A COMPARISON OF GROUND FLORA DIVERSITY BETWEEN FOREST AND PLANTATIONS IN DOI SUTHEP-PUI NATIONAL PARK

LA KARIMUNA

A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN
PARTIAL FULFILLMENT OF THE REQUIREMENTS
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TROPICAL ECOSYSTEMS
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Abstract

A study to compare ground flora diversity between forest and plantations in Doi Suthep-Pui National Park was undertaken from March to December 1994.

Five study sites, viz. evergreen forest, a regenerating gap, a eucalyptus plantation and a mature and young pine plantations were selected. An extensive qualitative survey and an intensive quantitative survey were carried out. One hundred permanent quadrats (2×2 m^2) were used for intensive ground flora surveys. All plants rooted in each quadrat were identified and scored for percent cover and Domin score every month. Soil samples were also collected and analyzed for texture, % organic matter, soil moisture at field capacity, pH, nutrients, etc. at the Faculty of Agriculture, Chiang Mai University. Soil moisture content was determined every month.

The total number of species recorded in the extensive qualitative survey was higher than that in the intensive quantitative survey. In the extensive qualitative survey the number of species recorded in evergreen forest, regenerating gap, eucalyptus, mature and young pine plantations was 174, 105, 86, 102 and 138 respectively. Herbaceous plant species dominated the ground flora in all five sites for both surveys. The highest species diversity (Hill's number, N1 and N2) and Evenness (Modified Hill's ratio) occurred in the evergreen forest (55.91, 35.69 and 0.63; respectively) and the lowest was in the mature pine plantation (16.46, 6.88 and 0.38; respectively). The similarity (Sorensen's index) of mature and young pine plantations was 0.66, while between regenerating gap and mature pine plantation it was 0.46. The highest relative growth rate (RGR) of tree seedlings was 0.234 cm growth/cm of original height/year in the regenerating gap, whilst the lowest was 0.017 cm growth/cm of original height/year in the mature pine plantation. The highest percent mortality of tree seedling was 15.60% in the mature pine plantation, while the lowest was 3.27% in the forest.

Cluster analysis and ordination using percent cover and soil characteristics had more or less the same result. Cluster analysis using the average percent cover from 100 quadrats (20 quadrats of each site) clearly distinguished three main groups. The first cluster included quadrats from the mature pine plantation and regenerating gap. The second group clustered together quadrats from the eucalyptus plantation and the forest. The third group included quadrats from the mature pine site and the young pine plantation. Ordination significantly showed the differentiation amongst five sites. Mature pine and young pine were very similar, whilst the regenerating gap was similar to both the forest and eucalyptus sites.

The use of indigenous species were recommended to conserve biological diversity within Doi Suthep-Pui National Park. It can be concluded that to preserve maximum biodiversity in either pine or eucalyptus plantation, young pine trees are better than eucalyptus. To allow best regeneration of forest trees, a pine plantation can be used for the early stages of regeneration, but after that the pines should be selectively cut down to allow other tree seedlings and saplings to grow naturally.

ชื่อเรื่องวิทยานิพนธ์ การเปรียบเทียบความหลากหลายของพืชพื้นล่างระหว่างป่าและพื้นที่เพาะปลูกในบริเวณอุทยานแห่งชาติดอยสุเทพ-ปุย

ชื่อผู้เขียน นาย La Karimuna

วิทยาศาสตรมหาบัณฑิต สาขาการประเมินความเสี่ยงทางด้านสิ่งแวดล้อมในระบบนิเวศเขตร้อน

คณะกรรมการสอบวิทยานิพนธ์

ดร.สตีเฟน เอลเลียต	**ประธานกรรมการ**
นายเจมส์ เอฟ แมกซ์เวลล์	**กรรมการ**
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บทคัดย่อ

การเปรียบเทียบความหลากหลายของพืชพื้นล่างระหว่างในพื้นที่ป่ากับพื้นที่เพาะปลูกบนอุทยานแห่งชาติดอยสุเทพ-ปุย ได้ศึกษาตั้งแต่เดือนมีนาคม ถึงเดือนธันวาคม พ.ศ. 2537

การศึกษาได้เลือกพื้นที่ 5 แห่ง ได้แก่ ป่าดิบเขา พื้นที่รกร้าง สวนป่ายูคาลิปตัส สวนป่าสนเต็มวัย และสวนป่าสนวัยอ่อน แบ่งการศึกษาเป็น การสำรวจโดยสังเขป และการสำรวจอย่างละเอียด การสำรวจอย่างละเอียดทำในกรอบสี่เหลี่ยมจตุรัส (ขนาด 2 x 2 ม.^{2}) จำนวน 100 กรอบ ที่ได้จัดทำไว้อย่างถาวร พืชทุกชนิดที่ขึ้นภายในกรอบ ได้ถูกจำแนกและให้คะแนนเป็นร้อยละตามการปกคลุมดิน และให้คะแนนแบบ Domin ทุกเดือน ตัวอย่างดินได้เก็บมาวิเคราะห์ลักษณะเนื้อดิน ร้อยละของอินทรีย์วัตถุในดิน ความชื้นในดินที่ระดับความจุสนาม ความเป็นกรดและด่างของดิน ธาตุอาหารในดินและอื่น ๆ ณ คณะเกษตรศาสตร์ มหาวิทยาลัยเชียงใหม่ ขณะที่ความชื้นในดินได้มีการตรวจวัดทุกเดือน

จำนวนชนิดของพืชทั้งหมดที่พบจากการสำรวจโดยสังเขปนั้น สูงกว่าจำนวนที่พบจากการสำรวจโดยละเอียด จากการสำรวจโดยสังเขปพบว่าจำนวนชนิดของพืชที่ขึ้นในป่าดิบเขา พื้นที่รกร้างสวนป่ายูคาลิปตัส สวนป่าสนเต็มวัย และสวนป่าสนวัยอ่อน มีจำนวน 174, 105, 86, 102 และ 138 ชนิด ตามลำดับ ในบรรดาพืชพื้นล่าง พืชประเภทไม่มีเนื้อไม้พบมากที่สุดบนทุกพื้นที่ในการสำรวจทั้งสองแบบ ความหลากหลาย (Hill's number, N1 และ N2) และความสม่ำเสมอของชนิดพืช (Modified Hill's ratio) พบสูงสุดในป่าดิบเขา (55.91, 35.69 และ 0.63 ตามลำดับ) และพบต่ำสุดในพื้นที่สวนป่าสนเต็มวัย (16.46, 6.88 และ 0.38 ตามลำดับ) ความคล้ายกัน (Sorensen's Index) ของสวนป่าสนทั้งสองเท่ากับ 0.66 ในขณะที่ระหว่าง

พื้นที่รกร้างและพื้นที่สวนป่าสนเต็มวัย เท่ากับ 0.46 ส่วนอัตราการเติบโตสัมพัทธ์ของลูกไม้พบสูงสุดในพื้นที่รกร้าง ซึ่งมีค่าเท่ากับ 0.234 ซม. ของการเติบโต/ซม. ของความสูงเริ่มต้นต่อปี ในขณะที่พบต่ำสุดในพื้นที่สวนป่าสนเต็มวัย ซึ่งมีค่าเท่ากับ 0.017 ซม. ของการเติบโต/ซม. ของความสูงเริ่มต้นต่อปี อัตราการตายของลูกไม้พบสูงสุดในพื้นที่สวนป่าสนเต็มวัย เท่ากับ 15.60% และพบต่ำสุด 3.27% ในพื้นที่ป่าดิบเขา

การวิเคราะห์ข้อมูลแบบ cluster และ ordination โดยใช้เปอร์เซ็นต์การปกคลุมดินและการวิเคราะห์ดินให้ผลที่ค่อนข้างจะคล้ายกัน การวิเคราะห์แบบ cluster ซึ่งใช้ค่าเฉลี่ยของเปอร์เซ็นต์การปกคลุมดินจาก 100 กรอบ (20 กรอบจากแต่ละพื้นที่ศึกษา) แสดงให้เห็นถึงความแตกต่างระหว่าง 3 กลุ่มหลักอย่างชัดเจน กลุ่มแรกคือกลุ่มของกรอบที่มาจากพื้นที่สวนป่าสนเต็มวัยและพื้นที่รกร้างกลุ่มที่สองจากกรอบที่มาจากพื้นที่สวนป่ายูคาลิปตัสและป่าดิบเขา กลุ่มที่สามคือกรอบที่มาจากพื้นที่สวนป่าสนเต็มวัยและสวนป่าสนวัยอ่อน การวิเคราะห์แบบ ordination ได้แสดงให้เห็นถึงความแตกต่างอย่างมีนัยสำคัญระหว่างพื้นที่ศึกษาทั้ง 5 โดยพื้นที่สวนป่าสนเต็มวัยและสวนป่าสนวัยอ่อนค่อนข้างคล้ายคลึงกัน ในขณะที่พื้นที่รกร้างจะมีความคล้ายคลึงกับทั้งพื้นที่ป่าดิบเขาและพื้นที่สวนป่ายูคาลิปตัส

พันธุ์พืชพื้นเมือง มีความเหมาะสมที่จะใช้อนุรักษ์ความหลากหลายทางชีวภาพบนอุทยานแห่งชาติดอยสุเทพ-ปุย และสามารถที่จะสรุปได้ว่าการที่จะรักษาความหลากหลายทางชีวภาพสูงสุดในพื้นที่เพาะปลูก การทำสวนป่าสนจะให้ผลดีกว่าการทำสวนป่ายูคาลิปตัส และเพื่อที่จะให้การฟื้นฟูสภาพป่าเกิดขึ้นได้ดีที่สุด การปลูกสนอาจทำได้ในช่วงต้น ๆ ของการฟื้นฟู แต่หลังจากเวลาผ่านไปขณะหนึ่ง ต้นสนควรถูกเลือกตัดออกไปเป็นบางส่วน เพื่อเปิดโอกาสให้ลูกไม้และไม้หนุ่มอื่น ๆ ได้เติบโตตามธรรมชาติ

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CHAPTER 1.
INTRODUCTION

Man-made activities are the most significant factors in changing the species composition of forest ecosystems in Thailand. For a long time, natural forests in Thailand have been exploited, cleared, and have suffered man-made damage and have therefore, greatly declined in extent. This has caused a huge reduction in plant and animal species diversity and structural complexity or even loss of species in forest communities. In 1950 about 32 million ha of Thailand was forested, but by 1985 natural forest had been reduced to only 14.4 million ha; a rate of deforestation of about 1.44% per year (**Flaherty and Filipchuk**, 1993). In addition, between 1976 and 1980 Thailand's annual deforestation was 333,000 ha with the rate of deforestation at 3.61%, the second highest after Nepal (4.33%) (**Lanly,** 1982, **Dankelman and Davidson**, 1988). According to Royal Forestry Department statistics, the logging ban in 1989 brought about an 84% reduction in the rate of deforestation in Thailand (**Elliott *et al.***, 1993).

The factors contributing to deforestation in Thailand are numerous and complex. Most are due to the pressure of increasing population, expansion for resettlement, logging, shifting cultivation, firewood and charcoal-making and the demand for wood for construction. Even some well-established national parks have large deforested areas. For example, Doi Suthep-Pui National Park has lost about a third of its forest cover and Doi Inthanon nearly half (**Elliott *et al.***, 1993). In 1981, when Doi Suthep-Pui was declared a national park, 1,956 people were living within the park's boundaries. By 1988 this number had increased, mostly by immigration, to 13,694 (**Kasetsart University**, 1988). Large tracts of forest still survive on the eastern side of the mountain. In other areas, the forest is fragmented, mostly due to agricultural development and fire.

The remaining forest in the park has become fragmented into tiny patches, each of which is unable to support viable populations of large animals and birds. Gaps can be small, due to fallen trees or large, due to landslides, logging and shifting cultivation. The time, climax forest takes to return to a site depends on the severity of disturbance, size, climatic, physical and other environmental factors, including human involvement. The greater the disturbance of a climax forest, the longer it will take to recover. Climax species are slow to recolonize land that has been totally cleared unless seed trees remain. For example, one such study was conducted in east Kalimantan and it was found that it took 60 - 70 years after the formation of a large gap for the number of growth-phase species to reach a maximum, and as long again for mature-phase species to dominate and for gap formation to begin again (**Whitten**, ***et al.***, 1987). However, for primary succession, on newly formed substrates such as coastal sediments, volcanic ash and lava, it may take hundreds of years for complete development. In Papua New Guinea, it was observed the establishment of primary forest on large landslides after only 50 years. However, this was on relatively good soils.

The public is gradually becoming aware of the need to restore natural forest ecosystems within national parks for wildlife conservation, watershed protection, eco-tourism, research and education. There has been enthusiastic support for several forest restoration projects. National parks are protected areas established to maintain ecological diversity and to conserve biological diversity. However, huge areas within national parks are being converted from natural forest to plantations. The main objective of plantations is to meet the demand for firewood and timber. There are two main kinds of plantations, viz. industrial plantations, e.g. teak, eucalyptus and pines; and non-industrial plantations, e.g. indigenous species (**Lanly**, 1982). By increasing the demand for wood for industrial use, eucalyptus has become one of the most popular species planted due to its ability to grow very fast and produce large quantities of wood in a given area when grown in well-managed plantations, both within and outside its natural range. Furthermore, many eucalyptus species are able to grow on sites with very low nutrient status, especially those deficient in nitrogen and phosphorus (**FAO**, 1988).

Recently, the interest of people in Thailand toward expanding eucalyptus and pine plantations has declined and there has even been opposition to reforestation programs using these species. This is because eucalyptus trees absorb a lot of water, thus depleting the water table. Roots and leaves of eucalyptus exude toxic chemicals, such as terpenes that may inhibit the establishment of other plants or may kill other organisms. It takes a long time for eucalyptus leaves to decompose and eucalyptus provides very little shelter for human and animals (**FAO**, 1988).

Reforestation projects often involve establishing plantations of pine or eucalyptus in national parks. Such plantations do not help to maintain biological diversity and may actually reduce it which really goes against the main objectives of national parks. This is because enormous areas of plantations, usually monocultures, are not adequate replacements for the original forest, even though most species used for plantations are able to grow very fast. In addition, species for plantations usually consume a lot of water, support low species diversity, have a simple structure, have allelopathic agents (e.g. phenols, terpenes, etc.), provide poor protection against soil erosion and have a high nutrient uptake. In terms of water consumption and nutrient uptake, it is related to biomass production(e.g. wood, branches and leaves), not such much to tree species. Natural forests also consume a lot of water but may increase useful water yield by increasing dry stream-flow and reducing reservoir sedimentation. Species for plantations particularly eucalyptus utilize less water than pine, but probably more than other broadleaved trees (**FAO, 1988**).

When Doi Suthep-Pui was designated as a National Park in 1981, about 66% of the area was covered by forest and the rest by other land uses. The preliminary management plan, divided the park into five land use zones, viz. (1) intensive-use-zone: an area with no attractions and no important natural resources. Such areas could be used for tourist development; 2) outdoor recreation zone: an area acting as a buffer zone to reduce the impact of the intensive use zones. (3) primitive zone: an area with high conservation value such as watershed areas and primary forest. (4) recovery zone: an area which has been disturbed or destroyed as a result of human activities such as on the western side of the summit of Doi Pui. (5) special use zone: an area occupied by government agencies. This zone would be returned to the National Park if the government agencies stop their activities (**Chansiritanorn**, 1987). The current land use pattern in Doi Suthep-Pui National Park has changed drastically. More than 40% of Doi Suthep-Pui's forest has been converted to other land use such as resettlement, tourist development, agriculture and plantations (**Amporn**, 1994; personal communication).

It is impossible to completely prevent all further conversion of forest because of economic, social and political reasons, but if commercial interests must have plantations in national parks, at least foresters and botanists could choose the sort of plantation species which support the highest biological diversity.

Although studies of forest regeneration have been conducted in Doi Suthep-Pui National Park (**Elliott *et al.***, 1989), few studies of the ground flora have been carried out. For example, **Phuakam** (1994) carried out a recent survey of the herbaceous ground flora in deciduous forest on the eastern side of Doi Suthep-Pui National Park at elevations of 670-750 m. Seventy one species of ground flora were recorded, belonging to 24 families and 60 genera. 16 species of annual plants and 55 perennial, including 40 monocotyledons, 31 dicotyledons and 14 topotypes. Studies of the ground flora in evergreen forest have never been conducted there. Therefore, it is necessary to do research to compare the ground flora diversity between forest, regenerating gaps, and tree plantations, such as eucalyptus, young and mature pine plantations.

The aims of this research were: (1) to determine how changing land use patterns in a national park affects its capacity to conserve diversity of ground flora and (2) to compare the diversity, composition and evenness of the ground flora communities between primary forest and tree plantations of pine and eucalyptus in evergreen forest from 1275 to 1550 m elevation.

CHAPTER 2.
LITERATURE REVIEW

Forests play a very important role in the environment. They are regulators of all our basic resources (e.g. soil, water and air), besides being the ultimate determinants of economic activities and playing a vital role in keeping a high quality of the environment up to the desired level. **Sharma *et al.***, (1989) explained that forests support high species diversity and give five important "F" commodities i.e., food, fodder, fertilizer, fuel and fibre which are renewable resources and need proper management for maintaining the sustainability of the human culture. In addition, **Groombridge**, (1992) stated that forests have the very important role of regulating water flow, conditioning local climate and protecting against soil erosion. For example, in Gambia, in 1965, when there was still good forest cover, the annual precipitation was 1240 mm, but between 1982 and 1988 when the forest had almost been completely destroyed, the mean level was almost halved to 650 mm (**Jones**, 1992). There is excellent evidence that the reduction of rainfall is a consequence of forest clearance. Therefore, preservation of tropical forests is vital for conserving biodiversity (**Groombridge**, 1992).

The tropics contain about one-third of the world's forests, including many fragile ecosystems, which are the planet's largest reservoirs of generate resources. They protect watersheds, regulate water resources and are the major source of timber and fuel-wood, as well as various foods, drugs, oils, waxes, fibers and other products which are important for local use as weed as international trade (**UNEP**, 1989). Forests support a very high biological diversity. A study conducted by **Whitten *et al.***, (1984) found that the diversity of tree species in Sumatran lowland forest is extremely high. In the valley area around the Ranum River in north Sumatra, Simpson's index of diversity for trees of 15 cm diameter and over at breast height was 0.96, and in the neighboring hill it was 0.93; whilst in a hill forest on Bangka Island (Indonesia) investigated by a CRES (Centre for Resource and Environmental Studies) team, the index of diversity was 0.94 (**Whitten *et al.***, 1984). In addition **Riswan** (1981) found that in heath forest in east Kalimantan, 454-750 trees of 10 cm diameter at breast height and over were found per ha.

However, nowadays tropical forests have become an international issue especially in relation to logging, shifting cultivation, forest fires, etc. Tropical forests are being destroyed and degraded at an accelerating rate. Some 11 million ha of natural tropical forest are cleared yearly 10 times the rate of reforestation. Forests are cut to make room for shifting cultivation by landless farmers, to provide land for what is claimed to be permanent agriculture, including cattle ranching, and to provide fuel and timber. It is estimated that tropical forests are being felled at the rate of 34 hectares a minute and that by the year 2000 two-fifths of the developing world's remaining forests and thousands of species will have disappeared (**UNEP**, 1989).

Between 1965 and 1975 the percentage forest cover in Thailand dropped from 55 to 38 percent (**Evans**, 1983). The area of deforested land in Chiang Mai Province doubled in the 10 years of 1975-1985 from 323,458 ha to 651,302 ha (**Grid**, 1988). FAO reports have also indicated that in Thailand there has been an increase in the rate of deforestation over the past decade with an annual rate of loss. 2.4 % has been estimated that around 204,000 km^2 of forest types are being lost annually (**Groombridge**, 1992).

The impact of destruction of Thailand's forest have brought about a variety of environmental problems, such as loss of forest cover, increased runoff and erosion and loss of many wildlife species (**Bhumibhamon**, 1986; **Parnwell**, 1988). In addition, plant extinctions result from many underlying forces, such as economics, politics, and psychology. The specific activities that cause extinction and the relative importance of each are habitat alteration, introduction of alien species and pest and predator control (**Chiras**, 1991).

Succession may be defined as an orderly process of plant community development in which one community is replaced by another in a relatively predictable fashion, culminating in a stable ecosystem where maximum biomass is supported in proportion to the energy flow per unit of area. Species diversity tends to increase with succession (**Sharma *et al.***, 1989). Recent studies indicate that the time taken for achieving the climax growth in primary succession is at least nearly 1000 years whereas secondary succession on deforested land or abandoned agricultural land proceeds rapidly, but still needs at least 200 years for the development of mature secondary forests.

The impact of land use now strongly outweighs that of climate as a vegetation determinant (**Hodgson**, 1986). Natural selection has established an equilibrium between climate and the genetic resources of each region. Vegetation is prevented from attaining such equilibrium by natural disturbances (e.g. volcanic eruptions, floods, etc.) and by human intervention. In many areas of intensive exploitation, the natural vegetation dominants are now confined to local refuges or have been eliminated completely (**Solomon and Shugart**, 1993).

Trees can also alter the local environment with respect to the nature of throughfall, soil moisture, soil nutrient availability and a myriad of other factors. **Shugart** (1987) treats the question of tree/environment interactions by considering the minimal categories of gap competition in trees. The different roles of trees with respect to gap colonization produces essentially different biomass and numbers of individuals when monospecies plots are simulated at small partial scales (ca. 0.1 ha).

Competition for occupancy of canopy gaps is important in understanding the dynamics of natural forests. Trees attain sufficient size to alter their own micro-environment and that of subordinate trees. The species, shapes and sizes of trees in a forest can have a direct influence on the local forest environment. The environment, in turn, has a profound influence on the performance of different species, shapes and sizes of trees. Thus, there can be a feedback from the canopy tree to the local microenvironment and subsequently to the seedling and sapling regeneration that may result in a future canopy (**Solomon and Shugart**, 1993).

Replanting trees, protecting forest against fire, designating forest reserves, providing irrigation, etc. are some of the ways to solve the problems of deforestation. A quick solution to the problem of deforestation has been the rapid establishment of small and large-scale eucalyptus and pine plantations. Although such plantation trees grow very quickly, they have proved to be socially unacceptable in areas where villagers rely on native forests for products such as bamboo shoots, mushrooms, medical plants etc. which do not grow in monocultures of exotic tree species (**Elliott *et al.***, 1989).

The ground flora of eucalyptus plantations contain less biomass and fewer plant species than in natural forest, despite a high light level beneath the canopy (**Del Moral and Muller**, 1970). This may be due to an inability of native plants to compete with eucalyptus trees for water and nutrients or because of the production of chemicals by eucalyptus tree which inhibit growth of other plants. **De Candolle** (1832) suspected that plants release toxic materials into soil and that these last long enough to necessitate the rotation of crops. From the beginning of this century evidence has accumulated that plants may, directly or indirectly, harm each other through release of chemicals to the environment, the phenomenon of allelopathy (**Rice**, 1979).

The increased use of the three-needle pine (*Pinus kesiya* Roy. ex Gord., Pinaceae) and two-needle pine (*Pinus merkusii* Jungh. & De Vriese, Pinaceae) for plantation establishment in the northern and northeastern regions of Thailand has led to growing interest in tree improvement programs for those species. The Thai Government has encouraged the participation of various institutions or funding agencies to promote plantations. In 1968 it was decided to start improvement work of these two local pine species and exotic conifers as well as fast-growing broad-leaved trees. The leading project to implement this program was the Thai-Danish Pine Project which concentrated on pine and eucalyptus plantations (**Kingmuangkau and Granhof**, 1983). A total area of reforestation of 48,000 ha per year has been implemented (**Petmak**, 1993). The total area of plantations amounting to 442,360 ha in 1982 was reported for the whole country while deforested areas amounting to 14.4 million ha. The tree species planted included indigenous species besides teak (*Tectona grandis* L. f.,Verbenaceae) such as *Dipterocarpus alatus* Roxb. ex G Don, Dipterocarpaceae), *Pinus kesiya* Roy. ex Gord. and *P. merkusii* Junh. & De Vriese (Pinaceae), *Gmelina arborea* Roxb. (Verbenaceae), *Casuarina equisetifolia* L. (Casuarinaceae), *Tetrameles nudiflora* R. Br. (Datiscaceae, Tetramelaceae), *Cassia siamea* Lam. (Leguminosae), *Azadirachta indica* A. Juss. (Meliaceae), *Rhizophora spp.* (Rhizophoraceae) and some species of bamboo. Others are some introduced species, viz. *Acasia auriculiformis* A. Cunn. ex Benth. (Leguminosae, Papilionoideae), *Melia azedarach* L. (Meliaceae), *Casuarina junghuniana* Sensu Corn. (Casuarinaceae), *Eucalyptus camaldulensis* Dehnh. (Myrtaceae), *Leucaena leucocephala* (Lam.) De Wit. (Leguminosae) (**Petmak**, 1993).

In view of its fast growing nature and money producing capacity, the eucalyptus is considered by profit oriented people as the "God-Sent-Plant" or "Green Gold", but the large scale of its plantating has generated much controversial debate by environmentalists and who have called it an "Ecological Monster". **Sharma *et al.***, 1989 showed that eucalyptus depletes the water table, degrades soil, provides little shade, is not easily bio-degradable and does not attract microorganisms (due to the exudation of some toxic chemicals by its roots) which kills all useful bacteria around the plant.

Most forest studies in tropical regions have mainly focused on the tree communities. There have been very few studies of the ground flora communities. Therefore, most of the techniques applied in the ground flora studies have been developed in temperate countries.

Southwood (1992), **Ludwig and Reynolds** (1988) **and Goldsmith *et al.***, (1986), indicate that quadrats are the most commonly used sample unit to survey the ground flora communities. The shape of a quadrat is a simple square or rectangular sample area for detailed examination. Quadrats may be used to select a "typical" sample or repeated over an area. They may be positioned regularly or randomly (considered to be the ideal method of sampling - each sample by definition has an equal chance of being chosen) (**Goldsmith *et al.***, 1986; and **McLean and Cook**, 1968). The number of quadrats used depends on the variability between samples. The minimum number is the number of quadrats that correspond to the point where the oscillations damp down.

The principal considerations in choosing the size of quadrats are the morphology of the species in the vegetation to be sampled and the homogeneity of the vegetation. Small quadrats are appropriate to the study of small plants; e.g. 10 x 10 cm or 25 x 25 cm quadrats may be suitable for chalk grassland, arable weeds and fixed dune grassland, and large quadrats for scrub and woodlands. A plot of 1-25 m^2 is considered as adequate for sampling herbaceous vegetation, while for small scrubs, a plot of 25 - 100 m^2 is preferred and in the forest, plots of 200-500 m^2 are used for tree, with appropriate sizes substituted for the shrub and herb layers (**Goldsmith *et al.***, 1986). In general, a quadrat size up to 0.25 m^2 is suitable for herbaceous vegetation, while sizes larger than 1 m^2 are required for work with woody species **Causton** (1988),. For example, in Coed Nant Lolwyn, Wales (U.K.), the ground flora in a deciduous woodland was surveyed by using 0.25 m^2 quadrats at 200 random sample points (**Causton**, 1988). The density of each species was recorded in each quadrat in this study, as a measure of the abundance of the ground flora. However, this technique has some disadvantages in that the definition of an individual depends on the morphology of the species concerned. This is because many grass shoots often join together underneath the soil by rhizomes and should be counted as one individual, it is very difficult to prove whether they are the same individual or not.

