Mn or Cu (White and Greenwood, 2013; White *et al*., 2013). Plant tolerant activity secretes organic acids into the soil, thus increasing P, Fe, Zn, Mn and Cu accessibility which may facilitate the benefits of woody plant under various vegetations (Zhang *et al*., 2010; Li *et al*., 2013).

According to the soil analysis, micronutrients were found to be higher in control site which suggests that there were no plants available to utilize the micronutrients in the site so they were found relatively in higher proportion. Whereas in other vegetations like *Casuarina* the plants exudates might have reduced micronutrient level. The present study also showed that the zinc content was higher in mixed vegetation that might have enhanced the bio-volume of woody plants especially the height of the trees. This might also be the reason for the increase in adult bio-volume in mixed vegetation when compared to *Acacia* and *Casuarina* vegetations as discussed earlier. Therefore all the essential micronutrients such as copper, iron, manganese, boron are found adequately in the soil environment that protects the plants from mineral deficiencies. These micronutrients would have enhanced the plant growth, energy capture and metabolic activities like photosynthesis and respiration (Grusak, 2001) and altogether helped to maintain ecosystem functions of the restored site.

5.5.2. Soil microorganisms

The study also examined the microbial diversity associated with different vegetation types in the restored site. Microbial diversity plays a significant role in maintaining forest ecosystem functions and does several services, comprising primary plant productivity, nutrient cycling, climate regulation and litter decomposition (van der Heijden *et al.*, 2008; Wagg *et al.*, 2014; Bardgett and Putten, 2014; Bodilier, 2011). However, there was limited information available to examine the relationship between microbial diversity and monoculture ecosystem functioning, particularly in dry terrestrial environment (Bell *et al.*, 2005; Peter *et al.*, 2011).

In the present study, total Bacterial spp was found to be significantly higher in different vegetation types followed by Actinomycetes spp and *Rhizobium* spp especially it was found in higher quantity in *Casuarina* vegetation. This might be due to the nitrogen fixing capacity of the plants in association with bacterial communities which are responsible for nitrogen fixation (diazotrophs). This interaction between host plants of *Casuarina* and bacterial communities increased the rate of nitrogen fixation in the root nodulation that have ensured nutrient recycling for enhanced plant diversity and growth forms. However Actinomycetes play a significant role in ecosystem function by secondary plant productivity. Actinomycetes were found in higher quantity on dead organic matter of leaves and woods under mixed vegetation which might have enhanced the rate of decomposition of organic substances in the soils of *Casuarina*, *Acacia* and mixed vegetations. Moreover, Actinomycetes are more resistant to the soil and responsible for further decomposition of humus in the soil that might have facilitated the enhanced plant productivity and nutrient recycling under these vegetations.

The results of the present study showed that microbial diversity positively influenced different vegetation types and this was similar to the findings of recent studies (Delgado-Baquerizo *et al*., 2015). In addition, *Rhizobium* species showed significant influences on different vegetation types which may be possibly due to the availability of legume plants of *Acacia* vegetation in higher proportion. In this restored site, it was found that *Rhizobium* sp fixes nitrogen in the root nodules of *Acacia* and *Casuarina* which may help to improve productivity and fertility of nitrogen deficient soil (Zahran, 1999). Thus the microbial communities observed in the present study played a vital role to increase soil nutrients and maintain the plant diversity, density and bio-volume of woody plants against various stress factors.

5.5.3. Leaf litter biomass

Leaf litter decomposition rates are generally increased by plant productivity and climatic factors such as temperature and moisture functions (Moorhead *et al*., 1999; Del Grosso *et al*., 2005). In the restored site, leaf litter compositions of different vegetations have increased the availability of macro and micro nutrients. Among them, nitrogen and phosphorus were higher in mixed vegetation due to higher rate of leaf litter decomposition possibly due to deposition of litter of *Acacia* in combination with leaf litter of a variety of other woody plants. The studies of Bernhard-Reversat (1996); Majalap (1999) and Inagaki *et al.* (2010) have reported the increase of N availability and N mineralization by litter fall in *Acacia mangium* plantation.

In the present study it was found that N, P, K production varied in different vegetations which may be attributed to decomposition of litter at different rates in different vegetations. However it might be influenced by soil conditions, climatic factors and decomposer communities (Aponte *et al*., 2012). Similarly the micronutrients such as Zn, Cu, Fe, Mn are available due to the activity of litter decomposition under different vegetation types. Hence increased micronutrient availability may be due to nutrient cycling process thereby increasing leaf litter decomposition rates under different vegetations. However further study is necessary to evaluate the rate of decomposition in leaf litter of different vegetation types.

Overall the study reveals that the available macro and micro nutrient influenced by the number of tree species by leaf litter decomposition. However the variability of nutrient in different vegetation may determine the ecosystem stability that is relating to ecosystem processes by the effect of leaf litter decomposition. Presently, for restoration management, the study results suggest conservation of locally available native tree species communities rather than large tree species of *Acacia, Casuarina* and *Eucalyptus* which would be important for sustainable land management, because the current environmental conditions of the study site are stabilized to natural ecosystem process due to the availability of soil nutrients, microbial communities and processes of leaf litter decomposition.

