THE EFFECTS OF PLANTED TREES AND BIRD COMMUNITY ON NATURAL-SEEDLING RECRUITMENT IN FOREST RESTORATION AREA USING FRAMEWORK TREE SPECIES METHOD

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A THESIS SUBMITTED TO THE GRADUATE SCHOOL IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE OF MASTER OF SCIENCE IN BIOLOGY

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ABSTRACT

This study was carried out to examine the effects of planted framework trees and bird community on natural-seedling recruitment in forest restoration area using the framework species method established by Forest Restoration Research Unit (FORRU), Biology Department, Faculty of Science, Chiang Mai University, in the upper Mae Sa Valley, Mae Rim District, Chiang Mai, in Doi Suthep-Pui National Park. Natural tree seedlings were surveyed beneath 5 species of framework trees: *Erythrina subumbrans*, *Hovenia dulcis*, *Melia toosendan*, *Prunus cerasoides* and *Spondias axillaris*. Five individual trees of each species were selected (25 trees) in 3 replicated plots of the same age (9-years since planting). Bird observations, using binoculars were carried out on each framework tree to determine species richness, diversity and numbers of visiting birds, which were assumed to affect natural-seedling recruitment. A total of 36 tree seedling species were found beneath the selected trees, of which 11 species were wind-dispersed and 25 species animal-dispersed. The population density of animal-dispersed tree seedlings was higher than the wind-dispersed seedlings beneath all selected framework trees. The sample plots beneath *Prunus cerasoides* supported the highest population density of tree seedlings. Mean survival rate of the seedlings was 96.1% indicating that the selected framework trees supported the recruitment of

seedlings very well during one year of seedling monitoring. A total of 48 bird species was recorded between July 2006 and June 2007. Two hundred and twenty eight individuals of birds were recorded using the selected framework tree species. The non-frugivorous birds were recorded using the selected framework tree species more than the frugivorous birds. The frugivorous birds were recorded more than the non-frugivorous birds only in the crowns of *Erythrina subumbrans*. The effects of bird communities on seedling recruitment were different between each selected framework tree. Bigger trees, which attract high number of birds by providing food resources, roosting and nesting sites may increase the seed deposition in the sampling plots more than smaller trees with less attractiveness. *Erythrina subumbrans* produces bright red color flower when they are leafless, which provide high quantities of nectar as a food sources for many birds species. *Melia toosendan* produces numerous, white flowers attracting many insects, and insectivorous birds to the trees. *Prunus cerasoides* attracted the most abundant of birds. High amount of branchlets, flowers and fruits of the trees provide lots of perching sites and food resources for the birds. The highest species richness of birds was observed in *Spondias axillaris*, which had multiple crowns as nesting sites. The lowest species richness, diversity and abundance of the birds were observed in *Hovenia dulcis*. Their crowns were not large enough to attract high number of birds. Moreover, the trees have not flowered yet since planting. Some possible physical and biotic factors in the sampling tree plots, which seemed to affect natural-seedling recruitment, were light intensity, litter accumulation, physical damage of the seedling due to tree falls. These factors were depended on the characteristics of each selected framework tree species.

ชื่อเรื่องวิทยานิพนธ์ ผลของไม้ปลูกและชุมชีพนกต่อการตั้งตัวของกล้าไม้ธรรมชาติในพื้นที่ฟื้นฟูป่าด้วยวิธีพรรณไม้โครงสร้าง

ผู้เขียน นายชวพิชญ์ ไวทยการ

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บทคัดย่อ

การศึกษาครั้งนี้มีขึ้นเพื่อตรวจสอบผลของไม้ปลูกและชุมชีพนกต่อการตั้งตัวของกล้าไม้ธรรมชาติในพื้นที่ฟื้นฟูป่าด้วยวิธีพรรณไม้โครงสร้างของ หน่วยวิจัยการฟื้นฟูป่า (FORRU) ภาควิชาชีววิทยา คณะวิทยาศาสตร์ มหาวิทยาลัยเชียงใหม่ ณ บ้านแม่สาใหม่ อ. แม่ริม จ. เชียงใหม่ ในเขตอุทยานแห่งชาติดอยสุเทพ-ปุย การสำรวจกล้าไม้ธรรมชาติทำโดยศึกษาภายใต้ทรงพุ่มของพรรณไม้โครงสร้าง 5 ชนิด ได้แก่ ทองหลางป่า (*Erythrina subumbrans*) หมอนหิน (*Hovenia dulcis*) เลี่ยน (*Melia toosendan*) นางพญาเสือโคร่ง (*Prunus cerasoides*) และ มะกั๊ก (*Spondias axillaris*) โดยเลือกพรรณไม้โครงสร้างชนิดละ 5 ต้น รวม 25 ต้นในแปลงปลูก 3 แปลงที่มีอายุ 9 ปีเท่ากัน การสำรวจนกที่เข้ามาเกาะพรรณไม้โครงสร้างด้วยกล้องส่องทางไกลแบบสองตา เพื่อศึกษาจำนวนชนิด ความหลากหลาย และจำนวนของนกที่มาเกาะ ซึ่งอาจมีผลต่อการตั้งตัวของกล้าไม้ธรรมชาติ พบกล้าไม้ทั้งสิ้น 36 ชนิด ภายใต้ทรงพุ่มของต้นไม้ที่คัดเลือก โดย 11 ชนิดเป็นกล้าไม้ที่มีเมล็ดกระจายโดยลมและ 25 ชนิดเป็นกล้าไม้ที่มีเมล็ดกระจายโดยสัตว์ ความหนาแน่นของกล้าไม้ที่มีเมล็ดกระจายโดยสัตว์มีค่าสูงกว่าความหนาแน่นของกล้าไม้ที่กระจายโดยลมภายใต้ทรงพุ่มของพรรณไม้ที่คัดเลือกทุกชนิด แปลงเก็บตัวอย่างใต้ทรงพุ่ม นางพญาเสือโคร่งพบความหนาแน่นของกล้าไม้มากที่สุด อัตราการรอดของกล้าไม้โดยเฉลี่ยคือ 96.1 % บ่งชี้ให้เห็นว่าพรรณไม้โครงสร้างที่คัดเลือกสามารถสนับสนุนการตั้งตัวของกล้าไม้ธรรมชาติได้ดีภายในหนึ่งปีที่มีการติดตามตรวจสอบกล้าไม้ พบนกทั้งหมด 48 ชนิด จากการสำรวจระหว่างเดือน กรกฎาคม

พ.ศ. 2549 จนถึงเดือน มิถุนายน พ.ศ. 2550 นกจำนวน 228 ตัว ถูกพบว่าใช้ประโยชน์จากพรรณไม้โครงสร้างที่คัดเลือก โดยนกที่ไม่กินผลไม้ใช้ประโยชน์จากพรรณไม้โครงสร้างมากกว่านกที่กินผลไม้ นกที่กินผลไม้พบมากกว่านกที่ไม่กินผลไม้ในทรงพุ่มของ ทองหลางป่า เท่านั้น ผลของชุมชีพนกต่อการตั้งตัวของกล้าไม้ธรรมชาติมีความแตกต่างกันในระหว่างพรรณไม้โครงสร้างแต่ละชนิด พรรณไม้ที่ใหญ่กว่าดึงดูดนกได้มากกว่า โดยเป็นแหล่งทรัพยากรอาหาร ที่เกาะพัก และที่ทำรัง อาจเพิ่มการถ่ายมูลเมล็ดลงในแปลงเก็บตัวอย่างมากกว่าพรรณไม้ที่มีขนาดเล็กกว่าและมีความสามารถในการดึงดูดนกได้น้อยกว่า ทองหลางป่า ออกดอกสีแดงสดเมื่อผลัดใบซึ่งสามารถให้น้ำหวานปริมาณมากเป็นแหล่งอาหารสำหรับนกหลายชนิด เลี่ยน ออกดอกสีขาวจำนวนมากซึ่งดึงดูดแมลงและนกกินแมลงจำนวนมาก นางพญาเสือโคร่ง ดึงดูดนกได้เป็นจำนวนมากที่สุด กิ่งเล็กๆ ปริมาณมาก รวมถึงดอกและผล สามารถให้ที่เกาะจำนวนมากและเป็นแหล่งอาหารแก่นก จำนวนชนิดของนกพบมากที่สุดในมะกั๊ก โดยนกใช้บริเวณของลำต้นแตกแขนงเป็นที่อาศัยทำรัง จำนวนชนิดของนก ความหลากหลายและจำนวนของนกพบน้อยที่สุดใน หมอนหิน เนื่องจากทรงพุ่มของพรรณไม้ไม่ใหญ่พอที่จะดึงดูดนก นอกจากนี้พรรณไม้ยังไม่เคยออกดอกตั้งแต่เริ่มปลูก ปัจจัยทางกายภาพและชีวภาพในแปลงตัวอย่างบางประการที่น่าจะมีผลต่อการตั้งตัวของกล้าไม้ธรรมชาติ ได้แก่ ความเข้มแสง การสะสมของเศษซากพืช ความเสียหายของกล้าไม้จากการร่วงหล่นของกิ่งไม้ ความแตกต่างของปัจจัยเหล่านี้ขึ้นอยู่กับลักษณะของพรรณไม้โครงสร้างแต่ละชนิดที่คัดเลือกด้วย

CHAPTER 1
INTRODUCTION

Rationale

Deforestation is undoubtedly, one of the most important environmental problems in Thailand. It has occurred throughout history in many countries of the tropics region (Tucker and Richards, 1983; Richards, 1984; Hecht and Cockburn, 1989; Williams, 1989, 1990). It is the main cause of biodiversity loss, flooding, soil erosion and climate change. According to the Royal Forest Department (RFD, 2004), Thailand's forest cover had been reduced from 53% in 1961 to 32 % in 2004. The annual lost of forest cover was an estimate 112,000 hectares (FAO, 2005). But, in fact, remaining natural forest cover might be lower than 15 % of the country area (Maxwell, 2001). Deforestation occurred in many ways. Illegal logging is one main cause. Despite the logging ban in 1989, it had the positive effect not much as expected and did little to limit environmental degradation (Pragtong, 2000). The forests were easy to accessible and illegal tree cutting remained widespread (RFD, 2002). Intensive agriculture system, such as slash-and-burn farming, which still practice in many tropical countries (Lambert, 1996) can clear large area of forest cover and quickly degrade the land (Delang, 2002). Forest fire occurred frequently and inhibited secondary succession and created fire-disclimax vegetation cover (e.g. Grassland dominated by *Imperata cylindrica*), which suppressed the regeneration of forest ecosystem (Kusipalo *et al*., 1995).

Many forest planting campaigns have been set up to restore natural forests through out the tropics (ITTO, 2005). Exotic and native fast-growing tree species were planted by various type of planting design (Lamb and Gilmour, 2003; Otsamo, 2002). In Thailand, reforestation project using fast – growing monoculture plantation were done by the Royal Forestry Department (RFD) since 1994. The plantation species were acacia, eucalyptus, pine, teak and other broadleaves species (FAO, 2001). Kamo (2002) reported that number of understorey plant species in the planted forest was larger than that in adjacent grassland. However, many evidence showed that monoculture plantations support low biodiversity and did not created a self-supporting ecosystem (Ruiz-Jaen and Aide, 2005; SER, 2004; Urbanska *et al*., 1997). Ecological restoration success could be based on vegetation structure, species diversity and ecosystem processes (McCoy and Mushinsky, 2002; Montagnini and Cusack, 2004; Rhodes *et al*., 1998; Wilkins *et al*., 2003). Thus, planting tree should promote biodiversity along with ecosystem structure and function. The formed of ecological restoration called "forest restoration" defined as "re-establishment of the original forest ecosystem that was present before deforestation occurred". The aims of this method is planting tree species that played a vital role in the forest recovery created forest structure with multi-layered canopy, increasing species diversity, improved soil conditions. Therefore, forest restoration is a specialized form of reforestation (Elliott, 2000).

It is assumed that recovery of wildlife and ecological processes in forest ecosystem will follow the establishment of vegetation (Toth *et al*., 1995; Young, 2000). For example, there is a strong correlation between vegetation structure and the recovery of forest birds in restoration sites (George and Zack, 2001; Tilghman, 1987; Twedt *et al*., 2002). Seed dispersal is an important ecological process that encourages natural forest regeneration, poor seed dispersal is a major limiting factor for forest recovery (Holl *et al*., 2000; Donath *et al*., 2003; White *et al*., 2004). Bird, especially, frugivorous birds play an important role in the re-establishment of tropical forests ecosystem because they act as "seed dispersal agents" that can disperse the seed throughout the landscape (Wunderle, 1997). Therefore, forest restoration should focus on planting the selected trees that accelerate natural forest regeneration by attracting seed-dispersing animals such as birds to encourage seed dispersal in restoration sites.

The Forest Restoration Research Unit (FORRU) at Chiang Mai University has been carrying out research of forest restoration. The unit has developed the framework species method of forest restoration. First developed in Queensland, Australia (Goosem and Tucker, 1995; Lamb *et al*., 1997; Tucker and Murphy, 1997; Tucker, 2000), one important characteristic of framework tree species is the provision of resources that attract seed-dispersing wildlife (e.g. fruits, nectar, nesting sites, etc.) at an early age (Goosem and Tucker, 1995). Birds attracted by the planted framework trees can disperse the seeds of many trees in the natural forest into the planted areas. Moreover, planted trees provide suitable conditions and microclimate for natural regeneration of forest ecosystem. Establishment of forest trees can come from the seeds produced by planted framework trees or seeds from other trees in the natural forest, so-called “natural seedling recruitment”.

This research examined the attractiveness of different framework tree species to seed-dispersing birds and how this consequently affects recruitment of natural tree seedlings. Knowledge about natural seedlings under different species of framework trees will help to improve tree species selection for suitable plantation design, to maximize the attractiveness of planted areas to seed-dispersing birds to accelerate natural tree-seedling recruitment.

Hypotheses

1) Different characteristics of each selected framework tree species attract different bird species, depending on the resources provided to the birds.
2) Natural seedling recruitment beneath the framework trees depends on the species of the framework tree.
3) High bird density, species richness and species diversity will increase the natural tree seedling recruitment rate beneath framework tree species.

Research Objectives

1) To determine the effects of planted framework trees and bird communities on tree seedling recruitment in forest restoration areas, using the framework species method.
2) To determine the suitable conditions beneath different species of framework trees, which enhance natural seedling recruitment.

Usefulness of the Research

This study should provide some ecological knowledge about the different abilities of each framework tree species, to attract birds to promote seedling recruitment by dispersing the seed under the tree crowns. The data can be applied to select the tree species that are suitable for accelerating natural forest regeneration.

CHAPTER 2
LITERATURE REVIEW

Seed dispersal and Forest Restoration

Seed Dispersal has the potential to speed up the succession-restoration process of natural forest (Corlett and Hua, 2000). Most of the tree species in the tropics are dispersed by animals rather than by wind, water or other forms of dispersal (Wunderle, 1997). In the forests of northern Thailand, dispersal of tree seeds by animals is more common by wind. Of the 475 tree species recorded for Doi Suthep-Pui National Park, only 29% are wind-dispersed. In deciduous dipterocarp-oak forest, 44% of tree species rely on the wind for seed dispersal. In contrast, in evergreen forests, only 21 % of tree species are wind-dispersed (FORRU, 2005). Many kind of animals, including numerous invertebrates, fish and reptiles, act as seed dispersers, but seed dispersal by vertebrates, especially by mammals and birds, is a key process in the dynamics of natural vegetation and in forest succession on degraded tropical forest land (Corlett, 1998). In the present day, large mammals-including elephants, rhinoceros, and wild cattle have been eliminated due to deforestation. Studies of frugivory and seed dispersal in deforested Asian landscapes have concentrated on birds, fruit bats and non-flying mammals.

Fruits bats are important seed dispersers. In tropical Asia The Lesser Short-nosed Fruit Bat (*Cynopterus brachyotis*) is probably the commonest and most widespread fruit bat (Lim, 1966; Lekagul and McNeely, 1977; Medway, 1978). Boon and Corlett (1989) investigated the influence of seed and fruit characteristics on the potential for seed dispersal by *Cynopterus brachyotis* in Singapore, in young secondary forest on the campus of the National University of Singapore and at the Singapore Botanic Gardens. Information on the feeding habits of *C. brachyotis* was obtained in four ways: by direct observation of wild bats; by collection of seeds and fruit remnants dropped under feeding roosts; by netting wild bats and collecting feces samples; and by offering a variety of fruits to captive bats and observing their behaviour. During the period of the study, the wild *C. brachyotis* ate a wide variety of fruits: both soft- and hard-fleshed, protected (with inedible rind) and unprotected, and with a wide range of seed and fruit sizes and seed numbers. The quality of seed dispersal provided depends on seed and fruit characteristics. faecal samples and discarded fruit remnants under temporary feeding roosts showed that *Adinandra dumosa* was the most important species in the diet at the University. The diet of the bats at the Botanic Gardens was more varied, but *Eugenia grandis* and Figs was clearly the preferred food when available. The fruit remnants under feeding roosts often included partly-eaten, seedless 'gall figs' of the dioecious *F. fistulosa*. The red, sweet and juicy seed figs of *F. grossularioides* were rejected by captive bats. The bat's habit of defecating in flight provides high quality dispersal for small-seeded. Larger seeds are mostly dropped under favored feeding roosts. Many of the dominants of older secondary forests in Singapore (e.g. *Calophyllum* spp., *Elaeocarpus* spp., *Eugenia* spp.) may be largely dispersed by *C. brachyotis*. However, since bats are nocturnal and cannot identified using binoculars, more research on bats should be consider to understand the role of them in forest restoration.

Non-flying mammal species that remain common and are likely to disperse seed between forest and degraded areas include common Wild Pig, Common Barking Deer, Hog Badger and various civet species, which are potentially important dispersal agents for large seeds (Dudgeon and Corlett, 1994), Some seeds taken by possums and rats may be dispersed to microsites suitable for germination and survival of seedlings. Possums excrete undamaged, germinable seeds of various sizes, and rats void small germinable seeds (Williams *et al.*, 2000; Dungan *et al.*, 2002). But, like bats that have nocturnal habits, very little information is available of these animals on the seed dispersing capabilities.

In large man-made deforested area, many factors limit forest regeneration. One of the most important factors is lack of natural seed sources and seed dispersers, which limit seed dispersal and natural seedling recruitment in deforested sites. The attractiveness of a site to tree seed dispersers determines the quantity and quality of seed dispersed into it. Many studies have shown that the seed rain beneath bird perches is significantly higher than nearby sites without perches (Debusche and Isenmann, 1994; Gale *et al*., 2003; Guevera *et al*., 1992; Kolb, 1993; McClanahan and Wolfe, 1993; Nepstad *et al*., 1991; Wilson and Crome, 1998). A study of abandoned pastures in the Amazon showed that the presence of fleshy fruits in a site tend to attract more avian seed dispersers, which increase other seeds to dispersed in the site (Nepstad, 1989). Structurally complex vegetation has been showed to be attractive to avian seed dispersers in study of old field succession (Wunderle, 1997). Vegetation structure can influence the perching behavior of frugivorous birds and so may influence deposition patterns of bird-dispersed seeds. Providing perches through partial reforestation of grassland should increase the density and diversity of seed input there by attracting birds and the seeds they ingest (McDonnell and Stiles, 1983; Debussche and Isenmann, 1994). Therefore, Forest restoration by planting trees should increase the seed input by providing perch sites, fleshy fruits and complexity of the vegetation structure to attract seed dispersers.

The Framework Tree Species Method, Originally conceived in northern Queensland, Australia to repair damaged tropical rain forest (Goosem and Tucker, 1995; Lamb *et al*., 1997; Tucker and Murphy, 1997; Tucker, 2000) has been successfully modified by The Forest Restoration Research Unit (FORRU) of Northern Thailand's Chiang Mai University, in collaboration with Doi Suthep-Pui National Park Headquarters authority to restore seasonally dry forests and degraded watershed sites in the mountains of Northern Thailand. The framework species method involves planting 20-30 carefully selected native forest tree species. The planted trees are rapidly re-established basic structure and functioning of forest ecosystems and improve condition for seed germination and seedling recruitment. Subsequently, biodiversity is restored when the planted framework trees attract seed-dispersing animals by produce resources (e.g. fruits, nectar-rich flowers or bird nest sites etc.).