Brockelman *et al.*, (1995) used one-hundred 5 m^2 plots in 1991 and ninety 5 m^2 quadrats in 1993 to survey trees and ground flora in natural teak forest in Thailand. There was a considerable difference in the species of ground flora found, reflected mostly in rarer species on both above and below 260 m MSL. Ninety seven of the 184 species recorded in 1991 were not seen in 1993 plots, and 85 of 172 species seen in 1993 were not found in 1991. This suggests the existence of a large pool of rare species in the forest, most of which remain undiscovered. There are marked seasonal changes throughout the year in the character of the ground flora.

Various measurements are made within quadrats. The most simple one is presence and absence of species, which is suitable for areas where species number is increasing markedly, or the vegetation can be quantified in terms of density, cover, biomass, basal area, etc.

Cover is defined as the proportion of the ground occupied by a perpendicular projection of the aerial parts of individuals under consideration (**Greig-Smith**, 1983), or the proportion of ground covered by a species and should be envisaged as a vertical projection of each species on to the ground (**Goldsmith**, 1991). In addition, **Myers and Shelton**, (1980) explained that cover is a convenient measure for working with many types of herbaceous vegetation especially those which density is not appropriate. Cover can be expressed as a percentage or placed in ranges of value, e.g. the "Domin" scale which was used in Europe and in the British National Vegetation Classification. This scale is pseudoquantitative, but is easily and quickly used in field. it also produces satisfactory ordination and classifications (**Goldsmith**, 1991; **Goldsmith *et al.***, 1986).

In a study by **Okali and Onyeachusim** (1991) of ground flora communities in a plantation and natural forest in Omo forest reserve, Nigeria, ten 1 m^2 quadrats were distributed randomly in 50 x 50 m^2 permanent plots in each area and all vascular plants less than 100 cm tall were recorded and their density used as an abundance score. The total number of species, recruitment and absence or extinctions of species in the ground flora were higher in the forest than in the plantation, but the density of plants and seasonal fluctuations in the density were higher in the plantation than in the forest.

Density is the number of individuals of a particular species per unit area. Counts are usually made in a number of replicate quadrats. The determination of the density of trees, shrubs, tussocks of grasses or sedges, arable weeds and conspicuous individual herbs, such as orchids, is simple; but species which spread vegetatively, such as grasses and clover, are often impossible to deal with in this way (**Ludwig and Reynolds**, 1988).

Diversity is a macroscopic property of communities, encompassing both the number of species present and the distribution of individuals between them. Ideally an index of diversity will vary from a minimum, when all the individuals present in a community belong to a single species, to a maximum, when each individual belongs to a different species. The weakness of diversity as an ecological tool lies in its ambiguity, as noted by **Odum** (1969), **Pielou** (1969) and **Hurlbert** (1971). Indices of diversity have been proposed by **Simpson (1949)** and **McIntosh** (1967), but the most commonly used index, the information content, "H'", was introduced by **Margalef** (1958) and **Moore and Chapman**, (1986).

Ludwig and Reynolds (1988) explained that species diversity is composed of two components, viz. species richness, the number of species in the community and species evenness or equitability, how the species abundances are distributed among the species. A number of indices have been proposed for characterizing species richness and evenness. Such indices are termed richness indices and evenness indices. Indices that attempt to combine both indices are called diversity indices. The major criticism of all diversity indices is that they attempt to combine and, hence confound a number of variables that characterize community structure: (1) the number of species, (2) relative species abundances (evenness), and (3) the homogeneity and size of the area sampled (**James and Rathbun**, 1981).

Mac Arthur (1955) and **Hutchinson** (1959) have suggested that diversity contributes to stability because it increases the number and complexity of biological interactions. It follows that, at the climax stage, when the vegetation is in equilibrium with the environment and is, therefore, stable; diversity should be high. Others

(**Connell and Slatyer,** 1964; **Sanders,** 1968) suggest that species diversity is the product of a stable environment. Environmental stability allows the evaluation of community diversity and subsequently community stability. Species richness and evenness may all be correlated to diversity.

Cluster analysis is a classification technique for placing similar entities or objects into groups or clusters. Cluster analysis models used in a hierarchical tree-like structure is called a **dendrogram (Ludwig and Reynolds**, 1988). Cluster analysis has been widely applied in the field of vegetation analysis. **Elliott *et al.***, (1989) employed the cluster analysis on a transect survey of monsoon forest in Doi Suthep-Pui National Park. Cluster analysis clearly distinguished two main associations: a deciduous (D) association, in which 88.2% of the trees were deciduous and a mixed evergreen-deciduous (M) association in which 49.6% of trees were deciduous and 43% evergreen. In addition, **Suwannaratana**, (1994) applied the cluster analysis to study the effect of irrigation on the ground flora diversity. However, it failed to demonstrate clear clusters among sites.

Goldsmith *et al.*, (1986) explained that ordination is a spatial arrangement of samples such that their position reflects their similarity. It is used as a framework upon which to compare species and environmental factors as a basis for making hypotheses about cause-and-effect relationships. In addition, ordination techniques are appropriate to any scale of study and published accounts range from the relatively local scale study of **Gittins** (1965) and **Austin** (1968) on small areas of calcareous grassland, to the more extensive studies of **Ashton** (1964) in the dipterocarp forests of Brunei and of **Greig-Smith, *et al.***, (1967) in the Solomon Islands.

The change of land use from primary forest in northern Thailand to coffee with pigeon pea (*Cajanus cajan* (L.) Mill. Leguminosae, Papilionoideae) and *Calliandra* *calothyrsus* Meisnn (Leguminosae, Mimosoideae) led to a reduction of the species diversity and the total dry matter of the ground flora (**Zimmermann**, 1993). In addition, a study was conducted by **Srivastava** (1986) in chir (*Pinus roxburghii* Sarg., Pinaceae) and teak plantations. The diversity and dominance indices were inversely correlated in a curvilinear fashion in both plantations. There was an inverse correlation between dominance index and total basal area in the chir plantation. Average number of species per quadrat, average diversity index and average basal area were higher in the chir plantation, while average dominance index was higher in the teak plantation. The total number of species was greater in the teak plantation despite that the average number of species per quadrat was less. Soil moisture content at depths from 10 to 185 cm was very different in the two plantations.

Lisboa and Vinha (1982) carried out a study on the frequency and coverage of herbaceous and woody species along four 25 m transects under cocoa (*Theobroma cacao* L., Sterculiaceae) trees in a new and a 60 year old plantation. *Paspalum conjugatum* Berg. (Gramineae) was the most frequent species in both areas, with 22% cover in the new and 17.4% in the old plantation. Next in frequency were *Commelina nudiflora* auct. non L. (=*C. diffusa* Burm. f., Commelinaceae), *Cyanthula achiranthoides* (Amaranthaceae) and *Borreria verticillata* Lmk. (Rubiaceae) in the new plantation and *Setaria poiretiana* (Schult.) Kunth and *S. achiranthoides* (Gramineae) in the old one. Shannon's diversity index showed less preponderance of the common over the rarer species in the old plantation.

The species number and diversity of ground flora may vary due to seasonal changes and land use pattern. **Okali and Onyeachusim** (1991) monitored seasonal changes in ground flora in 1981 and 1982 in a forest and *Gmelina arborea* Roxb. (Verbenaceae) plantation. Total species and rates of recruitment and extinction of species in the ground flora were higher in the forest than in the plantation, but the density of plants and seasonal fluctuations in the density were higher in the plantation than in the forest. Seasonal changes were brought about by recruitment of new seedlings by seed germination and by vegetative reproduction mainly during the favourable wet season, and death of plants mainly during the dry season. Lack of water in the dry season could be overcome by irrigation.

It has been postulated that extensive pine plantations interfere with the diversity and abundance of species, simplifying the ecological relationships between them. In order to validate this hypothesis for a *Pinus radiata* D Don (Pinaceae) plantation and the other in native shrub-land dominated by Teline (*Cytisus monspessulanus*, Leguminosae), Shannon-Wiener's index was calculated to estimate the diversity of the vegetation. Plant species diversity was higher in the shrub-land than in the pine stand (**Munoz and Murua**, 1989).

Conde *et al.*, (1983) carried out a study on plant species cover, frequency and biomass: early responses to clear-cutting, burning, windrowing, discing and bedding in *Pinus elliottii* Engelm. (=*P. palustris* Mill., Pinaceae) flatwoods along a 49 ha naturally-regenerated and mature flatwoods forest in north Florida. Planted pines were a fast increasing, but not dominant component, of the vegetation at two year old plantation. Previously dominant shrubs were severely reduced, often by approximately two orders of magnitude; woody cover was reduced from 151 to 12% of surface area at a plantation age of two years; woody biomass from 6223 to 521 kg/ha. Herbaceous cover increased from 38 to 51% of surface area in the two year old plantation; herbaceous biomass from 382 to 1439 kg/ha. Thus, a predominantly woody ecosystem was converted to a predominantly herbaceous one for two years following planting. There was little change in plant species richness as a result of this forest operation.

In terms of soil characteristics between plantation and forest, **Jamet** (1975) carried out a study to measure some chemical parameters of the soil under some 5-15 year old eucalypt stands, 6-11 year old pine stands and savanna vegetation in southern Congo. The organic matter was less under the eucalypt stands and much less under the pine stands than in the savanna soil. C/N was similar in all soils and the older plantations were the more acid and it was in the top soil. Furthermore, **FAO** (1988), the soil under a *Eucalyptus camaldulensis* Dehnh. (Myrtaceae) stand was compared with that under a mixed *Quercus sp.* stand in Spain. The soil was more acid, had lower exchange cation content, etc. under the eucalyptus. It was also becoming converted from mull to moder humus, while it was not under the mixed *Quercus sp.* stand.

Srivastava (1986) carried out a study in a 13 year old eucalyptus plantation and in a natural sal (*Shorea robusta* Gaertner f. (Dipterocarpaceae) forest in humid northern India, during the rainy season. The number of species was higher in plantations than in the sal forest. Sixty five compared with 37. There were most annuals in the former and perennials in the latter. Considering the effects of secondary products as inhibitors on the other plants, **Del Moral and Muller** (1969) asserted that the absence of annual vegetation near naturalized stands of *Eucalyptus camaldulensis* Dehnh. (Myrtaceae) could not be explained by differences in soil, grazing, light, etc. Extracted terpenes and water soluble toxins proved toxic to germinating seeds of annuals on heavier soil but not in sands. Ten phenolic toxins were isolated and five were identified. In addition, **Al-Mousawi and Al-Naib** (1975) confirmed that the scarcity of herbaceous species under *Eucalyptus microtheca* F. Muell. (Myrtaceae) in Iraq was probably due to phenolic and volatile contents in the leaves rather than to competition.

CHAPTER 3.
STUDY SITE DESCRIPTION

3.1. Introduction

This study was carried out in Doi Suthep-Pui National Park which lies a few km west of Chiang Mai, Thailand's second largest city. Doi Suthep-Pui National Park was designated as a national park in 1981 and is under the Royal Forestry Department. It covers 261 km^2. The summit of Doi Pui, 1685 m, is at 18° 50' N, 98° 54' E. The base rock is granitic, but shale occurs in some lowland places. Soils are generally deep and highly weathered.

Annual rainfall varies from about 1,000 mm/year at the base of the mountain to about 2,000 mm/year near the summit. There is a marked dry season from December to March, when rainfall is close to zero and a rainy season from May to November, with peak rainfall in August (about 250 mm). The cool season is from November to February when mean temperatures at the base of the mountain are 20-24°C, after which mean temperatures rise sharply and peak in April at 30°C. Temperatures at higher elevations are considerably cooler. Mean monthly rainfall and temperature of Chiang Mai and Chang Kian village are shown in Figure 3.1 and 3.2.

For a description of the vegetation of Doi Suthep-Pui see **Maxwell** (1988) and **Kuchler and Sawyer** (1967). There are two basic kinds of forest, viz. deciduous forest up to about 950 m elevation and evergreen forest above that. The evergreen forest contains some very large trees 30-40 m high, including *Sapium baccatum* Roxb. (Euphorbiaceae), *Eugenia albiflora* Duth. ex Kurz (Myrtaceae), *Lithocarpus elegans*

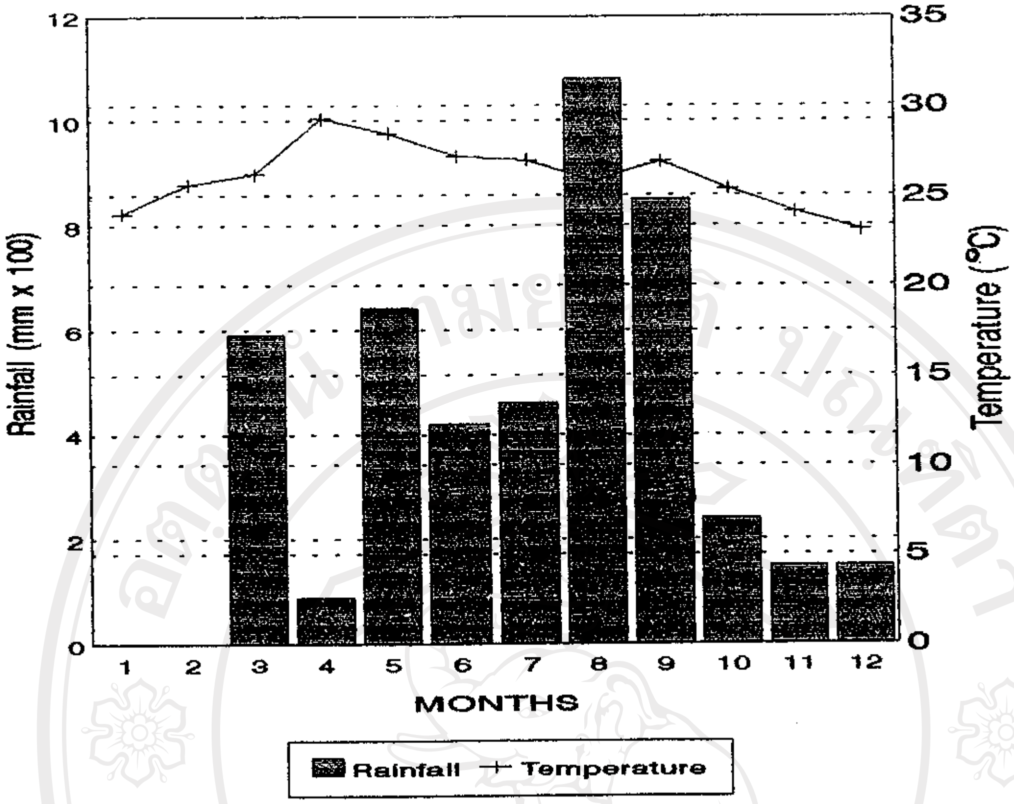


Figure 3.1. Mean Monthly rainfall and temperature of Chiang Mai, (Data from Seismic Station, Chiang Mai city, 1994).

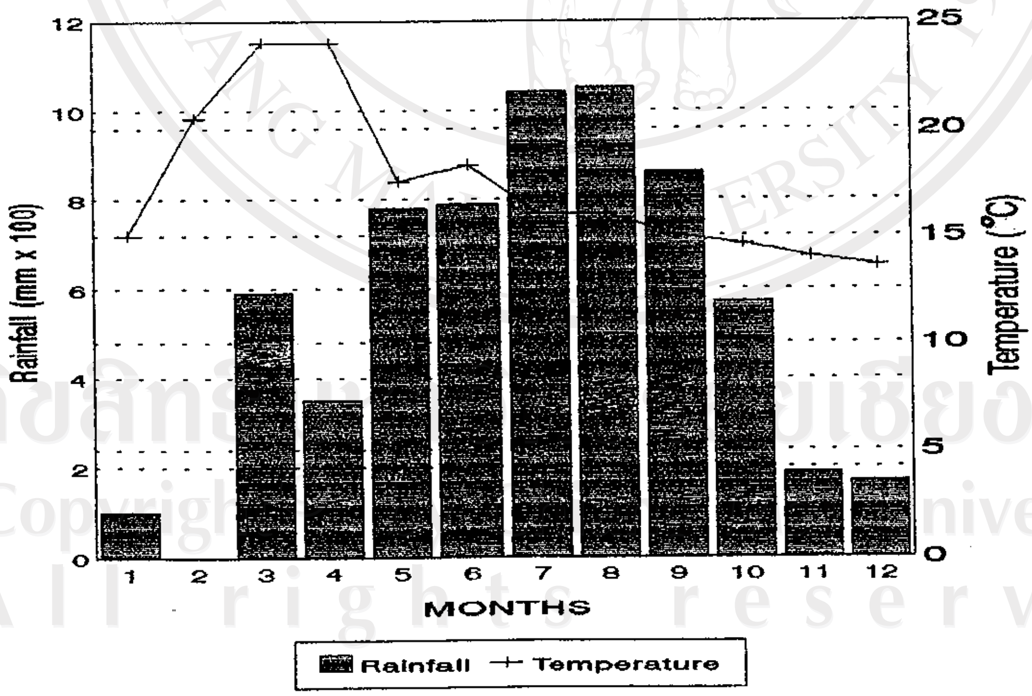
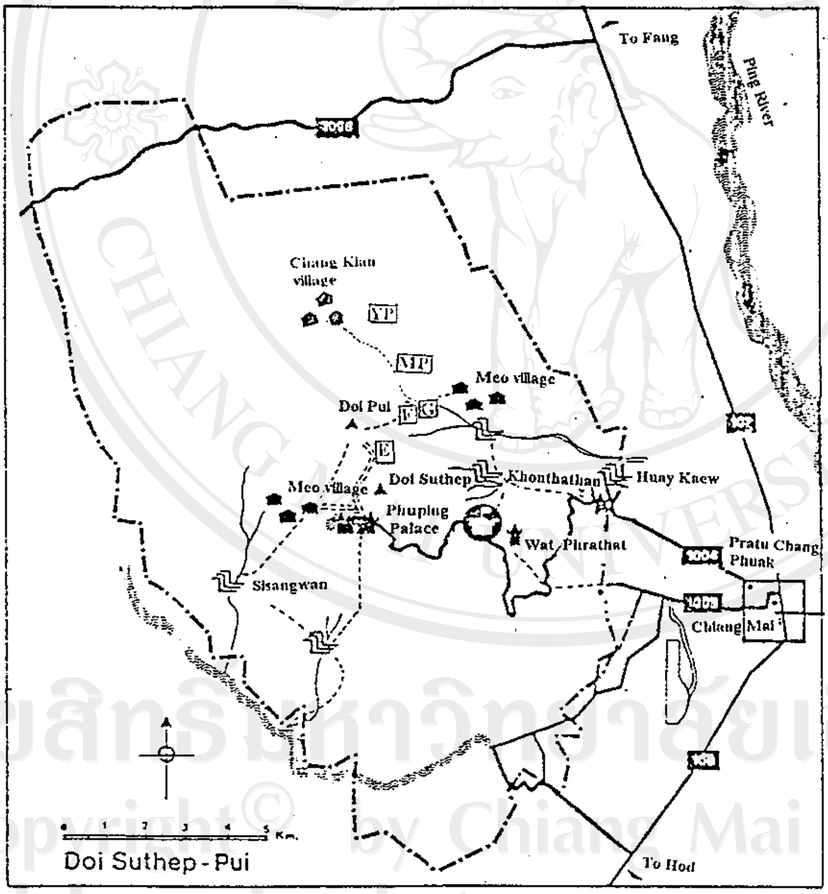


Figure 3.2. Mean Monthly rainfall and temperature of Doi Suthep-Pui National Park, (Data from Chang Kian Meterological Station, 1994).

(Bl.) Hatus. ex Soep. (Fagaceae), *Castanopsis diversifolia* King ex Hk. f. (Fagaceae). *Pinus kesiya* Roy. ex Gord. (Pinaceae) occurs naturally and has also been planted (Elliott and Maxwell, 1993).

Five sites were selected in evergreen forest (1525 mASL), viz. a regenerating gap (1500 mASL), a eucalyptus plantation (1550 mASL), a mature pine plantation (1375 mASL) and a young pine plantation (1275 mASL). The bedrock of all sites is granite. A sketch map showing Doi Suthep-Pui Headquarters, Chang Kian village, roads and locations of study sites is shown in Figure 3.3.



F = Evergreen forest site MP = Mature pine plantation site
G = Regenerating gap site YP = Young pine plantation site
E = Eucalyptus plantation site

Figure 3.3. Map showing Doi Suthep-Pui National Park, Chang Kian and Meo village, roads, Phuping Palace and locations of five study sites.

3.2. Site Description

3.2.1. Evergreen Forest

This site (c. 1525 m) is located at 7.9 km along the road from the Headquarters of Doi Suthep-Pui National Park. It consists of disturbed primary evergreen forest with some pine and much secondary growth which forms a dense forest understorey. The aspect is 25° southwest and the slope is 45% (Figure 3.4).

Figure 3.4. Vegetation of the evergreen forest, site 1, with *Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. & Vaugh. (Gramineae) in the foreground. The liana is *Spatholobus floribundus* Craib (Leguminosae, Papilionoideae), *Styrax benzoides* Craib (Styracaceae) (middle), and *Castanopsis tribuloides* (Sm.) A. DC. (Fagaceae) (left and right) are the more obvious trees represented. 18 July 1994, 1525 m.

The general soil characteristic is deep top soil, high organic matter content and high water holding capacity. The soil texture is sandy-loam. Tree species include *Helicia nilagirica* Bedd. (Proteaceae), *Castanopsis tribuloides* (Sm.) A. DC. (Fagaceae), *Schima wallichii* (DC.) Korth (Theaceae), *Vaccinium sprengelii* (D. Don) Sleum. (Ericaceae), *Aporusa villosa* (Lindl.) Baill. (Euphorbiaceae), *Styrax benzoides* Craib (Styracaceae), *Vernonia volkameriifolia* DC. var. *volkameriifolia* (Compositae) and *Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow. (Rubiaceae). Abundant herbaceous plants and climbers include *Microstegium vagans* (Nees ex Steud.) A. Camus (Gramineae), *Rubus blepharoneurus* Card. (Rosaceae), *Curculigo capitulata* (Lour.) O.K. (Hypoxidaceae), *Lepidagathis incurva* Ham. ex D. Don (Acanthaceae), *Polygonum chinensis* L. (Polygonaceae) and *Aerva sanguinolenta* (L.) Bl. (Amaranthaceae). There are also abundant vines, e.g. *Shuteria involucrata* (Wall.) Wight & Arn. (Leguminosae, Papilionoideae), *Smilax ovalifolia* Roxb. (Smilacaceae) and *Thunbergia similis* Craib (Acanthaceae).

3.2.2. Regenerating gap

This site (c. 1500 m) is located immediately adjacent to the evergreen forest site (site 1). It is a deforested open area with some secondary treelets and shrubs. The aspect is 65° northwest and the slope is 25% (Figure 3.5).

The general soil characteristic is a shallow top soil, less organic matter than in site 1 and low water holding capacity. The soil texture is sandy loam. Treelets include *Debregeasia longifolia* (Burm.f.) Wedd. (Urticaceae), *Prunus persica* (L.) Bat. (Rosaceae, peach, planted), *Artocarpus heterophyllus* Link. (Moraceae, jackfruit, planted), *Prunus cerasoides* D. Don (Rosaceae, planted), *Melastoma normale* D. Don var. *normale* (Melastomataceae) and *Trema orientalis* (L.) Bl. (Ulmaceae). The most

Figure 3.5. Regenerating gap, site 2, with site 1 in the background. ***Eupatorium adenophorum*** Spreng. (Compositae), ***Imperata cylindrica*** (L.) P. Beauv. var. ***major*** (Nees) C.E. Hubb. & Vaugh (Gramineae) (foreground), ***Thysanolaena latifolia*** (Roxb. ex Horn.) Honda (Gramineae) (middle), and secondary growth trees, e.g. ***Trema orientalis*** (L.) Bl. (Ulmaceae), are conspicuous. 18 July 1994, 1500 m.

abundant herbaceous plants in this site were *Eupatorium adenophorum* Spreng. (Compositae), *Thysanolaena latifolia* (Roxb. ex Horn.) Honda (Gramineae), *Thunbergia similis* Craib (Acanthaceae), *Clitoria mariana* L. (Leguminosae, Papilionoideae), *Urena lobata* L. ssp. *lobata* var. *lobata* (Malvaceae), *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try.(Dennstaedtiaceae) and *Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. ex Hubb. & Vaugh. (Gramineae).

3.2.3. Eucalyptus Plantation

This site (c. 1550 m) is located about 6.6 km along the road, north-west of the Headquarters of Doi Suthep-Pui National Park or 1.3 km from the forest site (site 1). The aspect is 60° northwest and the slope is 55% (Figure 3.6).

Figure 3.6. Site 3 is situated in a c. 37 year old *Eucalyptus camaldulensis* Dehnh. (Myrtaceae) plantation. The herbaceous ground flora includes the vine ***Rubus blepharoneurus*** Card. (Rosaceae) and ***Thysanolaena latifolia*** (Roxb. ex Horn.) Honda (Gramineae), a 2 - 5 m tall grass. 12 September 1994, 1550 m.

Eucalyptus camaldulensis Dehnh. (Myrtaceae), native to Australia, was planted in 1957 (c. 37 years of age) and is now 25-35 m tall, well spaced (c. 8 m). Charcoal and other evidence of ground fires are common. The general soil characteristic is shallow top soil, less organic matter than in site 1 and low water holding capacity. The soil texture is sandy-loam.

Some deciduous and evergreen tree or treelets grow at this site, e.g. *Litsea cubeba* (Lour.) Pers. (Lauraceae), and *Dillenia aurea* Sm. var. *aurea* (Dilleniaceae). There are also many herbaceous plants and weeds, e.g. *Urena lobata* L. ssp. *lobata* var. *lobata* (Malvaceae), *Rubus blepharoneurus* Card. (Rosaceae), *Polygonum chinensis* L. (Polygonaceae), *Microstegium vagans* (Nees ex Steud.) A. Camus (Gramineae), *Eupatorium adenophorum* Spreng. (Compositae), *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try.(Dennstaedtiaceae) and *Phragmites vallatoria* (Pluk. ex L.) Veldk. (Gramineae).

3.2.4. Mature Pine Plantation

This site (c. 1375 m) is located about 14.6 km along the road, north of the Headquarters of Doi Suthep-Pui National Park and close to Chang Kian Village, about 5.4 km from the forest site. The aspect is 30° southwest and the slope is 15% (Figure 3.7).

Pinus kesiya Roy. ex Gord. (Pinaceae) was planted in 1970-1971 (c. 25 years of age) and is now 15-20 m tall. Ground fires are frequent and there is some secondary growth. The general soil characteristic is very shallow top soil and very little organic matter (mostly pine leaves). The soil texture is sandy clay loam.