CHAPTER - 6

SUMMARY AND CONCLUSION

The Coromandal coast of South India along the Bay of Bengal extends from Ramanathapurum in South Tamil Nadu to Visakapattinam in Andra Pradesh. This belt harbours several patches of tropical dry evergreen forest (TDEF) vegetation. The present study site, a part of Coromandel Coast vegetation, is situated 10 km West of Puducherry town near Oussuteri towards inland from the coastal regions. It spreads over 160ha of which 40ha called 'Merville' have been afforested through eco-restoration from a barren eroded gulley landscape with red ferralitic soil over a period of more than 30 years by the involvement of Sri Aurobindo International Centre of Education.

Eco-restoration comprised of active human intervention through the introduction of drought tolerant nitrogen fixing species and TDEF elements found in the canyons of the original fragmented landscape. As a result the introduced TDEF species established themselves and naturally regenerated along the thickets. Lowland herbaceous species also established themselves as a green cover at ground level.

The present work has been taken up to ascertain the floristic composition, regeneration status, native species recruitment and to analyze the relationship between the soil characteristics, soil microorganisms and leaf litter decomposition with phytodiversity of the restored landscape.

Quantitative survey was carried out covering the entire study area. Three distinct vegetations types namely *Acacia*, *Casuarina* and mixed vegetations were selected for the study. Totally 85 square quadrats of 10 m x 10 m were laid and random samplings in all three vegetation types were made. The species richness, abundance, frequency, basal area, and bio-volume of different life stages namely adult, juvenile, sapling and seedling, were observed from these vegetations. Herbaceous plants, from three vegetations, were also identified and their abundance was recorded separately. The soil samples of different vegetation were analysed for various physico-chemical properties of the soil, soil-micro organisms and nutrients of leaf litter, following standard laboratory procedure.

In this study, the species richness, density, basal area and bio-volume among different habitat types such as *Acacia*, *Casuarina*, and mixed vegetation were statistically analysed by ANOVA. The relationship between density of adult woody trees, density of native juveniles, and saplings were analyzed by the model of multiple linear regressions among different habitat types were tested. In addition, the relationship between soil characteristics, soil micro-organisms, leaf litter decomposition and habitat types, phytodiversity were analyzed by Principal Component Analysis (PCA). All the statistical analysis were performed by the software SPSS version 16 and Past version 3.1.

As a result a total number of 236 plants species from 189 genera and 68 families were recorded. It includes 64 dicotyledons and 4 monocotyledons. There were 77 herbs, 42 shrubs, 76 trees and 41 climbers. The dominant families were Fabaceae (26 spp.), Euphorbiaceae (16 spp.), Rubiaceae (15 spp.), Mimosaceae (14 spp.), Acanthaceae (12 spp) and Caesalpinaceae (12 spp). The *Acacia* vegetation had 273 adults individuals, 642 juvenile, 1313 sapling and 9667 seedling. The *Casuarina* vegetation had 100 adults, 175 juvenile, 406 saplings and 3970 seedlings. Similarly from mixed vegetation there were 348 adults, 780 juvenile, 2744 sapling and 1 1538 seedlings.

The highest number of regenerated woody species was recorded in mixed vegetation (61) followed by *Casuarina* (18) and *Acacia* (17). Native species were more in mixed vegetation (50 native, 11exotic) when compared to *Acacia* (9 and 8) and *Casuarina* vegetations (9 each). There were 238 and 110 individuals of native and exotic species respectively. The high number of individuals among native was recorded in *Syzygium cumini* (25), among exotics it was in *Acacia auriculiformis* (58). The total number of regenerated species of herbs under *Acacia* vegetation was 26 that include 23 native and 3 exotic. The native and exotic species under *Acacia* vegetation included 2549 and 83 individuals respectively. In *Casuarina* vegetation it was 18 that include 15 native and 3 exotic. There were 207 and 62 individuals from native and exotic species respectively. Under mixed vegetation it was 74 that includes 62 native and 12 exotic.

The study reveals that species richness, density, basal area and bio-volume of adult and juveniles were found to be higher in mixed vegetation when compared to *Acacia* and *Casuarina* vegetations. In addition, species diversity of different life-stages was also relatively high in mixed vegetation than the others studied. Among the life-stages, seedlings and saplings were significantly higher in the under storey of different vegetations that confirms natural regeneration promote species turnover and hence increase floristic diversity and species composition. Moreover, the species turnover was relatively high under different vegetations that may increase species similarity composition between vegetation types.