Seed-dispersing animals transport seeds of many additional tree species from nearby natural forest into planted sites, which restores the forest to its original condition (FORRU, 2005)

Characteristics of Framework tree species to attract seed dispersers

The essential ecological characteristics of framework tree species are; high survival when planted out in deforested sites; rapid growth; dense, spreading crowns that shade out herbaceous weeds and flowering and fruiting, which attractive to wildlife. Trees that provide food or nesting sites can attract seed-dispersing animals for longer periods. Comparing 7-year-old and 5-year-old plantations with control sites, showed that plantations with a mixture of 20-30 fleshy-fruited trees had 72 plant species recruited in a site after 7 years. Older plantations had higher diversity than younger plots. The control site was dominated by grasses and supported only 19 plant species (Tucker and Murphy, 1997). Different framework tree species have different abilities to attract seed-dispersing birds, Table 2.1 shows the characteristics of 8 framework tree species (e.g. tree density in all forest restoration plots, mean girth at breast height (GBH), mean height and width crowned) at age 4 years old and the numbers of bird species observed in each tree.

Table 2.1 Characteristics of 8 framework tree species at age 4 years old and the numbers of bird species that used them (Toktang, 2005).

Frame work tree species	No.of bird sp.observed in each species	Density (trees/ha)	Mean GBH (cm)	Mean Height (cm)	Mean Width crown (cm)
1. *Melia toosandan*	32	106	37.5	970.3	423.3
2. *Erythrina subumbrans*	21	75	38.1	684.0	602.0
3. *Prunus cerasoides*	15	94	16.3	595.3	389.6
4. *Spondias axillaris*	14	175	27.8	734.9	439.1
5. *Ficus subulata* (2 year olds)	3	44	37.0	248.4	191.7
6. *Hovenia dulcis*	2	238	6.6	254.0	161.4
7. *Markhamia stipulata*	1	44	15.0	111.1	77.5
8. *Gmelina arborea*	0	50	22.2	367.3	252.

Many studies found that the fleshiness of fruit is an important factor that attracts seed-dispersing birds (Singhakan, 1986; Portigo, 1994; Chanthorn 2002 and Sanitijan, 2001). Fruits of many framework tree species planted by FORRU were found eaten by birds such as *Aphanamixis polystachya, Aglaia lawii, Bischofia javanica* Bl., *Callicarpa arborea* Roxb., *Cinnamonum iners, Duabanga grandiflora* (Roxb. *ex*. DC.) Walp., *Eurya accuminata* DC. *var. wallichiana* Dyer. *Michelia baillonii, Phoebe cathia, P. lanceolata and Prunus cerasoides* D. Don., *Ficus glaberrima* Bl., *F. hispida* L. f., *F. racemosa* L., *F. fistulosa* Rcinw. *ex Bl.* var. *fistulosa, F. subincisa Bl.* var. *subincisa, F. altissima, F. benjamina, F. subcordata.* These trees provide small to medium-sized fruits to attract animals within 3 years after planting. Some trees provide flowers producing high quantities of nectar e.g. *Erythrina subumbrans* (Hassk.) Merr. (FORRU, 2005).

Tree species used by birds as nesting sites, within 5 years after planting include *Alseodaphne andersonii*, *Balakata baccata* (Roxb.) Ess, *Bischofia javanica* Bl., *Cinnamonum iners*, *Duabanga grandiflora* (Roxb. *ex*. DC.) Walp., *Erythrina subumbrans* (Hassk.) Merr., *Eugenia albiflora*, *Ficus glaberrima* Bl., *F. semicordata* B.-H. *ex* J.E. Sm., *F. subincisa Bl.* var. *subincisa*, *Helicia nilagirica*, *Hovenia dulcis* Thunb., *Phoebe lanceolata*, *Prunus cerasoides* D. Don., *Pterospermum grandiflorum*, *Quercus semiserrata*, *Rhus rhetsoides* Craib and *Spondias axillaris* Roxb.

Birds as seed-disperser and natural forest regeneration

Birds are one of the most diverse groups of ecosystem service providing many ecological functions (e.g. seed dispersal, pollinator, pest control, carcass and waste disposal, nutrients depositor and ecosystem engineering). Bird seed dispersal might be the ecological function that affects the greatest number of species, especially considering its importance for late successional tropical trees with large seeds (Cagan, 2006). In tropical forests that have lost their large mammals, seed dispersal by birds might be the only option. Birds not only outperform primates in long-distance dispersal (Holbrook *et al*., 2002), but also generally disperse seeds to different areas (Clark *et al*., 2001; Howe and Smallwood, 1982). Consequently, seed dispersal could be the most influential avian ecological function, particularly in the tropics (Stile, 1985; Howe and Smallwood, 1982; Cordeiro and Howe, 2003). Seed dispersal by frugivorous birds plays an important role in forest succession and restoration by dispersing many seeds into forest gaps and increasing seed deposition at sites of potential future treefall gaps (Hoppes, 1988; Corlett, 1998). Frugivorous birds that can tolerate degraded landscape are more important at the initial stage of natural forest regeneration (Corlett, 1998). Common bird species, which contribute to the seed rain of deforested sites, are included passerine birds belonging to the Corvidae (magpies, jay, orioles etc.), Muscicapidae (thrushes, robin and chats), Sturnidae (starlings and mynas), Pycnonotidae (Bulbuls), Zosteropidae (white-eyes), Sylviidae-Garrulacinae (laughingthrushes) and frugivorous non-passerines Megalainidae (barbets) and some Columbidae (fruit - pigeons). Many of these are not strict frugivorous and are insectivores, which also take fruit as part of their diet (Corlett and Hua, 2000; FORRU, 2005). Some birds in the family Pycnonontidae play an important role in seed dispersal, such as Black-crested Bulbul (*Pycnonotus malanicterus*) which occurs in a wide range of habitats and can eat many kinds of fruits (Chanthorn, 2002, Pattanakaew, 2002). Sooty-headed Bulbul (*Pycnonotus aurigaster*), Flavescent Bulbul (*Pycnonotus flavescens*), and Red-whiskered Bulbul (*Pycnonotus jocosus*) were recorded as important seed dispersing agents in FORRU's planted area, they are common in the forest and are frequent visitors to deforested sites, several kilometers from natural forest (Scott *et al*., 2000)

Scott *et al*., (2000) studied the role of birds in forest regeneration by placed artificial bird perches, made of simple and inexpensive bamboo pole, in two deforested sites in the highlands of northern Thailand to compare the effects of perches on seed deposition at (1) site that were being planted with framework tree species and (2) site undergoing by natural regeneration. They observed which bird species used the perches, counted seeds dropped by the birds beneath the perches and monitored seedlings that subsequently established. The study showed that birds clearly use the perches often enough to significantly increased seed deposition in restoration sites, both seed rain and seed germination significantly increased below the perches compared with control plots with no perches. Seedling survival below the perches was also higher than in control plots. Several climax forest bird species, such as White-rumped Shama (*Lonchura striata*) and Hill Blue Flycatcher (*Cyornis banyumas*) were found in forest restoration plots, which have closed canopy tree cover, 2-3 years after planting framework tree species. The majority of bird-dispersed tree seeds were *Antidesma acidum* Retz. (Euphorbiaceae) Although bird perches are very inexpensive and require minimal labor, tree planting does appear to be more effective for restoring biodiversity in deforested sites compared with using perches alone. Natural tree recruitment beneath perches was higher at site with moderate disturbed and had some tree cover. Therefore, artificial perches should be place with restoration tree planting for more complex vegetation structure and food plants resources to attract seed-dispersing birds.

Graham (2002) compared bird visitation patterns to two tree species (*Dendropanax arboreus*, Araliaceae; *Bursera simaruba*, Burseraceae) in continuous forest and remnants of riparian vegetation in a region dominated by pasture in Los Tuxtlas, Veracruz, Mexico. Frequency of visitation, fruit consumption, consistency of visitation (percentage of total tree observation periods during which a given bird species was recorded), and species composition of birds at individuals of both tree species in continuous forest and riparian remnants were observed. The result showed that bird visitation rate, species richness, and fruit consumption rates were similar within both tree species in the two habitats. Bird species and fruit consumption in *Dendropanax* was different between continuous forest and remnants, suggesting that forest disturbance may affect the seed removal aspect of seed dispersal for this tree species. Bird visitation patterns in *Bursera* appeared unaffected by forest disturbance. Species that foraged in *Bursera* were for the most part habitat generalists and were common in both continuous and disturbed habitats. She concluded that habitat disturbance may influence avian visitation patterns, which may in turn affect subsequent recruitment patterns in some tree species. *Bursera* trees placed in a small remnant or open pasture would likely attract fruit-eating birds and potentially provide a focal point for regeneration. Therefore, *Bursera* can be an ideal species for reforestation initiatives.

Puttanakaew (2002) used artificial bird perches to study the correlation between bird-dispersed seed rain into regenerating sites and vegetation structure on eight plots in two study sites in northern Thailand. The density and species richness of birds and seeds was highest at the site with a greater area of and shorter distances to remaining forest patches. Areas with a high percentage of surrounding forest and with shorter distances to forest supported a higher density and species richness of birds and had higher seed input. Numbers of frugivorous birds observed on the plots were positively correlated with the density of trees and fruiting trees. Although artificial perches eventually lost their usefulness as canopy cover increased, plots with a higher percentage of canopy cover also had a higher percentage of seeds in control traps suggesting that overall bird-dispersed seed input increased during the regeneration process.

Ingle (2003) investigated seed dispersal by wind, birds, and bats between Philippine montane rainforest and successional vegetation. More woody species in the forest produced vertebrate-dispersed seeds than wind-dispersed seeds. Input of forest seeds into the successional area, both seed density and number of species were significantly affected by distance from forest, dispersal agent (wind, birds, bats), and the interaction between distance and dispersal agent. Input of vertebrate-dispersed successional seeds into forest was significantly affected by distance from source habitat, and the interaction between distance and dispersal agent (birds, bats). Frugivorous birds dispersed more forest seeds and species into the successional area than bats, and more successional seeds and species into the forest. Among species of vertebrate-dispersed successional seeds, probability of dispersal into forest declined significantly with seed size. From the result, recommended that planting forest trees that themselves produce seeds into degraded areas will be necessary to accelerate regeneration. Woody plants producing relatively small, wind- and bird-dispersed seeds should be suggest for early colonization of cleared areas.

Shiels and Lawrence (2003) added bird perches to six Puerto Rican landslides with three types of surfaces (bare, climbing fern, grass) to determine the ecological role of birds in plant succession and to test the practicality of perches to increase forest seed inputs and accelerate forest recovery on landslides. Six landslides were randomly chosen comprised of two landslides from each of the following three dominant ground cover types: climbing fern, grass, and bare. Four circular plots were established on each landslide. Two of the four plots on each landslide were randomly assigned introduced perches and two plots served as controls. Subplots were randomly put in each perch and each control plot to either trap seeds or record established forest seedlings. Bird observations were conducted on the six landslides that were used for perch additions. Numbers of bird-dispersed forest seeds were significantly higher in plots beneath introduced perches than in control plots. Perches did not increase tree seedling densities compared with control plots. Seven different bird species were observed on introduced perches, because 99% of the seed inputs to controls and perch plots in the six landslides were wind dispersed seeds. Perches in grass and fern-covered landslides tended to have a higher bird visitation rate than perches in bare landslides. Therefore, perches may be most successful on landslides that have enough vegetative ground cover. They concluded that bird perches provide habitat structure that can be used to accelerate forest seed inputs to landslides, but supplemental restoration techniques in addition to bird perches appear to be necessary and should be explored in future studies to increase forest seedling establishment and forest recovery on landslides.

Seedling Recruitment

Research on seedling recruitment or seedling establishment has concentrated in various factors such as mortality and competition for light, water, and nutrients. One of the main causes of mortality in seedlings is competition from other seedlings or from surrounding vegetation (Gross, 1980). Herb patches have a major influence in the density and distribution of tree seedlings (Maguire and Forman, 1983). For tree seedlings in forests, the presence of an understorey can reduce survival rates (Lorimer *et al*., 1994). Recruitment may be limited because seeds fail to arrive in the recruitment sites because of lacking in seed dispersers, predation of seeds and seedlings, and seasonal drought (Nepstad *et al*., 1990). Another factor limiting recruitment is the physical damage of the seedling, due to branch falls and other disturbance (Clark and Clark, 1989, 1991).

Dos Santos and Válio (2002) studied the effects of litter accumulation on seedling recruitment in a Southeast Brazilian tropical Forest. The monthly accumulation of litter and its relation to climatic factors (such as rainfall, photoperiod and temperature), also the litter effect on the recruitment of seedlings were observed in 40 sampling sites under the selected trees canopy in the Mata de Santa Genebra forest. The correlation between litter accumulation and climatic was very weak. Litter accumulation and seedling recruitment had large spatial and temporal variations in different sites. High seedling mortality was observed at all sites, mainly during the dry season. Biotic factors such as predators and disease may also cause seedling mortality. Under the canopy, the removal of the litter layer increased seedling emergence. Seedling recruitment also increased in response to rain.

Lambers and Clark (2003) determined the effects of dispersal, shrubs (*Rhododendron maximum*), and density-dependent mortality on seed and seedling distributions of Southern Appalachian trees. They quantified the spatial distribution of seed rain, seed bank densities, first-year seedlings, and older than first-year seedlings in five vegetation plots. The result showed that recruitment of all tree species is limited by seed dispersal at early life history stages. Seeds and seedlings of most species are clumped near adult trees. Seed size is generally negatively correlated with seed dispersal distances but positively correlated with seedling survival. Seedling densities of five species are decreased beneath *R. maximum*. Increased of seedling mortality under this shrub is likely a result of more than simply reduced light. Density-dependent mortality affected four species, decreasing seedling densities close to parent trees. Finally, they concluded that dispersal, density-dependent mortality, and *R. maximum* all these multiple factors are likely to interact to affect seed and seedling distributions.

Wilson *et al.*, (2003) studied the effects of possums and rats on seedling establishment at two forest sites in New Zealand. The seedling establishment was investigated in exclosures with mesh of two different sizes to exclude (1) possums and (2) possums and rats, at two mainland forest sites. One site was a fenced remnant of second-growth broadleaved-podocarp. The second site was protected beech-podocarp-broadleaved. Numbers of seedlings with true leaves differed significantly between treatments after 1.5 years at both sites and after 2 years in beech-podocarp-broadleaved forest. Both exclosure treatments increased seedling numbers in the second-growth broadleaved-podocarp, possums were present throughout the site but rats were rare. Thus, excluding rats did not further increase seedling establishment compared with excluding only possums. In contrast, in the beech-podocarp-broadleaved forest rats were present periodically throughout the study, but possums may have been scarce during the final 7 months as a result of pest control. Therefore, excluding possums did not significantly elevate seedling numbers, but excluding rats increased the number of seedlings with true leaves. They concluded that the consequences of these pest impacts on seedling recruitment for forest regeneration must be confirmed in longer-term studies. exclosures can be effectively used to experimentally separate the impacts of different herbivores on seedling establishment.

Lorena *et al*., (2005) studied canopy and soil effects in the facilitation of tree seedlings by pioneer shrubs, in two successional montane shrublands at the Sierra Nevada Protected Area, Spain. The canopy effect involves the microclimatic amelioration and the possession of canopy structures that protected seedling from herbivores (e.g. thorns, spines). The soil effect involves the modification that vegetations produce on chemical, physical and biological soil properties. Seedlings of *Quercus* and *Pinus* species were planted in four experimental treatments: (1) under shrubs; (2) in open interspaces without vegetation; (3) under shrubs where the canopies were removed; (4) in open interspaces but covering seedlings with branches, mimicking a shrub canopy. Seedling survival, heights, herbivory damage and the accumulated Relative Growth Rate (RGR) were calculated during the whole study period. Pioneer shrubs facilitated early recruitment of tree seedlings in the Mediterranean mountains. Seedling survival was higher with shrubs than for any other treatment without shrub in the study sites. Both canopy and soil effects benefited seedling performance. The canopy effect due to canopy shading was the main mechanism enhancing seedling survival and growth. Modification of soil physical and chemical properties by shrubs (soil effects) exerted a lower benefit over seedling survival and growth than the canopy effect.

Related research at study site

Chantorn (1999) studied the effects of forest restoration activities on the bird community of a degraded upland watershed at at Ban Mae Sa Mai, Doi Suthep-Pui National Park. He conducted bird surveys in tree planting plots, which had been planted with 29 "framework" tree species in June 1998 compared with non-planted control plots that were abandoned agricultural areas, undergoing natural regeneration. Furthermore, survey of birds feeding in fruiting trees in climax evergreen forest was carried out to help determine which bird species might be involved in dispersing seeds from forest to deforested areas. Sixteen bird species were observed in planted areas. The most common species was the Grey-breasted Prinia (*Prinia hodgesonii*). In the non-planted plots 33 species were observed. The most common species also included the Grey-breasted Prinia (*Prinia hodgesonii*) as well as the Red-whiskered Bulbul (*Pycnonotus jacosus*). In evergreen forest, he observed birds feeding in four fruiting trees species, *Ilex umbellulata* (Wall.) Loesn. (Aquifoliaceae), *Antidesma montamum* Bl. (Euphorbiaceae), *Nyssa javanica* (Bl.) Wang. (Nyssaceae) and *Ficus* sp. (Moraceae) the most common species was the Black-crested Bulbul (*Pycnonotus melanicterus*). He concluded that low bird species richness in the planted plots was probably the result of weeding activities, necessary to allow the planted trees to grow. It was expected that bird species richness would increase as the planted trees reach maturity and provide a greater variety of resources and niches, also reported by Anusarnsunthorn and Elliott (2004) and Scott *et al*., (2000).

Navakitbumrung (2003) studied effects of mature trees on seedling establishment on deforested sites at Ban Mae Sa Mai, to determine the effects of mature isolated trees on tree seedling recruitment in deforested areas and to find out which tree species should be planted to attract seed-dispersing birds. Seven species of remnant tree in deforested sites included *Albizia chinensis* (Obs.) Merr. (Luguminosae, Mimosaceae). *Callicarpa arborea* Roxn. var. *arborea* (Verbenaceae), *Castanopsis diversitifolia* (Kurz) King ex Hk. F. (Fagaceae), *Erythrina stricta* Roxb. (Leguminosae, Papilonoideae), *Eucalyptus camaldulensis* Dehnh. (Mytaceae), *Pinus kesiya* Roy. Ex Gord. (Pinaceae) and *Schima wallichii* (DC.) Korth. (Theaceae) were chosen. All naturally established tree seedling were surveyed in circular plot beneath fifty-one remnant trees , along with control plots (containing no tree) nearby each tree. Bird observations were done on the remnant trees studied and on fruiting trees in intact forest. He found that most remnant trees did not increase seedling recruitment beneath their crowns, except for *Schima wallichii* (DC.) Korth. (Theaceae), which was most attractive to birds. The density and species richness of animal-dispersed seedling beneath mature remnant trees did not depend on their species, no relationship between tree size and seedling density established beneath their crowns. Thirty-seven planted species in intact forest were dispersal by birds. He found Sooty-headed Bulbul (*Pycnonotus aurigaster*), Flavescent Bulbul (*Pycnonotus flavescens*), and Red-whiskered Bulbul (*Pycnonotus jocosus*) were importance dispersal agents in the FORRU’s planted areas.

Toktang (2005) studied the species diversity and composition of bird community in forest restoration area using framework tree species method at Ban Mae Sa Mai, Mae Rim District, Chiang Mai, in Doi Suthep-Pui National Park. Bird surveys were carried out to determine the species richness, diversity, abundance and density of birds in non-planted control plots planted plots of different ages established in 1998, 2000 and 2002. Observations of bird behavior in the planted trees were made. Thirty-six bird species were observed in the non planted control plots and a total of 68 species in planted plots; 43, 45 and 47 species in 2002, 2000 and 1998 planted plots respectively. Bulbul species e.g. Red-whiskered Bulbul, Sooty-headed Bulbul and Flavescent Bulbul (*Pycnonotus flavescens*) were the dominant species in the planted plots. Chestnut-capped Babbler (*Timalia pileata*), Red-whiskered Bulbul (*Pycnonotus jocosus*) and Grey-breasted Prinia (*Prinia hodgesonii*) were the dominant species in the non-planted control plots. The study showed that framework tree species plantation increased bird species richness and attracted several bird species, which could disperse seeds into planted areas and help accelerating forest regeneration. In addition, tree planting attracted more forest birds as the plots matured. Fifty-three percent of bird species recorded in planted plots were the same as bird species recorded in the nearest remnant patch of natural forest located 2-3 km away from the study plots.