The ground flora, due to shade and pine needles, is very sparse at this site, but coppicing stumps of *Albizia odoratissima* (L. f.) Bth. and *Dalbergia fusca* Pierre (Leguminosae, Mimosoideae), *Schima wallichii* (DC.) Korth (Theaceae) and

Fagerlindia sp. (Rubiaceae) are common. Charcoal and other evidence of ground fires are common in this site. *Clitoria mariana* L. (Leguminosae, Papilionoideae), a vine, is abundant from August to October.

Figure 3.7. ***Pinus kesiya*** Roy. ex Gord. (Pinaceae) was planted c. 25 years ago and was study site 4. Frequent fires have maintained a minimum of ground flora which include ***Clitoria mariana*** L. (Leguminosae, Papilionoideae), ***Osbeckia stellata*** Ham. ex Ker-Gawl. var. ***marginulata*** (Cl.) C. Han. (Melastomataceae), and ***Cheilanthes tenuifolia*** (Burm. f.) Sw. (Parkeriaceae). The leaf litter is about 10 - 12 cm thick. 12 September 1994, 1375 m.

3.2.5. Young Pine Plantation

This site (c. 1275 m) is located about 16.8 km along the road, north of the Headquarters of Doi Suthep-Pui National Park, is also close to Chang Kian village near site B (Faculty of Agriculture Station, Chiang Mai University), about 2.2 km from the mature pine plantation (site 4). The aspect is 90° west and the slope is 25% (Figure 3.8).

Figure 3.8. Site 5 is a c. 12 year old plantation of *Pinus kesiya* Roy. ex Gord. (Pinaceae). The ground flora, due to less shade, is better developed than in site 4. *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try. (Dennstaedtiaceae), *Clitoria mariana* L. (Leguminosae, Papilionoideae) and seedlings of *Styrax benzoides* Craib (Styracaceae) and *Schima wallichii* (DC.) Korth (Theaceae) are found. 12 September 1994, 1275 m.

Pinus kesiya Roy. ex Gord. (Pinaceae) was planted in 1982-1983 (c. 12 years of age) and is now 7-9 m tall. The ground flora is sparse and there is evidence of frequent fires and much secondary growth. The general soil characteristic is a shallow top soil, little organic matter and low water holding capacity. The texture is sandy clay-loam.

The most abundant tree seedlings are *Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cow. (Rubiaceae), *Castanopsis diversifolia* King ex Hk. f. (Fagaceae), *Dalbergia fusca* Pierre and *D. stipulacea* Roxb. (Leguminosae, Papilionoideae), *Aporusa villosa* (Lindl.) Baill., *Phyllanthus emblica* L. and *P. sootepensis* Craib (Euphorbiaceae) and *Styrax benzoides* Craib (Styracaceae). *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try. (Dennstaedtiaceae), *Smilax verticalis* Gagnep., *S. ovalifolia* Roxb. (Smilacaceae) and *Inula cappa* (Ham. ex D. Don) DC. *forma cappa* (Compositae) are common herbs.

The general description of each site is summarized in Table 3.1.

Table 3.1. The aspect, slope, and elevation of each site.

Site	Plot	Elevation (mASL)	Aspect (°)	Slope (%)
1	Evergreen Forest	1525	25 SW	45
2	Regenerating gap	1500	65 NW	25
3	Eucalyptus plantation	1550	60 NE	55
4	Mature pine plantation	1375	30 SW	15
5	Young pine plantation	1275	90 W	25

CHAPTER 4.

MATERIAL AND METHOD

4.1. Materials and Equipment:

4.1.1. Materials:

- Plastic bags and rubber bands
- Paper and paper bags
- Species list from Doi Suthep-Pui plant database from the CMU Herbarium, Biology Department, Chiang Mai University.
- Topographic map of Doi Suthep National Park

4.1.2. Equipment:

- Bamboo poles
- Tape meter (1.5 m and 50 m)
- Electric balance
- Altimeter
- Strong knife and scissors
- Collecting plant speciment (Poles)
- Metal labels and string wire
- Electric balance
- Nylon string
- Trowel
- Hammer
- Plant press
- Compass
- Camera

trees/treelets, vines, woody climbers, and shrubs both evergreen and deciduous, were recorded. FOXPRO 2.0 programme was used to record species at all sites during extensive qualitative and intensive quantitative survey. This programme was also employed to determine the number of overlapping species and Sorensen's index.

For the intensive quantitative survey, an area judged to be typical 100 x 50 m^2 was demarcated in each of the five sites. Twenty 2 x 2 m^2 quadrats were established within the sample plot using a regular sampling pattern, giving 100 quadrats in all. Nylon-string was used to delineate the quadrats and to avoid trampling the vegetation within them. The percent cover and Domin score of each species were recorded in every quadrat. Plants rooted within the quadrat but growing outside the quadrat were also recorded. Additional species found in the quadrats were added to the research database along with abundance scores. Percent cover and Domin score of each species were recorded every month from May to November 1994. Herbaceous plants, trees/treelets, vines, shrubs, and woody climbers found were recorded.

Species diversity and evenness indices were calculated for each site using the equations described below (Ludwig and Reynolds, 1988). Species diversity and evenness were plotted using both species frequency data and total percent cover of each species over all seven observations.

A species-area curve was plotted using species frequency data of each for all seven observations. The Statistical Package for the Social Sciences (SPSS) was used to carry out a cluster analysis and ordination of all 100 quadrats (Appendix 1). These analyses were carried out on the percent cover of each species averaged over the whole study period.

4.2. Methods

4.2.1. Study of ground flora community

Two main methods of data collection were used: an extensive, qualitative survey and an intensive, quantitative survey.

The extensive, qualitative survey was carried out using a check list from the Doi Suthep-Pui plant database from the CMU Herbarium, Biology Department, Chiang Mai University. This study was carried out by walking around each site for three months from March to May 1994. All non-woody plants and seedlings not taller than 2.5 meters found in each site seen in the ground flora and understorey, were recorded and a rough indication of abundance was noted using a scoring system of 1-5.

Abundance score used in this study was as follows:

0 = probably extirpated;

1 = down to a few individuals, in danger of extirpation;

2 = rare;

3 = medium abundance;

4 = common, but not dominant;

5 = abundant, species dominate in its normal habitat.

Seedlings and coppicings, less than 5 cm high were not recorded. Unknown species were collected, using a plant press and identified at the Herbarium, Chiang Mai University. Species richness was calculated for each site of the five sites using the equations described below (**Ludwig and Reynolds**, 1988). Similarity among the sites was calculated by using Sorensen's index. In this survey, herbaceous plants, The characteristics of each sample plot were as follows:

The sample plot in forest site was laid down 10° southwest. Twenty 2 x 2 m^2 quadrats were set up within the sample plot of 12.5 x 20 m apart.

The sample plot in the regenerating gap was laid down in two direction: 35° north-west with fourteen 2 x 2 m^2 quadrats of which 12.5 x 25 m apart and 45° north-east with six 2 x 2 m^2 quadrats of which 12.5 x 30 m apart.

The sample plot in the eucalyptus plantation was sloped 60° northeast. Twenty 2 x 2 m^2 quadrats were set up within the sample plot of which 12.5 x 20 m apart.

The sample plot in the mature pine plantation was sloped 20° northwest. Twenty 2 x 2 m^2 quadrats were set up within the sample plot of which 12.5 x 20 m apart.

The sample plot in the young pine plantation was sloped 90° west. Twenty 2 x 2 m^2 quadrats were set up within the sample plot of which 12.5 x 20 m apart.

The Domin score:

Class	Domin
+	isolated; cover small
1	scarce; cover small
2	very scattered; cover small
3	scattered; cover small
4	abundant; cover about 5%
5	abundant; cover about 20%
6	cover 25-33%

7 cover 33-50%

8 cover 50-75%

9 cover 75-under 100%

10 cover about 100%

4.2.2. Species Diversity: (Hill's number)

NUMBER 1: N1 = eH'

NUMBER 2: $N2 = 1/\lambda$

Where: H' is Shannon's index

λ is Simpson's index

4.2.3. Shannon's Index

$$H' = \sum_{i=1}^{S} (pi \ln pi), \quad \text{where} \quad pi = \frac{ni}{N}$$

4.2.4. Simpson's Index

$$\lambda = \sum_{i=1}^{S} pi^2$$

Where : H' = average uncertainty per species in an infinite community

S' = total number of species in the community

pi = proportional abundance of the i^{th} species

ni = number of individuals (abundance) of the i^{th}

N = total number of individuals (abundance)

4.2.5. **Species richness :**

NO = total number of species

4.2.6. **Evenness : (Modified Hill's Index)**

$$E5 = \frac{(1/\lambda) - 1}{eH' - 1}$$

Where :

$$\lambda = \sum_{i=1}^{S} pi^2$$

4.2.7. **Similarity coefficient: (Sorensen's index) of communities between sites**

$$Ss = \frac{2a}{b + c}$$

Where :

a = Number of species that present in both sites

b = Number of species that present only in site 1

c = Number of species that present only in site 2

4.2.8. **Difference coefficient:**

formula used for calculating the distance between sites is:

$$CRD_{jk} = \sqrt{2(1 - ccos_{jk})}$$

Where : CRD_{jk} = chord distance between SU j and SU k, which range from 0 to $\sqrt{2}$

ccos = chord cosine is computed from:

$$Ccos_{jk} = \frac{\sum_{i=1}^{S} (X_{ij} \cdot X_{ik})}{\sqrt{\sum_{i=1}^{S} X_{ij}^2 \cdot \sum_{i=1}^{S} X_{ik}^2}}$$

Where : X_{ij} = relative abundance of i^{th} species in SU j.

X_{ik} = relative abundance of i^{th} species in SU k.

4.3. Cluster Analysis and Ordination

Ludwig and Reynolds (1988) showed that Cluster analysis (CA) is used to place similar samples into clusters, which are arranged in a hierarchical tree-like structure called a dendrogram. Two ways of cluster analysis were used in this study, viz. (1) using the average percent cover for seven observations for 100 quadrats and (2) using the total number of twenty quadrats of percent cover in all over seven observations from five sample units (SUs). Clustering is by the flexible strategy with $\beta = -0.25$ and by Chord Distance (CRD) index.

Ordination methods implemented in this study was Polar Ordination (PO) method of **Bray and Curtis** (1957). The procedure involved the selection of SUs (sites) as endpoints (poles) on an axis, followed by a simple geometric positioning of the remaining SUs relative to these endpoint SUs. This was plotted using the same data as cluster analysis did, but this was done by computing the Percent Dissimilarity (PD) between SUs.

The equation used was as follows:

$$PD = 1 - [2W / (A + B)]$$

$$W = \sum_{i=1}^{S} [\min(X_{ij}, X_{ik})]$$

$$A = \sum_{i=1}^{S} X_{ij} \quad \text{and} \quad B = \sum_{i=1}^{S} X_{ik}$$

Where :

PD = Percent Dissimilarity between two sites

X_{ij} = relative abundance of i^{th} species at SU j.

X_{ik} = relative abundance of i^{th} species at SU k.

4.4. Seedlings

The size, species and health of tree seedlings found were recorded to determine an indication of how plantations may act as a nursery crop, facilitating the establishment of forest trees. One parameter is relative growth rate. The height of seedlings at the beginning and in the end of study were recorded in each quadrat to determine the relative growth rate (RGR). This was done to compare the relative growth rate projected in one year. The health of tree seedlings was determined by calculating the number of dead seedlings during observation within the quadrats.

The equation employed to determine the Relative Growth Rate (RGR) was as follows:

$$RGR = \frac{\text{Ln H2} - \text{Ln H1}}{\text{T2} - \text{T1}} \times 365 \text{ days} = \text{cm growth/cm of original height/year}$$

Where :

H1 = height at the beginning of observations

H2 = height at the end of observations

T2-T1 = number of days between T1 to T2

T1 = first measurement

T2 = second measurement

and the equation employed to determine the mortality of seedlings was as follows:

$$\text{Mortality} = (\text{ND} / \text{TN}) \times 100\%$$

Where :

ND = number of dead species

TN = total number of species

Age-class structure of tree seedlings was plotted using the data of the height of tree seedlings from 5 cm to 250 cm at the end of study which was classified into ten-age classes against the number of tree seedlings.

4.5. Soil Analysis

Thirty 1 kg soil samples were collected from each transect at the beginning of the intensive quantitative survey and analyzed for field capacity, organic matter, pH, nutrients, etc. (using standard methods at the Faculty of Agriculture Central Soil Laboratory). Every month 100 g soil samples were collected (in plastic bags fastened with rubber bands to avoid evaporation) to determine the soil moisture content. Soil samples were dried in an electric oven at 80°C for two days and the moisture content calculated as percentage of gram water per 100 gram dry soil using the formula:

$$\text{Soil moisture content} = \frac{B - C}{C - A} \text{ (g water/g dry soil)}$$

Where : A = paper bag weight.

B = paper bag + soil sample weight (sample initial weight).

C = paper bag + dry soil weight (sample final weight)

To demonstrate the grouping between sample units (SUs) based on the soil analysis results, a cluster analysis was plotted. This was done using the data from soil analysis of Faculty of Agriculture, Chiang Mai University. For data processing and presentation, FOXPRO 2.0, spreadsheet, ecostate, analysis of variance (ANOVA), SPSS, cluster analysis and ordination were used.

CHAPTER 5.

RESULT

5.1. Extensive Qualitative Survey

A total of 249 species were recorded in all sites, belonging to 191 genera and 101 families. Species from the Families Leguminosae (Papilionoideae), Compositae, Gramineae, Rubiaceae, and Zingiberaceae were abundant at all five sites, with the number of species out of the total species recorded of 9%, 7%, 6.8%, 4.5%, and 3.6%; respectively. A list of ground flora and tree seedling species found at all five sites is shown in Appendix 2.

The number of herbaceous plant species (298 species) recorded in the extensive qualitative survey at all five sites was the highest, followed by trees (163 species), vines (90 species), woody climbers (31 species), while the lowest was shrubs (23 species) for both evergreen and deciduous species (Table 5.1).

5.1.1. Species richness

Species richness is the number of species in a community. The species richness in the forest, regenerating gap, eucalyptus, mature pine and young pine plantation was 174, 105, 86, 102 and 138; respectively.

5.1.2. Similarity

The numbers of species common to site pairs are shown in Table 5.2. The forest and young pine plantation had the highest degree of overlap, whilst the lowest was between eucalyptus and mature pine plantations.

Table 5.1. Species composition found in five sites from the results of extensive qualitative survey

SPECIES COMPOSITION	SITES					TOTAL
	Forest	Reg.gap	Eucalypt	M.Pine	Y.Pine	
Trees :						
et/etlt	39	17	11	18	26	111
det/detlt	14	8	5	9	16	52
Shrubs :						
es/des	8	2	2	5	6	23
Woody climbers:						
ewc/dewc	13	8	3	1	6	31
Vines :						
ev/dev	21	16	15	16	22	90
Herbs	79	54	50	53	62	298
TOTAL	174	105	86	102	138	605

Note :

et/etlt = evergreen tree/evergreen treelet

det/detlt = deciduous or evergreen tree/deciduous or evergreen treelet

es/des = evergreen shrub/deciduous or evergreen shrub

ewc/dewc = evergreen woody climber/deciduous or evergreen woody climber

ev/dev = evergreen vine/deciduous or evergreen vine

Table 5.2. The number of overlapping species.

	FOREST	REG.GAP	EUCALYPT	M.PINE	Y.PINE
FOREST	-	87	64	71	92
REG.GAP		-	58	48	64
EUCALYPT			-	43	53
M.PINE				-	78
Y. PINE					-

Figure 5.1 shows the values on Sorensen's index for comparisons between sites.

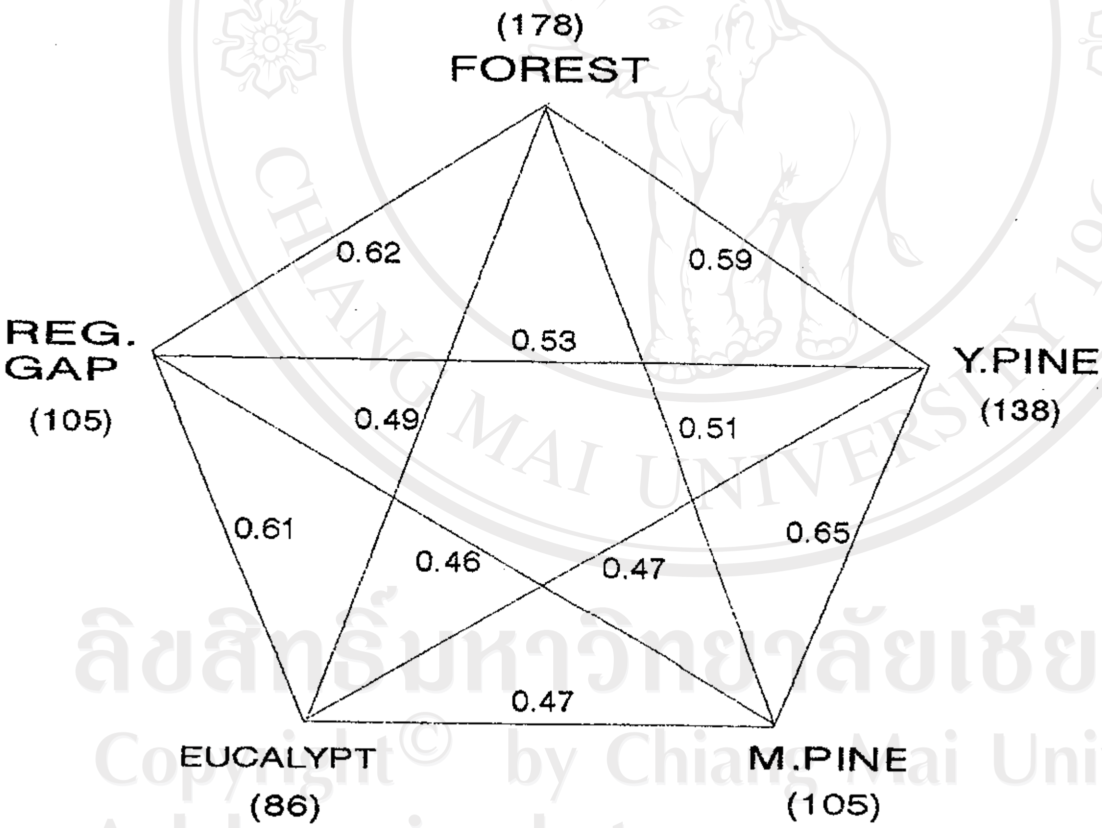


Figure 5.1. Similarities amongst sites using Sorensen's Index

The higher the number, the more similar the two sites are. The highest similarity occurred between the mature and young pine plantations, whilst the lowest was between the regenerating gap and mature pine plantation.

5.2. Intensive Quantitative Survey

The number of species recorded in the quantitative study was lower than in the extensive qualitative survey. A total of 197 species were recorded, belonging to 152 genera and 84 families. The number of species found in the forest, regenerating gap, eucalyptus, mature pine and young pine plantations was 132, 80, 76, 74 and 116; respectively. The list of all species found at all sites is shown in Appendix 3.

The number of herbaceous plant species (240 species) recorded in the intensive quantitative survey was the highest, followed by trees (129 species), vines (74 species), woody climbers (23 species) and the lowest was shrubs (12 species) for both evergreen and deciduous species (Table 5.3).

5.2.1. Species/Area curves

Species/area curves were plotted from species frequency data by combining presence/absence data of each species over all seven observation times and then summing the probabilities of each species occurring in a given number of quadrats.

Figure 5.2 shows that, particularly in the forest, young pine and mature pine, species-area curves nearly reach an upper asymptote, indicating that 20 quadrats were almost sufficient to adequately represent the whole community.

Table 5.3. Species composition found in five sites in intensive quantitative survey.

SPECIES COMPOSITION	SITES					TOTAL
	FOREST	REG.GAP	EUCALYPT	M.PINE	Y.PINE	
Trees :						
et/etlt	32	14	10	17	23	96
det/detlt	8	4	4	7	10	33
Shrubs :						
es/des	3	1	2	2	4	12
Woody climbers:						
ewc/dewc	10	4	2	1	6	23
Vines :						
ev/dev	18	11	15	11	19	74
Herbs	61	42	47	36	54	240
TOTAL	132	76	80	74	116	476

Note :

et/etlt = evergreen tree/evergreen treelet

det/detlt = deciduous or evergreen tree/deciduous or evergreen treelet

es/des = evergreen shrub/deciduous or evergreen shrub

ewc/dewc = evergreen woody climber/deciduous or evergreen woody climber

ev/dev = evergreen vine/deciduous or evergreen vine

5.2.2. Species Richness, Species Diversity and Evenness

Species diversity indices (both N1 and N2) were the highest in the forest site compared with the other sites, while the lowest was in mature pine plantation. The evenness indices in forest and young pine sites were shared the same but higher than that of other sites and the lowest occurred in the mature pine plantation. Species richness in the forest site was the highest, while the lowest was in the eucalyptus site (Table 5.4).

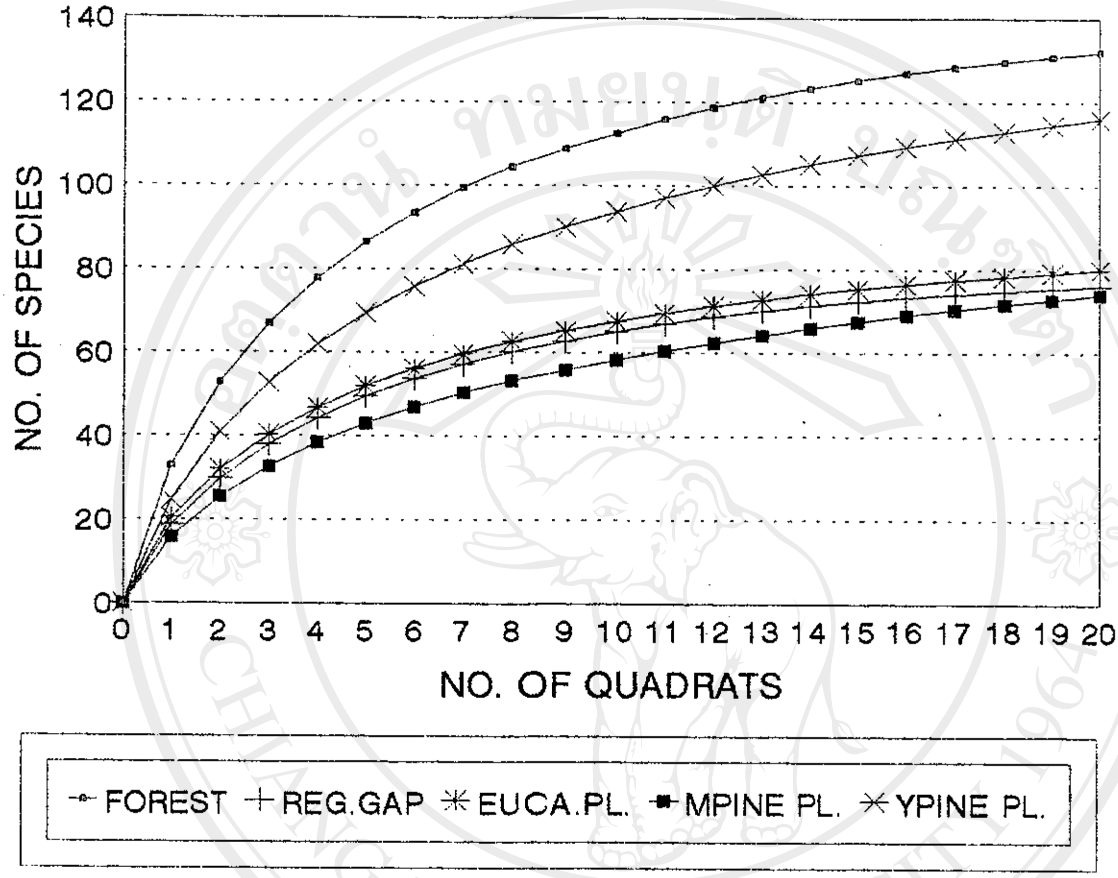


Figure 5.2. Species/area curves from species frequency data at all five sites

5.3. Cluster Analysis and Ordination

Two kinds of cluster analysis were applied as follows: i) using SPSS, using the mean percent cover over seven observations of all one hundred quadrats separately at all five sites and ii) using CLUSTER.BAS (Ludwig and Reynolds, 1988), using the

Table 5.4. Species richness, species diversity (Hill's number index) and evenness (Modified Hill's ratio) based on the mean of percent cover.

Sites	Species richness (species)	Sp. diver index N1 (species)	N2 (species)	Evenness Modified Hill's index
Evergreen forest	132	55.91	35.69	0.63
Regenerating gap	76	19.73	10.13	0.49
Eucalyptus plantation	80	26.10	15.87	0.59
Mature Pine plantation	74	16.46	6.88	0.38
Young Pine plantation	116	47.65	30.39	0.63

total percent cover of the twenty quadrats at each site combined over seven observations. Clustering among sites using average linkage between groups (cosine method) demonstrated clear grouping amongst the 100 quadrats (Figure 5.3). The mean percent cover of each species for 100 quadrats over all seven observations is presented in Appendix 4. Three main groups or clusters could be distinguished as follows: i) a cluster between some quadrats in mature pine plantation and regenerating gap, ii) a cluster between some quadrats in the eucalyptus and forest, and iii) a cluster between some quadrats in the mature pine plantation and young pine plantation. Hierarchical cluster analysis, using cosine index, is shown in Appendix 5

The results of clustering using CLUSTER.BAS with the flexible strategy (BETA = -0.25) based on cord distance using total percent cover of twenty quadrats combined at each site over seven observations is shown in Table 5.5.