Nevertheless the high number of native species is accumulated in terms of adult, juvenile, saplings and seedlings in all vegetation types. Many studies reported that exotic plantation embrace native regeneration by the influence of canopy characteristics and pioneer species. In this study, pioneer species are mostly native plants such as *Dodonea angustifolia, Benkara malabarica, Pterospermum suberifolium, Randia dumetorum* under mixed vegetation. In *Acacia* vegetation, *Morinda coreia* and *Hardwickia binata* and in *Casuarina* vegetation, native plants like *Memeyclon umbelatum, Ziziphus oenoplia, Azadirachta indica, Carrisa spinarum, Atalantia monophylla* were highly colonized. Of these, *Dodonea angustifolia, Benkara malabarica, Randia dumetorum, Azadirachta indicia* and *Ziziphus oenophila* are highly light tolerant species followed by shade tolerant *Memeyclon umbelatum, Hardwickia binata , Pterospermum suberifolium.* These light tolerant species might be recruited by natural dispersers, but shade tolerant species were highly influenced by planted native species through seed dispersal in this restored site. Therefore, the study clearly shows that exotic and mixed vegetation types enhance native plant diversity and regeneration by natural seed dispersal and the effect of native adult individuals.

Only few average vegetation parameters differed significantly among different vegetation such as adult species richness, sapling richness and adult basal area. However other parameters did not show any significant differences between different vegetations thus suggests the structure of life-stages were similar between vegetation types. Nevertheless, life-stage parameters such as species richness, density, basal area and bio-volume varied slightly between vegetations. Hence, the restoration process resulted in the good performance of introduced trees and the subsequent native plant regeneration which might be possibly due to facilitation of soil moisture, shade tolerannce and light demanding after seed dispersal. The study also showed the evidence of significant positive relationship existed between adult species richness and richness of juveniles, saplings and seedlings. It determines that the juveniles were highly dependent on adult and thus may indicate young plant was positively influenced by adult individuals. Therefore, adult plants may play a significant role in the success of regeneration and species composition under different vegetations.

Interestingly, the vegetation types were significantly related to soil physicochemical properties, soil microbes and nutrients of leaf litter decomposition. This study for the first time recorded greater diversity of microbial communities which established association with the plants and enhanced the soil health and wealth that resulted in establishment and diversity of plants. The present study also reported for the first time large turnover of essential elements through leaf litter decomposition by soil microorganisms. The cumulative effect of these processes helped the introduced species to establish themselves and enriched the eco-restored site.

To conclude, plant species diversity of different life-stages was positively influenced by different vegetations. In particular, mixed vegetation played a potential role to increase plant productivity by increasing soil fertility, microbial activity and nutrients of leaf litter decomposition. However, *Acacia* and *Casuarina* also played significant role in plant diversity and regeneration positively. Moreover, the regeneration process of different life-stages was influenced by natural seed dispersal mechanisms.

The study clearly shows that soil microbes, soil physicochemical properties and leaf litter decomposition played significant role in plant diversity and regeneration of species. The increase in growth and mean bio-volume of adult and juvenile individuals of different species in mixed vegetation may also be attributed to the enhanced nutrients and organic matter added to the soil by leaf litter fall. Overall the study concludes that the long term restoration effort is fruitful in converting the denuded landscape into a TDEF patch of diversified plant species that may further play a significant role for vegetation dynamics.

Further, long time research is required to monitor the plant growth success by the effect of climate change and disturbance which may be helpful for native forest management over space and time.

CHAPTER-7

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Appendix-1. Table 1 .The Family, Binomial, Vernacular Names, Life forms and Number of individuals of *Acacia*, *Casurina*, Mixed vegetations.

Family Names	**Binomial Names**	**Vernacular names**	**Life form**	***Acacia***	***Casurina***	**Mixed**	Grand Total
Acanthaceae	*Andrographis alata* (M.Vahl) Nees	Periya nangai	H	-	-	3	3
Acanthaceae	*Asystasia gangetica* (L) T. Anderson	—	H	3	-	165	168
Acanthaceae	*Barleria prionitis* L.	Kodippachalai	H	-	2	28	30
Acanthaceae	*Blepharis maderaspatensis* (L.) Heyne ex Roth	—	H	8	-	78	86
Acanthaceae	*Blepharis molluginifolia* Pers.	—	H	7	-	-	7
Acanthaceae	*Dipteracanthus patulus* (Jacq.) Nees	Pottakanchi	H	-	12	138	150
Acanthaceae	*Dyschoriste depresa* (L.)Nees	—	H	-	-	2	2
Acanthaceae	*Ecbolium viridae* (Forssk.) Alston	Nilaambari	H	-	-	15	15
Acanthaceae	*Justicia procumbens* L.	—	H	-	19	90	109
Acanthaceae	*Justicia prostrata* (C.B. Clarke) Gamble	—	H	40	-	62	102
Acanthaceae	*Lepidagathis cristata* Willd.	Karappanpoondu	H	525	49	79	653
Acanthaceae	*Stenosiphonium parviflorum* T. Anderson	—	SH	-	-	12	12
Agavaceae	*Agave sisalana* Perrine	—	SH	-	-	7	7
Agavaceae	*Sansevieria roxburghiana* Shultes & Schultes f.	Murvam	H	1	-	139	140
Amaranthaceae	*Achyranthes aspera* L.	Nayurivi	H	8	-	40	48
Amaranthaceae	*Allmania nodiflora* (L.) R.Br.	Vannikirai	H	3	-	4	7
Amaranthaceae	*Alternanthera ficoidea* (L.) Sm.	—	H	-	-	4	4
Amaranthaceae	*Amaranthus spinosus* L.	Mullukkirai	H	-	-	1	1
Amaranthaceae	*Celosia argentea* L.	Makilikirai	H	-	-	8	8
Amaranthaceae	*Psilotrichum nudum* (Wallich) Moq.	—	H	-	-	6	6
Anacardiaceae	*Anacardium occidentale* L.	Mundiri	T	3	-	1	4
Anacardiaceae	*Buchanania axillaries* (Desr.) T.P.Ramamoorthy	Mundamah	T	-	-	3	3
Anacardiaceae	*Lannea coromandelica* (Houtt.) Merr.	Anikkarai	T	1	2	11	14