CHAPTER 3
STUDY SITE

Planted plots description

Planted framework tree species plots established by FORRU were planted near Ban Mae Sa Mai (BMSM) in Doi Suthep-Pui National Park, Chiang Mai Province of northern Thailand (Figure 3.1 and 3.2). The planted plots had been covered with evergreen forest, cleared approximately 20 years previously, to provide land for cultivation of cash crops. Along the road and near the planted plots some fields were still cultivated for cabbage (Figure 3.3). The abandoned fields were dominated by herbaceous weeds such as *Pteridium aquilinum* (L.) Kuhn (Dennstaedtiaceae), *Bidens pilosa* L. var. *minor* (Bl.) Sherf, *Ageratum conyzoides* L., *Eupatorium odoratum* L. and *E. adenophorum* Spreng. (all Compositae), *Commelina diffusa* Burm. F. (Commelinaceae) and grasses, e.g. *Phragmites vallatoria* (Pluk. ex L.) Veldk., *Imperata cylindrical* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. ex Hubb. and Vaugh. and *Thysanolaena latifolia* (Roxb. Ex Horn.) Honda (all Gramineae) (Elliott *et al*., 2000 and Khopai, 2000).

Figure 3.1 Ban Mae Sa-Mai, Mae Rim District, in Doi Suthep-Pui National Park, Chiang Mai, Thailand. The main Forest restoration sites by FORRU (Photo taken by Peter Whitbread-Abrurat)

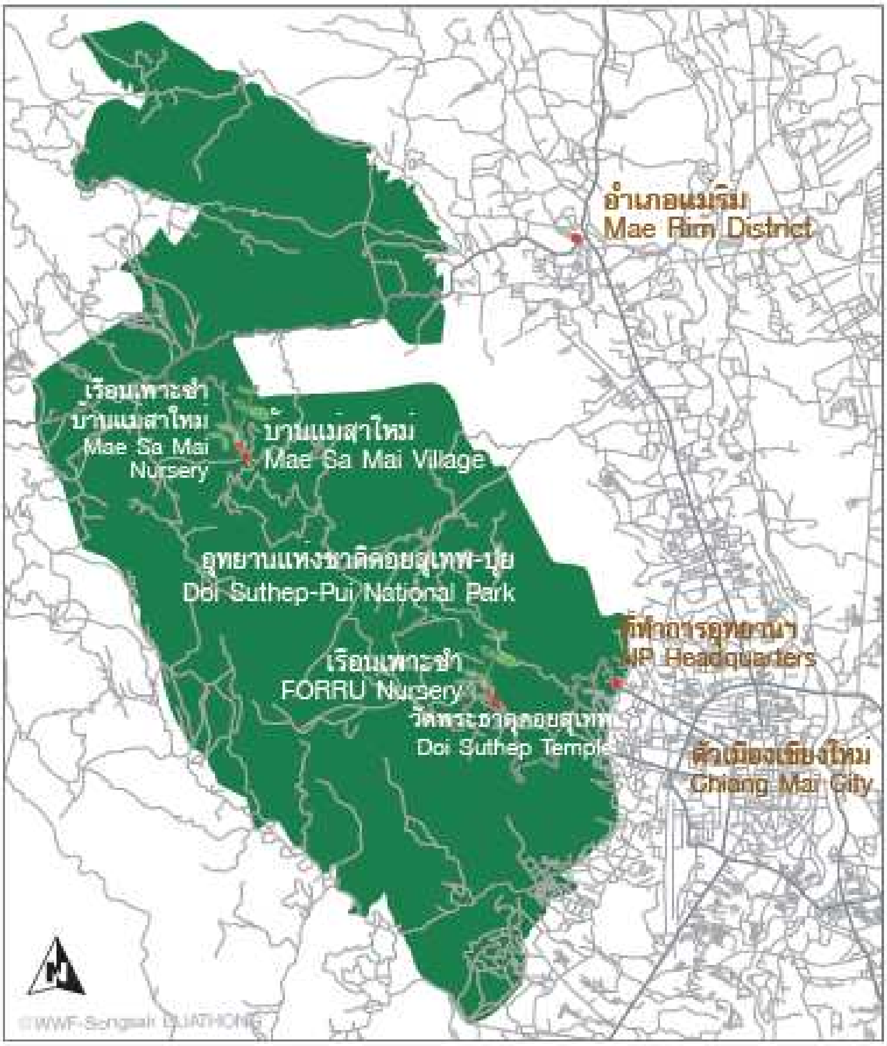

Figure 3.2 Map of Doi Suthep-Pui National Park, Chiang Mai.
The green color shows Doi Suthep-Pui National Park area and location of Ban Mae Sa Mai Village.

The remnant trees scattered around the restoration area included *Albizia chinensis* (Osb.) Merr. (Leguminosae, Mimosoideae), *Callicarpa arborea* Roxb. var. *arborea* (Verbenaceae), *Erythrina stricta* Roxb. (Leguminosae, Papilionoideae), *Gmelina arborea* Roxb. (Verbenaceae), *Heliciopsis terminalis* (Kurz) Sleum. (Proteaceae), *Sterculia villosa* Roxb. (Sterculiaceae) and *Schima wallichii* (DC.) Korth. (Theaceae) (Hitchcock and Kuaruk, unpublished). The other remnant trees in the areas were *Castanopsis diversifolis* (Kurz) king ex Hk. f. (Fagaceae), *Bauhinia variegata* L. (Leguminosae, Caesalpinioideae), *Trema orientalis* (L.) Bl. (Ulmaceae), *Ficus hispida* L. f. var. *hispida* (Moraceae) (Navakitbumrung, 2003). These trees species provided a potential seed source for natural forest regeneration. A natural sacred forest, located 2-3 km. away from the planted plots was evergreen forest with natural pine trees near the summit (Figure 3.4). Fruit bats and birds, especially bulbuls were the seed-dispersing agents, deposited small to medium-sized seeds from forest into the planted plots, although remnant populations of small to medium sized vertebrates (e.g. Common Barking Deer, Common Wild Pig, Hog Badger and civets) may play a role in long-distance seed dispersal. Dispersers of the largest seeds by large animal (e.g. Asian Elephant, wild cattle, rhinos) have been extirpated from the area.

Figure 3.3 Cabbage cultivation near the planted plot is very common agricultural landscape in Ban Mae Sa Mai

Figure 3.4 Natural sacred forest located 1-3 km. near the planted plots

1998 - Framework species plots

Plots planted in 1998 were positioned in a degraded watershed area, 3-5 km from the village (18° 52’N, 98° 51’E), altitude at 1,207-1,310 m above sea level (1,000 m elevation at BMSM village) (Elliott *et al*., 2000), 5-10 % of slope and 350° aspect (Khopai, 2000). Three replicated plots; 1998-1, 1998-2 and 1998-3 were positioned along or immediately below the ridges of a degraded watershed area, 2–3 km from the village, at 1207–1310 m above sea level, respectively (Figure 3.5). These plots were located adjacent to non-planted control plots The 1998-1 was located in altitude at 1,250 m approximately above sea level. This plot is one of the most well-known plots for FORRU visitors (Figure 3.6 and 3.7). The 1998-2 was located in altitude at 1,275 m approximately above sea level. In front of the plot is the cultivation land, used to grow cabbage or other cash crop every year (Figure 3.8 and 3.9). This plot is the shadiest plot with lowest ground vegetation cover. The 1998-3 was located in altitude at 1,300 m approximately above sea level. The remnant forest cover near this plot was burnt out by fire in the dry season 2006 (Figure 3.10 and 3.11). However, FORRU planted trees in June 2006 to restore this area (2006 plot).

These plots were located adjacent to non-planted control plots. Twenty-nine framework tree species were planted in 1998. Legumes (Family Leguminosae), Oaks and chestnuts (Fagaceae) and *Ficus* spp. (Moraceae) were considered potential framework tree species groups. Trees were planted randomly at a density of 500 saplings per rai (3125 per hectare) in each plot (40 x 40 m.). Averaging mean distance between planted trees was 1.8 m. The planted plots were 8-9 years old during the study period, with dense canopy cover and had the tallest trees, lowest ground flora cover and more shade compared with all other plots, planted after 1998. High amount of tree fall debris were found on the re-forest floor in the rainy season. The tallest planted trees were *Melia toosendan*, *Erytrina subumbran*, and *Spondias axillaris*. These tree species were selected in this study. They produced flowers and fruits to attract seed-dispersing animal such as bird and small mammal (FORRU, 2005)

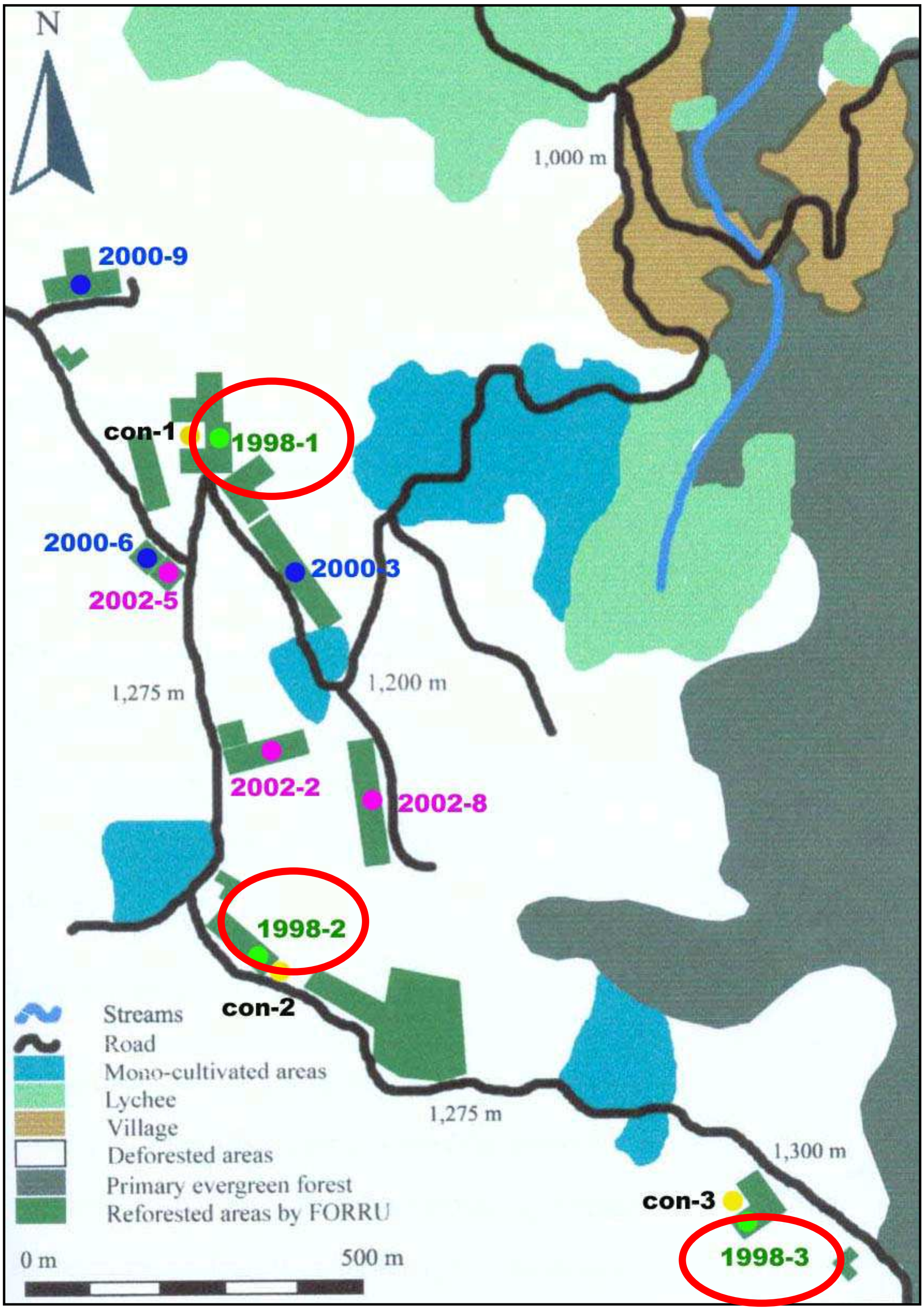

Figure 3.5 Map of study plots in FORRU's planted area at Ban Mae Sa Mai in Doi Suthep-Pui National Park. The red circles indicate the 3 replicated plots; 1998-1, 1998-2 and 1998-3 (Navakitbumrung, 2003).

Figure 3.6 Plot 1998-1 with the landmark sign in front of the plot

Figure 3.7 A look inside plot 1998-1

Figure 3.8 Plot 1998-2 shows many tall planted trees with cabbage cultivation in front of the plot

Figure 3.9 Inside plot 1998-2.

Figure 3.10 In front of plot 1998-3

Figure 3.11 Inside plot 1998-3 show high density of planted tree

CHAPTER 4
METHODOLOGY

1. Materials and equipments (Figure 4.1)

1. Measuring tape (1.5 and 50 m)
2. Plastic string
3. Knife and scissors
4. Bamboo poles
5. Hammer
6. Metal labels
7. Vernier caliper
8. Lux / Fc light meter, TENMARS, Model: DL -204
9. Binocular (8 x 32 mm)
10. Bird guide (Lekagul and Round, 1991)
11. Data sheet (seedling survey and bird survey)
12. Digital photo camera

Figure 4.1 Materials and equipment

2. Method

2.1) Tree seedling recruitment study

2.1.1) Framework tree selection

Five species of framework trees, which have different abilities to attract seed-dispersing birds according to the studied of Toktang (2005), were selected for this study (see Appendix A for details of each species). The 5 framework tree species are:

1. *Erythrina subumbrans* (Hassk.) Merr. (Figure 4.2)
2. *Hovenia dulcis* Thunb. (Figure 4.3)
3. *Melia toosendan* Sieb. & Zucc. (Figure 4.4)
4. *Prunus cerasoides* D.Don (Figure 4.5)
5. *Spondias axillaris* Roxb. (Figure 4.6)

Figure 4.2 *Erythrina subumbrans* (Hassk.) Merr. (Leguminosae, Papilionoidea)

Figure 4.3 *Hovenia dulcis* Thunb. (Rhamnaceae)

Figure 4.4 *Melia toosendan* Sieb. & Zucc. (Meliaceae)

Figure 4.5   *Prunus cerasoides* D.Don (Rosaceae)

Figure 4.6   *Spondias axillaris* Roxb. (Anacardiaceae)

Five individual trees of each species were selected (25 trees) from the 3 replicated planted plots in 1998 (Five trees in 1998-1, 10 trees in 1998-2 and 10 trees in 1998-3). Each plot was located in different areas.

2.1.2) Sampling plots

A total of 25 circular plots were laid out beneath each of the selected trees for seedlings sampling (Figure 4.7). Size and shape of the tree crowns determined the size of each sampling plots. The tree size (GBH) and plots areas are listed in Appendix B.

Figure 4.7 Sampling plot beneath the framework tree species

2.1.3) Seedling survey

All natural tree seedlings presented in each plot were surveyed. Seedlings were labeled, identified, and classified according to their seed-dispersal mechanism. All seedlings were identified by J.F. Maxwell, Plant taxonomist of CMU Herbarium. The root collar diameter and height of every seedlings were recorded to determine average relative growth rates (% per year). The first seedling survey was done during the dry season between March - April 2006, and monitored after the rainy season in November 2006. The final seedling survey was done in July 2007.

2.1.4) Survey of ground vegetation and light intensity measurement

Percent estimation was used to quantify abundance of the ground vegetation (Goldsmith *et al.*, 1986) as follow:

x = less than 1%, sparsely or very sparsely present, cover very small
1-5 % = small cover value
6-25 % = very numerous
26-50 % = covering ¼ to ½ of the area.
51-75 % = covering ½ to ¾ of the area
75-100 % = covering more than ¾ of the area

Light intensity measurements using Lux / Fc light meter were done beneath each selected tree for in July 2007.

2.2) Bird Survey

2.2.1) Bird observation time for each tree

Bird observations using binoculars were carried out on each framework tree crowns once a month for twelve months during July 2006 - June 2007. Time of the observation in each planted plot depended on the number of the studied tree. A total bird visitation period for each tree were 20 minutes/time. Randomly walks after every 5 minutes of observation from tree to tree were used to avoid time bias. The observation period for all selected tree in 1998-1 (5 trees) were made in the mornings during 6:30 – 8:30 and in the late afternoons during 16:00-18:00, whilst observation period for the selected trees in 1998-2 and 1998-3 (10 trees for each plot) were made in the mornings during 6:30 – 10:30 and in the late afternoons during 14.30-18:00.

2.2.2) Bird data collection

Bird species, number of birds, duration of visit, behavioral activity (e.g. perching, feeding on fruiting tree / insect / nectars, defecation under tree crowns) were recorded. The observed birds were classified according to their diet and the parts of the tree used by them (e.g. crown user, understorey user and ground user).

2.3) Data Analyses

The Microsoft Excel ® spread sheets were used to analyze both seedling and bird quantitative data (e.g. mean density, number of species per unit area). Ecological indices of the tree seedling and bird community were calculated for each of the studied plot by MVSP 3.1®, a multivariate statistical package programs (Kovach computing services, 2000).

Ecological indices

Species Richness

N0 = total number of seedling/bird species

Species diversity indices

Species diversity (Hill's number) of seedlings and bird communities in each studied plot were calculated by the following indices (N1, N2)

$N1 = e^{H'}$

$N2 = 1/\lambda$

Where: N1 = number of abundant species in the studied plot

N2 = number of very abundant species in the studied plot

H' = Shannon's index

λ = Simpson's index

Shannon's Index (H')

$$H' = \Sigma p_i \ln p_i$$

Simpson's Index (λ)

$$\lambda = \Sigma p_i^2$$

Where: p_i = proportion of individuals of the i th species

p_i = ni/N

Where: n_i = number of individual of the i th species

N = total number of individual

S = total number of species

Evenness (Modified Hill's Index)

$$\textbf{E5} = \frac{(1/\lambda) - 1}{e^{H'} - 1}$$

Similarity coefficients

The degree of similarity in seedlings and bird species composition among each of the studied trees were calculated on Microsoft Excel® spreadsheet using Sorensen's index.

$$\textbf{Sorensen's index.} = \frac{2C}{A + B}$$

where:

C = number of species found in both sampling units (SUs)

A = total number of species in the first sampling units

B = total number of species in the second sampling units

Relative growth rate

Root collar diameter and height of natural tree seedlings were recorded for the calculation of relative growth rate of root collar diameter (RRGR) and relative growth rate of height (RHGR) by formulas as follows:

Relative growth rate of root collar diameter (RRGR)

$$\text{RRGR (\% increase per year)} = \frac{[\ln(RCD2)-\ln(RCD1)]\times100\times365}{T2-T1}$$

where: RCD2 = root collar diameter of seedling in the last survey
RCD1 = root collar diameter of seedling in the first survey
T2-T1 = number of days between T1 and T2
ln = natural log

Relative growth rate of height (RHGR)

$$\text{RHGR (\% increase per year)} = \frac{[\ln(H2)-\ln(H1)]\times100\times365}{T2-T1}$$

where: H2 = height of seedling in the last survey
H1 = height of seedling in the first survey
T2-T1 = number of days between T1 and T2
ln = natural log

Seedling health

Health scores of the natural tree seedlings were recorded and calculated as follows:

$$Ha = \frac{(H1 + H2 + H3)}{3}$$

where: Ha = health average

H1 = health score of seedling species in first survey

H2 = health score of seedling species in second survey

H3 = health score of seedling species in third survey

The health sore was divided into 4 levels (Khopai, 2000):

0 = dead

1 = not healthy, no leaves but still alive

2 = normal, but may have some yellow leaves, brown spot, insect damage, etc.

3 = healthy

Seedling survival percentage

Percentage of seedling survival were calculated as follows:

$$\text{Survival (percentage)} = (SN / TN) \times 100$$

where: SN = Number survived

TN = Total number of seedlings

Statistical Analysis

The data on natural tree seedling and bird communities were tested for differences among plots beneath each of the studied framework tree species using *ANOVA* and *t-test* in the Microsoft Excel ® spreadsheet program. The linear comparison analysis using correlation in the Microsoft Excel ® spreadsheet program was used to test for relationship between seedlings and bird communities.