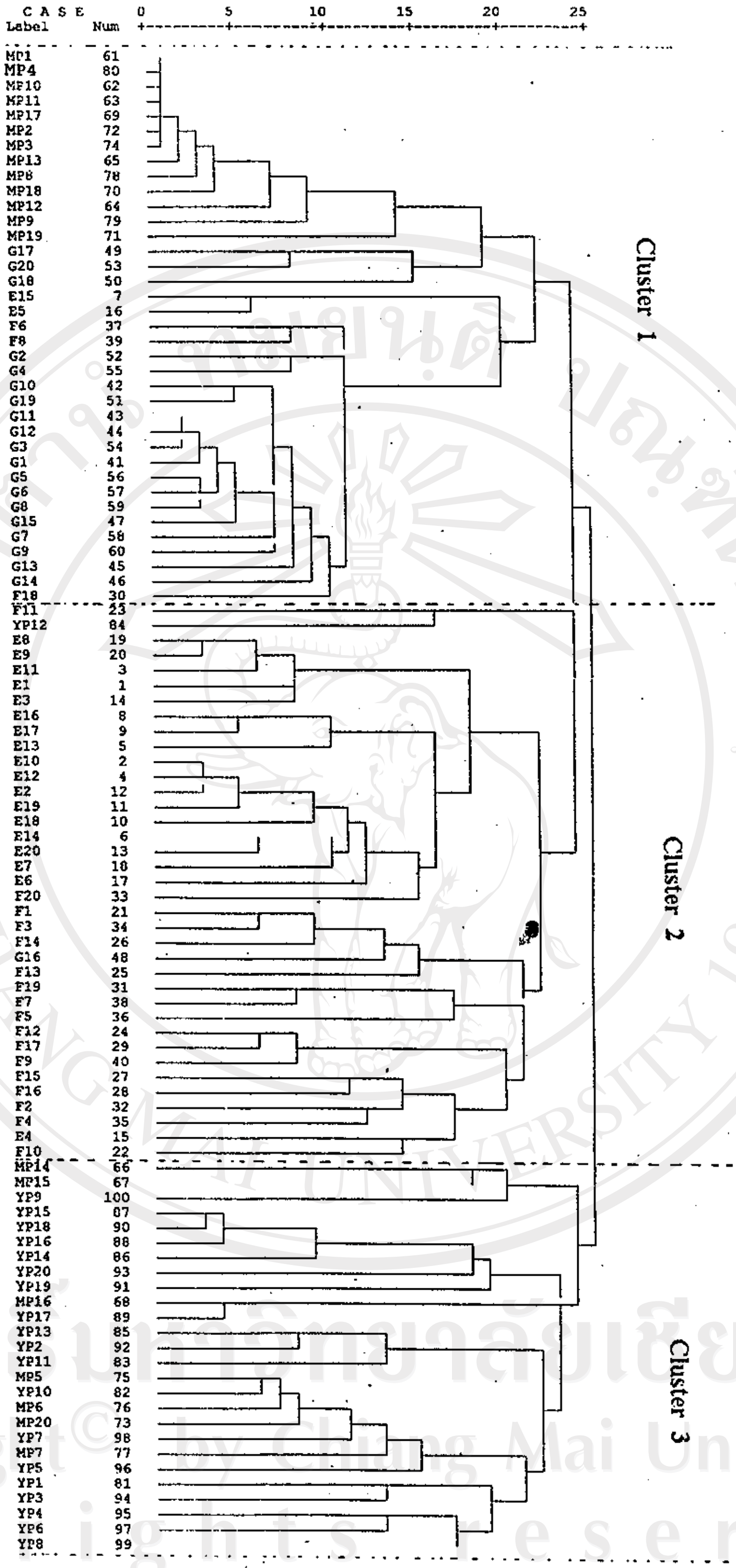


Figure 5.3. Dendrogram showing three main clusters using percent cover from 100 quadrats (method of Cosine index).

Table 5.5. Program CLUSTER.BAS results giving (a) distance between the five sites (SUs), and (b) clustering of the sites

(a) Chord Distance (CRD)

	Forest	Reg.gap	Eucalypt	M.pine	Y.pine
Forest	-	1.01	0.99	1.28	1.26
Reg.gap		-	1.24	1.19	1.27
Eucalypt			-	1.34	1.35
M.pine				-	1.26
Y.pine					-

(b) Clustering by the flexible strategy with $\beta = -0.25$

Clustering cycle	No. of Groups	Clustering level	Reference SUs	SUs in the group
1	4	0.99	1	3
2	3	1.16	1	2 3
3	2	1.26	4	5
4	1	1.37	1	2 3 4 5
4	1	1.37	1	all SUs form one group

Note :

Forest = evergreen forest

Reg.gap = regenerating gap

Eucalypt = eucalyptus plantation

M.pine = mature pine plantation

Y.pine = young pine plantation

SUs = sample units

A dendrogram showing the relationships among the five sites using Chord distance and the flexible strategy with β = -0.25 is presented in Figure 5.4. The first cluster occurred between the forest and eucalyptus plantation sites with the coefficient level = 0.99, followed by the second cluster between regenerating gap with both the forest and eucalyptus plantation with cluster level = 1.16 and the third cluster was between the mature pine and young pine plantations with cluster level = 1.26.

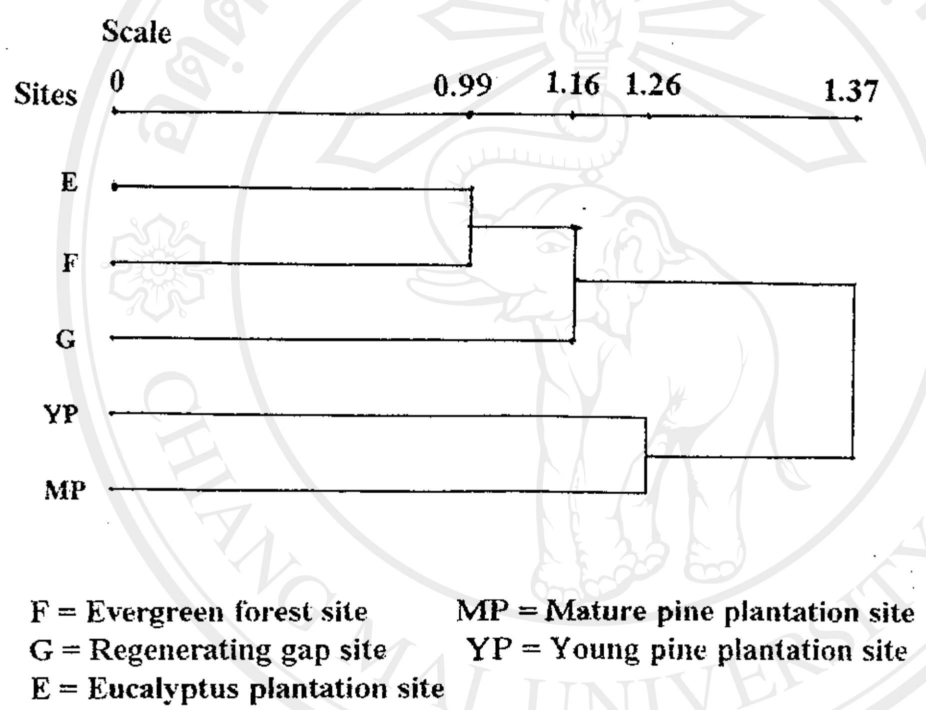


Figure 5.4. Dendrogram showing the relationship amongst sites using Chord Distance (CRD) and the flexible strategy β = - 0.25.

A simplified polar ordination was applied to the data of the percent cover of 197 species in all five sites. The BASIC program PO.BAS was used with PD (Percent Dissimilarity) as the resemblance measure (Table 5.6).

Table 5.6. Polar ordination results as summarized for five sites from the index of mean absolute distance, using BASIC program PO.BAS.

Enter the SU numbers for the endpoints of the X axis; 3, 4
Enter the SU numbers for the endpoints of the Y axis; 1, 2

Mean absolute distance between endpoint SU 3) and SU
1) = 1.24 2) = 1.47 4) = 1.82 5) = 1.69

Mean absolute distance between endpoint SU 4) and SU
1) = 1.65 2) = 1.67 3) = 1.82 5) = 1.24

Mean absolute distance between endpoint SU 1) and SU
2) = 1.35 3) = 1.24 4) = 1.65 5) = 1.52

Mean absolute distance between endpoint SU 2) and SU
1) = 1.35 3) = 1.47 4) = 1.67 5) = 1.69

X and Y coordinates for a two-dimensional polar ordination:

SU	X	Y
(1)	1.23	1.35
(2)	1.09	0
(3)	1.82	0.91
(4)	0	0.71
(5)	0.55	0.85

Note :

SU (1) = forest site

SU (2) = regenerating gap site

SU (3) = eucalyptus plantation site

SU (4) = mature pine plantation site

SU (5) = young pine plantation site

The X and Y axes of the five sites polar ordination based on percent cover of 197 species are drawn in Figure 5.5.

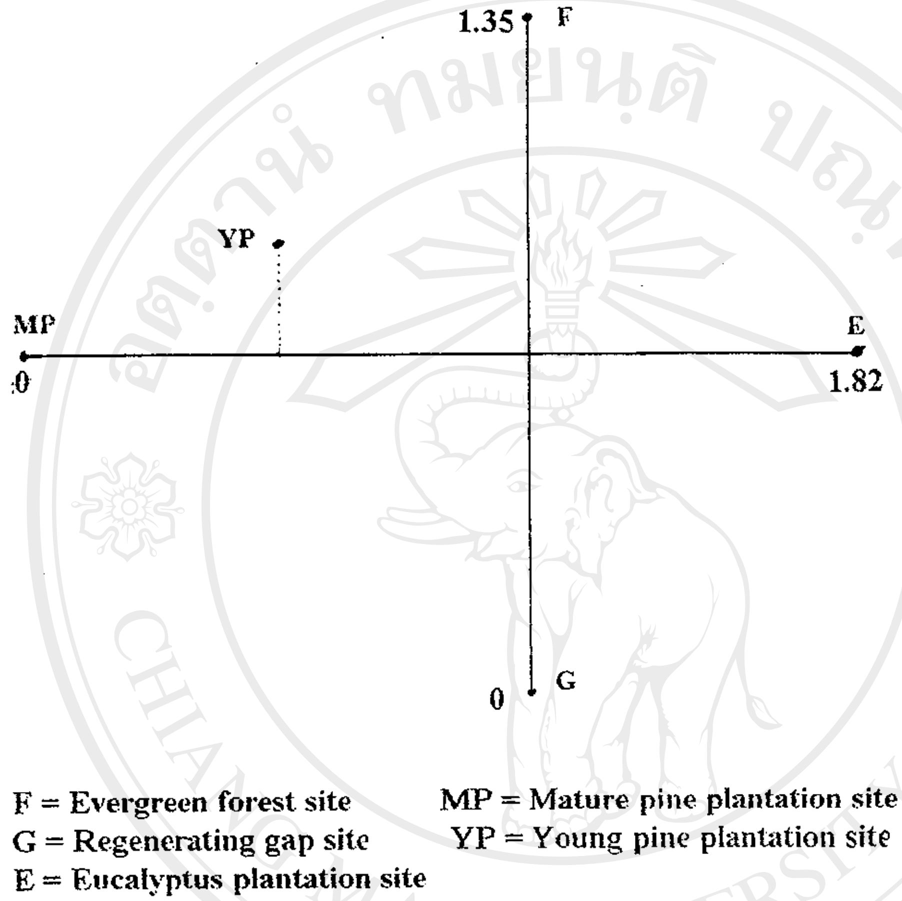


Figure 5.5. The X and Y axes of five sites system units polar ordination based on the percent cover of 197 species.

5.4. Seedling community

A total of 773 tree seedlings were recorded, belonging to 63 species, 47 genera and 31 families. Of about 80% of tree seedling were evergreen tree/treelet and the rest were deciduous tree/treelet. The relative growth rate and mortality of all seedlings were calculated. The list of seedling species found in all five sites is shown in Appendix 6.

The highest average relative growth rate of all tree seedlings occurred in the regenerating gaps, whilst the lowest was in the mature pine plantation. The highest mortality of tree seedlings occurred in the mature pine plantation, whilst the lowest was in the forest site. The highest tree seedling's density occurred in the forest site, whilst the lowest was in the eucalyptus site (Table 5.7).

Table 5.7. Relative Growth Rate (RGR), mortality (%), density (m^{-2}) and number of species of tree seedlings at all five sites.

	FOREST	REG.GAP	EUCALYP	M.PINE	Y.PINE
Relative Growth Rate (RGR)	0.195	0.234	0.021	0.017	0.089
Mortality (%)	3.27	10.40	8.90	15.60	12.71
Density (m^{-2})	3.44	1.34	0.45	1.19	3.25
No. of species	42	24	14	18	35

Note : Reg.gap = regenerating gap M.pine = mature pine plantation
Eucalyp = eucalyptus plantation Y.pine = young pine plantation

5.5. Age-class structure

An age structure of tree seedling at all five sites was shown in Figure 5.6. The forest site, regenerating gap and young pine sites show that regeneration was progressing, indicating the number of young seedlings were dominant. However, the mature pine and eucalyptus plantation sites show that degeneration occurred, indicating the number of adult seedlings were dominant.

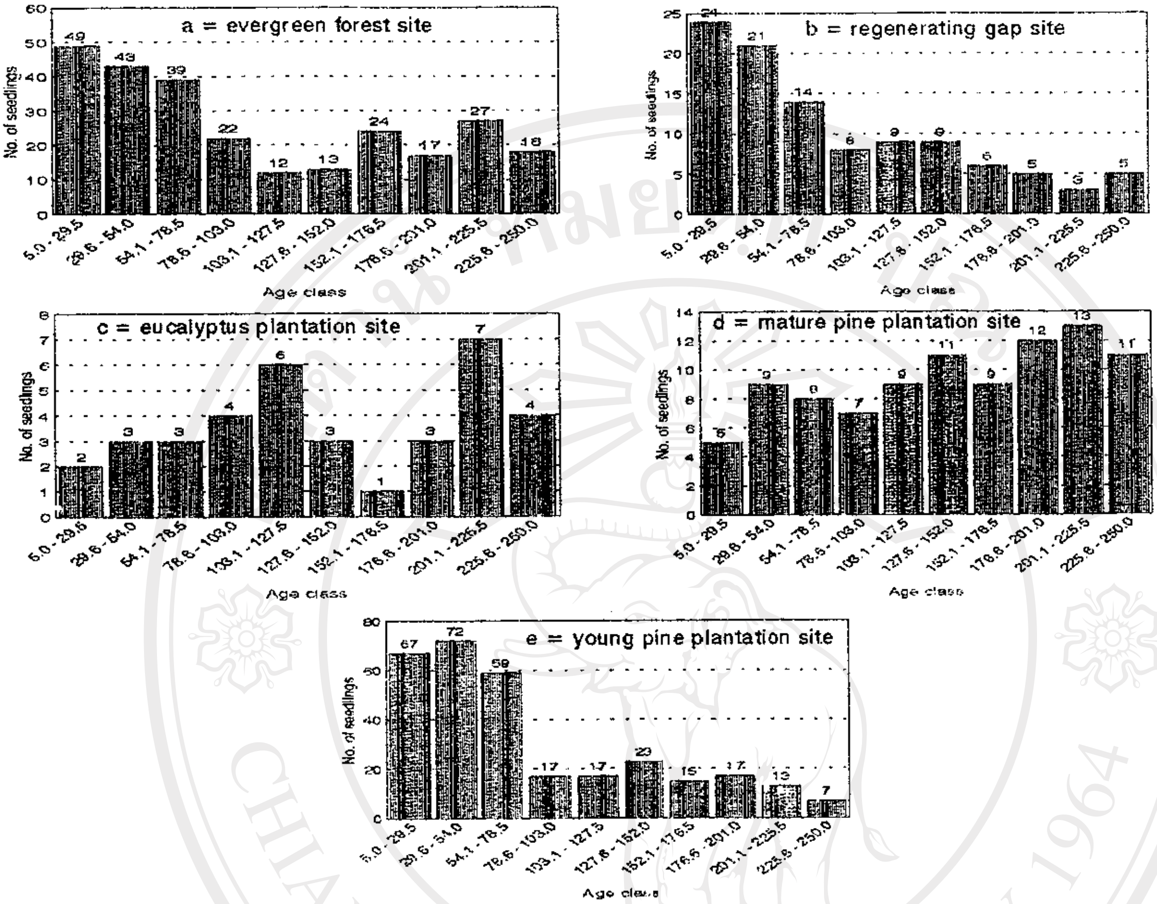


Figure 5.6. Age-class structure of tree seedlings at all five sites.

5.6. Soil Properties

The soil texture was mainly a sandy loam, except in the young pine plantation which was a sandy clay loam. There were highly significant differences in the clay content of the soil texture, while the silt content was not significantly different.

Field capacity in evergreen forest was the highest and significantly higher compared to the other sites. Organic matter content in the evergreen forest was the highest and the lowest was in the young pine plantation. The pH of the soil was about 5.3 - 5.8. The highest pH occurred in the regenerating gap whilst in the mature pine plantation it was the lowest. The nutrient content, especially percent nitrogen in the evergreen forest site, was the highest and significantly different compared to the other sites. However, the potassium content of soil in the regenerating gap was the highest and significantly different compared to the other sites. It was lowest in the mature pine plantation (Table 5.8).

Cluster analysis based on soil parameters, using SPSS (Statistical Packages for Social Sciences), showed that the lowest clustering coefficient was between mature pine and young pine plantation, followed by the regenerating gap and eucalyptus plantation site, and then cluster regenerating gap and eucalyptus plantation site with the evergreen forest site and finally fuse to form one cluster. The lower the coefficient is, the more similar the characteristics of the sites are (Figure 5.7).

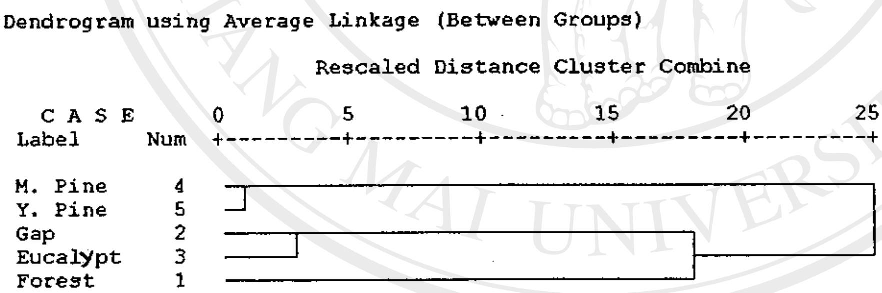


Figure 5.7. Dendrogram showing the clustering of sites using soil parameter.

Linear regression analysis using bivariate analysis showed that soil moisture at field capacity was influenced by organic matter. Of which 99.76% of the variation was accounted for the percent of organic matter. The equation formed from those can be seen as follows: Y = 0.05 (organic matter) + 21.09.

Table 5.8. Mean value of soil properties in all sites from six replications.

Properties	SITE					Level of significance
	FOREST	REG.GAP	EUCALYP	M.PINE	Y.PINE	
Soil texture						
% sand	69.64	63.71	60.34	57.24	56.41	*
% silt	19.59	24.02	22.32	15.76	17.15	ns
% clay	10.77	12.28	17.34	27.00	26.44	**
Nutrients						
% Nitrogen	0.69	0.45	0.46	0.42	0.37	**
Phosphorus (ppm exchangeable)	16.17	15.92	24.00	3.67	8.08	**
Potassium (ppm exchangeable)	116.35	156.03	145.93	32.90	75.45	**
pH	5.72	5.77	5.47	5.26	5.41	**
% organic matter	16.03	9.33	9.45	8.73	7.42	**
% moisture at field capacity	54.87	39.86	39.09	38.98	35.65	**

Notes:

ns = non significant

* = significant difference with 95 % confidence level

** = significant difference with 99 % confidence level

Forest = evergreen forest

Reg.gap = regenerating gap

Eucalyp = eucalyptus plantation

M.pine = mature pine plantation

Y.pine = young pine plantation

5.7. Soil Moisture Content

Figure 5.8 shows that soil moisture content was significantly higher in the evergreen forest than in all other sites (ANOVA, $p<0.05$). The monthly soil moisture content for five sites is shown in Appendix 7.

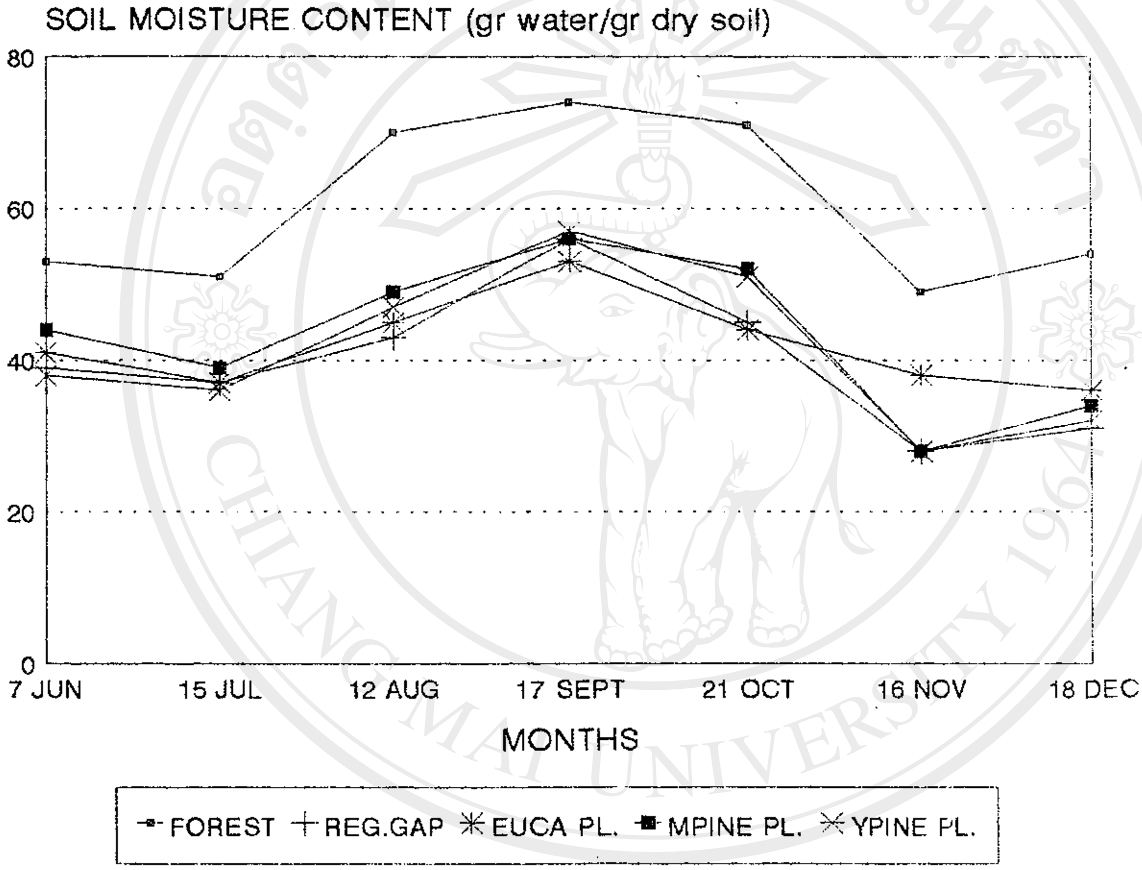


Figure 5.8. Monthly soil moisture content from five different sites

CHAPTER 6.
DISCUSSION

The extensive qualitative survey recorded more species than the intensive quantitative survey did (Table 5.1 and 5.3). This is because the extensive qualitative survey covered all species found growing in each site and additional species recorded during the intensive quantitative survey were added to the research database as part of the qualitative survey's result.

The results showed that the ground flora species composition in the forest site differed from the other sites. This was apparently due to environmental changes which occurred when the natural forest was cleared and converted to plantations. Such enviromental aspects as microclimate, temperature, humidity, precipitation and soil are the most significant factors contributing in changes species composition when the conversion of natural forest to plantations occurred. **Whitmore** (1992) asserted that at least three main reasons why some tropical rain forests are rich in species resulting from: (i) a large stable climatic history in an equiable environment, (ii) a forest canopy provides large number of spatial and temporal niches and (iii) richness results from interactions with animals, mainly as pollinators and dispersers, factors which can not be found in the plantations. In terms of soil nutrient content, especially nitrogen, such changes included a considerable reduction of nutrient reserves available to the vegetation, because of nutrient losses due to fire and cultivation, top soil losses due to heavy rain, opening of the nutrient cycle due to a loss of root-matting and subsequent high leaching rates, rapid reduction of organic matter in the soil resulting in a significant decrease in cation exchange capacity and in mineralized nutrients in erosion of the top layer of soil (**Spurr and Burton**, 1980).

Tables 5.1 and 5.3 show that herbaceous plants dominated the ground flora while shrubs were the most sparse (both in the extensive qualitative and intensive qualitative surveys). Forest supported the highest species composition, whilst the lowest was in the eucalyptus plantation, particularly for deciduous/evergreen vines, which was significantly lower than in the evergreen forest site. Replacement of natural forest with plantations therefore reduces the capacity of an area to support high number of species.

The number of species in common between forest and young pine plantation was the highest, whilst the lowest was between mature pine and eucalyptus plantations (Table 5.2). Presumably the higher the number is, the more similar are the characteristics of the sites. This indicated that the mature pine plantation had a very different species composition compared to the eucalyptus plantation or it can be said that very few species are common between the two sites. In terms of the value of Sorensen's index, the highest similarity was 0.66, between mature and young pine plantations, while the lowest was 0.46, between mature pine and eucalyptus plantations (Figure 5.1). This simply means that mature and young pine plantations had many species in common (shared), while the regenerating gap and mature pine sites had very few common species.

Species/area curves are very useful to determine the minimum area that adequately represents a community. Increasing the number of sample plots increases the number of species recorded. Figure 5.2 shows that, particularly in the forest, mature pine and young pine, species/area curves nearly reached an upper asymptote, indicating that twenty quadrats were almost sufficient to adequately represent the whole community at each site.

The species richness index (for both the extensive qualitative and intensive quantitative surveys) was highest in the forest (Table 5.4). As mentioned **by Ludwig and Reynolds** (1988), species richness is the number of species in the community.

The forest site supported the highest number of species, while the eucalyptus plantation supported the lowest (extensive survey). **Bruenig *et al.*,** (1991) explained that species richness was mainly related to site conditions and the evenness or diversity or mortality, small-scale and medium scale catastrophes, regenerate cycles and long-term successional changes in the vegetation, soil and physiognomy and texture (architecture) of crowns and canopies were expressions of adaptations to physical and other conditions of the site.

Species diversity indices (both N1 and N2) in the forest were the highest, while the lowest were in the eucalyptus plantation which was not very different to the mature pine plantation. It is suggested that both plantations (eucalyptus and mature pine) not only absorbed a lot of water from the soil, but also exuded chemical substances which may have adverse effects on other organisms, including herbaceous plant. **Poore and Fries**, (1988) revealed that certain species of eucalyptus may produce chemicals from their leaves or litter that inhibit the germination or growth of other plant species. Known as allelopathy, this effect is quite different from direct competition for water, minerals or light. Similarly **Del Moral and Muller** (1970) noted that *Eucalyptus camaldulensis* Dehnh. (Myrtaceae) inhibits improved grassland species including *Bromus mollis* L. (Gramineae) and *Lolium multiflorum* Lam. (Gramineae). There was more vegetation under oak, in 45% sunlight, than under the eucalyptus, in 64% sunlight. **Al-Mousawi and Al-Naib** (1975) found a scarcity of herbaceous plants in plantations of *Eucalyptus microtheca* F. Muell. (Myrtaceae) in central Iraq, which was not due to lack of moisture, nutrients or shading; but leaf extracts, decaying leaves and soil inhibited germination and growth of associated species. The volatile inhibitors found were the same as those identified for *Eucalyptus globulus* Labill. (Myrtaceae) by **Del Moral and Muller** (1969). They found that the absence of vegetation beneath *Eucalyptus globulus* Labill. (Myrtaceae) could not be attributed to competition for essential resources, but phytotoxins in fogdrip appeared to be capable of causing this. A number of annual grasses were tested with the solution coming through the canopy.