Anacardiaceae	*Mangifera indica* L.	Mamaram	T	-	-	1	1
Anacardiaceae	*Semecarpus anacardium* L.f.	Shenkottai	T	-	-	5	5
Annonaceae	*Annona squamosa* L.	Sita	T	-	-	2	2
Annonaceae	*Polyalthia longifolia* (Sonn.) Thwaites	Nettilingam	T	-	-	5	5
Apocynaceae	*Carrisa spinarum* L.	Chirukila	SH	144	92	504	740
Apocynaceae	*Ichnocarpus frutescens* (L.) R.Br.	Udagodi	C	12	1	5	18
Apocynaceae	*Plumeria rubra* L.	Malaiarali	T	-	-	5	5
Apocynaceae	*Rauvolfia tetraphylla* L.	Pampukalaachchedi	SH	-	-	1	1
Arecaceae	*Borassus flabellifer* L.	Panaimaram	T	14	4	14	18
Arecaceae	*Phoneix pusilla* Kunth	Eachimaram	SH	229	44	270	314
Aristolochiaceae	*Aristolochia indica* L.	Karudakkodi	C	1	1	3	4
Asclepiadaceae	*Gymnema sylvestre* (Retz.) R.Br.ex Roemer & Schultes	Shirukuinja	C	-	14	10	24
Asclepiadaceae	*Hemidesmus indicus* (L.) R.Br.	Nannari	C	112	60	236	296
Asclepiadaceae	*Pentatropis capensis* (L.f.) Bullock.	Uppili	C	-	-	1	1
Asclepiadaceae	*Pergularia daemia* (Forsskal) Chiov.	Velipparuthi	C	-	-	1	1
Asclepiadaceae	*Sarcostemma intermedium* Decne.	Kodikhalli	C	21	-	5	5
Asclepiadaceae	*Wattakaka volubilis* (L.f.) Stapf	Kodippalai	C	1	1	1	2
Asparagaceae	*Asparagus racemous* Willd.	Thannervittan kizhangu	C	-	-	1	1
Asteraceae	*Ageratum conyzoides* L.	Pumppillu	H	16	15	22	37
Asteraceae	*Vernonia cinerea* (L.) Less.	Mukuttipundu	H	-	11	134	145
Bignoniaceae	*Dolichandrone falcata* (DC.) Seemann	Kattuvarsana	T	-	-	4	4
Boraginaceae	*Carmona retusa* (M. Vhal) Masam	Kurangu vethilai	SH	7	5	45	57
Boraginaceae	*Ehretia pubescens* Benth.	Adalai	T	1	-	-	1
Caesalpiniaceae	*Bauhinia racemosa* Lam.	Atti	T	-	-	6	6
Caesalpiniaceae	*Bauhinia tomentosa* L.			-	-	2	2
Caesalpiniaceae	*Caesalpinia coriaria* (Jacq.) Willd.	Inkimaram	T	2	-	44	46
Caesalpiniaceae	*Cassia auriculata* L.	Avaram	SH	8	-	-	8
Caesalpiniaceae	*Cassia biflora* L.	–	SH	-	-	2	2