CHAPTER 5
RESULTS

1. TREE SEEDLING SURVEYS

1.1) Tree seedling recruitment in each selected framework tree plots

The total numbers of seedlings and seedling species of each seedling group shown in Table 5.1 was found beneath the selected framework trees between April 2006 and July 2007, of which 11 species were wind-dispersed (55 individuals) and 25 species were animal-dispersed (381 individuals). Seedling communities were composed of the group of seedlings, which were the same species as the planted framework trees in the 1998 plots, considered as “planted species” and the group of seedlings, which were the non-planted species in the 1998 plots, considered as “recruited species” (Table 5.2). Number of seedlings and number of species found in all sample tree plots are shown in Figure 5.1. The most abundant seedlings in all the sample plots beneath all selected framework tree were *Litsea monopetala* (Roxb.) Pers. (Lauraceae) (148 seedlings), *Castanopsis cerebrina* (Hickel & A. Camus) Barnett. (Fagaceae) (84 seedlings), *Phoebe lanceolata* (Wall ex Nees) Nees (Lauraceae) (61 seedlings), *Eugenia albiflora* Duth.ex Kurz. (Myrtaceae) (21 seedlings), *Aporusa octandra* (Buch.-Ham. ex D. Don) (Euphorbaceae) (17 seedlings) (Table 5.3). Natural tree seedlings in each selected framework trees were listed in Appendix C (Table C1).

Table 5.1 Total numbers of seedlings and numbers of seedling species found beneath the selected framework tree plots between April 2006 and July 2007

Seedling groups	No. of seedling species	No. of seedling
Wind-dispersed seedling	11	55
Animal-dispersed seedling	25	381
Total	**36**	**436**

Table 5.2 Number of seedling of planted and recruited (non-planted) species beneath each planted tree species crowns

Tree plots	No. of wind-dispersed seedling			No. of animal-dispersed seedling		
	Planted species	Recruited species	Tota l	Planted species	Recruite d species	Tota l
Erythrina subumbrans	2	18	**20**	44	78	**122**
Hovenia dulcis	3	2	**5**	5	10	**15**
Melia toosendan	6	5	**11**	43	45	**88**
Prunus cerasoides	8	8	**16**	81	36	**117**
Spondias axillaris	1	2	**3**	10	29	**39**
Total	**20**	**35**	**55**	**183**	**198**	**381**

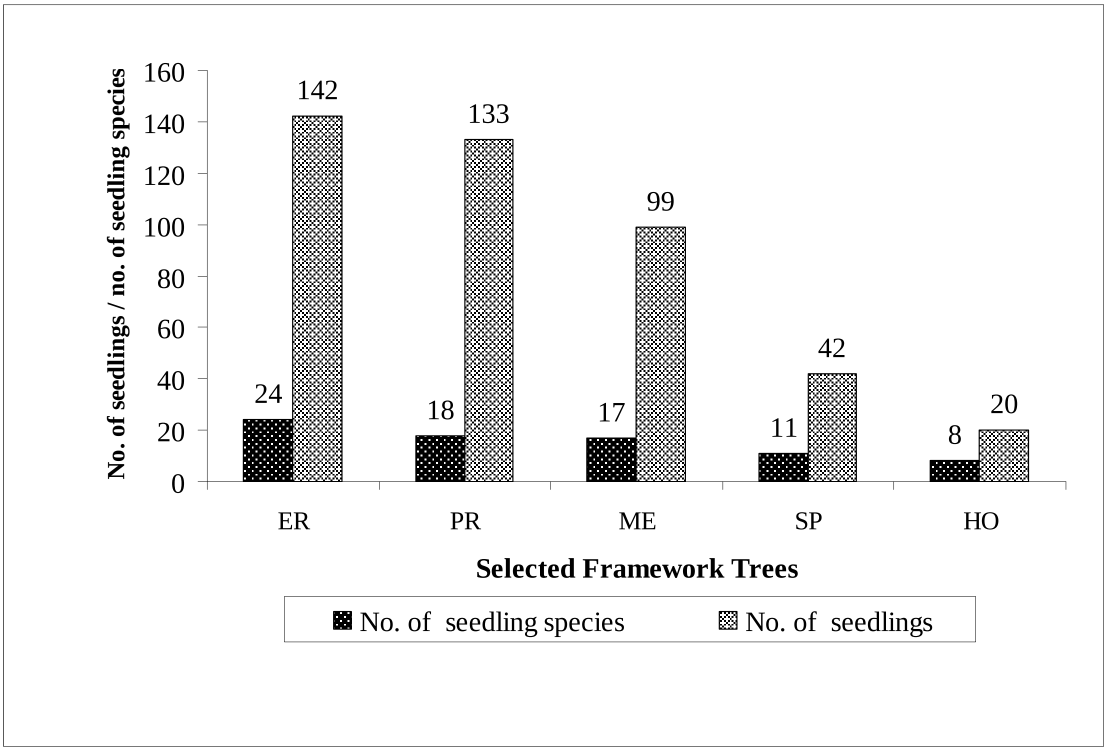

Figure 5.1 Numbers of seedlings and seedling species found in all sample plots beneath each selected framework tree species

Table 5.3 List of all tree seedlings found in each selected framework tree plots

No.	Species	Planted / Recruited*	Family	Dispersal mechanism†	Total no. of seedlings
1	*Albizia chinensis* (Osb.) Merr.	Recruited	Leguminosae, Mimosaceae	wind	6
2	*Albizia odoratissima* (L.f.) Benth.	Recruited	Leguminosae, Mimosaceae	wind	2
3	*Aporusa octandra* (Buch.-Ham. ex D. Don)	Recruited	Euphorbiaceae	animal	17
4	*Aquilaria crassna* Pierre ex Lecomte.	Recruited	Thymeleaceae	animal	1
5	*Archidendron clypearia* (Jack) I. C. Nielsen ssp. *clypearia* var. *clypearia*	Planted	Leguminosae, Mimosaceae	wind	12
6	*Bauhinia variegata* L.	Recruited	Leguminosae, Caesalpinioideae	wind	1
7	*Bombax anceps* Pierre var. *anceps*	Recruited	Bombaceae	wind	1
8	*Bridelia tomentosa* Blume var. *tomentosa*	Recruited	Euphorbiaceae	animal	2
9	*Castanopsis cerebrina* (Hickel & A. Camus) Barnett.	Planted	Fagaceae	animal	84
10	*Castanopsis tribuloides* (Sm.) A. DC.	Recruited	Fagaceae	animal	1
11	*Cinnamomum caudatum* Nees.	Recruited	Lauraceae	animal	1
12	*Cinnamomum iners* Reinw. ex Bl	Planted	Lauraceae	animal	1
13	*Engelhardia serrata* Blume.	Recruited	Juglandaceae	wind	2
14	*Engelhardia spicata* Blume. var. *spicata*	Recruited	Juglandaceae	wind	1
15	*Erythrina subumbrans* (Hassk.) Merr.	Planted	Leguminosae, Papilionoidea	wind	8
16	*Eugenia albiflora* Duth.ex Kurz.	Planted	Myrtaceae	animal	21
17	*Ficus hirta* Vahl. var. *hirta*	Recruited	Moraceae	animal	11
18	*Ficus hispida* L.	Recruited	Moraceae	animal	1
19	*Ficus subincisa* J.E. Sm.	Recruited	Moraceae	animal	3
20	*Helicia nilagirica* Bedd.	Planted	Proteaceae	animal	1
21	*Heliciopsis terminalis* Kurz.	Recruited	Proteaceae	animal	1
22	*Heynea trijuga* Roxb. ex Sims.	Planted	Meliaceae	animal	5
23	*Horsfieldia amygdalina* (Wall.) Warb.	Planted	Myristicaceae	animal	3
24	*Ixora cibdela* Craib.	Recruited	Rubiaceae	animal	1

Table 5.3 (continued)

No.	Species	Planted / Recruited*	Family	Dispersal mechanism†	Total no. of seedlings
25	*Litsea cubeba* Pers.	Recruited	Lauraceae	animal	1
26	*Litsea monopetala* (Roxb.) Pers.	Recruited	Lauraceae	animal	148
27	*Litsea salicifolia* Roxb. ex Nees.	Recruited	Lauraceae	animal	6
28	*Mallotus philippensis* (Lam.)	Recruited	Euphorbiaceae	wind	4
29	*Melia toosendan* Sieb. & Zucc.	Recruited	Meliaceae	animal	1
30	*Michelia baillonii* (Pierre) Finet & Gagnep.	Recruited	Magnoliaceae	animal	1
31	*Phoebe lanceolata* (Wall. ex Nees) Nees.	Planted	Lauraceae	animal	61
32	*Prunus cerasoides* D. Don	Planted	Rosaceae	animal	6
33	*Schima wallichii* (DC.) Korth.	Recruited	Theaceae	wind	13
34	*Sterculia villosa* Roxb.	Recruited	Sterculiaceae	animal	2
35	*Tarennoidea wallichii* (Hook.f.) Tirveng. & Sastre	Recruited	Rubiaceae	animal	1
36	*Wendlandia scabra* Kurz var. *scabra*	Recruited	Rubiaceae	wind	5
	Total				**436**

Remark: * (Elliott *et al*., 2000)

† (FORRU, 2000, 2005)

Population density (no./m^2) and species richness (no. of species/m^2) of total seedlings (Table 5.4) were highest in the *Prunus cerasoides*-plots, whilst *Hovenia dulcis*-plots supported the lowest. Population density and species richness of wind-dispersed seedling were highest in *Prunus cerasoides*-plots (Table 5.5), whilst species richness of animal-dispersed seedling were highest in *Erythrina subumbrans* and *Prunus cerasoides*-plots (Table 5.6) Population density of seedlings was correlated with the species richness of seedling (R^2=0.91)(Figure 5.2). Population density and species richness of seedlings in all tree plots were list in Appendix C (Tables C2-C4).

Table 5.4 Population density (no./m^2) and species richness (no. of species/m^2) of total seedlings in each sample tree plots (± standard deviation)

All seedling	ER	HO	ME	PR	SP
Population density	1.33 ± 0.72^{a}	0.30 ± 0.14^{b}	1.20 ± 1.59^{ab}	1.52 ± 1.14^{ab}	0.25 ± 0.17^{b}
Species richness	0.35 ± 0.15^{a}	0.21 ± 0.10^{ab}	0.30 ± 0.20^{ab}	0.38 ± 0.23^{ab}	0.11 ± 0.07^{b}

Remark: different superscript alphabets = significant differences (P≤0.05)

Table 5.5 Population density (no./m^2) of seedlings divided by dispersal mode beneath each sample tree plots (± standard deviation)

Dispersal mode	Population density				
	ER	HO	ME	PR	SP
Wind	0.19 ± 0.07^{a}	0.04 ± 0.10^{b}	0.08 ± 0.09^{ab}	0.23 ± 0.24^{ab}	0.02 ± 0.03^{b}
Animal	1.15 ± 0.68^{a}	0.26 ± 0.17^{b}	1.11 ± 1.59^{ab}	1.29 ± 1.04^{ab}	0.23 ± 0.14^{ab}

Remark: different superscript alphabets = significant differences (P≤0.05)

Table 5.6 Species richness (no. of species/m^2) of seedlings divided by dispersal mode beneath each sample tree plots (± standard deviation)

Dispersal mode	Species richness				
	ER	HO	ME	PR	SP
Wind	0.11±0.05[a]	0.03±0.05[ab]	0.05±0.04[ab]	0.13±0.12[ab]	0.02±0.03[b]
Animal	0.26±0.13[a]	0.18±0.11[ab]	0.25±0.17[ab]	0.25±0.11[a]	0.09±0.05[b]

Remark: different superscript alphabets = significant differences (P≤0.05)

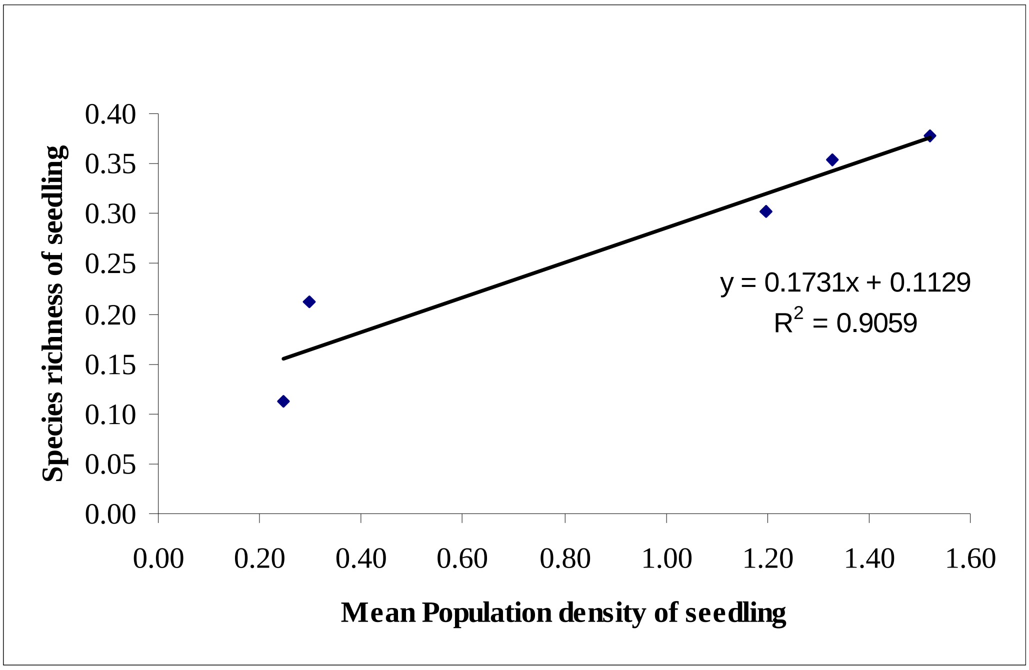

Figure 5.2 Population density of seedling was positive correlated with the species richness of seedling (R^2=0.90)

1.2) Ecological indices

Ecological indices were used to quantify seedling diversity in all sample plots beneath each selected framework tree species (Table 5.7). Highest species richness of seedlings (N0 = 12) was found in the *Erythrina subumbrans*-plot 1 (ER1) and *Melia toosendan*-plot 1 (ME1). Lowest species richness (N0 = 1) was found in the *Hovenia dulcis*-plot 2 (HO2). Species richness for each species of selected framework tree was highest beneath *Erythrina subumbrans*-plots (N0 = 24) and lowest in *Hovenia dulcis*-plots (N0 = 8).

Seedling diversity was highest in the *Erythrina subumbrans*-plots (Shannon's index, N1 = 8.39) and *Spondias axillaris*-plots (Simpson's index, N2 = 1.50), whilst the lowest diversity was found in the *Hovenia dulcis*-plots. (N1 = 6.07, N2 = 1.20). Highest evenness was found in the *Spondias axillaris*-plots (E5 = 0.12), whilst the lowest evenness was found in the *Prunus cerasoides*-plots (E5 = 0.03).

Table 5.7 Ecological indices of natural tree seedlings in all sample plots beneath each selected framework tree species

Tree plots		No. of seedling	Richness N0	Species diversity N1	N2	Evenness E5
Erythrina subumbrans	ER1	42	12	3.85	1.90	0.32
	ER2	36	6	2.97	1.86	0.44
	ER3	13	7	6.59	1.10	0.02
	ER4	31	9	6.40	1.22	0.04
	ER5	20	6	3.52	1.71	0.28
Total		**142**	**24**	**8.39**	**1.28**	**0.04**
Hovenia dulcis	HO1	7	6	5.74	1.05	0.01
	HO2	2	1	****	****	****
	HO3	2	2	2.00	1.00	0.00
	HO4	6	3	2.75	1.36	0.21
	HO5	3	2	1.89	1.50	0.56
Total		**20**	**8**	**6.07**	**1.19**	**0.04**
Melia toosendan	ME1	21	10	6.58	1.21	0.04
	ME2	4	4	4.00	1.00	0.00
	ME3	3	3	3.00	1.00	0.00
	ME4	57	7	2.98	1.72	0.36
	ME5	14	6	4.65	1.26	0.07
Total		**99**	**17**	**5.98**	**1.35**	**0.07**
Prunus cerasoides	PR1	15	8	7.32	1.09	0.01
	PR2	11	6	5.33	1.15	0.03
	PR3	62	7	2.02	3.39	2.35
	PR4	26	7	5.67	1.21	0.04
	PR5	19	5	3.97	1.32	0.11
Total		**133**	**18**	**8.08**	**1.25**	**0.03**
Spondias axillaris	SP1	8	2	1.75	2.33	1.76
	SP2	4	3	2.83	1.20	0.11
	SP3	3	2	1.89	1.50	0.56
	SP4	11	5	3.19	1.62	0.28
	SP5	16	7	3.79	1.60	0.21
Total		**42**	**11**	**5.01**	**1.50**	**0.12**

Remark: **** Two seedlings per one species, therefore can't calculate diversity and evenness.

1.3) Similarity indices

Sorensen's index was used to compare the seedling communities in all sample plots beneath each selected framework tree species. The similarity coefficient equals to 1, when two seedling communities in the sampling plots have identical species composition and 0 when there is no shared species.

The *Melia toosendan* and *Prunus cerasoides*-plots were the most similar (Sorensen's index = 0.62), whilst the most different seedling communities was found between the *Erythrina subumbrans* and *Spondias axillaris*-plots (Sorensen's index = 0.42) (Table 5.8). Wind-dispersed seedling communities between *Hovenia dulcis* and *Prunus cerasoides*-plots were the most similar (Sorensen's index = 0.89), whilst most different was found between *Prunus cerasoides* and *Spondias axillaris*-plots (Sorensen's index = 0.44) (Table 5.9). Animal-dispersed seedling communities between *Prunus cerasoides* and *Spondias axillaris*-plots (Sorensen's index = 0.70), whilst most different was found between *Erythrina subumbrans* and *Hovenia dulcis*-plots (Sorensen's index = 0.42) (Table 5.10).

Table 5.8 Similarity coefficients (Sorensen's index) of natural tree seedling communities between framework tree species

Plot pairs	ER	HO	ME	PR	SP
ER	-	0.44	0.49	0.57	0.42
HO	0.44	-	0.56	0.62	0.45
ME	0.49	0.56	-	0.57	0.52
PR	0.57	0.62	0.57	-	0.56
SP	0.42	0.45	0.52	0.56	-

Table 5.9 Similarity coefficients (Sorensen's index) of wind-dispersed seedling communities between framework tree species.

Plot pairs	ER	HO	ME	PR	SP
ER	-	0.50	0.62	0.53	0.50
HO	0.50	-	0.86	0.89	0.67
ME	0.62	0.86	-	0.60	0.57
PR	0.53	0.89	0.60	-	0.44
SP	0.50	0.67	0.57	0.44	-

Table 5.10 Similarity coefficients (Sorensen's index) of animal-dispersed seedling communities between framework tree species.

Plot pairs	ER	HO	ME	PR	SP
ER	-	0.42	0.50	0.59	0.43
HO	0.42	-	0.47	0.50	0.50
ME	0.50	0.47	-	0.56	0.67
PR	0.59	0.50	0.56	-	0.70
SP	0.43	0.50	0.67	0.70	-

1.4) Relative growth rate (RGR) of seedlings

Relative growth rate of root collar diameter (RRGR) and relative growth rate of height (RHGR) were calculated for natural tree seedlings in all tree plots. Seedlings in each framework tree species plots (Table 5.11) were divided into 2 groups according to their dispersal mechanism (Table 5.12). RRGR (cm.) of seedling species (Table 5.13) was highest for *Ixora cibdela* (Rubiaceae), 51.3 (%/year) followed by *Wendlandia scabra* var. *scabra* (Rubiaceae), 48.7 (%/year) and *Horsfieldia amygdalina* var. *amygdalina* (Myrsinaceae) 42.5 (%/year). RHGR (cm.) of seedling species was highest for *Heliciopsis terminalis* (Proteaceae) 146.0 (%/year) followed by *Engelhardia spicata*. var. *spicata* (Juglandaceae) 51.9 (%/year) and *Bauhinia variegata* (Leguminosae, Caesalpinioideae) 45.0 (%/year).