In contrast, **Chaubey *et al.,*** (1988), conducted a study of the ground flora using quadrats in a range of teak (*Tectona grandis* L. f., (Verbenaceae) plantation in edapho-climatic regions of Madya Pradesh (Nainpur: 1-2, 4-6 and 16-17 year old plantations; and Bijawar: 2-3 and 20-23 year old plantations), and in adjoining natural forests. The importance value indices found in both the plantation sites and their adjacent natural forests were higher in the plantations than in the forest. The total number of ground flora species, total plant density and above-ground biomass were also higher in plantations than in the adjoining natural forests. The community coefficient of similarity between each plantation and its adjoining forests increased with the age of the plantation. Furthermore, **Chaubey *et al.,*** (1988) carried out a comparative studies on floristic composition, species diversity and quantitative ecological parameters (frequency, density, basal area and importance value index (IVI) for each species in teak plantations of different ages and their adjoining natural forests. No discernable differences were found in the floristic composition of tree species under teak plantations and their adjoining forests. Total density (trees/ha) and total basal area (m^2/ha) were also higher in teak plantations than in adjoining natural forests. Most of the common species which were present both in plantations and in natural forests has a higher frequency, density, basal area and IVI in plantations than in adjoining natural forests.

In line with **Chaubey, *et al.*** (1988), **Pande *et al.,*** (1988) carried out a comparative vegetative analysis of some plantation ecosystems at New Forest, Dehra Dun, Uttar Pradesh. Plantations were of *Pinus roxburghii* Sarg. (Pinaceae), *Tectona grandis* L. f. (Verbenaceae), *Shorea robusta* Gaertner f. (Dipterocarpaceae) and *Eucalyptus sp.* (Myrtaceae). Tree density and species richness were highest in the older plantations. Total basal cover ($cm^2/100\ m^2$) was : pine>sal>teak>eucalyptus. Importance value index (IVI) was highest for eucalyptus and sal (both 300 followed by teak and pine in their prespective plantations. On the basis of both density and IVI the greatest diversity was found in the pine plantation, and the least in the eucalyptus plantation. The distribution pattern of different tree species was contagious for all plantations except pine, where it was random. The highest value of dominance concentration were found for sal (*Shorea robusta* Gaertner f., Dipterocarpaceae) and eucalyptus. This is attributed to their monoculture nature. This was apparently because there was no effect of toxic chemical substances resulting from teak trees.

Evenness index in the forest site was the highest (Table 5.4). The higher the evenness index, the more evenly distributed are individuals among species. This simply means that most of the individuals in the forest area are evenly distributed among species or species tend to be equally abundant. However, the evenness index in eucalyptus site was the lowest, indicating that most of the species were rare and few were dominant. In the eucalyptus plantation, *Pogostemon auriculatus* (L.) Hassk. (Labiatae), *Rubus blepharoneurus* Card. (Rosaceae), *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try. (Dennstaedtiaceae), *Ettingera littoralis* (Kon.) Gise (Zingiberaceae) and *Microstegium vagans* (Nees ex Steud.) A. Camus (Gramineae) were abundant. It is suggested that those species are tolerant under eucalyptus trees which exudate chemical substances in its surroundings. However, it was very difficult to conclude that those species were able to grow in the eucalyptus plantation since there is not enough information about this.

In terms of similarities and differences, Chord distance index between young pine plantation and eucalyptus plantation site was the highest. This means that very few species in both sites are shared. However, the lowest CRD index was between the forest site and eucalyptus sites. This means that many species of both sites are shared.

Cluster analysis and ordination showed more or less the same results. Figures 5.4, 5.5 and 5.7 show that mature and young pine plantations were clustered. This means that both sites had a similar characteristic in terms of percent cover coinciding with the similarities of species recorded. However, in the same figures it shows that forest and eucalyptus sites were clustered together. Theoretically, the forest should not be grouped in the same cluster with the eucalyptus plantation since they are different in their capacity to conserve biological diversity as mentioned before (Table 5.4).

Ordination method using mean absolute distance showed that the lowest mean absolute distance was 1.24, between mature and young pine plantations. This value was the same as between forest and eucalyptus sites. This simply means that both sites had similar characteristics in terms of percentage cover and species involved. The highest mean absolute distance was 1.82, between eucalyptus and mature pine plantations (Figure 5.5). This simply means that both sites had no influence or similar characteristics in the effects on the percent cover species recorded.

Table 5.7 shows the relative growth rate (RGR), mortality and density of tree seedlings in all five sites. The RGR in the regenerating gap was the highest, followed by the forest was and the lowest was in the mature pine plantation. Species which grow in the gap were mostly pioneer species. They are able to grow fast under high light intensity, resulting in maximum rate of photosythesis. **Whitmore** (1992) and **Grime** (1979) revealed that early successional species are shade-intolerant (i.e. light demanding) and are photosythetically efficient by virtue of their multilayer foliage canopy which is suitable for high illumination. Such canopies are also selected to be water conservative and, for this reason, early succesion species may persist on shallow or arid soil. **Bazzaz** (1979) reviews evidence for the water efficiency and high maximum photosythesis of early succession herbs and trees.

The highest mortality occurred in the mature pine plantation, while the lowest occurred in the forest site. The characteristic of ground layer in the mature pine was open the canopy sparse so that results in high light intensity passing through to the ground flora. Drought mortality is distictly different from heat injury and can take place after the succulent stage. It will not occur if seedling roots extend themselves rapidly enough to maintain contact with portions of the soil where water is available. This is one reason why shaded seedlings are more likely to die of drought than those growing in the open since seedlings in shaded place have a less extensive/deep root system that exposed one (**Smith**, 1986). In addition, new seedlings are most vulnerable during the first few weeks of their existence, while their stems are still green and succulent. Heat injury resulting from extremely high temperature on surfaces exposed to direct solar radiation takes a heavy toll, particularly among conifers. Cutworms and other insect larvae are particularly active during the beginning of cool season. This was one reason why some of herbs and seedlings died. It was noted that caterpilars and adult insects damaged the leaves of herbs and stems of seedlings, particularly in the young pine plantation, there were a few seedlings of *Schima wallichii* (DC.) Korth (Theaceae) and *Styrax benzoides* Craib (Styracaceae) eaten by caterpillars. In the forest site, *Aerva sanguinolenta* (L.) Bl. (Amaranthaceae), *Thunbergia similis* Craib (Acanthaceae) and *Impatiens violaeflora* Hk. f. (Balsaminaceae) were some herbs that were eaten by caterpillars and insects.

The growth of ground flora species, including tree seedlings in the pine plantation may have been inhibited by the chemicals in pine leaves. The leaves of pine trees in both young and old pine plantations suppress the development of ground flora. The thickness of fallen young pine and old pine leaves was 3-4 cm and 9-11 cm; respectively. In addition, pine leaves take a long time to decompose, exude chemical substances which are able to inhibit the growth of the understorey communities. Besides that, frequent fires in eucalyptus and both pine plantations have resulted in the reduction of the ground cover of ground flora which is even barren in some areas. The same thing may have been happening in the eucalyptus plantation, where very few ground flora and tree seedlings were recorded. Similarly **Bernhard-Reversat** (1982) made a laboratory study of the decomposition of *Eucalyptus camaldulensis* litter. He found that there was abundant litter fall, but that the proportion of the fine material in the surface soil was small; the disappearance and mineralisation of the litter was relatively slow, but mineralisation of carbon continued in old litter; the litter was retained in the soil if there was sufficient clay in it, and there was a reduction of organic matter in the silty-clay fraction of the soil.

Table 5.8 shows that organic matter content in the evergreen forest was the highest and the lowest was in the young pine plantation. The nutrient content, especially percent nitrogen in the evergreen forest was the highest and significantly higher compared to the other sites, eventhough phosphorus and potassium (ppm exchangeable) in the plantations were higher. In plantation site, there was a secondary product from either pine or eucalyptus tree which has a negative impact that even may kill other organisms, whereas in the forest site it was not. It is also the fact that in plantation seed predator and dispersal are absence, resulting in lacking of seed in the soil so that even though in plantation it contains higher phosphorus and potassium (ppm exchangeble), those nutrients will remain in the soil since very few plants may absorb them. This could be explained that the forest site to have the highest species diversity is due to the high nutrient content, especially percent nitrogen in the soil and the absence of toxic substances in its surroundings. However, it is very difficult to conclude since the higher species diversity in some cases, especially in tropical rain forest, can be found on nutrient-poor soil. **Whitmore** (1992) revealed that the most species-rich community is that at an intermediate stage in recovery from disturbance since it contains both pioneer and climax species eventhough it is under the scarcity of nutrients.

One of the paradoxes of tropical rain forest is that however luxuriant rain forest vegetation may appear its presence is not an indication of great fertility of the soil. Rain forest exists on a very small nutrient budget and it survives only by maintaining an almost closed nutrient cycle. The conversion of natural forests to plantations completely disrupted nutrient cycles, especially uptake by plants and from decomposition. In a recent study at Yurimaguas in the Peruvian Amazon it has been found that the biomass of decomposers dropped from 54 to 3 g m^{-1} in the conversion from natural forest to arable agriculture and plantations (**Whitten *et al.*,** 1987). In addition, **Smith** (1986) revealed that if organic materials were allowed to decay naturally, most of the nutrients are ultimately returned to the soil and living organisms. In the meantime, they remain unavailable to the vegetation. Substantial amounts of nitrogen remain bound away in the body proteins of the microorganisms responsible for the final decay. If this kind of dead organic decay takes place, some of the energy stored in them goes to nourish the large and small organisms that churn it and are chiefly responsible for maintaining its good physical properties. The concomitant incorporation of organic matter in the mineral soil is important in maintaining the capacity of the soil to hold water, oxygen and nutrients. Unfortunately, I did not find any references about a direct relationship between organic matter content and species diversity. However, **Chiras** (1991) explained that by increasing human desires, natural forests converted to other land uses, cultivation and plantations for example, brought the reduction up to 50% or even more of the soil capacity to support biological diversity. This is because most of the plantations are open ground so if the rain does come, water falls down on through the soil surface and soil nutrients are washed away and the land gradually become useless. Therefore, the capacity of the soil to conserve various species in the area goes down dramatically, the only plants that can grow are ones which are tolerant to poor soil content.

In the pine plantation site there was evidence of frequent fires. Fire can directly or indirectly influence the growth of the ground flora and seedling communities. If fire occurs the ground flora, including tree seedlings and soil organisms are often killed. **Smith** (1986) explained that if dead organic matter is burnt, its stored energy goes mostly to heat the air and stored chemical nutrients are released. Some nitrogen compounds are volatilized and lost into the atmosphere. Most of the nutrient elements that are of essentially mineral origin are returned to the soil in a more readily available form than before. It is possible for some chemical nutrients, especially nitrates, nitrogen and potassium, to be made mobile enough by burning to accelerate loss by leaching and surface runoff.

Figure 5.6 shows that in the young pine plantation, forest and the regenerating gap regeneration was progressing where the number of young tree seedlings were higher than adult tree seedlings. However, in the fourth class-age, there were few tree seedlings present. It was, therefore, assumed that fire had occurred in the area, including the forest site. In contrast, in the mature pine and eucalypt plantations, it indicated that degeneration was occuring since the number of young tree seedlings was lower than adult tree seedlings. **Smith** (1986) explained that the profile of a stand is a good criterion of age distribution because trees of the same age grow in height at roughly the same rate, provided site condition are uniform; those that do not keep pace are suppressed and disappear. An uneven-aged stand is usually distinctly irregular in height; the greater the number of age classes, the more uneven the canopy. A stand is a contiguous group of trees sufficiently uniform in species composition, arrangements of age classes, and condition to be a distinguishable unit. The internal structure of stands varies mainly with respect to the degree that different species and age classes are intermingled. The simplest kind of structure in exemplified by that of the pure, even-aged plantation consisting of trees of single species. The range of complexity can extend to a wide variety of combinations of age classes and species in various vertical and horizontal arrangements.

The fluctuation of the number of tree seedlings for each age-class structure is affected by many factors. True regeneration cuttings and natural lethal disturbances of similar magnitude determine the times when new trees appear or start active development on any given unit of ground area. Each new aggregation of tree seedlings so produced is an age class of trees all of essentially the same age. Differences in timing of regenerative events create various spatial patterns of age classes. The area occupied by a given age class can be of any size, provided that it is large enough that some new trees can continue to grow in height without being arrested by the expansion of the crowns of older adjacent trees.

Variation of soil moisture mainly depends on rainfall. The higher, the rainfall is, the higher, the soil moisture content is. All monthly soil moisture records showed that the forest site had the highest soil moisture content, significantly higher than those of the other sites (Figure 5.8). **Suwannaratana** (1994) asserted that soil moisture content is one of the most important factors affecting the structure and species composition of forests.

In this study, most soil properties were significantly different among sites, except silt content. The soil texture is mainly a sandy loam, except in the young pine plantation which was a sandy clay loam. Field capacity in the evergreen forest was the highest and significantly higher compared to the other sites. However, the potassium content of soil in the regenerating gap was the highest while the lowest was in the mature pine plantation (Table 5.8). **Jammet** (1975) made a comparison between pine and eucalypt plantation (*Eucalyptus camaldulensis* Dehnh., *E. saligna* Sm. and *E. platyphylla* sp. (Mystaceae) and a unnamed species of pine) on sandy soils at Pointe Noire on the coastal plain of the People's Republic of Congo. The soils were weakly acid with a low clay fraction and poor in organic matter. There was better humification under the eucalyptus plantation a reduction of calcium and weak acidification under both, but especially under the pines where there was also a tendency of podzolisation.

Extensive plantations of fast growing tree species, including eucalyptus and pines will reduce the water yield in a region. By growing quickly, they consume much ground water and they may affect soil fertility under certain circumtances (**FAO**, 1988). Pine and eucalypt plantations have a high water usage per unit time, and this is consistent with their high rate of growth. One interesting observation made during the study was the changes in abundance for a perennial fern, *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try. (Dennstaedtiaceae) in the regenerating gap and in the young pine plantation. This species is abundant in the beginning of the cool season and died off at the middle of cool season, after that they grew up again near the end of cool season. It was assumed that the fluctuation of percent cover was due to the availability of water in the soil.

Another interesting observation was of *Clitoria mariana* L. (Leguminosae, Papilionoideae) growing in the mature pine plantation. This was abundant from August to October 1994, but in December 1994, it died off completely. After fruiting, it completed it's cycle since it is a deciduous herb. At the same site, *Piloselloides hirsuta* (Forssk.) C. Jeff. (Compositae) was herb which found on June 1994. This herb has a tap-root which was able to regrow, especially after fire occurred. In the regenerating gap, *Shuteria involucrata* (Wall.) Wight & Arn. (Leguminosae, Papilionoideae) and *Eupatorium adenophorum* Spreng. (Compositae) were abundant during the study.

Melastoma normale D. Don var. *normale* (Melastomataceae), an evergreen treelt, was found at all five sites and it was abundant in the regenerating gap. This species can be used for indicator of forest after disturbance. The fact that this species is commonly found in the area after the forest was cleared. This is partly because the soil has lost nutrients and becomes more acid and compacted. (**Whitmore**, 1992). It was found in the Philippines that *Trema orientalis* (L.) Bl. (Ulmaceae) restores phosphorus and *Melastoma cf. polyanthum* (Melastomataceae), restores potassium to the above ground biomass. This is presumably one reason that in the regenerating gap, it contains higher potassium in the soil.

Pine seedlings were few in the middle of the cool season but most of them died off at the end of this season because of environmental factors, e.g. pathogen and insect damage. In the young pine plantation, many young seedlings of *Styrax benzoides* Craib (Styracaceae) and *Schima wallichii* (DC.) Korth. (Theaceae) were common in the beginning of the cool season, and up to the end of this study a few seedlings can still be found. In the regenerating gap and forest, there were a few seedlings growing such as *Engelhardia serrata* Bl. and *E. spicata* Lechen. ex Bl. var. *colekrookeana* (Ldl. ex Wall.) O.K. (Juglandaceae), *Castanopsis tribuloides* (Sm.) A. DC. (Fagaceae), *Helicia nilagirica* Bedd. (Proteaceae), *Albizia odoratissima* (L. f.) Bth. (Leguminosae, Mimosoideae), *Vaccinium sprengelii* (D. Don.) Sleum. (Ericaceae), and *Wendlandia tinctoria* (Roxb.) DC. ssp. *floribunda* (Craib) Cowan (Rubiaceae). Most of them were found under the shade of *Eupatorium adenophorum* Spreng. (Compositae), especially in the regenerating gap. Figure 5.9 shows the seedling of *Engelhardia serrata* Bl. (Juglandaceae) growing healthy under the shade of *Eupatorium adenophorum* Spreng. (Compositae) which was found in the regenerating gap. The density of seedlings was quite low, even though in general the relative growth rate (RGR) was higher compared to other sites. I would recommend that these species be used for reforestation project.

Figure 5.9. Seedling of *Engelhadia serrata* Bl. (Juglandaceae) growing under the shade of *Eupatorium adenophorum* Spreng. (Compositae) in the regenerating gap site.

CHAPTER 7.
CONCLUSION AND RECOMMENDATION

Species richness, species diversity and evenness at the forest site were the highest, whilst the lowest was in the eucalyptus plantation. The highest occurred between the mature and young pine plantations, whilst the lowest was between the regenerating gap and eucalyptus plantation. In terms of CRD value, in the forest and eucalyptus site it was the lowest. This means that the eucalyptus plantation had a very low capacity to support a ground flora and tree seedlings.

The gap showed signs of healthy regeneration, since it supported a few tree seedlings of both pioneer and climax trees with the highest relative growth rate, even though the density of tree seedlings was low. In this case, human intervention is needed to accelerate reforestation of the gap. In line with the above result, the age-class structure gave the same indication, that regeneration was progressing in the gap.

Soil properties for all five sites were very similar. Soil texture was mainly clay loam, except in young pine plantation where it was sandy clay loam. Nutrient content (nitrogen, phosphorus and potassium) differed significantly amongst sites ($P < 0.05$). Soil moisture content in the forest was significantly higher compared to other sites, while among the other four sites there were no significant differences. Organic matter was highly correlated with soil moisture content at field capacity ($P < 0.05$).

Changes in land use from natural forest to plantations, affects a site's capacity to support a diverse ground flora. The reduction in species number, species diversity and evenness of the ground flora and tree seedling community was the evidence that plantations are not adequate substitutes for natural forest in terms of conserving biological diversity.

In the case of Doi Suthep-Pui National Park it would be better not to have more plantation of either eucalyptus or pine. Eucalyptus trees had a more severe negative impact than pine trees on the ground flora and tree seedling community, especially the mature pine plantation. The existing eucalyptus trees within the National Park could be systematically replaced by plantations of various indigenous tree species.

Some tree seedlings found in the forest and the regenerating gap are recommended for planting in reforestation programmes even though they grow slowly. Such species are: *Castanopsis tribuloides* (Sm.) A. DC. (Fagaceae), *Styrax benzoides* Craib (Styracaceae), *Engelhardia serrata* Bl. and *E. spicata* Lechen. ex Bl. var. *colebrookeana* (Ldl. ex Wall.) O.K. (Juglandaceae), *Albizia odoratissima* (L. f.) Bth. (Leguminosae, Mimosoideae), *Schima wallichii* (DC.) Korth. (Theaceae), *Vaccinium sprengelii* (D. Don) Sleum. (Ericaceae) and *Helicia nilagirica* Bedd. (Proteaceae). Unfortunately, in the hot/dry season due to high light intensity, many seedlings dry up, especially the leaves of seedlings, but a few healthy seedlings under herbaceous plants or shrubs in the gap can still be found. Therefore, it is necessary to do more research concerning indigenous tree species, focusing on the effect of shading on the growth of tree seedlings in the nursery and/or in the field. So I suggest to use those species to replace both eucalyptus and pine plantations if we would like to achieve the main objective of National Parks which is to conserve the highest biological diversity.

Most results showed that the forest site was the best for most parameters concerned, while the least was in plantation, especially in eucalyptus plantation site.

If we have the choice, we should choose not to have such plantations in national parks. However, if we must have plantations in national parks young pine trees are better than eucalyptus to preserve biological diversity. To allow best regeneration of forest trees, a pine plantation could be used for the early stages of regeneration, but after that the pines should be selectively cut down to allow the tree seedlings and saplings to grow naturally.

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APPENDIX

APPENDIX 1. Species/area curves and Cluster Analysis

a). Species/area Curves

In this study the species/area curves was constructed from the percentage cover which can not be used to calculate the normal species/area curves. This is due to the difficulties to calculate the number of individual for each species. Species/area was used to determine the minimal area plotted or a suitable quadrat size (**Goldsmith and Harrison, 1976**). The formula used in this study was modified to use the frequency of occurrence of each species in quadrat.

When : Q = Number of total quadrat

n = Number of quadrat contain species S

S = Summary of the probability of all species absence

PAqS = Probability of species A in X quadrat

PBqS = Probability of species B in X quadrat.

The probability to have species A in X quadrat can be calculated by :

$$PAq1 = 1 - \frac{Q - n - 0}{Q - 0}$$

$$PAq2 = 1 - \left\{ \frac{Q - n - 0}{Q - 0} \times \frac{Q - n - 1}{Q - 1} \right\}$$

$$PAqm = 1 - \left\{ \frac{Q-n-0}{Q-0} \times \frac{Q-n-1}{Q-1} \times \ldots \times \frac{Q-n-(m-1)}{Q-(m-1)} \right\}$$

Sum (probability of absence) = PAqx + PBq + ... + PZ

The expected number of species in n quadrat (N)

N = S - Sum (probability of absence)

APPENDIX 1. (Continued)

b). Cluster Analysis

In this study the index of cluster used was cosine of vectors of variables. The subunits will be projected onto a circle of unit radius through the use of direction cosine. The index can be calculated with the formula below:

$$\text{Cosine} = \frac{\sum_{n=1}^{S} (X_i Y_i)}{\sum_{n=1}^{S} X_i^2 . \sum_{n=1}^{S} Y_i^2}$$

After the first calculation the most similar subunits will be grouped together and form the artificial subunit. The similar between all units will then be calculated again and the most similar will be put together. This cycle will be done until all subunits be grouped together.

APPENDIX 2. List of ground flora and tree seedlings in all five sites
The result of Extensive Qualitative Survey.

Botanical name	**Family**	**Habit***	**Site ****
Actinidia rubricaulis Dunn	Actinidiaceae	ewc	f g
Aeginetia indica Roxb.	Orobanchaceae	h	f
Aerva sanguinolenta (L.) Bl.	Amaranthaceae	h	f g e p y
Afgekia filipes (Dunn) Gees.	Leguminosae, Papilionoideae	dwc	f g
Ageratum conyzoides L.	Compositae	h	f g e p
Albizia odoratissima (L. f.) Bth.	Leguminosae, Mimosoideae	dt	f p y
Alpinia blepharocalyx K. Sch.	Zingiberaceae	h	f g e y
Antidesma acidum Retz.	Euphorbiaceae	etlt	f p y
Amorphophallus yunnanensis Engl.	Araceae	h	f g e y
Apodytes dimidiata E. Mey. ex Arn.	Icacinaceae	det	g
Aporusa villosa (Lindl.) Baill.	Euphorbiaceae	detlt	f p y
Archidendron clypearia (Jack)			
ssp. *clypearia* var. *clypearia*	Leguminosae, Mimosoideae	et	f p y
Archidendron glomeriflorum (Kurz)	Leguminosae,Mimosoideae	et	f y
Argyreia capitiformis (Poir.) Oost.	Convolvulaceae	ev	f g e y
Argyreia henryi (Craib) Craib	Convolvulaceae	ev	y
Argyreia obtecta (Choisy) Cl.	Convolvulaceae	ev	y
Arisaema album N.E. Br.	Araceae	h	f g
Arisaema cuspidatum (Roxb.) Engl.	Araceae	h	f e p y
Aschynanthus hosseusii Pell.	Gesneriaceae	es	f
Aspidistra longifolia Hk. f.	Liliaceae	h	f e
Bauhinia ornata Kurz var.			
S.S. Lar.	Leguminosae,Caesalpinoideae	dwc	f g
Beilschmeidia sp.	Lauraceae	et	f g
Betula alnoides B.-H.	Betulaceae	et	f g e
Bidens pilosa L. var. *minor* (Bl.)	Compositae	h	e y
Blumea balsamifera (L.) DC.	Compositae	h	f g e p y
Boehmeria diffusa Wedd.	Urticaceae	etlt	f
Borreria alata (Aubl.) DC.	Rubiaceae	h	f g p
Borreria laevis (Lmk.) Griseb.	Rubiaceae	h	f g p y
Borreria repens DC.	Rubiaceae	h	f
Bridelia pubescens Kurz	Euphorbiaceae	h	y
Caesalpinia cucullata Roxb.	Leguminosae, Caesalpinoideae	ewc	f
Cajanus goensis Dalz.	Leguminosae, Papilionoideae	ev	f g e p y
Calamus kerrianus Becc.	Palmae	ewc	f

Canarium subulatum Guill.	Burseraceae	det	f
Castanopsis diversifolia King ex	Fagaceae	et	f g e p y
Castanopsis tribuloides (Sm.) A.	Fagaceae	et	f
Celosia argantea L.	Amaranthaceae	h	g
Cheilanthes tenuifolia (Burm. f.)	Parkeriaceae	h	p
Cissus discolor Bl. var. *discolor*	Vitaceae	ev	f p y
Cissus repens Lmk.	Vitaceae	ev	e
Clematis acuminata DC. var.			
sikkimensis Hk. f. & Th.	Ranunculaceae	ev	f
Clerodendrum glandulosum Colebr.	Verbenaceae	etlt	g e y
Clerodendrum infortunatum Craib	Verbenaceae	etlt	e
Clerodendrum serratum (L.) Spr.			
wallichii Cl.	Verbenaceae	etlt	f
Clitoria mariana L.	Leguminosae, Papilionoideae	ev	f g e p y
Codonopsis javanica (Bl.) Hk. f.	Campanulaceae	ev	f e p y
Coloasia fallax Schott	Araceae	h	y
Commelina diffusa Burm. f.	Commelinaceae	h	f g e p y
Commelina paludosa Bl.	Commelinaceae	h	f g y
Conyza japonica (Thunb.) Less. ex	Compositae	h	f g e y
Conyza sumatrensis (Retz.) Walk.	Compositae	h	f e
Costus speciosus (Koeh.) J.E. Sm.	Zingiberaceae	h	f e p
Crassocephalum crepidoides (Bth.) S.	Compositae	h	e p y
Crepis chloroclada Coll. & Hemsl.	Compositae	h	f y
Crotalaria alata D. Don	Leguminosae, Papilionoideae	ev	f p y
Crotalaria albida Hey. ex Roth	Leguminosae, Papilionoideae	h	p y
Crotalaria kurzii Baker ex Kurz	Leguminosae, Papilionoideae	h	y
Cruddasia insignis Prain	Leguminosae, Papilionoideae	h	f g p y
Curculigo capitulata (Lour.) O.K.	Hypoxidaceae	h	f g e p y
Curcuma aff. comosa Roxb.	Zingiberaceae	h	f y
Curcuma ecomata Craib	Zingiberaceae	h	f g e p
Curcuma zedaria (Berg.) Rosc.	Zingiberaceae	h	f p
Cyclea polypetala Dunn	Menispermaceae	ev	f g e y
Cynodon dactylon (L.) Pers.	Gramineae	h	f g e p
Cyperus brevifolius (Rottb.) Hassk.			
var. *brevifolius*	Cyperaceae	h	f p y
Cyperus killingiana Endl.	Cyperaceae	h	f g e p y
Cyperus nutans Vahl var. *nutans*	Cyperaceae	h	p y
Cyrtococcum accrescens (Triw.)	Gramineae	h	y
Cyrtococcum oxyphylum (Steud.)	Gramineae	h	f g p y
Dalbergia fusca Pierre	Leguminosae, Papilionoideae	dt	f y