Caesalpiniaceae	*Cassia javanica* L.	—	T	-	-	1	1
Caesalpiniaceae	*Cassia mimosoides* L.	—	H	-	-	9	9
Caesalpiniaceae	*Cassia siamea* Lam.	Manjakonnai	T	10	28	-	38
Caesalpiniaceae	*Cassia tora* L.	Tagarai	H	-	-	5	5
Caesalpiniaceae	*Delonix regia* (Hook.) Raf.	Mayilkonrai	T	-	-	1	1
Caesalpiniaceae	*Hardwickia binata* Roxb	Acha	T	2	-	2	2
Caesalpiniaceae	*Peltophorum pterocarpum* (DC.) Backer ex K. Heyne	Ivalvagai	T	-	4	-	4
Capparidaceae	*Cadaba fruiticosa* (L.) Druce	Vezhuthi	SH	-	-	6	6
Capparidaceae	*Capparis brevispina* DC.	—	SH	12	20	70	102
Capparidaceae	*Capparis sepiaria* L.	Sength thari	SH	-	-	2	2
Capparidaceae	*Capparis zeylanica* L.	Aathandai	C	-	-	2	2
Caryophyllaceae	*Polycarpaea corymbosa* (L.) Lam.	Nilaisedachi	H	-	-	3	3
Casuarinaceae	*Casuarina equisetifolia* Forster & Forster f.	Chavuku	T	1	55	4	60
Casuarinaceae	*Casuarina junghuhniana* Miq.	—	T	14	52	11	77
Celastraceae	*Cassine glauca* (Rottb.)	Karuvali	T	-	-	2	2
Celastraceae	*Maytenus emarginata* (Willd.) Ding Hou	—	SH	16	1	55	72
Cleomaceae	*Cleome aspera* J. Koenig ex DC.	—	H	-	-	3	3
Cleomaceae	*Cleome viscosa* L.	—	H	-	-	2	2
Clusiaceae	*Garcinia spicata* Hook.f.	Kokottai	T	-	-	9	9
Comberetaceae	*Terminalia arjuna* (DC.) Wight & Arn	Vellamaruthu	T	1	-	2	3
Comberetaceae	*Terminalia cattapa* L.	Natuvadham	T	-	-	1	1
Commelinaceae	*Commelina benghalensis* L.	Kanavazhai	H	-	-	253	253
Commelinaceae	*Cyanotis tuberosa* (Roxb.) Schultes & Schultes f.	—	H	-	-	79	79
Convolvulaceae	*Evolvulus alsinoides* (L.) L.	Vishnukarandi	H	73	-	133	206
Convolvulaceae	*Merremia tridentata* (L.) Hallier f.	—	C	11	4	67	82
Convolvulaceae	*Ipomoea carnea* Jacq.ssp.fistulosa (Choisy) D. Austin	—	SH	-	-	1	1
Convolvulaceae	*Ipomoea sepiaria* J. Koenig ex Roxb.	Talikkirai	C	8	-	-	8
Cordiaceae	*Cordia dichotoma* G.Forst	—	T	-	-	3	3

Crassulaceae	*Kalanchoe pinnata* (Lam.) Pers.	Runakalli	H	-	-	1	1
Cucurbitaceae	*Coccinia indica* Wight & Arn.	Kovai	C	-	-	2	2
Cucurbitaceae	*Cucumis melo* L.	Sukkangkai	C	-	-	1	1
Cucurbitaceae	*Diplocyclos palmatus* (L.) C. Jeffrey	Sirumpalai	C	-	4	10	14
Cucurbitaceae	*Kedrostis foetidissima* (Jacq.) Cogn.	–	C	-	-	10	10
Cucurbitaceae	*Mukia maderaspatana* (L.) M. Roemer	Musumusukkai	C	-	-	3	3
Ebenaceae	*Diospyros ferrea* (Willd.) Bakh.	Iramballi	SH	68	34	231	333
Euphorbiaceae	*Breynia retusa* (Dennst.) Alston	–	SH	9	4	38	51
Euphorbiaceae	*Breynia vitis-idaea* (Burm.f.) C. Fischer	Kattuniruri	SH	3	1	23	27
Euphorbiaceae	*Bridelia retusa* (L.) Sprengel	Mullu-vengai	T	-	1	5	6
Euphorbiaceae	*Croton bonplaindonus* Baillon	Reilpoondu	H	-	-	6	6
Euphorbiaceae	*Drypetes sepiaria* (Wight & Arn.) Pax & Hoffm.	Virai	T	-	-	3	3
Euphorbiaceae	*Euphorbia cyathophora* Murray	–	H	-	-	6	6
Euphorbiaceae	*Fleuggea leucopyrus* Willd.	Vellaipoola	SH	29	13	94	107
Euphorbiaceae	*Jatropha gossypiifolia* L.	Adalai	SH	-	-	1	1
Euphorbiaceae	*Mallotus philippensis* (Lam.) Muell. Arg.	Kapli	SH	-	6	106	112
Euphorbiaceae	*Phyllanthus debilis* Klein ex Willd.	–	H	-	-	81	81
Euphorbiaceae	*Phyllanthus urinaria* L.	–	H	-	-	6	6
Euphorbiaceae	*Phyllanthus madrespatensis* L.	Melanelli	H	12	14	-	26
Euphorbiaceae	*Phyllanthus polyphyllus* Willd.	Sirunelli	T	11	-	104	115
Euphorbiaceae	*Sebastiania chamaelea* (L.) Muell. Arg	–	H	65	46	775	886
Euphorbiaceae	*Suregada angustifolia* (Muell. Arg).	Kakaipalai	SH	22	14	214	250
Euphorbiaceae	*Tragia involucrata* L.	Cendthati	C	-	21	-	21
Fabaceae	*Abrus precatorious* L.	Kundumani	C	2	-	132	134
Fabaceae	*Aeschynomene indica* L.	Nettithakkai	H	-	-	2	2
Fabaceae	*Alysicarpus monilifer* (L.) DC.	Kasukodi	H	-	-	25	25
Fabaceae	*Atylosia scarabaeoides* (L.) Benth.	–	C	-	13	4	17
Fabaceae	*Butea monosperma* (Lam.) Taubert	Porasu	T	-	-	1	1