Table 5.11 Mean RRGR and RHGR of all seedlings in each framework tree plots (± standard deviation)

Tree plots	n	RRGR (%/year)^{ns}	RHGR(%/year)^{ns}
Erythrina subumbrans	142	26.0±45.2	20.3±26.6
Hovenia dulcis	20	41.1±56.6	16.8±21.9
Melia toosendan	99	16.2±35.3	16.3±12.5
Prunus cerasoides	133	44.1±46.2	14.0±11.1
Spondias axillaris	42	22.2±37.9	19.3±40.0
Total	**436**	**35.2±50.0**	**18.4±21.3**

Remark: ns = no significant difference between each framework tree plots (P≥0.05)

Table 5.12 Mean RRGR and RHGR of each seedling groups according to their dispersal mechanism (± standard deviation)

Seedling groups	n	RRGR (%/year)^{ns}	RHGR(%/year)^{ns}
Wind-dispersed seedling	55	25.6±19.5	18.2±23.1
Animal-dispersed seedling	381	34.7±23.9	15.3±17.4
Total	**436**	**35.2±50.0**	**18.4±21.3**

Remark: ns = no significant difference between seedling groups (P≥0.05)

Table 5.13 Mean relative growth rate (%/year) of root collar diameter (RRGR) and relative growth rate of height (RHGR) of seedling species (± standard deviation)

No.	Botanical Name	Pioneer / Climax tree species*	n	RRGR (%/year)	RHGR (%/year)
1	*Albizia chinensis* (Osb.) Merr.	Pioneer	6	19.4±64.1	32.7±45.7
2	*Albizia odoratissima* (L.f.) Benth.	Pioneer	2	-8.5±22.0	30.6±43.7
3	*Aporusa octandra* (Buch.-Ham. ex D. Don)	Climax	17	18.7±14.6	19.9±33.2
4	*Aquilaria crassna* Pierre ex Lecomte.	Climax	1	16.4	-43.5
5	*Archidendron clypearia* (Jack) I. C. Nielsen ssp. *clypearia* var. *clypearia*	Climax	12	31.4±49.0	37.4±58.8
6	*Bauhinia variegata* L.	Pioneer	1	27.4	45.0
7	*Bombax anceps* Pierre var. *anceps*	Pioneer	1	28.4	26.8
8	*Bridelia tomentosa* Blume var. *tomentosa*	Pioneer	2	17.7±183.5	-38.9±98.6
9	*Castanopsis cerebrina* (Hickel & A. Camus) Barnett.	Climax	84	8.3±130.1	18.4±49.7
10	*Castanopsis tribuloides* (Sm.) A. DC.	Climax	1	0.0	30.6
11	*Cinnamomum caudatum* Nees.	Pioneer	1	9.3	13.7
12	*Cinnamomum iners* Reinw. ex Bl	Pioneer	1	2.0	12.2
13	*Engelhardia serrata* Blume.	Pioneer	2	11.2±15.4	12.8±98.0
14	*Engelhardia spicata* Lechen. ex bl. var. *spicata*	Pioneer	1	35.2	51.9
15	*Erythrina subumbrans* (Hassk.) Merr.	Pioneer	8	23.4±26.6	20.8±42.3
16	*Eugenia albiflora* Duth.ex Kurz.	Pioneer	21	8.0±33.8	22.8±42.5
17	*Ficus hirta* Vahl. var. *hirta*	Climax	11	4.2±25.8	13.1±16.7
18	*Ficus hispida* L.	Climax	1	38.2	20.9
19	*Ficus subincisa* J.E. Sm. var. *subincisa*	Climax	3	12.9±34.6	10.6±77.5
20	*Helicia nilagirica* Bedd.	Climax	1	21.7	5.3
21	*Heliciopsis terminalis* Kurz.	Climax	1	-4.9	146.0
22	*Heynea trijuga* Roxb. ex Sims.	Climax	5	1.7±13.9	5.7±15.0
23	*Horsfieldia amygdalina* (Wall.) warb. var. *amygdalina*	Climax	3	42.5±44.3	25.9±1.4
24	*Ixora cibdela* Craib.	Pioneer	1	51.3	21.2

Table 5.13 (continued)

No.	Botanical Name	Pioneer / Climax tree species*	n	RRGR (%/year)	RHGR (%/year)
25	*Litsea cubeba* Pers.	Pioneer	1	4.4	25.9
26	*Litsea monopetala* (Roxb.) Pers.	Pioneer	148	33.1±135.6	8.4±1.0
27	*Litsea salicifolia* Nees ex Roxb.	Pioneer	6	19.2±0.1	24.9±32.8
28	*Mallotus philippensis* (Lam.)	Pioneer	4	14.5±44.1	1.9±21.6
29	*Melia toosendan* Sieb. & Zucc.	Pioneer	1	17.2	26.9
30	*Michelia baillonii* Puerre	Climax	1	-7.6	3.7
31	*Phoebe lanceolata* (Wall. ex Nees) Nees.	Pioneer	61	20.2±57.3	10.4±3.0
32	*Prunus cerasoides* D. Don	Pioneer	6	5.5±41.1	16.0±66.3
33	*Schima wallichii* (DC.) Korth.	Pioneer	13	25.4±14.6	37.0±3.4
34	*Sterculia villosa* Roxb.	Pioneer	2	1.8	31.9
35	*Tarennoidea wallichii* (Hook.f.) Tirveng. & Sastre	Climax	1	2.1	17.3
36	*Wendlandia scabra* Kurz var. *scabra*	Pioneer	5	48.7±28.1	21.9±0.8
	Total		**436**	**35.2±50.0**	**18.4±21.2**

Remark: * (FORRU, 2000, 2005)

1.5) Health average and percent survival rate

The health average score and % survival rate of all natural tree seedlings were calculated (Table 5.14). Twenty-eight species from 36 species of tree seedlings had 100 % survival rate from 20 April 2006 - 21 July 2007 (458 days). *Sterculia villosa* had the lowest average health score and % survival rate. Seven species were recorded as dead - *Albizia chinensis* (1 individual), *Castanopsis cerebrina* (1 individual), *Erythrina subumbrans* (1 individual), *Litsea monopetala* (5 individuals), *Phoebe lanceolata* (3 individuals), *Prunus cerasoides* (2 individuals), *Schima wallichii* (1 individual) and *Sterculia villosa* (1 individual). *Melia toosendan*-plots had the highest % survival rate of tree seedlings (97.9%), whilst *Hovenia dulcis*-plots had lowest % survival rate of tree seedling (95.0%). Average health score of seedlings under each selected framework tree were slightly different with lowest average health score recorded in *Spondias axillaris*-plots (Table 5.15).

Table 5.14 The health average score and % survival rate of all natural tree seedlings.

No.	Species	Total no. of seedlings	Remaining	%Survival	Average health
1	*Albizia chinensis* (Osb.) Merr.	6	5	83.3	3.0
2	*Albizia odoratissima* (L.f.) Benth.	2	2	100	3.0
3	*Aporusa octandra* (Buch.-Ham. ex D. Don)	17	17	100	2.5
4	*Aquilaria crassna* Pierre ex Lecomte.	1	1	100	2.5
5	*Archidendron clypearia* (Jack) I. C. Nielsen ssp. *clypearia* var. *clypearia*	12	12	100	2.6
6	*Bauhinia variegata* L.	1	1	100	2.5
7	*Bombax anceps* Pierre var. *anceps*	1	1	100	2.3
8	*Bridelia tomentosa* Blume var. *tomentosa*	2	2	100	2.9
9	*Castanopsis cerebrina* Kurz.	84	83	98.8	2.6
10	*Castanopsis tribuloides* (Sm.) A. DC.	1	1	100	3.0
11	*Cinnamomum caudatum* Nees.	1	1	100	2.7
12	*Cinnamomum iners* Reinw. ex Bl	1	1	100	2.2
13	*Engelhardia serrata* Blume.	2	2	100	2.5
14	*Engelhardia spicata* Lechen. ex bl. var. *spicata*	1	1	100	2.6
15	*Erythrina subumbrans* (Hassk.) Merr.	8	7	87.5	2.3
16	*Eugenia albiflora* Duth.ex Kurz.	21	21	100	2.7
17	*Ficus hirta* Vahl. var. *hirta*	11	11	100	2.5
18	*Ficus hispida* L.	1	1	100	2.2
19	*Ficus subincisa* J.E. Sm. var. *subincisa*	3	3	100	2.8
20	*Helicia nilagirica* Bedd.	1	1	100	3.0
21	*Heliciopsis terminalis* Kurz.	1	1	100	3.0

Table 5.14 (continued)

No.	Species	Total no. of seedling	Remaining	%Survival	Average health
22	*Heynea trijuga* Roxb. ex Sims.	5	5	100	2.1
23	*Horsfieldia amygdalina* (Wall.) warb. var. *amygdalina*	3	3	100	2.6
24	*Ixora cibdela* Craib.	1	1	100	2.7
25	*Litsea cubeba* Pers.	1	1	100	2.7
26	*Litsea monopetala* (Roxb.) Pers.	148	141	96.6	2.4
27	*Litsea salicifolia Nees ex* Roxb.	6	6	100	2.6
28	*Mallotus philippensis* (Lam.)	4	4	100	2.5
29	*Melia toosendan* Sieb. & Zucc.	1	1	100	3.0
30	*Michelia baillonii* Puerre	1	1	100	2.8
31	*Phoebe lanceolata* (Wall. ex Nees) Nees.	61	58	95.0	2.6
32	*Prunus cerasoides* D. Don	6	4	66.6	2.2
33	*Schima wallichii* (DC.) Korth.	13	12	92.3	2.7
34	*Sterculia villosa* Roxb.	2	1	50.0	1.6
35	*Tarennoidea wallichii* (Hook.f.) Tirveng. & Sastre	1	1	100	3.0
36	*Wendlandia scabra* Kurz var. *scabra*	5	5	100	2.8
	Total	**436**	**419**	**96.1**	**2.6**

Table 5.15 The average health score and % survival rate of all natural tree seedlings under each selected framework tree plots from 20 April 2006 - 21 July 2007.

Tree plots	No. of seedlings	Remaining	%Survival	Average Health
Erythrina subumbrans	142	135	95.0	2.6
Hovenia dulcis	20	19	95.0	2.6
Melia toosendan	99	97	97.9	2.6
Prunus cerasoides	133	127	95.4	2.6
Spondias axillaris	42	41	97.6	2.5
Total	**436**	**419**	**96.1**	**2.6**

1.6) Ground vegetation and some physical parameters surveyed in each selected framework tree plot

Percent ground vegetation cover, % open area, dominant ground vegetation (any species which were not tree seedlings, cover more than 1% of the plot area) and light intensity measurement were done in each tree plot (Table 5.16). Ground vegetation in all tree plots composed of ferns, grasses, herbs, shrubs and woody climbers. All species of ground vegetation and light intensity in each tree plot were listed in Appendix D (Table D1) and Appendix E (Tables E1-E10), respectively.

Table 5.16 Percent ground vegetation cover, % open area, light intensity (Lux/m^2) and dominant ground vegetation species (3 species with highest percent cover) in each tree plots.

Tree plots		Cover	Light Intensity (Lux/m^2)	Dominant species
Erythrina subumbrans				*Eupatorium adenophorum*, *Commelina diffusa*, *Dioscorea prazeri*
	ER1	10%	1084	
	ER2	35%	718	
	ER3	25%	1084	
	ER4	30%	1666	
	ER5	25%	1925	
Average		**25%**	**1296**	
Hovenia dulcis				*Paspalum conjugatum*, *Dioscorea prazeri*, *Thysanolaena latifolia*
	HO1	40%	949	
	HO2	<1%	622	
	HO3	35%	1142	
	HO4	15%	1056	
	HO5	1%	755	
Average		**23%**	**905**	
Melia toosendan				*Paspalum conjugatum*, *Imperata cylindrica*, *Commelina diffusa*
	ME1	40%	1446	
	ME2	15%	800	
	ME3	60%	1029	
	ME4	30%	1548	
	ME5	15%	1053	
Average		**32%**	**1175**	

Table 5.16 (continued)

Tree plots		Cover	Light Intensity (Lux/m^2)	Dominant species
Prunus cerasoides				*Eupatorium adenophorum*, *Paspalum conjugatum*, *Eupatorium odoratum*
	PR1	15%	1032	
	PR2	25%	1277	
	PR3	30%	1033	
	PR4	20%	1687	
	PR5	5%	915	
Average		**19%**	**1189**	
Spondias axillaris				*Paspalum conjugatum*, *Eupatorium adenophorum*, *Camchaya eberhardtii*
	SP1	40%	843	
	SP2	5%	784	
	SP3	15%	1340	
	SP4	15%	1060	
	SP5	20%	1048	
Average		**19%**	**1015**	

Figures 5.3-5.10 show correlations between the natural tree seedling communities and the conditions below tree canopies. Light intensity in each tree plots showed a strong positive correlation with population density (R^2 = 0.92)(Figure 5.3) and species richness (R^2 = 0.97) of recruit tree seedlings (Figure 5.4), whilst both light intensity and % ground cover show negative correlation with mean relative growth rate of root collar of seedling (R^2 = 0.53)(Figure 5. 5),(R^2 = 0.22)(Figure 5.9).

Figure 5.3 Correlation between Population density of recruit seedling and light intensity (R^2 = 0.92)

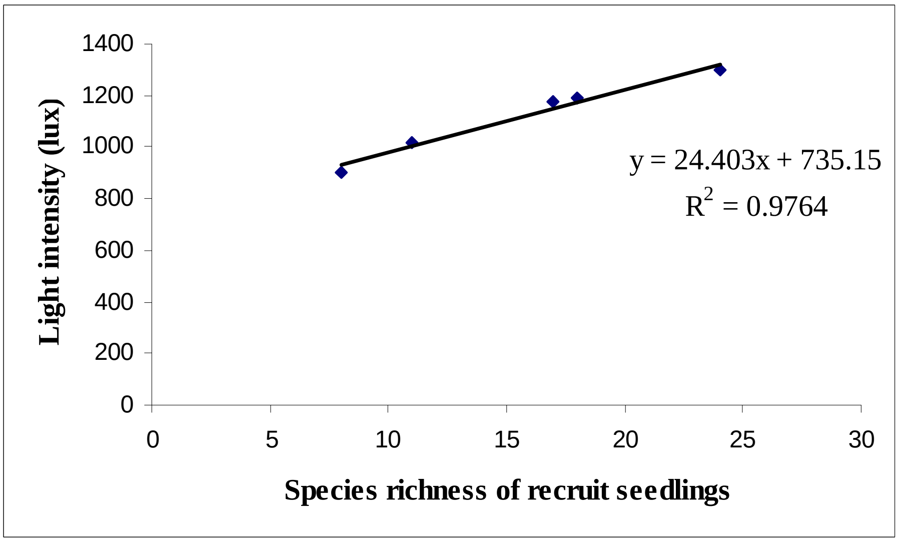

Figure 5.4 Correlation between species richness of recruit seedlings and light intensity (R^2 = 0.97)

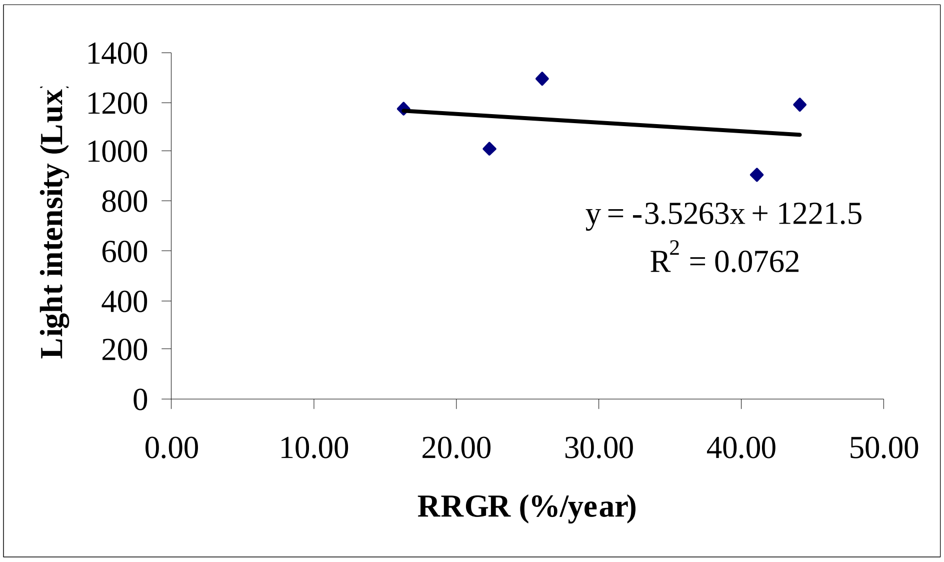

Figure 5.5 Correlation between mean relative growth rate (%/year) of root collar diameter (RRGR) of recruit seedling and light intensity (R^2 = 0.07)

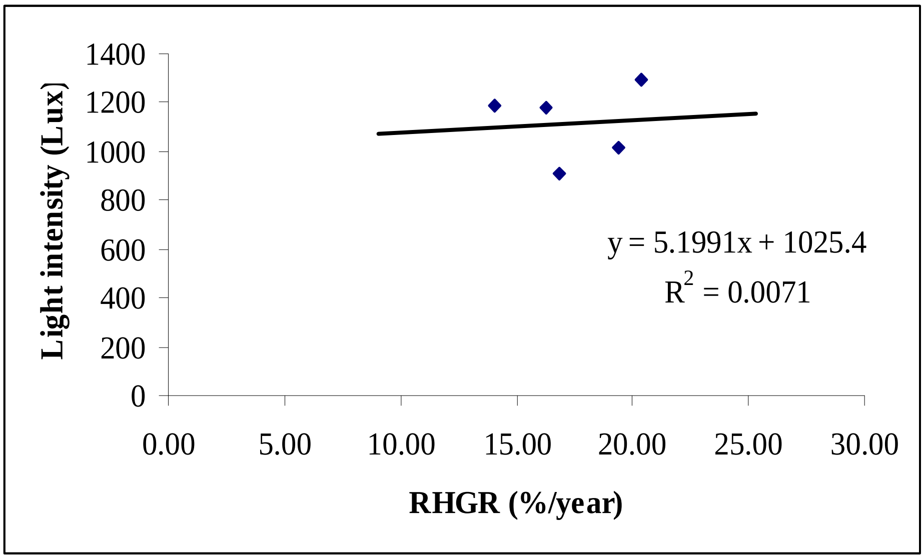

Figure 5.6 Correlation between mean relative growth rate (%/year) of height (RHGR) of recruit seedling and light intensity (R^2 = 0.007)

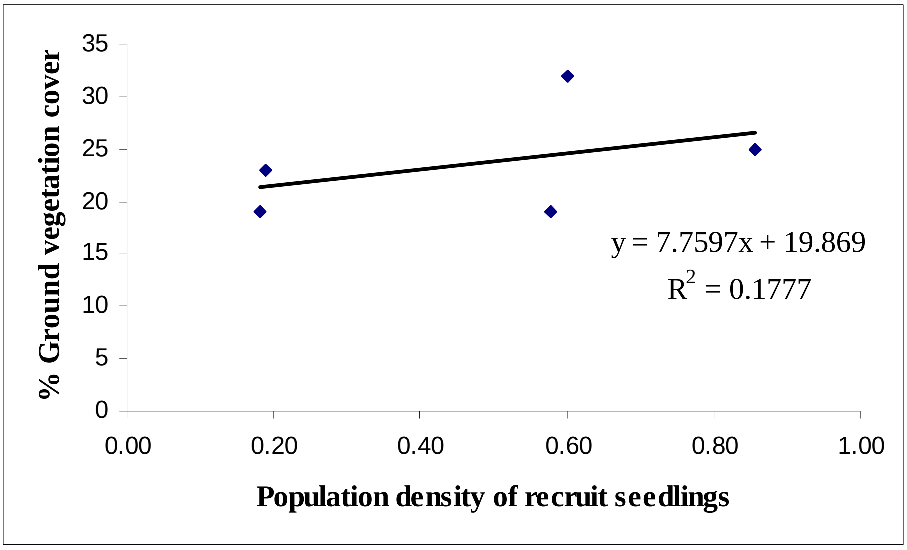

Figure 5.7 Correlation between Population density of recruit seedlings and % ground vegetation cover (R^2 = 0.17)