Dalbergia stipulacea Roxb.	Leguminosae, Papilionoideae	dwc	p y
Debregeasia longifolia (Burm. f.)	Urticaceae	etlt	f g
Dendrobium compactum Rol. ex W.	Orchidaceae	h	f
Desmodium repandum (Vahl) Merr.	Leguminosae, Papilionoideae	h	f g e p y
Dianella ensifolia (L.) DC.	Liliaceae	h	f g e
Dichrocephala integrifolia (L. f.)	Compositae	h	p y
Digitaria setigera Roth ex Roem. &			
Schult. var. *setigera*	Gramineae	h	g p
Dillenia aurea Sm. var. *aurea*	Dilleniaceae	det	e p y
Dioscorea alata L.	Dioscoreaceae	ev	y
Dioscorea bulbifera L.	Dioscoreaceae	ev	p y
Dioscorea decipiens Hk. f.	Dioscoreaceae	ev	f g e p y
Dioscorea glabra Roxb. var. *glabra*	Dioscoreaceae	ev	p y
Dioscorea membranacea Pierre ex Prain &	Dioscoreaceae	ev	e
Dioscorea pentaphylla L. (? var.			
Prain & Burk.)	Dioscoreaceae	ev	f g p y
Diospyros glandulosa Lace	Ebenaceae	et	f
Dischidia major (Vahl) Merr.	Asclepiadaceae	h	f
Disporum calcaratum Wall. ex D. Don.			
rubiflorum Gagnep	Liliaceae	h	f e p y
Drymaria diandra Bl.	Caryophylaceae	h	e p y
Elephantopus scaber L. var. *scaber*	Compositae	h	y
Elscholtzia blanda Keng	Labiatae	h	g
Embelia stricta Craib	Myrsinaceae	dwc	f g y
Engelhardia serrata Bl.	Juglandaceae	dt	f g y
Engelhardia spicata Lechen. ex Bl.			
var. *colebrookeana* (Ldl. ex Wall.)	Juglandaceae	dt	f g
Eragrostis nigra Nees ex Steud.	Gramineae	h	f y
Ettingera littoralis (Kon.) Gise.	Zingiberaceae	h	e
Eucalyptus camaldulensis Dehnh.	Myrtaceae	et	e
Eugenia albiflora Duth. ex Kurz	Myrtaceae	et	f y
Eugenia fruticosa (DC.) Roxb.	Myrtaceae	et	f
Eugenia subviridis Craib	Myrtaceae	et	f g e y
Eugenia tetragona Wight	Myrtaceae	et	f g e y
Euodia triphylla DC.	Rutaceae	etlt	f
Eupatorium adenophorum Spreng.	Compositae	h	f g e p y
Eupatorium odoratum L.	Compositae	h	g e y
Fagerlindia sp.	Rubiaceae	es	f p y
Ficus hispida L. f. var. *hispida*	Moraceae	detlt	e p y
Placourtia indica (Burm. f) Merr.	Flacourtiaceae	dt	e y

Flemingia sootepensis Craib	Leguminosae, Papilionoideae	detlt	f g e p y
Galinsoga parviflora Cav.	Compositae	h	f g
Globba clarkei Baker	Zingiberaceae	h	f g e
Glochidion eriocarpum Champ.	Euphorbiaceae	et	f p y
Gnetum montanum Mgf.	Gnetaceae	ewc	f
Gomphostemma lucidum Wall. ex	Labiatae	h	f g e p y
Gynura longifolia Kerr	Compositae	h	f g e
Hedyotis auricularia L.	Rubiaceae	h	p y
Hedyotis tenelliflora Bl. var.	Rubiaceae	h	f g p y
Hedyotis vestita R. Br. ex G. Don	Rubiaceae	h	f
Helicia nilagirica Bedd.	Proteaceae	et	f p y
Heliciopsis terminalis (Kurz) Sleum.	Proteaceae	et	f g y
Hydrocotyle siamica Craib	Umbelliferae	h	f e
Hypopithys lanuginosa Rafin.	Ericaceae	h	p
Hypoxis aurea Lour.	Hypoxidaceae	h	f g y
Impatiens violaeflora Hk. f.	Balsaminaceae	h	f e
Imperata cylindrica (L.) P. Beauv.			
var. *major* (Nees) C.E. Hubb. &	Gramineae	h	f g e p y
Indigofera dousa B.-H. ex D. Don	Leguminosae, Papilionoideae	es	f
Inula cappa (Ham. ex D. Don) DC. *forma*	Compositae	h	f p y
Jasminum nervosum Lour.	Oleaceae	ev	g
Kuniwatsukia cuspidata (Bedd.)	Athyriaceae	h	f g e p y
Lantana camara L.	Verbenaceae	es	f
Leea indica (Burm. f.) Merr.	Leeaceae	dtlt	f g e p y
Lepidagathis incurva Ham. ex D.	Acanthaceae	h	f e y
Lespedeza parviflora Kurz	Leguminosae, Papilionoideae	etlt	f p y
Liparis siamensis Rol. ex Dow	Orchidaceae	h	f
Litsea cubeba (Lour.) Pers.	Lauraceae	etlt	f g e
Litsea sp.	Lauraceae	etlt	f
Lygodium flexuosum (L.) Sw	Schizocaceae	ev	p y
Macaranga denticulata (Bl.) M.-A	Euphorbiaceae	etlt	f e y
Maesa montana A. DC.	Myrsinaceae	etlt	f
Malaxis orbicularis (W.W. Sm. & J. F.			
Tang & Wang	Orchidaceae	h	f p
Markhamia stipulata (Wall.) ex			
stipulata	Bignoniaceae	det	y
Melastoma normale D. Don var.	Melastomataceae	etlt	f g p y
Melodorum oblongum Craib	Annonaceae	sh	g
Micromelum minutum (Forst. f.) Wight	Rutaceae	etlt	f g
Microstegium vagans (Nees ex Steud.) A.	Gramineae	h	f g e p y

Millettia pachycarpa Bth.	Leguminosae, Papilionoideae	dwc	f g
Millettia pubinervis Kurz	Leguminosae, Papilionoideae	dwc	f
Mimosa pudica L. var. *hispida* Bren.	Leguminosae, Mimosoideae	h	f p y
Mucuna macrocarpa Wall.	Leguminosae, Papilionoideae	ewc	f g e y
Murdannia loureiri (Hance) Rao &	Commelinaceae	h	p y
Musa acuminata Colla	Musaceae	h	g e
Mussaenda parva Wall. ex G. Don	Rubiaceae	ewc	f
Mussaenda sanderiana Ridl.	Rubiaceae	es	f g e p y
Olea salicifolia Wall. ex G. Don	Oleaceae	det	f g e p y
Ophiopogon intermedius D. Don	Liliaceae	h	f g
Osbeckia stellata Ham. ex Ker-			
var. *marginulata* (Cl.) C. Han	Melastomataceae	etlt	p y
Oxalis corniculata L.	Oxalidaceae	h	g e y
Palaquium garrettii Flet.	Sapotaceae	et	f y
Pachyrhizus erosus (L.) Urb.	Leguminosae, Papilionoideae	h	f
Parthenocissus semicordata (Wall.)	Vitaceae	h	f e
Paspalum conjugatum Berg.	Gramineae	h	f g e p y
Passiflora siamica Craib	Passifloraceae	ev	e y
Pavetta fruticosa Craib	Rubiaceae	ds	f p y
Peliosanthes teta Andr. ssp. *humilis* (Andr.)	Liliaceae	h	f
Pennisetum purpureum Schumach.	Gramineae	h	g p y
Peristylus constrictus (Lindl.) Lindl.	Orchidaceae	h	f
Phoebe aff. cathia (D. Don)	Lauraceae	et	p y
Phoebe lanceolata (Nees) Nees	Lauraceae	et	f g p y
Phoebe sp. (A)	Lauraceae	et	f g
Phoebe sp. (B)	Lauraceae	et	p
Phragmites vallatoria (Pluk. ex L.)	Gramineae	h	f g e y
Phyllanthus emblica L.	Euphorbiaceae	det	p y
Phyllanthus sootepensis Craib	Euphobiaceae	det	p y
Pilea trinervia Wight	Urticaceae	h	f
Piloselloides hirsuta (Forssk.) C.	Compositae	h	p y
Pinus kesiya Roy. ex Gord.	Pinaceae	et	f p y
Planchonella punctata Flet.	Sapotaceae	et	f
Plantago major L.	Plantaginaceae	h	f y
Plectranthus coetsa B.-H. ex G.	Labiatae	h	g
Plectranthus ternifolius D. Don	Labiatae	h	p
Pogostemon auriculatus (L.) Hassk.	Labiatae	h	f g e
Pollia haskarlii R. Rao	Commelinaceae	h	f g y
Polygonum barbatum L.	Polygonaceae	h	f
Polygonum chinense L.	Polygonaceae	h	f g e p y

Portulaca oleracea L.	Portulaceae	h	e
Pouzolzia hirta Hassk.	Urticaceae	h	f g y
Pouzolzia pentandra (Roxb.) Benn.	Urticaceae	h	e
Pouzolzia zeylanica (L.) Benn.	Urticaceae	h	f g p y
Pratia begoniifolia (Wall. ex Roxb.)	Campanulaceae	h	y
Prunus cerasoides D.Don	Rosaceae	det	g
Pteridium aquilinum (L.) Kuhn ssp.			
aquilinum var. *wightianum* (Ag.)	Dennstaedtiaceae	h	f g e p y
Pteris biaurita L.	Pteridaceae	h	f
Pteris vittata L.	Pteridaceae	h	y
Pterospermum acerifolium Willd.	Sterculiaceae	det	f
Pueraria imbricata Maes.	Leguminosae, Papilionoideae	ev	f g e
Pueraria stricta Kurz	Leguminosae, Papilionoideae	ds	f y
Rauvolfia ophiorrhizoides (Kurz)	Apocynaceae	etlt	f
Rhus chinensis Mill.	Anacardiaceae	dtlt	f p y
Rourea minor (Gaertn.) Leenh. ssp.	Connaraceae	ewc	g
Rubus blepharoneurus Card.	Rosaceae	ev	f g e p y
Saccharum arundinaceum Retz.	Gramineae	h	g e
Sacciolepis indica (L.) Chase	Gramineae	h	e p
Sapindus rarak DC.	Sapindaceae	det	g
Saurauia nepalensis DC.	Sauraliaceae	h	y
Schima wallichii (DC.) Korth	Theaceae	et	f p y
Scleria reticulata (Holtt.) Kern	Cyperaceae	h	f e
Scleria terrestris (L.) Fass.	Cyperaceae	h	f g e p y
Semecarpus cochichinenses Engl.	Anacardiaceae	h	y
Setaria palmifolia (Koen.) Stapf var.	Gramineae	h	f g e
Setaria parviflora (Poir.) Kerg.	Gramineae	h	g e p
Shuteria involucrata (Wall.) Wight	Leguminosae, Papilionoideae	ev	f g e p
Sida rhombifolia L. ssp. *rhombifolia*	Malvaceae	h	f g
Smilax corbularia Kunth ssp.	Smilacaceae	ev	f p
Smilax lanceifolia Roxb.	Smilacaceae	ev	f e
Smilax ovalifolia Roxb.	Smilacaceae	ev	f g e p y
Smilax verticalis Gagnep.	Smilacaceae	ev	f y
Smilax zeylanica L. ssp. *hemsleyana*			
(Craib) T. Koy.	Smilacaceae	ev	g
Solanum barbisetum Nees	Solanaceae	h	g y
Solanum macrodon Wall. ex Nees	Solanaceae	sh	e
Sonerila kerrii Craib	Melastomataceae	h	p
Sonerila nisbetiana Craib	Melastomataceae	h	p y
Spatholobus floribundus Craib	Leguminosae, Papilionoideae	ewc	f

Stemona sp.	Stemonaceae	v	f g
Sterculia ornata Wall. ex Kurz	Sterculiaceae	det	f
Stereospermum colais (B.-H. ex Dillw.)	Bignoniaceae	det	y
Streptocendron juventas (Burm. f.)	Asclepiadaceae	ev	y
Styrax benzoides Craib	Styracaceae	et	f g e p y
Synedrella nodiflora (L.) Gaertn.	Compositae	h	f
Tetrastigma sp.	Vitaceae	ewc	f g e y
Themeda triandra Forssk.	Gramineae	h	f g p y
Thunbergia geoffrayi R. Ben.	Acanthaceae	ev	p
Thunbergia similis Craib	Acanthaceae	etlt	f g e p y
Thysanolaena latifolia (Roxb.) ex Horn.)	Gramineae	h	g e y
Trema orientalis (L.) Bl.	Ulmaceae	etlt	g
Trevesia palmata (Roxb.) Vis.	Araliaceae	et	f g
Triumfetta pilosa Roth.	Tiliaceae	h	f y
Triumfetta rhomboidea Jacq. (*T.)*	Tiliaceae	h	f
Turpinia pomifera (Roxb.) Wall. ex	Staphyleaceae	et	f
Urena lobata L. ssp. *lobata* var.	Malvaceae	h	f g e p y
Vaccinium apricum Flet.	Ericaceae	etlt	f y
Vaccinium sprengelii (D. Don)	Ericaceae	etlt	f p y
Vernonia sutepensis Kerr	Compositae	h	f g e y
Vernonia volkameriifolia DC. var.	Compositae	etlt	f g p y
Vigna dalzelliana (O.K.) var.	Compositae	ev	y
Vigna radiata (L.) Will.	Leguminosae, Papilionoideae	ev	f g y
Viola pilosa Bl.	Violaceae	h	f
Wendlandia paniculata (Roxb.) DC.	.		
scabra (Kurz) Cowan	Rubiaceae	etlt	y
Wendlandia tinctoria (Roxb.) DC.			
ssp. *floribunda* (Craib) Cowan	Rubiaceae	etlt	f g y
Xeuxine affinis (Lindl.) Bth. ex Hk.	Orchidaceae	h	f
Zanthoxyum acanthopodium DC.	Rutaceae	etlt	f g e
Zingiber kerrii Craib	Zingiberaceae	h	f p
Zingiber smilesianum Craib	Zingiberaceae	h	f g e p y
UNKNOWN HERB		h	f g
UNKNOWN SEEDLING (A)			g
UNKNOWN SEEDLING (B)			f g
UNKNOWN SEEDLING (C)			f
Note : (*)	**Note (**)**		
et = evergreen tree; **ev** =	**f** = found in the evergreen forest site		
etlt = evergreen treelet; **dev** =	**g** = found in the regenerating gap site		

det = deciduous tree; vine	**e** = found in the eucalyptus plantation site
detlt = deciduous treelet; **h** = herb	**p** = found in the mature pine plantation site
es = evergreen shrub;	**y** = found in the young pine plantation site
des = deciduous shrub;	
ewc = evergreen woody climber;	
dewc = deciduous woody climber;	

APPENDIX 3. List of ground flora and tree seedlings in all five sites
The result of Intensive Quantitative Survey.

Botanical name	Family	Habit(*)	Site(**)
Actinidia rubricaulis Dunn	Actinidiaceae	ewc	f y
Aerva sanguinolenta (L.) Bl.	Amaranthaceae	h	f g e y
Afgekia filipes (Dunn) Gees.	Leguminosae, Papilionoideae	dwc	f g
Ageratum conyzoides L.	Compositae	h	f
Albizia odoratissima (L. f.) Bth.	Leguminosae, Mimosoideae	dt	f p y
Alpinia blepharocalyx K. Sch.	Zingiberaceae	h	f g e
Antidesma acidum Retz.	Euphorbiaceae	etlt	f p y
Amorphophallus yunnanensis	Araceae	h	f g e y
Aporusa villosa (Lindl.) Baill.	Euphorbiaceae	detlt	y
Archidendron clypearia (Jack)			
ssp. *clypearia* var. *clypearia*	Leguminosae, Mimosoideae	et	f p y
Archidendron glomeriflorum (Kurz)	Leguminosae, Mimosoideae	et	f y
Argyreia capitiformis (Poir.)	Convolvulaceae	ev	f g e y
Argyreia henryi (Craib) Craib	Convolvulaceae	ev	y
Argyreia obtecta (Choisy.) Cl.	Convolvulaceae	ev	y
Arisaema cuspidatum (Roxb.)	Araceae	h	f g e p y
Aspidistra longifolia Hk. f.	Liliaceae	h	f
Bauhinia ornata Kurz var.			
K. & S.S. Lar.	Leguminosae, Caesalpinoideae	dwc	f g
Betula alnoides B.-H.	Betulaceae	et	f g
Bidens pilosa L. var. *minor* (Bl.)	Compositae	h	e y
Blumea balsamifera (L.) DC.	Compositae	h	f g e y
Boehmeria diffusa Wedd.	Urticaceae	etlt	f
Borreria laevis (Lmk.) Griseb.	Rubiaceae	h	f g p y
Bridelia pubescens Kurz	Euphorbiaceae	h	y
Caesalpinia cucullata Roxb.	Leguminosae, Caesalpinoideae	ewc	f
Cajanus goensis Dalz.	Leguminosae, Papilionoideae	ev	f g e y
Canarium subulatum Guill.	Burseraceae	det	y
Castanopsis diversifolia King ex	Fagaceae	et	f g e p y
Castanopsis tribuloides (Sm.) A.	Fagaceae	et	f
Cheilanthes tenuifolia (Burm. f.)	Parkeriaceae	h	p
Cissus discolor Bl. var. *discolor*	Vitaceae	ev	f y
Clematis acuminata DC. var.			
sikkimensis Hk. f. ex Th.	Ranunculaceae	ev	f
Clerodendrum glandulosum Colebr.	Verbenaceae	etlt	g e y

Clerodendrum infortunatum	Verbenaceae	etlt	e
Clerodendrum serratum (L.) Spr.			
wallichii Cl.	Verbenaceae	etlt	f
Clitoria mariana L.	Leguminosae, Papilionoideae	ev	f g e p y
Codonopsis javanica (Bl.) Hk. f.	Campanulaceae	ev	f e p y
Commelina diffusa Burm. f.	Commelinaceae	h	f g e p y
Commelina paludosa Bl.	Commelinaceae	h	f g y
Conyza japonica (Thunb.) Less.	Compositae	h	f y
Conyza sumatrensis (Retz.)	Compositae	h	f e
Costus speciosus (Koeh.) J.E.	Zingiberaceae	h	p
Crassocephalum crepidoides (Bth.) S.	Compositae	h	e p y
Crotalaria alata D. Don	Leguminosae, Papilionoideae	ev	p y
Crotalaria albida Hey. ex Roth	Leguminosae, Papilionoideae	h	y
Crotalaria kurzii Baker ex Kurz	Leguminosae, Papilionoideae	h	y
Cruddasia insignis Prain	Leguminosae, Papilionoideae	h	f g e p y
Curculigo capitulata (Lour.) O.	Hypoxidaceae	h	f g e p y
Curcuma aff. comosa Roxb.	Zingiberaceae	h	f y
Curcuma ecomata Craib	Zingiberaceae	h	f g e p
Curcuma zedoaria (Berg.) Rosc.	Zingiberaceae	h	f p
Cyclea polypetala Dunn	Menispermaceae	ev	f g e y
Cynodon dactylon (L.) Pers.	Gramineae	h	g e p
Cyperus brevifolius (Rottb.)			
var. *brevifolius*	Cyperaceae	h	f p y
Cyperus killingiana Endl.	Cyperaceae	h	f g e p y
Cyperus nutans Vahl var. *nutans*	Cyperaceae	h	p y
Cyrtococcum oxyphylum (Steud.)	Gramineae	h	f g e p y
Dalbergia fusca Pierre	Leguminosae, Papilionoideae	dt	p y
Dalbergia stipulacea Roxb.	Leguminosae, Papilionoideae	dwc	y
Debregeasia longifolia (Burm. f.)	Urticaceae	etlt	g
Desmodium repandum (Vahl)	Leguminosae, Papilionoideae	h	f g e p y
Dianella ensifolia (L.) DC.	Liliaceae	h	f g e y
Dichrocephala integrifolia (L. f.)	Compositae	h	p
Digitaria setigera Roth ex			
Schult. var. *setigera*	Gramineae	h	g p
Dillenia aurea Sm. var. *aurea*	Dilleniaceae	det	e
Dioscorea bulbifera L.	Dioscoreaceae	ev	p y
Dioscorea decipiens Hk. f.	Dioscoreaceae	ev	f g e p y
Dioscorea glabra Roxb. var.	Dioscoreaceae	ev	p y
Dioscorea membranacea Pierre			
ex Prain & Burk.	Dioscoreaceae	ev	e

Dioscorea pentaphylla L. (? var.			
communis Prain & Burk.)	Dioscoreaceae	ev	f g p y
Dischidia major (Vahl) Merr.	Asclepiadaceae	h	f
Disporum calcaratum Wall. ex			
var. *rubiflorum* Gagnep	Liliaceae	h	f e p y
Drymaria diandra Bl.	Caryophylaceae	h	y
Embelia stricta Craib	Myrsinaceae	dwc	f g y
Engelhardia serrata Bl.	Juglandaceae	dt	f g y
Engelhardia spicata Lechen. ex			
colebrookeana (Ldl. ex Wall.)	Juglandaceae	dt	f
Eragrostis nigra Nees ex Steud.	Gramineae	h	y
Ettingera littoralis (Kon.) Gise.	Zingiberaceae	h	e
Eucalyptus camaldulensis	Myrtaceae	et	e
Eugenia albiflora Duth. ex Kurz	Myrtaceae	et	f y
Eugenia fruticosa (DC.) Roxb.	Myrtaceae	et	f
Eugenia tetragona Wight	Myrtaceae	et	f g e p y
Euodia triphylla DC.	Rutaceae	etlt	f
Eupatorium adenophorum	Compositae	h	f g e y
Eupatorium odoratum L.	Compositae	h	g e y
Fagerlindia sp.	Rubiaceae	es	p y
Ficus hispida L. f. var. *hispida*	Moraceae	detlt	e y
Placourtia indica (Burm. f)	Flacourtiaceae	et	e y
Flemingia sootepensis Craib	Leguminosae, Papilionoideae	detlt	f g e p y
Globba clarkei Baker	Zingiberaceae	h	f g e
Glochidion eriocarpum Champ.	Euphorbiaceae	et	f
Gomphostemma lucidum Wall.	Labiatae	h	f g e p y
Gynura longifolia Kerr	Compositae	h	f e
Hedyotis tenelliflora Bl. var.	Rubiaceae	h	f g p y
Hedyotis vestita R. Br. ex G.	Rubiaceae	h	f
Helicia nilagirica Bedd.	Proteaceae	et	f p y
Heliciopsis terminalis (Kurz)	Proteaceae	et	f g y
Hydrocotyle siamica Craib	Umbelliferae	h	f e
Hypopithys lanuginosa Rafin.	Ericaceae	h	p
Hypoxis aurea Lour.	Hypoxidaceae	h	f g y
Impatiens violaeflora Hk. f.	Balsaminaceae	h	f e
Imperata cylindrica (L.) P.			
major (Nees) C.E. Hubb. &	Gramineae	h	f g e p y
Inula cappa (Ham. ex D. Don)			
forma cappa	Compositae	h	f e p y
Kuniwatsukia cuspidata (Bedd.)	Athyriaceae	h	f g e p y

Leea indica (Burm. f.) Merr.	Leeaceae	dtlt	f g e p y
Lepidagathis incurva Ham. ex D.	Acanthaceae	h	f e y
Lespedeza parviflora Kurz	Leguminosae, Papilionoideae	etlt	p
Litsea cubeba (Lour.) Pers.	Lauraceae	etlt	f g e
Litsea sp.	Lauraceae	etlt	f
Lygodium flexuosum (L.) Sw	Schizocaceae	ev	p y
Macaranga denticulata (Bl.) M.-	Euphorbiaceae	etlt	e y
Maesa montana A. DC.	Myrsinaceae	etlt	f
Markhamia stipulata (Wall.) ex			
Sch. var. *stipulata*	Bignoniaceae	det	f y
Melastoma normale D. Don var.	Melastomataceae	etlt	f g p y
Micromelum minutum (Forst. f.) Wight	Rutaceae	etlt	f e
Microstegium vagans (Nees ex			
Camus	Gramineae	h	f g y
Millettia pachycarpa Bth.	Leguminosae, Papilionoideae	dwc	f g
Millettia pubinervis Kurz	Leguminosae, Papilionoideae	dwc	f
Mimosa pudica L. var. *hispida*	Leguminosae, Mimosoideae	h	y
Mucuna macrocarpa Wall.	Leguminosae, Papilionoideae	ewc	f g e y
Murdannia loureiri (Hance) Rao &	Commelinaceae	h	p y
Musa acuminata Colla	Musaceae	h	e
Mussaenda sanderiana Ridl.	Rubiaceae	es	f e p y
Olea salicifolia Wall. ex G. Don	Oleaceae	det	f g e p y
Ophiopogon intermedius D. Don	Liliaceae	h	f g
Oxalis corniculata L.	Oxalidaceae	h	g e
Palaquium garrettii Flet.	Sapotaceae	et	y
Parthenocissus semicordata	Vitaceae	h	f e
Paspalum conjugatum Berg.	Gramineae	h	f e
Passiflora siamica Craib	Passifloraceae	ev	e y
Pavetta fruticosa Craib	Rubiaceae	ds	f p y
Pennisetum purpureum	Gramineae	h	p y
Phoebe aff. cathia (D. Don)	Lauraceae	et	p y
Phoebe lanceolata (Nees) Nees	Lauraceae	et	f p
Phoebe sp.	Lauraceae	et	f p
Phragmites vallatoria (Pluk. ex L.)	Gramineae	h	f g e y
Phyllanthus emblica L.	Euphorbiaceae	det	p y
Phyllanthus sootepensis Craib	Euphobiaceae	det	p y
Pilea trinervia Wight	Urticaceae	h	f
Piloselloides hirsuta (Forssk.) C.	Compositae	h	p y
Pinus kesiya Roy. ex Gord.	Pinaceae	et	p y
Planchonella punctata Flet.	Sapotaceae	et	f