Fabaceae	*Canavalia virosa* (Roxb.) Wight & Arn.	Kattu kozhiavarai	C	-	-	1	1
Fabaceae	*Crotalaria nana* Burm.f.	–	H	49	-	30	79
Fabaceae	*Crotalaria medicaginea* Lam	–	H	1000	16	756	1772
Fabaceae	*Crotolaria montana* Roth	–	H	-	-	17	17
Fabaceae	*Dalbergia latifolia* Roxb.			2	-	3	5
Fabaceae	*Dalbergia paniculata* Roxb.	Arivaagai	T	3	-	19	22
Fabaceae	*Derris ovalifolia* (Wight & Arn.) Benth.	–	C	73	7	82	162
Fabaceae	*Derris scandens* (Roxb.) Benth	Thirundankodi	C	-	-	1	1
Fabaceae	*Desmodium triflorum* (L.) DC	–	H	-	20	12	32
Fabaceae	*Galactia tenuiflora* (Willd.) Wight & Arn.	–	C	24	-	67	91
Fabaceae	*Gliricidia sepium* (Jacq.) Kunth ex Walp.	Vivasaiyathagrai	T	1	3	9	13
Fabaceae	*Indigofera aspalathoides* Vahl ex DC.	Sivanrvempu	H	51	-	546	597
Fabaceae	*Indigofera astragalina* DC.	–	H	-	-	4	4
Fabaceae	*Indigofera trifoliata* L.	–	H	-	-	2	2
Fabaceae	*Indigofera trita* L.f.	–	H	-	-	1	1
Fabaceae	*Pongamia pinnata* (L.) Pierre	Pongan	T	1	-	-	1
Fabaceae	*Pseudarthria viscida* (L) Wight & Arn	Pitani	H	-	3	4	7
Fabaceae	*Pterocarpus santalinus* L.f.	Cencantham	T	1	13	3	17
Fabaceae	*Rhynchosia minima* (L.) DC.	–	C	79	69	173	321
Fabaceae	*Stylosanthes fruticosa (*Retz.) Alston	–	H	42	-	48	90
Fabaceae	*Tephrosia maxima* (L.) Pers.	–	H	20	-	61	81
Flacourtiaceae	*Flacourtia indica* (Burm.f.) Merr.	Katukalai	SH	18	21	50	89
Gentianaceae	*Enicostema axillare* (Lam.) A. Raynal	Vellaragu	H	2	-	-	2
Hernandiaceae	*Gyrocarpus americanus* Jacq.	Karamanikkay	T	-	-	1	1
Hippocrateaceae	*Reissantia indica* (Willd.) Hall'e	Odankodi	C	1	4	4	9
Lamiaceae	*Hyptis suaveolens* (L.) Poit.	–	H	-	-	5	5
Lamiaceae	*Leucas aspera* (Willd.) Link	Thumbai	H	-	-	2	2
Lamiaceae	*Ocimum canum* Sims	Naai alangi	H	-	-	1	1

Lamiaceae	*Orthosiphon thymiflorus* (Roth) Sleesen	–	H	-	-	11	11
Lamiaceae	*Scutalaria violacea* Heyne ex Benth.	–	H	-	-	4	4
Lauraceae	*Cassytha filiformis* L.	Erumaikkottan	C	3	-	3	6
Linaceae	*Hugonia mystax* L.	Motirakanni	C	50	34	174	258
Loganiaceae	*Strychnos minor* Benth	–	C	2	-	82	82
Loganiaceae	*Strychnos nux-vomica* L.	Yetti	T	-	-	1	1
Malvaceae	*Sida acuta* Burm.f.	Ariva-mooku keerai	H	-	-	15	15
Malvaceae	*Sida cordata* (Burm.f.) Borssum Waalkes	Palampasi	H	-	-	4	4
Malvaceae	*Sida rhombifolia* L.	Chitr mutti	H	-	-	6	6
Malvaceae	*Pavonia zeylanica* (L.) Cav.	Mammatti	H	-	1	1	2
Melastomataceae	*Memeyclon edule* Roxb.	Kaya	T	92	45	312	449
Melastomataceae	*Memeyclon umbelatum* Burm.f.	Alamaram	SH	75	82	175	332
Meliaceae	*Azadirachta indica* Adr.Juss.	Vepa	T	104	50	316	470
Meliaceae	*Khaya senegalensis* (Desv.) A.Juss	Sivandhdenai	T	-	-	1	1
Meliaceae	*Walsura trifoliata* (Adr. Juss.) Harms	Walsura	T	-	-	1	1
Menispermaceae	*Cissampelos pareira* L. var. hirsuta (DC.) Forman	Appatta	C	-	5	20	25
Menispermaceae	*Cocculus hirsutus* (L.) Diels	Kattukodi	C	1	1	4	6
Menispermaceae	*Pachygone ovata* (Poiret) Hook.f. & Thomson	Kadukkodi	C	-	13	1	14
Menispermaceae	*Tinospora cordifolia* (Willd.) Hook.f. & Thomson	Chindilkodi	C	-	-	10	10
Mimosaceae	*Acacia auriculiformis* A. Cum. ex Benth.	Pencilmaram	T	1791	158	1193	3142
Mimosaceae	*Acacia ampliceps* Maslin	–	T		-	1	1
Mimosaceae	*Acacia colei* Maslin & L.A.J. Thomson	–	T	531	315	146	992
Mimosaceae	*Acacia chundra* (Rottler) Willd.	Karungkali	T	14	27	49	90
Mimosaceae	*Acacia holosericea* A.cum	–	SH	5609	1811	3464	10884
Mimosaceae	*Acacia leucophloea* (Roxb.) Willd.	Velvelam	T	3	21	10	34
Mimosaceae	*Acacia mangium* Willd	–	T	126	17	7	150
Mimosaceae	*Acacia mellifera* (M.Vahl) Benth	–	SH	1	-	1	1
Mimosaceae	*Acacia tumida* Benth	–	T	51	-	13	64