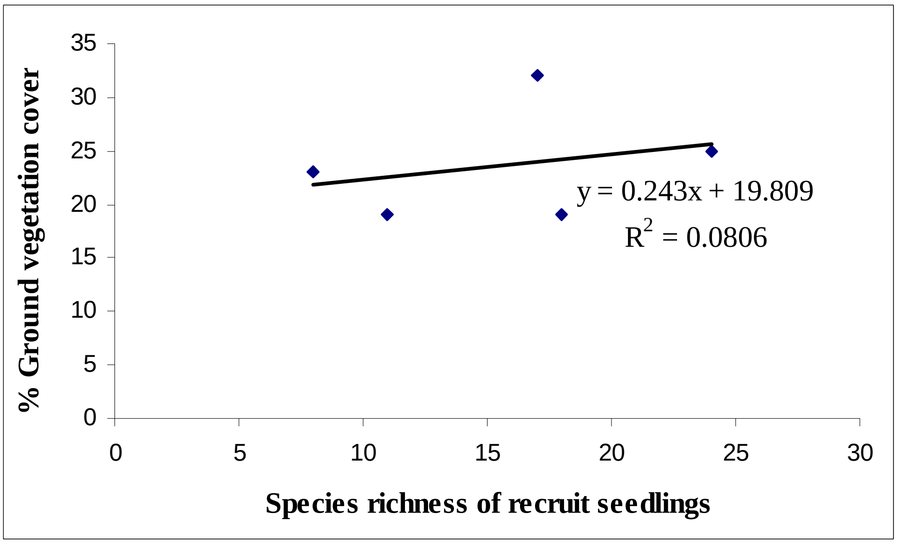

Figure 5.8 Correlation between species richness of recruit seedlings and % ground vegetation cover (R^2 = 0.08)

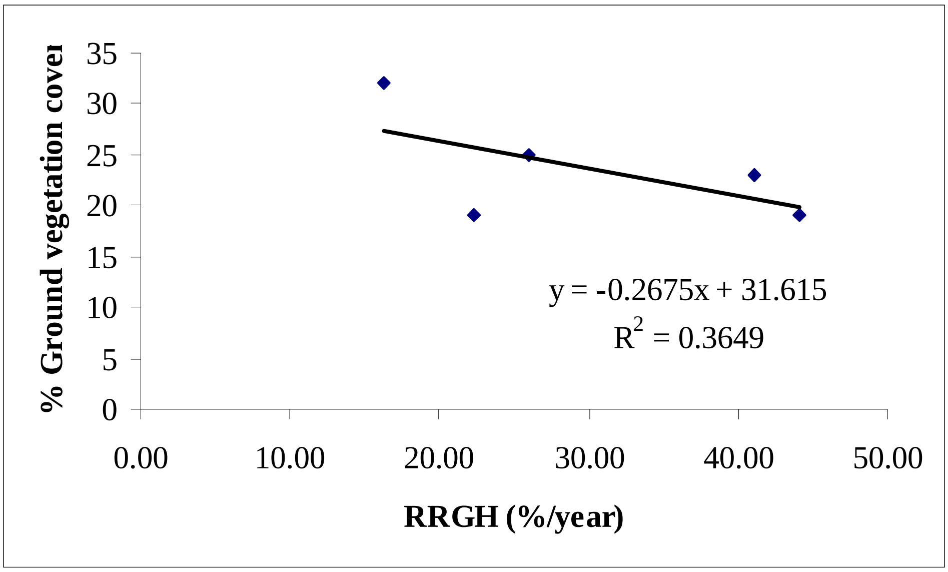

Figure 5.9 Correlation between mean relative growth rate (%/year) of root collar diameter (RRGR) of recruit seedling and % ground vegetation cover (R^2 = 0.36)

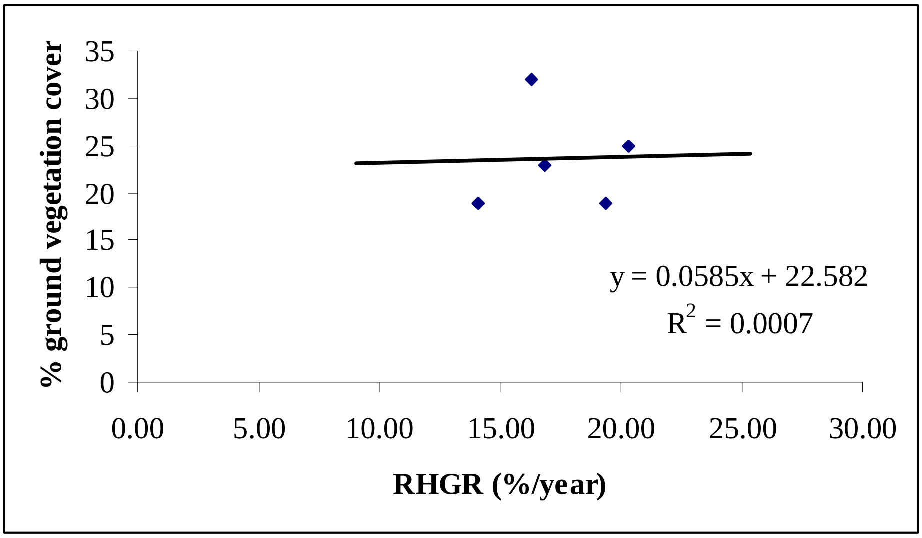

Figure 5.10 Correlation between mean relative growth rate (%/year) of height (RHGR) of recruit seedling and % ground vegetation cover (R^2 = 0.0007)

2. BIRD SURVEYS

2.1) Bird visitation observed in selected framework tree species

A total of 49 bird species (228 individuals) using the selected framework trees were recorded between July 2006 and June 2007. Observed bird were divided into two groups according to their diets, which were frugivorous birds (bird feeding mainly on fruits) and non-frugivorous bird (bird that not feeding mainly on fruits, including carnivores, insectivores, nectarivores). Non-frugivorous birds were recorded using the selected framework tree species more than frugivorous birds (Table 5.17). Frugivorous birds were observed more than non-frugivorous bird only in *Erythrina subumbrans*, whilst non-frugivorous bird were observed more than frugivorous bird in *Hovenia dulcis*, *Melia toosendan*, *Prunus cerasoides* and *Sponias axillaris* (Figure 5.11). The highest number of birds recorded were White-rumped Shama (*Copsychus malabaricus*) (20 individuals), Red whiskered Bulbul (*Pycnonotus jocosus*) (16 individuals) and Japanese White-eye (*Zosterops japonicus*) (13 individuals) (Table 5.18). All bird species observed in all planted plots and numbers of birds observed in each selected tree were listed in Appendix F (Table F1 and Table F2).

Table 5.17 A total number of birds and number of bird species found in the selected framework tree plots between April 2006 and July 2007

Bird groups	No. of birds species	No. of bird
Frugivores	17	94
Non- frugivores	29	131
Unidentified species	3	3
Total	**49**	**228**

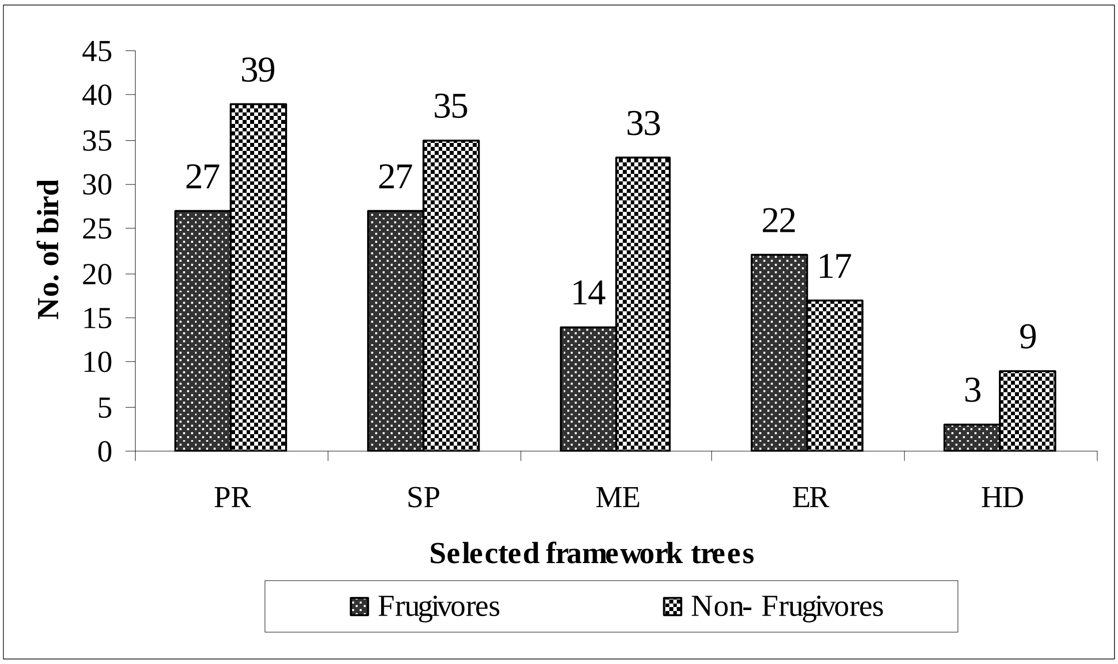

Figure 5.11 Number of individual of each bird groups recorded using the selected framework tree species

Table 5.18 List of all bird recorded using the selected framework trees

No.	Scientific Name	Common Name	Diets*	No. of birds
1	*Phylloscopus borealis*	Arctic Warbler	non-frugivores	9
2	*Dicrurus leucophaeus*	Ashy Drongo	non-frugivores	2
3	*Megalaima* sp.	Barbet sp.	frugivores	1
4	*Hemipus picatus*	Bar-winged Flycatcher-shrike	non-frugivores	11
5	*Pycnonotus melanicterus*	Black-crested Bulbul	frugivores	11
6	*Aethopyga saturata*	Black-throated Sunbird	non-frugivores	10
7	*Megalaima asiatica*	Blue-throated Barbet	frugivores	1
8	*Phylloscopus reguloides*	Blyth's Leaf-warbler	non-frugivores	9
9	*Dicaeum ignipectus*	Buff-bellied Flowerpecker	frugivores	3
10	*Pycnonotus* sp.	Bulbul sp.	frugivores	2
11	*Lanius collurioides*	Burmese Shrike	non-frugivores	1
12	*Aegithina tiphia*	Common Iora	non-frugivores	3
13	*Orthotomus atrogularis*	Dark-necked Tailorbird	non-frugivores	2
14	*Phylloscopus fuscatus*	Dusky Warbler	non-frugivores	1
15	*Pycnonotus flavescens*	Flavescent Bulbul	frugivores	6
16	*Seicercus valentini*	Golden-spectacled Warbler	non-frugivores	1
17	*Parus major*	Great Tit	frugivores	10
18	*Phaenicophaeus tristis*	Green-billed Malkoha	frugivores	1
19	*Culicicapa ceylonensis*	Grey-headed Flycatcher	non-frugivores	4
20	*Cyornis banyumas*	Hill Blue Flycatcher	non-frugivores	8
21	*Upupa epops*	Hoopoe	frugivores	2
22	*Phylloscopus inornatus*	Inornate Warbler	non-frugivores	1
23	*Zosterops japonicus*	Japanese White-eye	frugivores	13

Table 5.18 (continued)

No.	Scientific Name	Common Name	Diets*	No. of birds
24	*Ficedula westermanni*	Little Pied Flycatcher	non-frugivores	1
25	*Arachnothera longirostra*	Little Spiderhunter	non-frugivores	1
26	*Anthus hodgsoni*	Olive-backed Pipit	non-frugivores	3
27	*Zosterops palpebrosus*	Oriental White-eye	frugivores	9
28	*Dicaeum concolor*	Plain Flowerpecker	frugivores	1
29	*Cacomantis merulinus*	Plaintive Cuckoo	frugivores	1
30	*Pellorneum ruficeps*	Puff-throated Babbler	frugivores	4
31	*Ficedula parva albicilla*	Red-throated Flycatcher	non-frugivores	5
32	*Pycnonotus jocosus*	Red-whiskered Bulbul	frugivores	16
33	*Pericrocotus flammeus*	Scarlet Minivet	non-frugivores	11
34	*Pycnonotus aurigaster*	Sooty-headed Bulbul	frugivores	10
35	*Picumnus innominatus*	Speckled Piculet	frugivores	4
36	*Arachnothera magna*	Streaked Spiderhunter	non-frugivores	7
37	*Aethopyga* sp. (female)	Sunbird sp. (female)	non-frugivores	2
38	*Phylloscopus trochiloides plumbeitarsus*	Two-barred Warbler	non-frugivores	5
39	Unknown sp. 1	Unknown sp. 1	unknown	1
40	Unknown sp. 2	Unknown sp. 2	unknown	1
41	Unknown sp. 3	Unknown sp. 3	unknown	1
42	*Sitta frontalis*	Velvet-fronted Nuthatch	frugivores	1
43	*Phylloscopus* sp.	Warbler sp.	non-frugivores	1
44	*Sasia ochracea*	White-browed Piculet	frugivores	2
45	*Pomatorhinus schisticeps*	White-browned Scimitar-Babbler	frugivores	1
46	*Pteruthius flaviscapis*	White-browned Shrike-Babbler	non-frugivores	2

Table 5.18 (continued)

No.	Scientific Name	Common Name	Diets*	No. of birds
47	*Garrulax leucolophus*	White-crested Laughingthrush	frugivores	4
48	*Copsychus malabaricus*	White-rumped Shama	non-frugivores	20
49	*Rhipidura albicollis*	White-throated Fantail	non-frugivores	2
	Total			**228**

Remark: * (Lekagul and Round, 1991; Kopkate, 1998-2001)

Population density (no./m^2) and species richness (no. of species/m^2) of bird (Table 5.19) were highest in the *Prunus cerasoides*-plots, whilst *Hovenia dulcis*-plots supported the lowest bird density and richness. Population density of frugivorous bird was higher than the non-frugivorous bird only in *Erythrina subumbrans* (Table 5.20). Species richness of non-frugivorous bird was higher than frugivorous bird in all selected tree plots (Table 5.21). Population density of bird was correlated with the species richness of bird (R^2=0.99) (Figure 5.12). Population density and species richness of birds in all tree plots were listed in Appendix F (Tables F3-F5).

Table 5.19 Population density (no./m^2) and species richness (no. of species/m^2) of total birds in each sample tree plots

All seedling	ER	HO	ME	PR	SP
Population density ^{ns}	0.33±0.06	0.15±0.18	0.44±0.20	0.82±0.52	0.35±0.09
Species richness	0.23±0.08^a	0.09±0.10^b	0.27±0.12^a	0.50±0.32^a	0.23±0.06^a

Remark: different superscript alphabets = significant differences (P≤0.05)

ns = no significant difference between tree species (P≥0.05)

Table 5.20 Population density (no./m^2) of each bird groups beneath each sample tree plots

	Population density				
Bird groups	ER	HO	ME	PR	SP
Frugivores	0.17±0.08^a	0.02±0.03^b	0.10±0.10^{ab}	0.34±0.32^{ab}	0.15±0.10^{ab}
Non - frugivores ^{ns}	0.16±0.07	0.12±0.18	0.32±0.17	0.47±0.25	0.20±0.03

Remark: different superscript alphabets = significant differences (P≤0.05)

ns = no significant difference between tree species (P≥0.05)

Table 5.21 Species richness (no. of species/m^2) of each bird groups beneath each sample tree plots

	Species richness				
Bird groups	ER	HO	ME	PR	SP
Frugivores	0.10 ± 0.06^{a}	0.02 ± 0.02^{b}	0.07 ± 0.06^{ab}	0.17 ± 0.16^{ab}	0.07 ± 0.05^{ab}
Non - frugivores	0.13 ± 0.06^{ab}	0.07 ± 0.07^{a}	0.20 ± 0.11^{ab}	0.33 ± 0.18^{b}	0.16 ± 0.03^{b}

Remark: different superscript alphabets = significant differences ($P\leq0.05$)

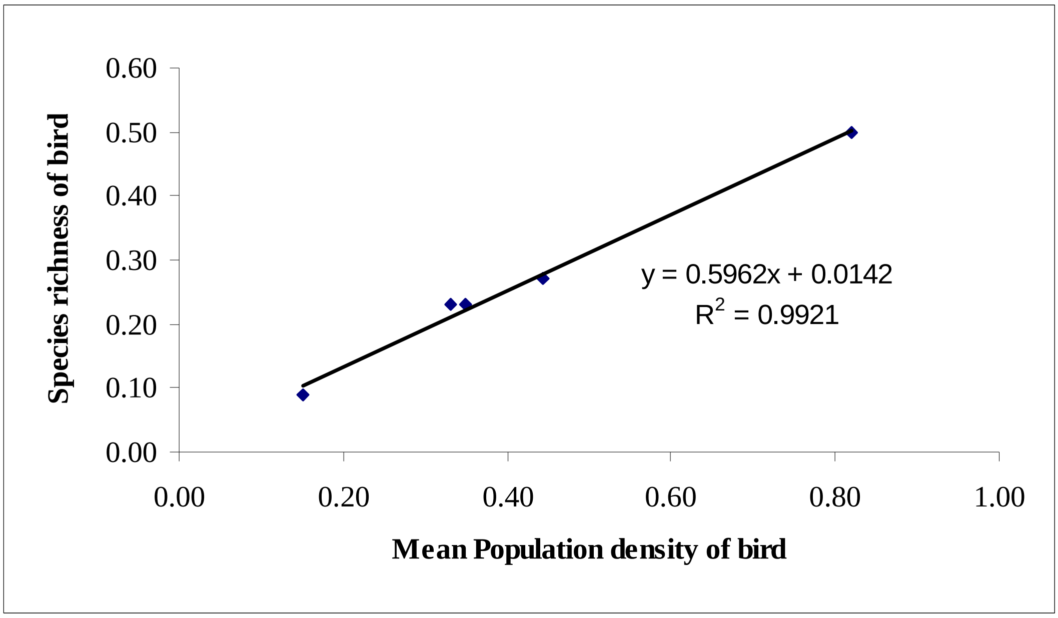

Figure 5.12 Population density of bird was positively correlated with the species richness of bird (R^2=0.99)

2.2) Ecological indices

Ecological indices were used to quantify bird diversity in all selected framework tree species (Table 5.22). Highest species richness of bird (N0 = 11) was found in *Prunus cerasoides*-plots (PR2) and *Spondias axillaris*-plots (SP2). No bird species was found in *Hovenia dulcis*-plots (HO2 and HO5). Species richness for each species of selected framework tree was highest in *Spondias axillaris*-plots (N0 = 28) and lowest in *Hovenia dulcis*-plots (N0 = 8).

Bird diversity was highest for *Spondias axillaris*-plots (Shannon's index, N1 = 21.41), whilst lowest species diversity was found in *Hovenia dulcis*-plots (N1 = 7.24). Highest evenness was found in the *Hovenia dulcis*-plots (E5 = 0.01), whilst lowest evenness was found in *Prunus cerasoides*-plots and *Spondias axillaris*-plots (E5 = 0.002).

Table 5.22 Ecological indices of birds in each selected framework tree species

Tree plots		No. of bird	Richness N0	Species diversity N1	N2	Evenness E5
Erythrina subumbrans	ER1	7	5	4.371	1.167	0.049
	ER2	7	5	4.711	1.105	0.028
	ER3	12	5	4.242	1.245	0.076
	ER4	6	5	4.764	1.072	0.019
	ER5	7	6	5.743	1.050	0.011
Total		**39**	**19**	**15.753**	**1.054**	**0.004**
Hovenia dulcis	HO1	3	3	3.001	1.000	0.000
	HO2	3	2	1.891	1.499	0.560
	HO3	0	0	****	****	****
	HO4	6	3	2.748	1.364	0.208
	HO5	0	0	****	****	****
Total		**12**	**8**	**7.236**	**1.082**	**0.013**
Melia toosendan	ME1	20	8	6.228	1.188	0.036
	ME2	6	5	4.764	1.072	0.019
	ME3	8	6	5.658	1.076	0.016
	ME4	7	5	5.743	1.050	0.011
	ME5	8	5	4.455	1.167	0.048
Total		**49**	**23**	**18.412**	**1.050**	**0.003**
Prunus cerasoides	PR1	12	8	7.236	1.082	0.013
	PR2	15	11	10.004	1.050	0.006
	PR3	10	6	4.998	1.185	0.046
	PR4	16	9	8.174	1.081	0.011
	PR5	13	8	6.290	1.164	0.031
Total		**66**	**25**	**20.573**	**1.045**	**0.002**
Spondias axillaris	SP1	13	8	6.855	1.115	0.020
	SP2	16	11	9.718	1.062	0.007
	SP3	15	10	8.619	1.082	0.011
	SP4	6	5	4.764	1.072	0.019
	SP5	12	7	6.449	1.100	0.018
Total		**62**	**28**	**21.413**	**1.046**	**0.002**

Remark: **** No bird observed using the trees, therefore can't calculate diversity and evenness.