Plantago major L.	Plantaginaceae	h	f
Plectranthus ternifolius D. Don	Labiatae	h	p
Pogostemon auriculatus (L.) Hassk.	Labiatae	h	f e
Pollia haskarlii R. Rao	Commelinaceae	h	f
Polygonum chinense L.	Polygonaceae	h	f g e y
Portulaca oleracea L.	Portulaceae	h	e
Pouzolzia hirta Hassk.	Urticaceae	h	f g
Pouzolzia zeylanica (L.) Benn.	Urticaceae	h	f g e p
Pratia begoniifolia (Wall. ex Roxb.) Ldl.	Campanulaceae	h	y
Prunus cerasoides D. Don	Rosaceae	det	g
Pteridium aquilinum (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try.	Dennstaedtiaceae	h	f g e p y
Pueraria imbricata Maes.	Leguminosae, Papilionoideae	ev	f g e
Rauvolfia ophiorrhizoides (Kurz) Kerr	Apocynaceae	etlt	f
Rhus chinensis Mill.	Anacardiaceae	dtlt	f p
Rubus blepharoneurus Card.	Rosaceae	ev	f g e y
Sacciolepis indica (L.) Chase	Gramineae	h	e p
Saurauia nepalensis DC.	Sauraliaceae	h	y
Schima wallichii (DC.) Korth	Theaceae	et	f p
Scleria reticulata (Holtt.) Kern	Cyperaceae	h	f e
Scleria terrestris (L.) Fass.	Cyperaceae	h	f g e y
Semecarpus cochichinensis Engl.	Anacardiaceae	h	y
Setaria palmifolia (Koen.) Stapf var. *palmiflora*	Gramineae	h	f e
Setaria parviflora (Poir.) Kerg.	Gramineae	h	g e p
Shuteria involucrata (Wall.) Wight & Arn.	Leguminosae, Papilionoideae	ev	g e
Sida rhombifolia L. ssp. *rhombifolia*	Malvaceae	h	g
Smilax corbularia Kunth ssp. *corbularia*	Smilacaceae	ev	f
Smilax lanceifolia Roxb.	Smilacaceae	ev	f e
Smilax ovalifolia Roxb.	Smilacaceae	ev	f g e y
Smilax verticalis Gagnep.	Smilacaceae	ev	f
Smilax zeylanica L. ssp. *hemsleyana* (Craib) T. Koy.	Smilacaceae	ev	g
Solanum barbisetum Nees	Solanaceae	h	y
Spatholobus floribundus Craib	Leguminosae, Papilionoideae	ewc	f
Stemona sp.	Stemonaceae	v	g
Streptocendron juventas (Burm. f.) Merr.	Asclepiadaceae	ev	y
Styrax benzoides Craib	Styracaceae	et	f g e y
Tetrastigma sp.	Vitaceae	ewc	f g e y
Themeda triandra Forssk.	Gramineae	h	g y

Thunbergia similis Craib	Acanthaceae	etlt	g e y
Thysanolaena latifolia (Roxb.ex Horn.) Honda	Gramineae	h	g e y
Trema orientalis (L.) Bl.	Ulmaceae	etlt	g
Trevesia palmata (Roxb.) Vis.	Araliaceae	et	f
Urena lobata L. ssp. *lobata* var. *lobata*	Malvaceae	h	f g e y
Vaccinium apricum Flet.	Ericaceae	etlt	f
Vaccinium sprengelii (D. Don) Sleum.	Ericaceae	etlt	f y
Vernonia sutepensis Kerr	Compositae	h	f g e y
Vernonia volkameriifolia DC. var.			
volkameriifolia	Compositae	etlt	f
Vigna radiata (L.) Will.	Leguminosae, Papilionoideae	ev	f g
Viola pilosa Bl.	Violaceae	h	f
Wendlandia tinctoria (Roxb.) DC.			
ssp. *floribunda* (Craib) Cowan	Rubiaceae	etlt	y
Zanthoxylum acanthopodium DC.	Rutaceae	etlt	f g e
Zingiber kerrii Craib	Zingiberaceae	h	f
Zingiber smilesianum Craib	Zingiberaceae	h	f g e y
UNKNOWN HERB		h	f
UNKNOWN SEEDLING (A)		et	f
UNKNOWN SEEDLING (B)		et	f
UNKNOWN SEEDLING (C)		et	g

Note : (*)	**Note : (**)**
et = evergreen tree;	**f** = found in the evergreen forest site
etlt = evergreen treelet;	**g** = found in the regenerating gap site
det = deciduous or evergreen tree;	**e** = found in the eucalyptus plantation site
detlt = deciduous treelet;	**p** = found in the mature pine plantation site
ewc = evergreen woody climber;	**y** = found in the young pine plantation site.
dewc = deciduous woody climber;	
es = evergreen shrub;	
des = deciduous shrub;	
ev = evergreen vine;	
dev = deciduous vine;	
h = herb.	

APPENDIX 4. **The average percent cover of each species for 100 quadrats over all seven observations at five sites**

FOREST SITE

Species	F1	F2	F3	F4	F5	F6	F7	F8	F9	F10	F11	F12	F13	F14	F15	F16	F17	F18	F19	F20
Actinidia rubricauli	0	0	0	3.1	0.7	0	0	0	0	0	0	0	1.3	0	0	0	0.1	0	0.4	0
Aerva sanguinolenta	11.4	1.7	4.3	0	10.7	7.7	0.7	5	5.7	1.7	0.3	1.4	0.7	9.3	6.4	4.9	13.6	2.9	5.7	7.9
Afgekia filipes (Dun	0	0	0	0	0	0	0	0	2.1	0	0	0	4.7	0	0	0	0	1.4	0	0
geratum conyzoides	0	0	0	0.6	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0
lbizia odoratissima	0	0.9	4.6	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0
lpinia blepharocaly	0	0	0	2.1	0	0	12.1	0	0	0	10	0	5.7	0	0	5.7	0	0	0.3	0.3
morphophallus yunna	0	1.7	0	0	0.3	0	5	0	0	0	0	0	0	2.4	0	0	0	0	0	3.1
ntidesma acidum Ret	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0	3.6	0	0	0.3	0.3	0
pporusa villosa (Lin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rchidendron clypear	0	0	0	0	0	0	0	0	0.3	2.1	0	0	0	0	0	1.6	0	0	0	0
rchidendron glomeri	0	0	0	0.1	0	0	0	0	0	0	0	8.6	0	0	0	0	0	0	0	6.4
rgyreia capitiformi	0	0	2.3	0	0	0.3	0	3.9	0	0	0	0.	0	0	11	0	5	0	4.6	0
rgyreia henryi (Cra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rgyreia obtecta (Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
risaema sp.	0	2.4	0	0.3	0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0
spidistra longifoli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.1	5	0	10.3	0	0
auhinia ornata Kurz	0	0	0	0	0	0.3	0	0	2.4	0	0	0	0	0	0	0	0	0	0	2.4
etula alnoides B.-H	0	0	0.3	0	0	0	0	0	0	2.7	0	0	0	1.4	0	0	0	0	0	0
idens pilosa L. var	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lumea balsamifera (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	4.3
oehmeria diffusa We	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
orreria laevis (Lak	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0.7	0	0	0	0
ridelia pubescens K	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
aesalpinia cucullat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0
ajanus goensis Dalz	1.1	0	0	7.9	0	0	0	0	5	0.3	0	0	3.1	0	0.1	0	25	0	0	0
narium subulatum G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
stanopsis diversif	10	7.9	0.6	0.6	3.7	0.7	2.3	0.7	0	0	5.7	0	5.3	8.4	3.7	0	0	0	30	0
stanopsis tribuloi	0	0	3.3	0	0	2.9	5.7	0	2.9	0	0	0	0	0	0	1.3	7.1	0	0	0
eilanthes tenuifol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ssus discolor Bl.	0	0	0	0	0	0	0	0	0.1	0	2	0.4	0.1	0.3	2.1	0	0	0	0	0
esatis acuminata D	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0
erodendrum glandul	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
erodendrum infortu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
erodendrum serratu	0	0	0	0	0	2.1	0	0	0	0.9	0.	0	0	0	0	0	0	0	0	0
itoria mariana L.	2.7	0	3.1	7.9	3.1	19.6	0	2.4	22.9	0.1	5.7	1.4	0	3.1	11.7	2.9	0.3	2.4	0	0.6
donopsis javanica	0	0	0	0	0	0	0	0	0	0	9.6	0	0.3	0	0	0	0	0	0	0
mmelina diffusa Bu	0	0.1	0	0.7	0.6	2.6	0	0	4.6	0	0.7	0.9	0	0	0	15	5.7	1.4	0	0
mmelina paludosa B	0	0	0.3	0	0	2.3	0	3.4	0	0.1	0	0	0	0	0	0	0.7	0	1.4	0
nyza japonica (Thu	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	11.4
nyza sumatrensis (	0	0	0	0.1	0	0	0.3	0	0.1	0.7	0	0.7	0	0.1	4	0	0	0	4.1	0
stus speciosus (Ko	0	0	0	0	0	0.3	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0
assocephalum crep	0	0	0	0.3	0	0	0	0	0.7	0	0	0	0	0.3	0	0	0	0	0	0
otalaria alata D.D	0	0	0	0	0	0	0	0	0	0.7	0	0.3	0.3	0	0	0	0	0	0	0
talaria albida He	0	0	0	0	0.7	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0.7	0
talaria kurzii Ba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ddasia insignis P	0	0	0	0	0	2.7	0	2.7	0	0	0	0	0	0	6.4	2.9	3	0	0	0
culigo capitulata	7.4	0	3.9	3.1	0.3	3.1	2.1	9.4	1.7	0	5.9	0.3	2.1	5.3	6.3	5.7	0	5.3	0	0
cuma aff. comosa	0	13.6	0	0	0	0	0	0	0.3	0	1.4	0	0	0	0	0	0	0	0	0
cuma ecomata Cra	0	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	11.4	0	0	0	0
cuma zedoaria (Ber	0	0	0	7.4	0	0	0	0	0	0	0	0	0	0	0	0	10.7	0	0	0
lea polypetala Dw	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	5	2	7.9
don dactylon (L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
erus brevifolius	0	0	0	0	0.3	0	0	0	0.1	0	2.4	0	0	0	0	0	0	0	0	0
erus killingiana	0	0	0	0.3	0	0	2.4	0	0	0.9	0	0	0	0	0	0	0	5.7	0	0
erus nutans Vahl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
tococcum oxyphylu	3.7	0	0	8.9	0.4	0.1	0	7.7	0	0	0	1.7	0	24.3	0	0	0	5	0	0
bergia fusca Pier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
bergia stipulacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
bregeasia longifol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
sodium repandum (	0	0	0	0	3.4	0	0	0	0	4.6	0	0	0	0	0	0	0	0	0	0
nella ensifolia (	5.3	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0
hrocephala integr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
gitaria setigera R	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
llenia aurea Sm. v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea bulbifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea decipiens	0	0	0	0	0	3	4.9	3.4	0	0	0	0	0	0	0	0	0.7	0.3	0	5
scorea glabra Rox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea membranace	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea pentaphyll	2.4	0.7	3.9	1.9	4.6	0	0	0	0	9.4	0	0	3	5.7	5.7	0	0.7	0.6	0	0

GAP SITE

Species	S1	S2	S3	S4	S5	S6	S7	S8	S9	S10	S11	S12	S13	S14	S15	S16	S17	S18	S19	S20
Actinidia rubricauli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Aerva sanguinolenta	0	0	0	4.3	0	4.6	0	0	0	0	0	0	2.3	0	0	0.3	0	0	0	1.3
Afgekia filipes (Dun	0	0	0	0	0	0	0	0	0	5.3	0	0	0	0	0.6	0	0	0	0	0
geratum conyzoides	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lbizia odoratissima	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lpinia blepharocaly	0	0	0	0	0	0	0	6	0	0	0	0	1.4	0	0	0	2.9	0	0	0
morphophallus yunna	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0
ntidesma acidum Ret	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
pporusa villosa (Lin	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rchidendron clypear	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rchidendron glomeri	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rgyreia capitiformi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	11.4	12.9	0	0	0	0
rgyreia henryi (Cra	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rgyreia obtecta (Ch	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
risaema sp.	0	0	0	1.5	0	0	0	0	0	3.1	0.1	0	0.3	0	0	0	0	0	0	0
spidistra longifoli	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
auhinia ornata Kurz	0	0	0	0	0	15.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0
etula alnoides B.-H	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0
idens pilosa L. var	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lumea balsamifera (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
oehmeria diffusa We	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
orreria laevis (Lak	0	0	1.6	0	0	0	0	0	0	0	0	11.3	2.6	0	0	0	0	2.3	0	0
ridelia pubescens K	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
aesalpinia cucullat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ajanus goensis Dalz	15	0	0	0	0	4.7	0	0	0	0.3	7.1	5	0	7.9	9.3	21.4	8.6	0	0	0
narium subulatum G	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
stanopsis diversif	2.1	0	1	0.1	0	2	1.7	0.3	0	0	0	0	0	0	0	0	0	0	0	0
stanopsis tribuloi	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
eilanthes tenuifol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ssus discolor Bl.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
esatis acuminata D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
erodendrum glandul	0	10.7	0	0	0	0	0	0	0	11.4	0	0	0	0.7	0	7.9	0	13.6	0	0
erodendrum infortu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
erodendrum serratu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
itoria mariana L.	17.1	7.9	28.6	1	3.4	27.9	11.4	25	31.4	68.9	35	35.7	0	1	25.7	7.1	37.9	28.6	42.9	15.7
donopsis javanica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
mmelina diffusa Bu	0	15.7	0	0	0	0	6.4	2.1	0	0	14.3	0	0	0	0	7.9	0	0	0	0
mmelina paludosa B	0	3.6	0	0	0	0	7.4	0.7	0	0	0.7	0	0	0	0	0	0	2.3	0	0
nyza japonica (Thu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nyza sumatrensis (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
stus speciosus (Ko	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
assocephalum crep	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
otalaria alata D.D	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
talaria albida He	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
talaria kurzii Ba	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ddasia insignis P	0.7	0	0	0	0	0	0	0	0	21.4	0	16.4	0	0	0	0	25	30	35	10
culigo capitulata	0	0	0	0	0	0	5.3	0	0	0	0	0	0.3	0	0	15	0	0	0	5
cuma aff. comosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cuma ecomata Cra	0	0	0	0	3.7	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0
cuma zedoaria (Ber	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lea polypetala Dw	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	4.3	0	0	0.7	0	0
don dactylon (L.	0	0	0	0	0	0	0	0	0	0	2.4	5.7	0	0	0	0	0	0.7	0	0
erus brevifolius	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
erus killingiana	0	0	3.7	2.1	0.1	3.1	0	0	3.7	0	0	2.3	4.1	0	0	5	0	0	0	0
erus nutans Vahl	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
tococcum oxyphylu	3.1	0	4	3.7	0	2.4	17.4	0	0	0	2.1	0	4.6	36	2.6	6.4	0	0	0	0
bergia fusca Pier	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
bergia stipulacea	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
bregeasia longifol	30.7	13.6	1.4	33.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
sodium repandum (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.7	1.7	11.4
nella ensifolia (	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
hrocephala integr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
gitaria setigera R	0	0	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0
llenia aurea Sm. v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea bulbifera	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea decipiens	0	10	0	0	0	0	1.9	0	0	0.7	0	0	0	0	0	0	0	0	0	1.3
scorea glabra Rox	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea membranace	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
scorea pentaphyll	0	0	0	0	0	0	0.1	0	0	0	2.4	0	0	0	0	0	0	3	0	0

MATURE PINE PLANTATION SITE

YOUNG PINE PLANTATION SITE

E13	E14	E15	E16	E17	E18	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9	MP10	MP11	MP12	MP13	MP14	MP15	MP16	MP17	MP18	MP19	MP20	YP1	YP2	YP3	YP4	YP5	YP6	YP7	YP8	YP9	YP10	YP11	YP12	YP13	YP14	YP15	YP16	YP17	YP18	YP19	YP20
0	0	9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0
2	0	6.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	2.9	0	0	0	2.1	2	4.6	0.3	0	0.1	3.6	1.1	0	7.1	4.6	0	1.9	3.6	0	21.6	0	0	0	0	15.7	0	0	0	0	6.7	0	0	0	0	0	0	0
0	0	24.3	2.1	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	2	0
0	0	0	0	0	0	0	0	0	3.9	14.6	0	12.9	3.7	6	0.9	0	1.1	0	0	0	1.6	2.9	10	3.6	7.4	0	9.3	9.3	2.9	5.7	8.6	4.1	4.9	4.1	8.6	13.6	0	10	9.3	0	0	5.7	0	0
.0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	3.1	3.7	0	0	0	0	0	0	0	3.9	0	10.7	0	0	0	0	0.7	0	0.7	0	45	0	0	0	0	0	0	5.7	17.9	0.7
0	0	0	0	0	0	0	0	0	1.9	0	0	0	2.4	0	1.9	0	0	5	2.3	0	0.6	5	0	5.7	0	0	0	1	0	0	0	0	20.7	0	0	0	0	11.6	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	16.4	0	3.1	1.6	0	0	14.3	0	0	30.7	15.7	25.7	0	0	0	8.6	11	0	0
0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.9	2.3	4.7	2.3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0.3
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0.3	0	3.6	0	0	0	0	0	0	0.3	0	0	0	0
0	0	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	1.1	0	0	0	0	0	0	1.3	0	0	0	0.9
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5.3	0	0	0	0	0	0	0	0
0	0.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.4	0	0	0	1.9	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0.1	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0.6	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	3.7	0.6	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	13	7.9	3.9	7.9	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	0	0	0	0	0	3.3	0	0	24.3	0	4.1	0	0	0	0	0	0	0	11.4	0	0	0	0	0	0	0	0	0	0	0	5.1	0	0	1.4	0	0	0	0	4.7	10
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	12.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	6.4	0.7	0.7	0.7	.9	62.1	65	29.3	12.9	11.4	29.3	26	72.1	62.1	15	37.4	0	2.1	1.4	45.3	27.9	13.6	3.6	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0.3	0	0	0
	0	0	.0	1.1	0.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0.9	1.6	2.6	0.3	0	0	2.3	0	0	0	0	1	0	1.6	0	3.7	2.1	2.9	0	2.9
	0	3.7	0	2.1	0	0	2.1	0	0	0	0	3	0	0	0	0	0	0	0	0	1.6	0	0	0.3	0	1.7	0	0	0	0	0	0	0	0	0	1.9	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	2	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.5	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0
	0.6	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	1.7	0	1.9	0	0	4.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.1	0.3	0	0	0.3	0	0.1	0	1.1	0	0	0	0	0.3	0	0.1	0	0	0.3
	0	0	0	0	0	0	0.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0.3	0.3	0	0	0	0	0.3	0	0	0.1	0	0.3	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0.3	0	0	1	0	0	0	0.3	0	0	0	0	0.3	0.3	0	0.1	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	2.6	0	0	0	0
	0	0	8.1	1.4	8.1	0	0	1.6	0	0.3	0	0	0	0	0	1.3	0	0	0.1	1.3	0.3	1.1	0	1.3	1.4	0	0	2.9	0.1	0.4	0.1	0	0	0	2	2.3	0	0	0	0	0.6	2.3	2.9	0.9
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0
	0	0	1.7	2.1	0.7	0	0	0	0	1.9	0	0	3.4	0	0	0	1.4	0	0	0.1	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	3.6	0	0	1.4	0	0	0	0	1.1	1.9	0	0	0	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	2.9	0	0	0	0	0	0	0.7	0	0	0	0	0	2.7	0
	0	0	0	0	0	0	0	0	0	0.3	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0.3	0.9	0	0	0	1.7	0	0	0	0	0	0	0	0	2.3	0	0	0.3	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0
	0	1.4	0	0.5	2.5	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	3.1	0	0.3	0.6	0	1.4	0	0.1	2.1	0	0	0.3	1.9	2.1	0	0	1.9	2.3
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	4.7	0	0	0	0	0	3.5	0	0	0	2.6	0	0
	0	0	0	0	0	0	0	2	47.9	50	20	0	4.6	0	0	0.7	5.4	1.9	0	3.3	3.1	0	0	19.5	3.7	2.5	0	3.7	8.4	0.7	15.4	0	0	16.4	13.6	0	1.6	0	0	0	13.6	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	4.1	0	0	0	0	0	0	1.7	2.9	1.4	2.6	0	2	0	2	0	0	2.3	2.4	0	0	0	0	0	0	0
	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	1.3	0	0	0	0	1.7	0	0	0	0
	7	10	0	3	0	5.9.7	0	0	0	0	0	0	0	3.9	0	1.7	0	0	0	1.1	0	0	0	0	3.1	0	0	0	0	2.3	0	0	2.3	0	0	0	0	0	0	0	0	0	0	1.9
	0	0	0	0	0	0	0	9.1	0	0.3	0	0	0	0.3	0	1.3	0	0	0	0	0	0	0	0	0	1.6	0.1	0	3.1	0	0	2	0	0	2.3	1.1	5	2.9	0.3	2.1	2.9	1.1	2	0
	0	0	0	0	17.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
	0	0	0	0	0	0	0	0	0	2.1	0	0	1	1.3	0	0.3	0	3.1	1.4	0	0	0	0	0.1	0	1	0	1.6	0	0	0	0	0.4	0	0	0	1.7	0	0	0	0	0	0	0

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APPENDIX 4. (continued)