Mimosaceae	*Adenanthera pavonina* L.	Anai kundumani	T	-	-	1	1
Mimosaceae	*Albizia lebbeck* (L.) Benth.	Vagai	T	-	-	10	10
Mimosaceae	*Dichrostachys cinerea* (L.) Wight & Arn.	Vidathalan	SH	4	3	57	64
Mimosaceae	*Leucaena leucocephala* (Lam.) de Wit	Nattukavanthal	T	9	2	250	261
Mimosaceae	*Pithecellobium dulce* (Roxb.) Benth.	Kodukapuli	T	-	-	1	1
Molluginaceae	*Mollugo disticha* Ser.	—	H	-	-	381	381
Molluginaceae	*Mollugo pentaphylla* L.	Seragapoondu	H	-	-	1818	1818
Moraceae	*Ficus benghalensis* L.	Aalamaram	T	1	-	2	3
Myrtaceae	*Eucalyptus citriodora* Hook.	—	T	2	6	5	13
Myrtaceae	*Syzygium cumini* (L.) Skeels	Naaval	T	1	-	28	29
Nyctaginaceae	*Boerhavia diffusa* L.	Mukkuratti	H	-	-	44	44
Ochnaceae	*Ochna obtusata* DC.	Padalakkonai	SH	5	10	55	70
Olacaceae	*Ximenia americana* L.	Chiru-illanthi	SH	-	-	32	32
Oleaceae	*Jasminum angustifolium* (L.) Willd.	Kaattumalligai	C	717	669	1731	3117
Oleaceae	*Jasminum angustifolium var. sessiliflorum* (Vahl) P.S. Green	Kuruvilaangkodi	C	-	-	2	2
Orchidaceae	*Eulophia epidendraea* (Retz.) C. Fischer	—	H	6	3	2	11
Passifloraceae	*Passiflora foetida* L.	Siruppunaikkali	C	3	7	14	24
Pedaliaceae	*Martynia annua* (Houstonun in Martyn) L.	Thelkodukukai	H	-	-	1	1
Plumbaginaceae	*Plumbago zeylanica* L.	Chitramulam	H	-	-	1	1
Poaceae	*Bambusa arundinacea* Willd.	Mungil	T	16	-	12	28
Polygalaceae	*Polygala arvensis* Willd.	—	H	185	15	82	282
Rhamnaceae	*Scutia myrtina* (Burm.f.) Kurz	Kokimullu	SH	5	4	9	18
Rhamnaceae	*Ventilago maderaspatana* Gaertner	Vempadam	C	-	18	7	25
Rhamnaceae	*Ziziphus oenoplia* (L.) Miller	Suraimullu	C	107	107	300	514
Rhamnaceae	*Ziziphus xylopyrus* (Retz.) Willd.	Kotteilandai	T	1	-	24	25
Rubiaceae	*Benkara malabarica* (Lam.) Triv.	Pudan	SH	475	104	749	1328
Rubiaceae	*Borreria hispida* (L). Schumann	Nathaichuri	H	-	-	200	200
Rubiaceae	*Borreria ocymoides* (Burn.f.) DC			-	-	84	84