2.3) Similarity indices

Sorensen's index was used to compare the bird communities in all selected framework tree species. The similarity coefficient equals to 1, when two bird communities in the sampling plots have identical species composition and 0 when there is no shared species.

Similarity coefficients calculation (Table 5.23) showed that bird communities that used *Melia toosendan* and *Prunus cerasoides* were the most similar (Sorensen's index = 0.54), whilst the most different bird communities was found between *Hovenia dulcis* and *Melia toosendan* (Sorensen's index = 0.26). Frugivorous bird communities between *Prunus cerasoides* and *Spondias axillaris* were the most similar (Sorensen's index = 0.55) (Table 5.24), whilst the most different was found in *Erythrina subumbrans* and *Hovenia dulcis* (Sorensen's index = 0.18). Non-frugivorous bird communities between *Erythrina subumbrans* and *Melia toosendan* (Sorensen's index = 0.61), whilst the most different was found in *Hovenia dulcis* and *Melia toosendan*-plots (Sorensen's index = 0.32) (Table 5.25).

Table 5.23 Similarity coefficients (Sorensen's index) of bird communities between framework tree species.

Plot pairs	ER	HO	ME	PR	SP
ER	-	0.37	0.52	0.45	0.47
HO	0.37	-	0.26	0.30	0.39
ME	0.52	0.26	-	0.54	0.51
PR	0.45	0.30	0.54	-	0.52
SP	0.47	0.39	0.51	0.52	-

Table 5.24 Similarity coefficients (Sorensen's index) of frugivorous bird communities between framework tree species.

Plot pairs	ER	HO	ME	PR	SP
ER	-	0.20	0.40	0.35	0.38
HO	0.20	-	0.22	0.18	0.20
ME	0.40	0.22	-	0.63	0.53
PR	0.35	0.18	0.63	-	0.59
SP	0.38	0.20	0.53	0.59	-

Table 5.25 Similarity coefficients (Sorensen's index) of non-frugivorous bird communities between framework tree species.

Plot pairs	ER	HO	ME	PR	SP
ER	-	0.47	0.64	0.52	0.53
HO	0.47	-	0.30	0.36	0.40
ME	0.64	0.30	-	0.53	0.55
PR	0.52	0.36	0.53	-	0.46
SP	0.53	0.40	0.55	0.46	-

2.4) Minutes observed of birds using the selected framework trees

Over 1200 minutes were used for bird observation in all selected framework tree. A total minute record for each bird groups using each selected tree species was done. Highest minute observations of bird were record in *Prunus cerasoides* and lowest in *Hovenia dulcis*. Total minutes observed of non-frugivorous bird were higher than frugivorous bird (Table 5.26). A total minutes and average minute observed for each bird species using each selected tree species were record (Table 5.27). Minutes observed of bird in each tree plots of each selected framework tree were listed in Appendix F (Table F6).

Table 5.26 Total minute record for each bird groups using each selected tree species

Bird Groups	ER	HO	ME	PR	SP	Total(Min)
Non - Frugivores	4.16	2.46	10.57	21.52	12.33	52.24
Frugivores	3.37	4.00	2.45	11.03	6.33	27.58
Unidentified	-	-	0.12	-	0.03	0.15
Total	**7.53**	**6.46**	**13.42**	**32.55**	**19.06**	**80.22**

Table 5.27 Total minutes and average minutes observed for each bird species using each selected tree species

No.	Common Name	No. of birds	ER	HO	ME	PR	SP	Total(Min.)	Average (Min.)
1	Arctic Warbler	9	0.45	-	0.15	3.50	1.03	5.53	1.01
2	Ashy Drongo	2	-	-	1.30	-	0.33	2.03	1.02
3	Barbet sp.	1	0.22	-	-	-	-	0.22	0.22
4	Bar-winged Flycatcher-shrike	11	0.11	0.03	0.24	-	0.10	0.48	0.04
5	Black-crested Bulbul	11	0.18	-	-	0.18	0.53	1.29	0.12
6	Black-throated Sunbird	11	0.32	0.12	-	1.04	0.11	1.59	0.14
7	Blue-throated Barbet	1	0.38	-	-	-	-	0.38	0.38
8	Blyth's Leaf-Warbler	8	-	0.48	-	0.43	1.26	3.29	0.41
9	Buff-bellied Flowerpecker	3	-	-	0.04	0.05	-	0.09	0.03
10	Bulbul sp.	2	-	-	0.29	-	-	0.29	0.15
11	Burmese Shrike	1	-	-	-	-	0.18	0.18	0.18
12	Common Iora	3	0.1	-	0.10	1.45	-	2.05	1.08
13	Dark-necked Tailorbird	2	-	-	-	0.44	-	0.44	0.22
14	Dusky Warbler	1	-	-	-	-	1.05	1.05	1.05
15	Flavescent Bulbul	6	-	-	-	3.33	0.18	3.51	0.59
16	Golden-spectacled Warbler	1	0.1	-	-	-	-	0.10	0.10
17	Great Tit	10	-	1.40	0.49	4.09	2.09	8.47	1.25
18	Green-billed Malkoha	1	-	-	-	-	0.38	0.38	0.38
19	Grey-headed Flycatcher	4	-	-	0.11	0.16	-	0.27	0.07
20	Hill Blue Flycatcher	8	0.08	0.03	0.16	3.54	0.34	4.55	0.57
21	Hoopoe	2	-	-	-	0.08	0.16	0.24	0.12
22	Inornate Warbler	1	-	0.02	-	-	-	0.02	0.02
23	Japanese White-eye	13	0.18	-	0.32	1.43	-	2.33	0.18
24	Little Pied Flycatcher	1	-	-	0.19	-	-	0.19	0.19
25	Little Spiderhunter	1	-	-	0.09	-	-	0.09	0.09
26	Olive-backed Pipit	3	-	-	-	0.47	-	0.47	0.16

Table 5.27 (continued)

No.	Common Name	No. of birds	ER	HO	ME	PR	SP	Total(Min.)	Average (Min.)
27	Oriental White-eye	9	-	-	0.22	0.49	0.18	1.29	0.14
28	Plain Flowerpecker	1	-	-	-	0.13	-	0.13	0.13
29	Plaintive Cuckoo	1	-	-	-	3.42	-	3.42	3.42
30	Puff-throated Babbler	4	0.02	2.20	-	-	0.16	2.38	1.00
31	Red-throated Flycatcher	5	-	-	-	1.32	0.53	2.25	0.45
32	Red-whiskered Bulbul	16	0.48	-	0.17	0.04	0.39	1.48	0.09
33	Scarlet Minivet	11	0.20	-	2.34	-	0.06	3.00	0.27
34	Sooty-headed Bulbul	10	0.18	-	0.12	-	1.12	1.42	0.14
35	Speckled Piculet	4	0.38	-	3.21	1.24	-	5.23	1.31
36	Streaked Spiderhunter	7	0.08	-	0.09	0.06	0.04	0.27	0.04
37	Sunbird sp. (female)	2	0.08	-	-	-	0.06	0.14	0.07
38	Two-barred Warbler	5	-	-	1.04	0.44	0.32	2.20	0.44
39	Unknown sp. 1	1	-	-	0.08	-	-	0.08	0.08
40	Unknown sp. 2	1	-	-	-	-	0.03	0.03	0.03
41	Unknown sp. 3	1	-	-	0.04	-	-	0.04	0.04
42	Velvet-fronted Nuthatch	1	-	-	-	-	0.10	0.10	0.10
43	Warbler sp.1	1	-	-	-	-	0.09	0.09	0.09
44	White-browed Piculet	2	-	-	-	0.06	-	0.06	0.03
45	White-browned Scimitar-Babbler	1	-	-	-	0.09	-	0.09	0.09
46	White-browned Shrike-Babbler	2	-	-	-	-	0.05	0.05	0.03
47	White-crested Laughingthrush	4	0.50	-	-	-	-	0.50	0.13
48	White-rumped Shama	18	1.16	1.38	0.23	1.07	4.28	8.52	0.47
49	White-throated Fantail	4	-	-	0.12	-	0.34	0.46	0.12
	Total	**228**	**8.00**	**6.46**	**13.54**	**31.55**	**19.09**	**79.44**	**0.35**

2.5) Bird behavior and their usage sites on the selected framework tree species

Activities of birds were observed in all selected framework tree. Bird behavior was divide into 3 types; (1) perching, (2) feeding on insect, fruit and nectar and (3) defecation (dropped feces) in the tree plots (Table 5.28). Most bird perched on the tree and then flew away. Feeding on insect was observed more than feeding on fruit and nectar. Defecation was observed in *Melia toosendan*, *Prunus cerasoides* and *Spondias axillaris*. Bird behavior in each selected framework tree is listed in Appendix F (Table F7).

Table 5.28 Activities of birds observed in all selected framework tree

Tree plots	No. of birds	Activities
Erythrina subumbrans	39	P,FI,FN
Hovenia dulcis	12	P,FI
Melia toosendan	49	P,FI,DE
Prunus cerasoides	66	P,FI,FF,FN,DE
Spondias axillaris	62	P,FI,DE

Remark: FF=feeding on fruit; FN=feeding on nectar; FI=feeding on insects DE=defecation.

There are 3 main parts on the studied trees as the bird-usage sites; (1) The tree crowns, (2) the tree trunk and branches under the tree crowns and (3) the ground under the tree crowns. Bird observed using tree crown were “Crown user”, whilst bird observed using the part under the tree crowns were “Understorey user” and bird observed using or feeding on the ground under the tree crowns were “Ground user” Many bird species observed using only one part of the tree, whilst some bird observed using many parts of the tree. The tree trunk and branches under the tree crowns were the most frequently used by birds followed by the tree crowns and the ground under the tree crowns (Table 5.29). Highest number of crown user bird species was observed in *Prunus cerasoides*, whilst highest number of understorey user and ground user bird were observed in *Spondias axillaris* (Table 5.30). Number of bird species, number of bird observed and their using sites in each selected framework tree were listed in Appendix F (Table F8).

Table 5.29 Number of bird in each using sites of each selected framework trees

Tree plots	No. of birds	No. of bird in each using sites CU	UU	GU
Erythrina subumbrans	39	29	8	2
Hovenia dulcis	12	2	8	2
Melia toosendan	49	18	30	1
Prunus cerasoides	66	25	33	8
Spondias axillaris	62	30	30	3
Total	**228**	**104**	**109**	**16**

Remark: US= Crown user; UU= Understorey user; UG= Ground user.

Table 5.30 Number of bird species in each using sites of each selected framework trees

Tree plots	No. of bird species	No. of bird species in each using sites CU	UU	GU
Erythrina subumbrans	19	12	7	2
Hovenia dulcis	8	2	5	2
Melia toosendan	23	11	14	1
Prunus cerasoides	25	7	20	3
Spondias axillaris	28	13	14	3
Total	**49**	**18**	**30**	**5**

2.6) Correlations between seedling communities and bird communities

Correlations were used to show the relationship of natural tree seedlings and the bird communities observed in all framework tree plots. The population of seedlings, which were the same species of planted trees in 1998 plots were subtracted from this analysis, to focus only in the recruit seedling species (non-planted species) and birds which were assumed to affect natural tree seedling recruitment such as the population density of recruit seedlings and birds (Figure 5.13), the species richness of recruit seedlings and birds (Figure 5.14). Correlation between recruit animal-dispersed seedlings and seed-dispersing birds (frugivorous bird) were done to show the relation between the population density of recruit animal-dispersed seedlings and the seed-dispersing birds (Figure 5.15) and the relation between the species richness of recruit animal-dispersed seedlings and the seed-dispersing birds (Figure 5.16).

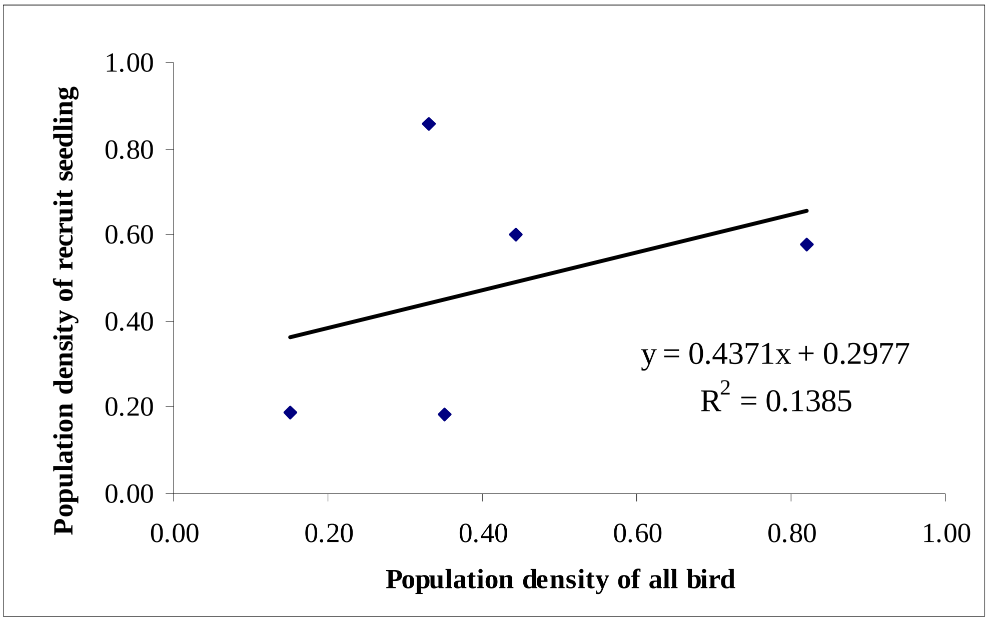

Figure 5.13 Correlation between the population density of recruit seedling and the population density of bird in all framework tree plots (R^2 = 0.13)

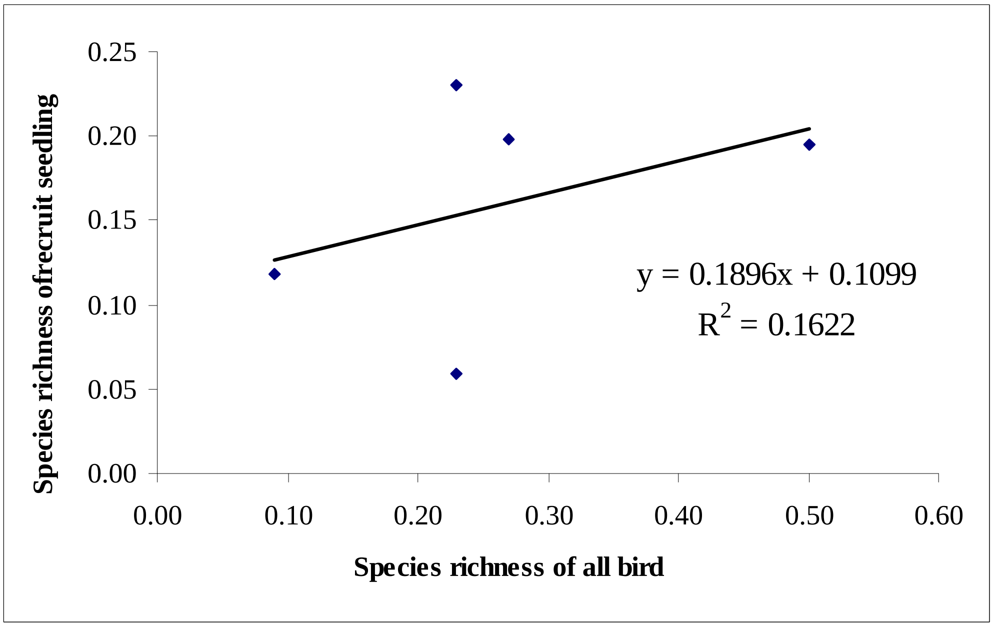

Figure 5.14 Correlation between the species richness of recruit seedling and the species richness of bird in all framework tree plots (R^2 = 0.16)

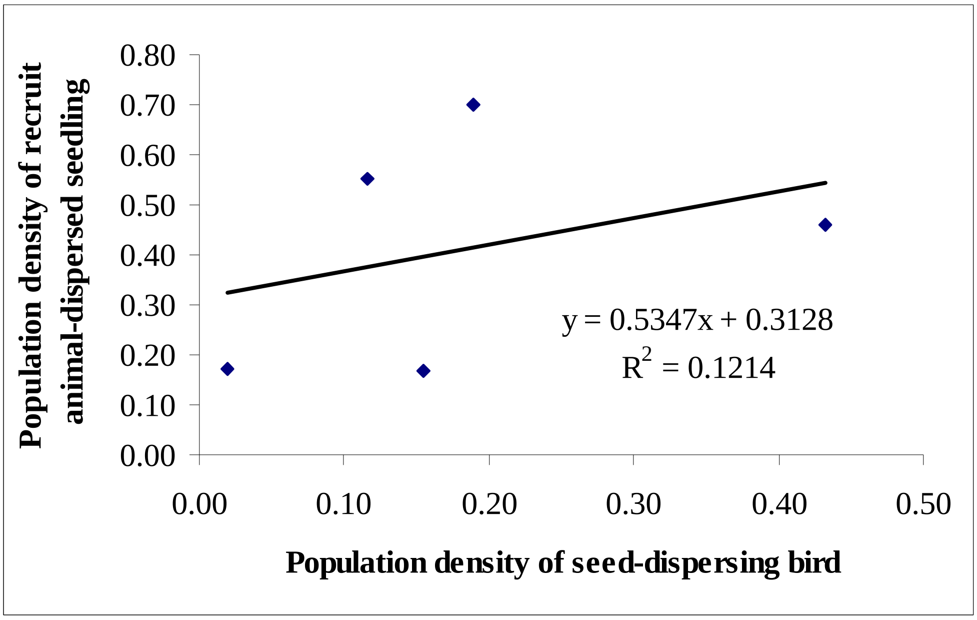

Figure 5.15 Correlation between the population density of recruit animal-dispersed seedling and the population density of seed-dispersing bird in all framework tree s plots (R^2 = 0.12)

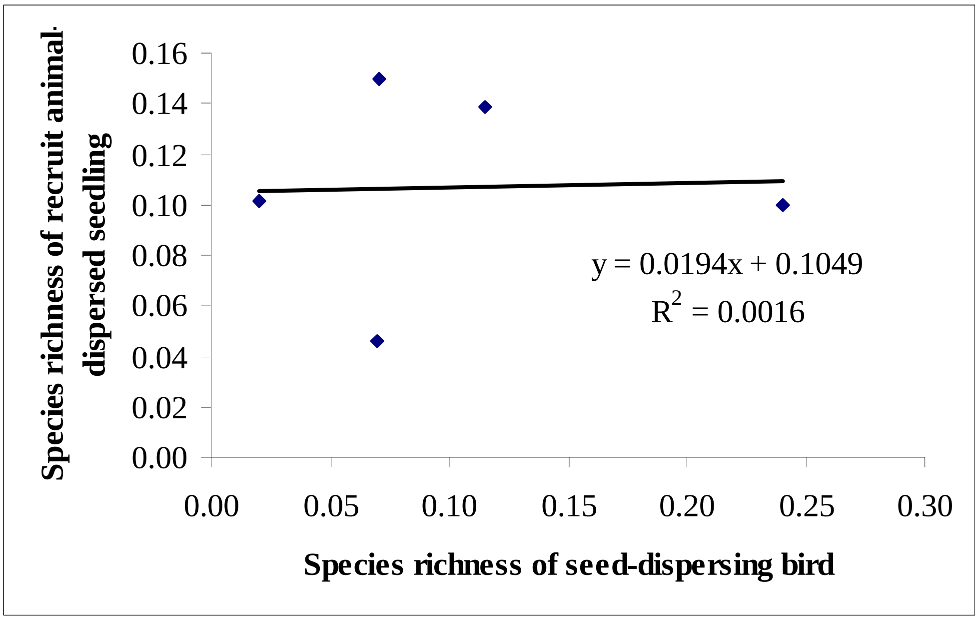

Figure 5.16 Correlation between the species richness of recruit animal-dispersed seedling and the species richness of seed-dispersing bird in all framework tree plots (R^2 = 0.0016)

2.7) Effects of tree size on natural seedling recruitment and bird communities

Linear-regression analyses were used to determine the relations between selected framework tree size with density and species richness of natural seedling recruitment. Population density and species richness of seedling beneath *Erythrina subumbrans* and *Melia toosendan* had significant relationship with GBH. *Prunus cerasoides* had significant relationship between population density of seedling and GBH. *Spondias axillaris* had significant relationship between population density of seedling and crown width (Table 5.31).