Dischidia major (Vah	0	0	0	0	0	0	0	0	0.3	0	0	2.4	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Disporum calcaratum	0	2.3	0	0	0	1.7	0	0.7	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eltingera (Achasma)	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Embelia stricta Crai	0	0	8.6	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	16.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Engelhardia serrata	3.3	0	5.7	0	0	0	0	7.7	0	0	0	3.7	4.6	0	9.4	5.4	10.7	0	0.3	0	0	0	3	0	0	0.6	1.7	0	2.6	0	0	0	0	5.6	0	0	0	0	0	0
Engelhardia spicata	4.1	0	0	0	6.4	0	0	0	0	5.7	0	0	0	0	0	0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eragrostis nigra Nee	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eucalyptus camaldule	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eugenia albiflora Du	0	0	0	0	10.7	0	0	0	0	0	0.7	0	0.7	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eugenia fruticosa (D	0	0	3.7	0	0	0	0	0	5.7	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eugenia tetragona Wi	0	2.6	0	0	0	0	0	0	0	0	17.9	6	2.6	8.3	0	3.9	0	0	0.7	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0.3	0	0	0	0
Euodia triphylla DC.	0	2.6	0	0.3	0	0	0	6.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Eupatorium adenophor	4.6	0	0	0.7	5.3	50.7	14.3	55.7	22.9	11.4	3.3	0	0	1.4	0	0.5	30.7	35.7	17.1	0	78.4	28.6	88.6	71.4	87	82.9	49.3	77.9	50.7	47.9	80.7	74.3	78.6	88.6	81.4	2.9	2.9	0	78.6	27.9
Eupatorium odoratum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0
Fagerlindia sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ficus hispida L.f. v	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flacourtia indica (B	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Fleacagia sp.	0	0	0	0	5.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Flemingia sootepensi	0	9.6	6.4	18.6	0	0	0	5.7	0	25.7	16.7	23.6	0	0	20	27.9	11.4	11.4	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0.1	0	0	0	0
Globba clarkei Baker	0	0	0	0	1.9	0	0.6	0	0.3	0	0	0	0	0.3	4.3	0	0	2.1	0	0	0	3	0	2.6	0.3	2	3.9	0	1	0	1	0	0	2	0	0	0	0	0	0
Glochidion eriocarpu	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Gomphostemma lucidum	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0
Gynura longifolia Ke	0	0	0	0	0	0	0	0	0	0	0	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hedyotis tenelliflor	0	0	0	0	6.4	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	9.3	3.6	0	9.3	8.1
Hedyotis vestita R.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Helicia nilagirica B	1.7	7.9	0	0	0	8.1	0	2.3	95.2	5.3	6.7	76.7	6	0	7.9	0	82.9	9.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Heliciopsis terminal	0	0.3	0	0	6.6	0	0	0	0	0	5.7	0	0	4.3	0	0	0	0	9.4	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	4.1	0	0	0	0	0	0
Hydrocotyle siamica	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypopitys lanuginosa	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Hypoxis aurea Lour.	0	0	0	2.6	3.7	0	0	17.1	0	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0
Impatiens violaeflor	0	0	0	0	0	0	0	0	0	0	0.7	0	0.3	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Imperata cylindrica	0	3.1	0	0	0	4.4	0	3.9	0	4.4	11.4	0	0	0	0	0	0	0	0	0	0	0	0	0	4.4	10.3	16.4	0.3	0	0.7	4.4	0	0	0.3	0	10.7	61.4	32.9	27.1	35
Inula cappa (Ham. ex	0	0	0	0	0	0	1.1	0	0.7	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Iwaivatsutia cuspida	0	0	0	0	0	0	0	0	0	0	0	0.3	2.4	0	0	0	0	0	0	10	0	0	7.1	0	0	11.4	10.7	4.4	1.4	2.1	0.7	3.6	12.1	8.6	25.9	24.3	14.3	26.4	0	0
Leea indica (Burm. f	0	0	0	0	3.6	0	0	0	0	0	2	0	0	3.7	0	8.6	0	0	0	0	0	0	0	0	0.7	0	0.3	0	0	0	0.6	0	0	0	0	0	0	0	0	0
Lepidagathis incurva	16.4	3.2	5.7	0	18.6	11.3	0	23.6	3.7	0	0	0.7	0	27.9	0	0	16.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lespedeza parviflora	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Litsea cubeba (Lour.	0	0	0	0	0	0	0	0	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	1	0	0	0	0	0	0	0	0	70.7	0	0
Litsea sp.	0	0	0	0	0	0	0	0	4.4	0	0	0	4.5	0	0	0	0	0	0	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Lygodium flexuosum (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Macaranga denticulat	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Maesa montana A. DC.	0.9	0.3	0	0	2.9	0.7	3.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Markhamia stipulata	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Melastoma normale D.	0	0.3	0	2	2.1	3.7	0	0.9	0	0	0	0	0	0	0	3.1	0	0	0	0	0	0	0	0	0	0	7.9	0	0	0	0	0.7	0	0	0	0	0	0	10.7	0
Micromelum minutum (	0	0	0.3	0	1.6	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Microstegium vagans	52.9	14.3	25	16.4	4.7	0	0	0	0.7	0	0	0.7	18.6	31.4	0	0	22.1	1.4	0	0	0	0	16.4	0	0	11.4	6.7	0	0	0	3	2.1	0	40.7	14.3	59.3	0	0	0	0
Millettia pachycarpa	0	0	0	11.4	0	7.9	0	0	0	0	0	0	7.9	0	0	0.7	0	10	0	0	0	0	0	9.6	0	8.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Millettia pubinervis	0	0	0	0	5.3	0	0	0	0	7.9	0	0	14.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mimosa pudica L. var	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mucuna macrocarpa Wa	0	11.4	7.9	2.1	0	0	0.7	0	0	0	0	0	0	0	0	0	0	15	0	13.9	0	0	0	0	0	0	0	0.7	1.4	0	0	0	0	0	0	0	0	0	0	0
Murdannia loureiri (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Musa acuminata Colla	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Mussaenda sanderiana	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Olea salicifolia Wal	0	2.6	0	0	0	0	0	3.4	0	7.9	6.4	0	0	0	0	0	0	8.6	5.7	2.4	0	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Ophiopogon intermedi	3.7	7.1	0	0	1.9	3.1	0	3.6	5.9	0	3.1	3.9	3.4	0	0	0.3	0	3.1	0	6.6	0	0	0	4.3	0	0	0	0.3	0	0	0.3	0	0	0	0	0	0	0	0	0
Oxalis corniculata L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.1	2.1	0	1.4	1.6	0	1.6	4.1	0	0	0	0	0	0	0
Palaquium garrettii	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Parthenocissus semic	1.1	5.9	2.3	5.7	1	0	7.9	1.6	17.9	0	3.6	7.1	15.7	10.7	2.9	5	0	0	0	4.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Paspalum conjugatum	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Passiflora siamica C	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pavetta fruticosa Cr	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pennisetum purpureum	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoebe aff. cathia (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoebe lanceolata (N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phoebe sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phragmites vallatori	0	0	0	0	0	0	0	0	0	5.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	4.3	0	0	0	0	0	35.7
Phyllanthus emblica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Phyllanthus sootepen	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pilea trinervia Wigh	0	0	2.4	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Piloselloides hirsut	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Pinus kesiya Roy. ex	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Planconella punctata-	0	0	2.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plantago major L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0.7	0	0	0	1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Plectranthus ternifo	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0.3	0	0	0	0	0		0	0	0	0	0	0.3	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	0	0	0	0	2	0	0	0	0
0	0	0	0	25.7	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	1.1	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	2.9	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	2.4	4.6	0	0.7	0	0.3	0	0	0	0	0	0	0	0	0	0	0.7
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	1.7	0	0	0		0	0	0	0	0	0	0	0	0	0	0	3.1	0	0	0	0	0	2	4.1	0	3.3	0	0	1.3	0	3.4	4.9	49.3	5.7	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
.7	10.3	7.1	2.3	5	20	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3	5.6	0	0	0	4.1	7.1	10	6.4	0	0	3.1	2.1	15	0.7	0	0	0	0	0
0	0	0	0.3	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.7	0	0	0	1.3	0	0	0	0
0	0	0	0	0	0	0	0		4.3	36.4	0	0.3	0	0	0	0	0	0	2.4	0	0	0	9.4	0	1.6	1.9	14.3	9.3	3.7	1.6	8.6	0	0	0	0	8.6	8.6	3.3	0	2.1	3.7	3.7	2.7	6.7
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	12.9	0	0		0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	5.4	0	0	0	0	0	0	0	0	0	9.3	0	0.7	0	5.3
0	7.9	5.7	5.7	5	5	0	13.6		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	1.4	0	9.3	0	10.7	0	0		0	1.4	0	0	0	0	0.3	7.4	0	1.9	2.7	1.6	0	0	0	4.9	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0	1.9	0	0	0
0	0	2.1	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		4.4	2.4	0.3	0	1.4	0	0	1.6	3	2	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	2.1	0	0	1.7	0	0	0	0	0	3.7	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	1.6	0	0.1	4.7	3.3	2.1	0.1	0.6	0.3	5.3	6	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0.3	6.7	0	0	0	0	1.6
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.4	6	0	2.9	0	0	0	0	0	0	0	0	0	4.6	0	0	0	3.1
0	0	0.3	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0.3	1	0	0	0	0	1.5	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0.3	0	0	0.3	0
0	0.3	0	0	0	0	0	0.3		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	2.9	0	2.9	0	0	0	0.1		0	2.7	2.7	2.4	1.1	0	2.4	1.9	1.6	1.7	0	0	1.4	1.1	4.6	0	0	5.3	5.3	1.7	2	3.3	1.7	0.1	0	3.3	0	2.1	2.4	2.6	0	4	2.1	0	1.6	0
0	0	0	0	0	0	0	0		0	0	2.4	0	4.1	4.3	0	0	0	0	1.1	0	0	0	0	0	4.6	11.4	0	0	5.5	4.6	0.3	0	0	0	0	0	10.7	4.6	3.7	0	2.7	5.3	0	2.6
0	2.9	1.4	0	0	0	0	0	4	0.3	0	0.3	0	0	0	1.3	0	0	0	0	0	0.3	0	0.7	3.6	7.1	0	13.6	0	0	0	9.3	0	5.3	0	0	0	0	0	0	3.1	0	0	0	0
0	0	0	0.7	0	0	0	0		1.6	0	0	0.3	0	0	0	0	0	0	1.6	0	0	0	0	0	0	3.4	4.3	0	0	0	0	3.7	0	0	0	0	0	0	2.9	0	0	0	5.3	0
0	0.3	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.6	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0.7	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1.9	2.1	29.3	2.7	2.9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0
0	0	0	0	1.3	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6	4.6	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	3.4	0	0	0	0
0	0	0	0	0	0	0	0		0.1	0	4.4	3	0	0	0	8.1	0	4.6	0	0	0	7.6	0	0	4.1	3.7	3.4	0	0	0	0	0	0	0	0	0	0	4.1	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	15.3	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	2.6	0	2.4	0	0	3.7	2	0	2.4	0	1	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.9	0	0
0	3.1	0	0	0	0	0	1.9		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0.3	0	0	0	0	0.7	5	0	10	0
0	0	0	0	0	0	0	0		0	1.9	0	0	0	0.9	1.6	0	0	0	0	0	0	2	2	0	3.7	0	0	1	0	0	3.3	0	0	2.1	3.3	0	0	0	0	0	0	0	0	0.3
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	8.1	0	9.3	0	0	2.4	16.4		0	0	0	0	0	0	7.1	0	0	0	0	0	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	1.1	3.7	0	0	0	0	0	0	0
0	0	0	0	0	2.5	0	0		0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	1.3	0	0	0	0	0	1	0.3	1.3	0	0	0	0	1.7	0	0	2.6	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	1.7	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.1	0	0	0	0	0	0	0	0	0
1	0	0	7.9	0	0.1	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.9	0	3.7	0	2.4	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	10.7	1.9	0	0	0	0	0	0	0	0.3	0	0	0	0	2.9	0.7	0	0	4.5	0	0	0	2.7	0	0	0	5.7	0.7	5	0	0	0.3	0	2
0	0	0	0	0	0	0	0		1.3	0	2.7	0.1	0.3	0	0	0	0	0	0	0	0	0	0	0	1.6	1	0.3	0	0	0	1.9	0	0	0	0.3	1	0	0	0.3	0	0	2.4	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	1.1	0	0	0	0	0	0.1	0	7.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	2	0	0	0	2
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	13.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	2.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	38.6	60	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	0	0
0	0	0	0	0	0	0	0	.3	0	0	19.3	0	0	0	0	0	0	0	2.4	0.1	0.7	0	0	0	0	0	0	5	0	7.4	0	19.3	5.7	0.3	0.3	6.4	0	0	2.4	0	0	10	10	0
0	0	0	0	0	0	0	0		0	0	0	3.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.1	0	0	0	0	0	0.3	0	0	0	0	0	0	0	5	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		2.9	0	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	5	0	0	15.8	0	0	0	0	15	0	0	0	14.2	1.1	0	0	4.7	0	0	1.4	0	0	0	0	0	23.6	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0		0	0	0	0	0	0	0	0	4.1	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX 4. (continued)

gostemon auriculat	0	10.3	0	2.3	4.1	0	5.7	0	0	2.7	0	5	0	4.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	41.4
llia baskarlii R.	0	0.7	6.4	0	7.7	0	0	12.1	0	0	0	0	0	0	0	0	1.4	0.3	1.4	3.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lygonum chinense L	10	21.7	6	20.7	6.1	2.1	25	19.3	27.9	0	10.7	9.6	10.3	0	11.4	2.4	0	5.3	30	10.7	0	0	0	2.1	0	0	0	0	0	10	7.6	0	0	0	0.7	19.3	8.6	0	0	7.4	9.3
rtulaca oleracea L	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
zolzia hirta Hass	0.3	12.1	0	8.6	0	5	0	0	0	0	6	0	0	0	2.1	13.1	19.3	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	1.4	0	0	0
zolzia zeylanica	10	0	7.9	0	0	0	0	8.6	0	0	1.7	0	0	4.3	0	0	0	0	9.3	1.7	0	0	0	0.3	0	0.1	4.1	0	0	0	0	0	10	0	0	0	0	2.1	0	0	0
atia begoniifolia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
anus cerasoides D.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	22.9	0	0	0	0	2.1	41.4	22.1	28.6	0	17.1	21.4	0	0	0	0.7	0	0	0	0	0
eridium aquilinum	0	0	0	0	0	0	7.1	0	0	0	0	0	0	0	0	9.3	0	0	0	0	3.6	0	0	0	4.3	11.4	0	0	0.7	12.1	2.1	0	12.4	0	18	15	0	2.1	0	0	2.9
eraria imbricata K	0	0	0	18.6	0	27.9	11.4	11.4	12.9	10	2.1	0	0	0	0	0	11.4	0	0	6	15	3.1	24.3	0	0	0	0	0	0	10.7	0	12.4	0	6.4	0.7	20	12.9	0	8.1	5.7	0
uvolfia ophiorrhiz	0	0	0	0	0	0	0	0	0	0	0	0	10.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
us chinensis Mill.	0	0	0	0	0	34.3	0	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
ous blepharoneurus	8.6	0	15.7	9.9	8.4	5.3	0	4.6	7.1	10	5.7	11	0	17.9	14.3	12.1	30	9.3	16	30	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0.7	0	0	0	11.4
cciolepsis indica	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rauia nepaulensis	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
iaa wallichii (DC	0	0	0	0	0	0	0	0	54.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
leria reticulata (	0	0	0	0	0	0	0	0	0	0	0	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
leria terrestris (	0.3	9.6	0	3.1	1.7	3.4	0	0	0	0.7	0.1	1.9	0	0	5.7	0	0.1	0.1	0	0	4.4	0	0	2.4	0.3	5.3	3.1	1.9	3.4	0	0	12.9	4.1	0	0	0.6	4.4	0	0	0	0.7
aria pallide-fusc	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	7.1	0	0	0	1.4	0
aria palmifolia (	0	5.7	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
aria parviflora (	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.3
teria involucrata	4.6	36.7	0	17.1	16.4	0	35	0	0	0	0	27.9	11.4	12.4	12.4	23.1	29.3	17.1	0	0	31.4	0	19.3	21.4	38.6	29.3	21.4	55.7	72.9	28.6	24.3	22.9	13.6	7.9	16.4	34.3	0	8.6	5.7	15.7	12.9
a rhombifolia L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5	0	6	7.1	0
lax corbularia Ku	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lax lanceifolia R	0	0	0	0	0	2.4	4.6	0	0	0	0	0	0	0	0	0	0	2.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lax ovalifolia Ro	1.9	10.3	0	0	0	0	0	0	0.1	0.1	4.3	6	0.7	0.7	0.1	3.9	3.1	0.6	0	0.7	0	0	0	0	0	0	0	0	0	0.7	6.4	0	0	0	0	0.6	0	0	0	0	0
lax verticalis Ga	0	0	0	0	0	0	5	0	25.7	0	3.6	10.7	0	7.1	0	0	0	0	0	9.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
lax zeylanica L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
anum barbisetum N	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
tholobus floribun	0	0.1	0	0	6.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
aona sp.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0
eptocaulon juvent	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
rax benzoides Cra	0	2.3	0	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.1	0	0.1	0	0	0	0	0.7	0	0	0	0	0	0	0
rastigma sp.	5	4.1	0	6.7	0	0	0	0	0	0	2.3	0	0	0	0	.0	0.3	0	0	4.6	0	0	0	0	0	0.3	0	0	0	0	0	5.7	0.3	0	0	0.7	0.3	2.9	0	0	0
meda triandra For	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0
abergia similis C	1.6	3.6	1.9	2.4	0	12.1	10.3	9.9	11	0	3.6	1.3	2.4	0	10	0	0	3.1	25	35	0	0	0	0	0	0	0	0	0	0	0	7.9	0	0	0	0	0	2.1	4.4	0	0
sanolaena latifol	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.9	0	0	0	0	0	0	0	0	0	26.4	0	0	0	0	40.7	0
na orientalis (L.	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	40.7	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0
vesia palmata (Ro	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0
na lobata L. ssp.	0	0	0	0	0	0	0	0	6.4	0	0	0	0	0	0	0	0	0	0	0	29.3	0	31.4	0	20	15	15	0	54.3	26.4	40	22.9	85	0	0	24.3	23.6	0	13.6	10	0
clnium apricum Fl	0	0	0	0	0	0	10.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
cinium sprengelii	3.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
nonia sutepensis	.0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0
nonia voltaeriif	0	0	0.7	17.9	8.1	0	44.3	0	0	10	0	0	0	0	0	0	0	0	76.4	7.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
na radiata (L.) W	0.9	[illegible]	0	0.9	4	0	0	0	0	0	0	0	0	0	0	0	2.4	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1.4	0	0	0	0	0	0	0
la pilosa Bl.	0	0	0	3.4	0.7	0	0	0	0	0	0	0	0	0	0	0	0.3	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
landia tinctoria	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
thoxyum acanthopo	0	0	0	0	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	10	0	0	0	0	0.3	0	0	0	0.7	0	0	0	0
giber kerrii Crai	0	0	4.9	0	0	0	3.3	0	3.1	4.3	0	1.4	0	3.9	0.7	0	0	3.9	3.1	7.9	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
giber smilesianum	0	1.6	3.4	0	6.4	0	14.3	0.7	10.7	3.4	0	10.3	0	10.7	4.3	0.7	0	5.3	2.3	6.4	0	0	0	0.3	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0
KNOWN SEEDLING (A,	0	0	0	0	0	5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KNOWN SEEDLING (B,	0	0	0	0	0	0	0	7.7	0	4.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
KNOWN SEEDLING (ga	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0
KNOWN HERB (forest	0	0	0	0.3	0	0	2.7	0.3	6.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

0	0	2.9	17.9	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0
4.7	0.7	14.3	42.9	5.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	3	0	1.9	4.1	0	0	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.6	0	0	0	0.3	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0.3	0	0	1.4	2.1	2.4	0	0	0	0	0	0	0	0	0	1.4	0.7	1	5	5	0.7	2.1	1.7	0	0	0	0	0	3.3	4.1	22.9	37.1	35.7	3.4	45.7	8.6
1.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	2.4	0	0	0	0	0	0	0	0	0	0	0	0	3.9	0	1	5	2.3	4	3.3	14.3	9.3	0	0	2.9	0	0	0	7.4	0	0	14.3	7.1
30.7	22.1	45	46.4	27.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0
0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0
0	0	0	0	0	0.3	0	0	2.5	0	0	5.3	0	0	0	0	3.3	0	0	0	22.1	0	0	6.7	0	0	0	0	0	0	0	0	0	0	0	3	0	0	0	0	0	31.3	0	7.9
0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	4.9	5.7	5.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2.6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	3.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0.7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0.1	0	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.7	0	0	0.3	0	0	0	0	0	3.6	0	8.6
0	0.3	0	0	2.4	0	0	0	0	0	0.3	0	0	0	0	0.7	0	0.1	0	0	0	0	0	0	0	0	0	0	2.9	3.7	8.6	3.6	0	0	3.6	0	0	0	0	0	0	1.6	4.1	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0
0	0	0	0	0	0	0	0	0	0	14.6	0	0	0	0	0.3	0	0	0	1.4	0	0	2.9	0	5.6	0	2.1	0	2.4	1	0	0	0	3	2.1	2.3	0	0	0	0	1.7	1.3	3.9	2
0	0	0.3	0.3	0.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0	0	0	0	0	0	2	2	0	0	0	0	0	0	0	1.7	0	0	0	0	0	0	0	0	0
0	0	0	0	0	10	13.9	7.1	11.4	20.3	1.4	3.6	10	4.3	3.1	8.1	2.1	17.1	8.6	2.9	3	6.4	7.4	2.1	8.4	0	1.7	0	0	3	3	2.3	0	0	0	3.4	0	3.3	0	0	1.9	0	0	0.6
0	15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	4.1	0	0.3	1.3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
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0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	4.6	0	0	0	0	0	0	0	0	1.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	9.3	4.6	0	0	3.3	0	0	3.3	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	3.7	0	0	0	0	0	0.3	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	2.6	0	0	0	0	0	0	0	0	0	0.4	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	7.3	0	0	0	2	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
27.1	17.9	26.4	12.9	33.6	0	0	0	1.9	0	0	0	0	4.4	0	0	0	0	0	0	0	0	0	3.9	3.1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0.3	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	6.4	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

APPENDIX 5. Hierarchical Cluster Analysis (using Cosine Index)

Agglomeration Schedule using Average Linkage (Between Groups)

Stage	Clusters Combined Cluster 1	Clusters Combined Cluster 2	Coefficient	Stage Cluster 1st Appears Cluster 1	Stage Cluster 1st Appears Cluster 2	Next Stage
1	61	80	.986894	0	0	3
2	72	74	.983573	0	0	6
3	61	62	.980226	1	0	4
4	61	63	.978416	3	0	5
5	61	69	.973011	4	0	6
6	61	72	.949911	5	2	7
7	61	65	.928514	6	0	16
8	43	44	.923328	0	0	9
9	43	54	.913877	8	0	14
10	56	57	.906196	0	0	15
11	19	20	.904733	0	0	30
12	2	4	.890880	0	0	17
13	87	90	.888573	0	0	21
14	41	43	.886682	0	9	18
15	56	59	.885059	10	0	18
16	61	78	.883593	7	0	20
17	2	12	.882702	12	0	25
18	41	56	.862556	14	15	22
19	68	89	.861174	0	0	94
20	61	70	.852990	16	0	34
21	87	88	.836007	13	0	50
22	41	47	.809883	18	0	32
23	8	9	.803289	0	0	53
24	42	51	.800695	0	0	36
25	2	11	.798329	17	0	49
26	24	29	.786034	0	0	44
27	6	13	.781653	0	0	52
28	75	82	.781199	0	0	33
29	21	34	.764354	0	0	47
30	3	19	.762141	0	11	42
31	7	16	.759804	0	0	87
32	41	58	.753702	22	0	35
33	75	76	.749841	28	0	43
34	61	64	.745549	20	0	51
35	41	60	.741768	32	0	36
36	41	42	.724478	35	24	46
37	1	14	.715463	0	0	42
38	49	53	.709435	0	0	72
39	37	39	.704117	0	0	58
40	85	92	.703790	0	0	65
41	52	55	.692807	0	0	55
42	1	3	.692530	37	30	80
43	73	75	.692105	0	33	56
44	24	40	.691125	26	0	85
45	31	38	.688094	0	0	76
46	41	45	.687567	36	0	48
47	21	26	.671338	29	0	64
48	41	46	.669730	46	0	54
49	2	10	.668857	25	0	57
50	86	87	.662657	0	21	81
51	61	79	.645403	34	0	67
52	6	18	.635614	27	0	57
53	5	8	.623370	0	23	75
54	30	41	.618621	0	48	55
55	30	52	.602532	54	41	58
56	73	98	.597857	43	0	62
57	2	6	.595909	49	52	61
58	30	37	.581727	55	39	87
59	27	28	.578621	0	0	68
60	32	35	.549362	0	0	68
61	2	17	.530884	57	0	73

APPENDIX 5. (continued)

62	73	77	.527228	56	0	71
63	95	97	.522448	0	0	77
64	21	48	.513184	47	0	70
65	83	85	.502539	0	40	92
66	81	94	.495151	0	0	82
67	61	71	.464395	51	0	84
68	27	32	.460004	59	60	78
69	15	22	.459487	0	0	78
70	21	25	.451648	64	0	90
71	73	96	.434189	62	0	88
72	49	50	.430961	38	0	84
73	2	33	.423808	61	0	75
74	23	84	.413563	0	0	97
75	2	5	.379712	73	53	80
76	31	36	.358395	45	0	89
77	95	99	.357650	63	0	82
78	15	27	.349475	69	68	85
79	66	67	.332328	0	0	86
80	1	2	.314886	42	75	91
81	86	93	.312085	50	0	83
82	81	95	.293704	66	77	88
83	86	91	.285539	81	0	95
84	49	61	.270426	72	67	93
85	15	24	.260305	78	44	89
86	66	100	.233932	79	0	96
87	7	30	.228287	31	58	93
88	73	81	.219518	71	82	92
89	15	31	.219202	85	76	90
90	15	21	.209939	89	70	91
91	1	15	.184749	80	90	97
92	73	83	.181644	88	65	94
93	7	49	.173582	87	84	98
94	68	73	.137396	19	92	95
95	68	86	.124999	94	83	96
96	66	68	.098715	86	95	99
97	1	23	.095886	91	74	98
98	1	7	.089103	97	93	99
99	1	66	.035057	98	96	0

APPENDIX 6. List of tree seedlings found in all five sites

Botanical name	Family	Habit*	Site**
Albizia odoratissima (L. f.) Bth.	Leguminosae, Mimosoideae	dt	f p y
Antidesma acidum Retz.	Euphorbiaceae	etlt	f p y
Aporusa villosa (Lindl.) Baill.	Euphorbiaceae	detlt	p y
Archidendron clypearia (Jack) Niels.			
ssp. *clypearia* var. *clypearia*	Leguminosae, Mimosoideae	et	f p y
Archidendron glomeriflorum (Kurz) Niels.	Leguminosae, Mimosoideae	et	f y
Betula alnoides B.-H.	Betulaceae	et	f g
Boehmeria diffusa Wedd.	Urticaceae	etlt	f
Bridelia pubescens Kurz	Euphorbiaceae	det	y
Castanopsis diversifolia King ex Hk. f.	Fagaceae	et	f g e p y
Castanopsis tribuloides (Sm.) A. DC.	Fagaceae	et	f
Clerodendrum glandulosum Colebr. ex Lindl.	Verbenaceae	etlt	g e y
Clerodendrum infortunattum Craib	Verbenaceae	etlt	e
Clerodendrum serratum (L.) Spr. var.			
wallichii Cl.	Verbenaceae	etlt	f
Dalbergia fusca Pierre	Leguminosae, Papilionoideae	dt	y
Debregeasia longifolia (Burm. f.) Wedd.	Urticaceae	etlt	g
Engelhardia serrata Bl.	Juglandaceae	det	f g y
Engelhardia spicata Lechen. ex Bl. var.			
colebrookeana (Ldl. ex Wall.) O.K.	Juglandaceae	det	f g
Eucalyptus camaldulensis Dehnh.	Myrtaceae	et	f e
Eugenia albiflora Duth. ex Kurz	Myrtaceae	et	f y
Eugenia fruticosa (DC.) Roxb.	Myrtaceae	et	f
Eugenia tetragona Wight	Myrtaceae	et	f e p
Euodia triphylla DC.	Rutaceae	etlt	f
Fagerlindia sp.	Rubiaceae	etlt	p y
Ficus hispida L. f. var. *hispida*	Moraceae	detlt	e y
Flacourtia indica (Burm. f.) Merr.	Leeaceae	dt	e
Flemingia sootepensis Craib	Leguminosae, Papilionoideae	etlt	f g e p y
Helicia nilagirica Bedd.	Proteaceae	et	f p y
Heliciopsis terminalis (Kurz) Sleum.	Proteaceae	et	g y
Leea indica (Burm. f.) Merr.	Leeaceae	detlt	f g e p y
Lezpedeza parviflora Kurz	Leguminosae, Papilionoideae	etlt	p
Litsea cubeba (Lour.) Pers.	Lauraceae	etlt	f g e
Litsea sp.	Lauraceae	etlt	f
Macaranga denticulata (Bl.) M.-A	Euphorbiaceae	etlt	e y

Maesa montana A. DC.	Myrsinaceae	etlt	f
Markhamia stipulata (Wall.) ex Sch. var.			
stipulata	Bignoniaceae	det	y
Melastoma normale D. Don var. *normale*	Melastomataceae	etlt	g p y
Micromelum minutum (Forst. f.) Wight & Arn.	Rutaceae	etlt	f
Olea salicifolia Wall. ex G. Don	Oleaceae	det	f g e p y
Palaquium garrettii Flet.	Sapotaceae	et	f y
Phoebe aff. cathia (D. Don) Kosterm.	Lauraceae	et	p y
Phoebe lanceolata (Nees) Nees	Lauraceae	et	f
Phoebe sp.	Lauraceae	et	f p
Phyllanthus emblica L.	Euphorbiaceae	det	p y
Phyllanthus sootepensis Craib	Euphorbiaceae	det	p
Pinus kesiya Roy. ex Gord.	Pinaceae	et	p y
Planchonella punctata Flet.	Sapotaceae	et	f
Prunus cerasoides D. Don	Rosaceae	det	g
Rauvolfia ophiorrhizoides (Kurz) Kerr	Apocynaceae	etlt	f
Rhus chinensis Mill.	Anacardiaceae	detlt	f g y
Schima wallichii (DC.) Korth	Theaceae	et	f p y
Styrax benzoides Craib	Styracaceae	et	f g e p y
Trema orientalis (L.) Bl.	Ulmaceae	etlt	g
Trevesia palmata (Roxb.) Vis.	Araliaceae	etlt	f g
Vaccinium apricum Flet.	Ericaceae	etlt	f y
Vaccinium sprengelii (D. Don) Sleum.	Ericaceae	etlt	f p y
Vernonia volkameriifolia DC. var. *volkameriifolia*	Compositae	etlt	f p y
Wendlandia tinctoria (Roxb.) DC.			
ssp. *floribunda*, (Craib) Cowan	Rubiaceae	et	p y
Zanthoxyum acanthopodium DC.	Rutaceae	etlt	g e
UNKNOWN SEEDLING (A)			f
UNKNOWN SEEDLING (B)			f g
UNKNOWN SEEDLING (C)			g
UNKNOWN SEEDLING (D)			f y
Note (*):	Note (**):		
et = evergreen tree seedling;	f = found in the evergreen forest site		
etlt = evergreen treelet seedling;	g = found in the regenerating gap site		
det = deciduous tree seedling;	e = found in the eucalyptus plantation site		
detlt = deciduous treelet seedling.	p = found in the mature pine plantation		
	y = found in the young pine plantation site		

APPENDIX 7. Monthly records of soil moisture content (g water/g dry soil)

Month	Forest	Reg. Gap	Eucalypt	M.Pine	Y.Pine
7 June	0.53	0.39	0.41	0.44	0.38
15 July	0.51	0.37	0.37	0.39	0.36
12 Aug	0.70	0.43	0.45	0.49	0.47
17 Sept	0.74	0.56	0.53	0.56	0.57
21 Oct	0.71	0.45	0.44	0.52	0.51
16 Nov	0.49	0.28	0.38	0.28	0.28
21 Dec	0.54	0.33	0.41	0.35	0.35

Note :

Forest = evergreen forest

Reg.gap = regenerating gap

Eucalypt = eucalyptus plantation

M.pine = mature pine plantation

Y.pine = young pine plantation

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