Rubiaceae	*Canthium coromandelicum* (Burm.f.) Alston	Theranai	SH	15	11	53	79
Rubiaceae	*Ixora finlaysoniana* Wallich ex Don	—	SH	-	-	1	1
Rubiaceae	*Ixora pavetta* Andrews	Sulundu korai	T	181	110	364	655
Rubiaceae	*Mitrangyna parvifolia* (Roxb.) Korth.	Neerkadambai	T	-	-	1	1
Rubiaceae	*Morinda coreia* Buch.-Ham.	Nuna	T	14	3	23	40
Rubiaceae	*Morinda pubescens* J. E. Smith	Nuna	T	10	13	36	59
Rubiaceae	*Oldenlandia herbacea* (L.) Roxb.	Kattu kothammali	H	277	-	240	517
Rubiaceae	*Oldenlandia umbellata* L.	Saiver	H	-	-	83	83
Rubiaceae	*Pavetta indica* L.	Pavatai	SH	-	-	1	1
Rubiaceae	*Psilanthus wightianus* (Wight & Arn.) J. Leroy	Veadan	SH	1	-	8	9
Rubiaceae	*Randia dumetorum* (Retz.) Poiret	Madukkarai	SH	157	57	652	866
Rubiaceae	*Tarenna asiatica* (L.) Kuntze ex Schumann	Kura	SH	60	31	44	135
Rutaceae	*Aegle marmelos* (L.) Corr. Serr.	Vilvam	T	1	-	-	1
Rutaceae	*Atalantia monophylla* (L.) Corr. Serr.	Kattunarangm	T	12	196	94	302
Rutaceae	*Clausena dentate* (Willd.) Roemer	Kattu karivepplai	SH	4	5	6	15
Rutaceae	*Chloroxylon swietienia* DC.	Vammarai	T	-	-	1	1
Rutaceae	*Glycosmis mauritiana* (Lamk.) Yuich.Tanaka	Kongi	SH	-	-	2	2
Rutaceae	*Limonia acidissima* L.	Vilang	T	-	-	1	1
Rutaceae	*Narangi crenulata* (Roxb.) Nicolson	Naai valathi	T	-	-	1	1
Rutaceae	*Toddalia asiatica* (L.) Lam. var. floribunda Gamble	Kindumullu	SH	12	18	70	100
Santalaceae	*Santalum album* L.	Sandanam	T	-	-	1	1
Sapindaceae	*Allophylus serratus* (Roxb.) Kurz	Amalai	SH	-	18	111	129
Sapindaceae	*Dodonea angustifolia* L.f.	Virali	SH	695	109	734	1538
Sapindaceae	*Lepisanthes tetraphylla* (Poiret) Leenh	Kugamathi	T	-	2	3	5
Sapindaceae	*Sapindus emargiata* M.Vahl	Pounanga	T	-	-	1	1
Sapotaceae	*Manilkara hexandra* (Roxb.) Dubard	Ulagai ppallai	T	1	-	3	4
Sapotaceae	*Mimusops elengi* L.	Magizamaram	T	6	-	1	7
Scrophulariaceae	*Striga angustifolia* (D.Don) C.J.Saldanha	—	H	-	-	6	6

Sterculiaceae	*Helicteres isora* L.	Valamburi	T	2	-	-	2
Sterculiaceae	*Hildegardia populifolia* (Roxb.) Schott & Endrl.	Malaipooarusu	T	-	-	3	3
Sterculiaceae	*Guazuma ulmifolia* Lam.	Kattu Rudrasam	T	-	-	1	1
Sterculiaceae	*Kleinhovia hospita* L.	Panaitteku	T	-	-	1	1
Sterculiaceae	*Melochia corchorifolia* L.	Pinnakkuppundu	H	2	1	9	12
Sterculiaceae	*Pterospermum suberifolium* Lam.	Polavu	T	-	-	791	791
Sterculiaceae	*Waltheria indica* L.	Shembudu	H	199	3	343	545
Tiliaceae	*Corchorus aestuanus* L.	Poonakukerai	H	-	-	2	2
Tiliaceae	*Grewia rhamnifolia* Heyne ex Roth	—	C	-	-	1	1
Tiliaceae	*Triumfetta rotundifolia* Lam.	Adaiyoti	H	1	2	2	5
Turneraceae	*Turnera ulmifolia* L.	—	H	-	-	3	3
Verbenaceae	*Lantana camara* L.	Unnichedi	SH	11	5	94	110
Verbenaceae	*Gmelina asiatica* L.	Nilakkumil	SH	3	-	27	30
Verbenaceae	*Stachytarpheta jamaicensis* (L.) Vahl	Semainaiuruvi	H	-	-	5	5
Vitaceae	*Cissus quadrangularis* L.	Perandai	C	-	2	19	21
Vitaceae	*Cissus vitiginea* L.	Katutherachi	C	6	4	144	154
Violaceae	*Hybanthus enneaspermus* (L.) F.Muell.	Orilaittamarai	H	27	37	120	184

Derris ovalifolia

Dodonea angustifolia

Diospyros ferrea

Ixora pavetta

Morinda coreia

Phoneix pusilla

Plate-1. Common species associated with *Acacia* vegetation

Acacia chundra

Atalantia monophylla

Dichrostachys cinerea

Capparis brevispina

Carmona retusa

Flacourtia indica

Plate-2. Common species associated with *Casuarina* vegetation

Acacia leucophloea

Allophylus serratus

Buchanania axillaries

Carrisa spinarum

Derris scandens

Fleuggea leucopyrus

Plate -3. Common species associated with mixed vegetation


Asystasia gangetica


Hybanthus enneaspermus


Indigofera astragalina


Justicia procumbens


Polygala arvensis


Tephrosia maxima

Plate -4. Common herbaceous species found in all vegetation

Derris ovalifolia

Eulophia epidendraea

Gymnema sylvestre

Garcinia spicata

Striga angustifolia

Ximenia americana

Plate -5. Rare and Endemic species in the study area