Table 5.31 Linear-regression analysis between selected framework tree sizes with population density (no./m^2) and species richness (no. of species/ m^2) of natural seedling recruitment in each tree plots

Tree plots	Population density		Species richness	
	GBH	Crown width	GBH	Crown width
Erythrina subumbrans	P=0.02	ns	P=0.03	ns
Hovenia dulcis	ns	ns	ns	ns
Melia toosendan	P=0.001	ns	P=.007	ns
Prunus cerasoides	P=0.03	ns	ns	ns
Spondias axillaris	ns	P=0.03	ns	ns

Remark: ns = no significant differences ($P \geq 0.05$)

For wind-dispersed seedlings (Table 5.32), significant relationships between tree size with population density and species richness of seedling were varied for each tree species except for *Hovenia dulcis*. For animal-dispersed seedlings (Table 5.33), a significant relationships between tree size with population density and species richness of seedling were shown for all tree species except for crown width of *Prunus cerasoides* and population density of seedling.

Table 5.32 Linear-regression analysis between selected framework tree sizes with population density (no./m^2) and species richness (no. of species/ m^2) of wind-dispersed seedling in each tree plots

Tree plots	Population density		Species richness	
	GBH	Crown width	GBH	Crown width
Erythrina subumbrans	ns	ns	P=0.01	ns
Hovenia dulcis	ns	ns	ns	ns
Melia toosendan	P=0.001	ns	P=0.001	ns
Prunus cerasoides	P=0.002	P=0.01	P=0.004	P=0.01
Spondias axillaris	ns	P=0.001	ns	P=0.001

Remark: ns = no significant differences (P≥0.05)

Table 5.33 Linear-regression analysis between selected framework tree sizes with population density (no./m^2) and species richness (no. of species/ m^2) of animal-dispersed seedling in each tree plots

Tree plots	Population density		Species richness	
	GBH	Crown width	GBH	Crown width
Erythrina subumbrans	P=0.03	P=0.006	P=0.03	P=0.01
Hovenia dulcis	P=0.03	P=0.01	P=0.03	P=0.0008
Melia toosendan	P=0.004	P=0.01	P=0.01	P=0.004
Prunus cerasoides	P=0.005	ns	P=0.02	P=0.03
Spondias axillaris	P=0.0002	P=0.01	P=0.004	P=0.02

Remark: ns = no significant differences (P≥0.05)

Relationships between bird communities and tree size were also analyzed (Table 5.34). Significant relationships between population density and species richness of bird with tree size were shown for all tree species except for *Spondias axillaris*.

Table 5.34 Linear-regression analysis between selected framework tree sizes with population density (no./m^2) and species richness (no. of species/ m^2) of bird communities in each tree plots

Tree plots	Population density		Species richness	
	GBH	Crown width	GBH	Crown width
Erythrina subumbrans	ns	ns	ns	P=0.0004
Hovenia dulcis	P=0.027	ns	P=0.033	ns
Melia toosendan	P=0.011	P=0.036	P=0.028	P=0.002
Prunus cerasoides	P=0.057	P=0.01	P=0.075	P=0.009
Spondias axillaris	ns	ns	ns	ns

Remark: ns = no significant differences ($P \geq 0.05$)

For non-frugivorous birds (Table 5.35), significant relationships between tree size with population density and species richness of bird were varied for each tree species except for *Spondias axillaris*, *Melia toosendan* and *Prunus cerasoides* have significant relationship between population density and species richness of bird with tree size (both GBH and crown width). For frugivorous birds (Table 5.36), significant relationship between tree size with population density and species richness of seedling were shown for all tree species except for tree size of *Erythrina subumbrans* and population density of bird.

Table 5.35 Linear-regression analysis between selected framework tree sizes with population density (no./m^2) and species richness (no. of species/ m^2) of non-frugivorous bird

Tree plots	Population density		Species richness	
	GBH	Crown width	GBH	Crown width
Erythrina subumbrans	ns	P=0.012	ns	P=0.023
Hovenia dulcis	P=0.02	ns	P=0.025	ns
Melia toosendan	P=0.008	P=0.019	P=0.015	P=0.006
Prunus cerasoides	P=0.004	P=0.002	P=0.007	P=0.002
Spondias axillaris	ns	ns	ns	ns

Remark: ns = no significant differences (P≥0.05)

Table 5.36 Linear-regression analysis between selected framework tree sizes with population density (no./m^2) and species richness (no. of species/ m^2) of frugivorous bird

Tree plots	Population density		Species richness	
	GBH	Crown width	GBH	Crown width
Erythrina subumbrans	ns	ns	P=0.047	P=0.02
Hovenia dulcis	P=0.023	P=0.018	P=0.043	P=0.007
Melia toosendan	P=0.004	ns	P=0.006	ns
Prunus cerasoides	P=0.003	P=0.026	P=0.004	P=0.026
Spondias axillaris	P=0.023	P=0.016	P=0.028	P=0.016

Remark: ns = no significant differences (P≥0.05)

CHAPTER 6
DISCUSSION

1. Tree seedling communities beneath each selected framework tree species

Seedling communities in all sample plots beneath each selected framework tree species were divided into 2 seedling groups according to their mode of dispersal, wind-dispersed seedling and animal-dispersed seedling. According to Wunderle (1997), most of the tree species in the tropics are dispersed by animal rather than wind. In this study mean population density (no./m^2) and species richness (no. of species/m^2) of animal-dispersed seedling were found beneath the selected framework trees more than wind-dispersed seedlings (Tables 5.4 and 5.5). This result briefly suggested that animal seed dispersers such as birds and small mammals play an important role in natural forest regeneration (Corlett, 1998). However, it is possible that many seedling species in this studied were not dispersed from the non-planted trees because they were the same species with the planted framework species in 1998. The seedlings of the non-planted tree species were considered as naturally recruited species (Table 6.1).

From all 25 tree plots beneath each selected framework tree, seedling species composition and abundance were different among tree species and among different trees of the same species. However, animal-dispersed seedling was found higher than wind-dispersed seedling beneath all the studied trees. *Erythrina subumbrans*-plots were the most abundant in seedling richness and diversity, whilst *Hovenia dulcis*-plots supported the lowest (Table 5.6). Many factors affect seedling communities beneath each tree species. Different tree species characteristic such as tree height, canopy width and their denseness are important factors to consider.

Erythrina subumbrans (ER) had large mean crown width, which reflected the size and shape of the seedling sample plots beneath them. Crown width determines shade and influences soil moisture content under the trees (Verdú and García-Fayos, 1996). Such factors may then influence the density and distribution of tree seedlings (Maguire and Forman, 1983). From the first seedling survey during the dry season in 2006, the trees shaded out their leaves, made the trees leafless, which resulted in an open gap under their crowns. This seemed to create suitable conditions for seedling recruitment, which agreed with the previous study of another *Erythrina* tree species by Navakitbumrung (2003). He concluded that the low shade and long leafless period of *Erythrina stricta* might provide germination and recruitment of wind-dispersed species, in contrast with *Melia toosendan* (ME) and *Spondias axillaris* (SP). ME has slightly lower mean crowns width compared to ER, whilst SP had largest mean canopy width and providing the largest sample plots. However, ME and SP have denser multiple crowns than ER. This characteristic is suitable for shading out weeds in the first 2 years of forest regeneration. But, the dense multiple crowns seemed to create unfavorable conditions for the naturally established trees, because they shade out seedlings too. SP have more height and dense multiple crowns with many branches of pinnately-compound leaf and create more shady condition compared with ME. Thus, the number and species diversity of seedlings in SP plots were lower than ME plots suggested that different characteristic in crowns shape gave a different resulted for seedling communities beneath them.

Hovenia dulcis (HO) had the smallest tree size (GBH) and provided the smallest seedling sample plots in this study. In all planted plots since 1998, the trees have been under the shade of other framework trees. Therefore, HO-plots have very small amount of seedling.

Prunus cerasoides (PR) supported the highest population density (no./m^2) and species richness (no. of species/m^2) of seedlings for both wind-dispersed and animal-dispersed seedling communities. One dominant tree seedling species in the PR-plots was *Castanopsis cerebrina* (Fagaceae). There were 62 seedlings (from 133 individuals of all seedlings in PR-plots) growing densely beneath one PR-plot (PR3) (Table 5.6). It was observed that one-planted *Castanopsis cerebrina* tree was standing near this tree plot. Many *Castanopsis cerebrina* trees produce high amount of seeds after the rainy season. The seeds came from the planted trees in 1998. Therefore, the *Castanopsis cerebrina* seeds were dispersed directly from the nearby mother tree into the planted plots. Dropped seeds of this large-seeded species were clumped around the mother trees. Lambers and Clark (2003) found that seed size is generally negatively correlated with seed dispersal distances but positively correlated with seedling survival. Moles and Westoby (2004) suggested that large-seeded species have higher seedling emergence rate through early seedling establishment than small-seeded species. In some tree plots clumped seedlings of *Castanopsis cerebrina* were colonized the ground and shaded out many smaller seedlings (small-seeded species).

In contrary with *Castanopsis cerebrina*, one seedling of the animal-dispersed species, *Aquilaria crassna* Pierre ex Lecomte. (Thymeleaceae) was found beneath one ME plot. Several saplings were found in other planted plots too. The mother trees of *Aquilaria crassna* were found far away form the FORRU planted site for some distance in Doi Suthep-Pui National Park (Maxwell, personal communication). Large animals, probably civets or barking deer might play a role in recruitment of this species into the tree plot rather than birds due to its large seed size.

2. Relative growth rate, health and survival of natural tree seedlings

Relative growth rates of root collar diameter (RRGR) and relative growth rate of height (RHGR) of animal-dispersed seedlings were higher than wind-dispersed seedlings (Table 5.10). Growth rates of seedlings depend on different conditions created by each framework tree. Many seedling species found in this studied were " Pioneer tree species "- trees that produce small fruits and seed dispersed by wind or small birds. Seedlings of pioneer trees can grow only in full sunlight, whereas some species were " Climax tree species ", which grow in shade and their seedlings are shade-tolerant (Whitmore, 1989). From the survey some wind-dispersed species such as *Archidendron clypearia* ssp. *clypearia* var. *clypearia* (Leguminosae, Mimosaceae), *Schima wallichii* (Theaceae) and *Wendlandia scabra* var. *scabra* (Rubiaceae) and many animal-dispersed species such as *Eugenia albiflora* (Myrtaceae), *Litsea monopetala* and *Phoebe lanceolata* (Lauraceae) grew very well under the sunlight gap conditions created by each framework tree. Different sunlight gap conditions depend on the shape of tree crowns. Lorena *et al*., (2005) concluded that canopy shading was the main mechanism, enhancing seedling survival and affecting the growth rate of natural tree seedlings.

Survival rate and average health score of all seedlings showed that selected framework tree can support the recruitment of natural tree seedlings very well with 96.10% of survival rate and mean average health score of each seedling species was ranked from 1.67-3.00 after 15 months (Table 5.13). Physical damage of seedlings was found in many tree plots such as ER and ME. Most seedling damage and death was caused by branches of the trees that fell into the plots. Litter accumulation in the tree plots might affect seedling communities. This agrees with many studies in natural forests, which showed that the presence of litter layer strongly influenced seedling recruitment (Erikkson, 1995; Benitez-Malvido, 1999; Kotorava and Leps, 1999). Wardle (1992) also reported that the decay of leaf litter can release phytotoxic substances, which can inhibit seed germination and the early growth of seedlings. Dalling *et al*., (2002) reported that small-seeded pioneer tree species are inhibited by leaf litter on the soil, whilst large-seeded pioneer tree species can germinate and regenerate under a litter surface. Based on the seedling surveys, leafless or damaged seedlings were found beneath or surrounded by litter layer presented in some tree plots, However many seedlings re-sprouted their shoots and flush their leaves again after the second monitoring in November 2006.

Other conditions in the tree plots which affected seedling recruitment were light intensity and ground vegetation. Seedling density and richness were positively correlated with light intensity (Figure 5.3 and 5.4). Studies in the tropics also showed strong positive relationships with light availability (Oberbauer and Strain, 1985; Ashton, 1995; Agyeman *et al*., 1999), with pioneer trees having a much higher growth response to light intensity than shade-tolerant species (Veenendaal *et al.,* 1996). However, weak positive correlations between RHGR and light intensity were shown in this study. This may be the influence from competition interaction. For example, ER plots had highest light intensity due to the crown shape that allowed high levels of light and created favorable conditions for both tree seedling recruitment and herbaceous ground vegetation. This allowed the herbaceous ground vegetation to compete with tree seedlings and then affected tree seedling growth. This result agreed with the previous study of Maguire and Forman (1983), who concluded that competition from herb cover affect seedling growth and distribution.

3. Bird communities observed for each selected framework tree species and their effects on seedling recruitment

More than 250 individuals of birds were observed in planted plots. Two hundred twenty-eight birds were recorded using the selected framework tree species. Various groups of bird were observed in each tree. Non-frugivorous birds were observed more frequently than frugivorous birds. It can be explained that not all selected trees in this study produced high amounts of fruit or food resources to attract high number of frugivorous birds.

Tree size and crown shape can influence the birds that use them. Birds could be divided into 3 groups according to the part of tree they use. Birds that were found only in the tops of trees or spent their time mostly in the crown are “crown users” e.g. Ashy Drongo (*Dicrurus leucophaeus*), Barbet (*Megalaima* spp.), many species of Bulbul (*Pycnonotus* spp.) and nectarivores such as sunbirds (*Aethopyga* spp.) and spiderhunters (*Arachnothera* spp.). Birds that perch under the tree crowns, resting or clinging on the tree trunks in search for food are “understorey users” including many species of Warbler (*Phylloscopus* spp.), Flycatcher (*Culicicapa* spp., *Cyornis* spp. and *Fecidula* spp.), other insectivores and nectativores. Birds that searched for food on the ground are “ground users” including Puff-throated Babbler (*Pellorneum ruficeps*), Olive-backed Pipit (*Anthus hodgsoni*), Dusky Warbler (*Phylloscopus fuscatus*) and White-rumped Shama (*Copsychus malabaricus*).

Tall tree species in this study- ER, ME, and SP were used frequently by crown users as perching sites. Tree crowns of those 3 species provided ideal points for birds to sit and look out for food, since they were taller than the other species in the planted plots. It was observed that ER produce flowers in December 2006 - Jan 2007. The trees produced bright red color flower, when they were leafless, which provided high quantities of nectar as a food sources for many birds species such as Ashy Drongo, Black-throated sunbird (*Aethopyga saturata*), Slender-billed Oriole (*Oriolus tenuirostris*). Many birds search for insects in the ER flowers. Frugivorous bird such as Red-Whiskered Bulbul (*Pycnonotus jocosus*) and Sooty-headed Bulbul (*Pycnonotus aurigaster*) were observed frequently on the tree tops. ME was very attractive to the birds according to the study of Toktang (2005). The numerous, white flowers attract many insects attracting many insectivorous birds. Twenty four bird species were recorded as regular visitors, including 5 Bulbul species, which are important seed dispersing agents. They are common in the forest and are frequent visitors to deforested sites (Scott *et al*., 2000). Bulbuls occur in a wide range of habitats and can eat many kinds of fruits (Chanthorn, 1999, 2002; Pattanakaew, 2002; Sanitjun, 2002). SP supported the highest species richness of birds, which used their multiple crowns in search for food or perching at roosting sites. Observations in August 2006 found one bird nest, put within the “basket-shape” formed by multiple-secondary stem of SP tree in 1998-1 plot. The multiple crowns of SP trees supported nesting birds from the 5th year after planted (FORRU, 2005). A previous study by Voysey (1999) also reported that animal-dispersed seeds might be deposited more frequently in nesting or roosting sites.

PR supported the highest abundance of birds, even though the trees were smaller than ER, ME and SP. High amount of branchlets of the tree may provided lots of perching sites for birds. PR produced flowers and fruits in January 2007. Birds such as Sunbirds, Spiderhunters and White-eyes feed on the nectar, whilst bulbuls ate the fruits. Black-throated sunbird, Japanese White-eye (*Zosterops japonicus*), Oriental White-eye (*Zosterops palpebrosus*) and Streaked Spiderhunter (*Arachnothera magna*) used the trees frequently. Flavescent Bulbuls fed on PR fruits. Great Tit (*Parus major*), three species of Warbler (*Phylloscopus* spp.), White-rumped Shama and other insectivores spent most time under the tree crown, gleaning insects from the leaves and on the ground under the trees.

HO supported the lowest richness, diversity and abundance of birds. Similarity coefficients of HO-bird communities compared with other species were low. This tree was the smallest selected framework species in this study. Their crowns were not large enough to support high number of birds. One important thing to consider is that HO has not yet flowered and provided fruit since planting. Therefore, resources to attract birds were not present.

The duration of bird visitations to the trees depended on each bird group or bird species with their specific feeding behavior. Speckled Piculet (*Picumnus innominatus*) spent most of the time pecking noisily on the framework tree branches, searching for insect larvae. Warblers (*Phylloscopus* spp.) and Flycatchers (*Culicicapa* spp., *Cyornis* spp. and *Ficedula* spp.) searched for insects by flying in the tree crowns moving down to the sub-canopy or fed on the ground beneath each tree. Non-frugivorous birds, nectarivores and insectivores, spent more time finding their food in the trees more than frugivorous birds. However, due to seed-disperse inability, non-frugivorous bird seemed to have very little effect on natural seedling recruitment.

Fruit availability is the crucial factor influencing frugivore communities (Howe & Estabrook 1977, Thompson & Willson 1979). During bird observations in this study, fruit production of framework tree in the planted plots, especially for the understorey tree species was low. Many frugivorous birds flew away immediately after perching on the non-fruit source trees, resulted in weak correlations between recruit-seedling communities and seed-dispersing bird communities due to low probability of seed deposition under the non-fruit trees (Figures 5.13-5.16), although the treefall gaps that provide an open area for the birds to searching for food and seedling recruitment were presented in many tree plots. Blake and Hoppes (1986) suggested that high amounts of fruit-eating birds in gaps may be a direct result of higher amounts of fruiting plants in gaps. High frequency of bird visitation and number of seeds dispersed per visit are due to more fruit availability of trees is one of the main factors that affect the quantity of the seeds dispersed by the seed-dispersing birds in the planted plots. Bird species that visited frequently and consumed large numbers of fruits were likely to carry many seeds away from the parent tree (Schupp 1993, Graham *et al.*, 1995). Differences in fruit size were also important for seed dispersal. Smaller fruit with smaller seed might attract more bird species, which carry the seeds from non-planted sites. The small-seeded tree species have a higher probability of being dispersed because they can be swallowed by birds with smaller gape widths (Jordano, 1987; Levey, 1987; Wheelwright, 1993). However, the presence of both small seeded-species and large-seed species such as *Aquilaria crassna* in ME plot, suggest that some seed-dispersing animals, probably the terrestrial vertebrate can disperse both small and large seedling tree species, enhance the natural recovery of tree diversity in the forest restoration sites.

CHAPTER 7
CONCLUSIONS AND RECOMMENDATIONS

1. The effects of planted trees and bird communities on natural-seedling recruitment were different between each selected framework tree. Different tree species characteristic such as tree height, crown width and their denseness were important factors affecting seedling communities by creating suitable condition for natural-seedling recruitment.

2. Differences fruits and other resources availability between each tree species affected bird communities that play an import role on natural forest regeneration by dispersing seeds into the forest restoration plots. Bigger trees, which attract high number of seed-dispersing birds by providing food resources, perching and nesting sites may increase duration of bird visit and their behaviors, which enhance the seed deposition and natural-seedling recruitment in the plots more than smaller trees with less attractiveness characteristic.

3. Seedling emergence, survival and growth rates depended on various conditions beneath each study trees. Some possible parameters which seemed to affect natural-seedling recruitment are light intensity, litter accumulation, physical damage of the seedling due to tree falls. These parameters were different depend on each tree species.

Recommendations

This study concentrated on the relationship between the planted trees and birds, which perform seed dispersal as an important ecological function of the forest ecosystem, to understand the plant and animal interactions affect natural forest regeneration, from the recruitment of vegetation by animal-seed dispersal in the restoration area. However, more study in the future should be considered to understand these interactions. Some recommendations are:

1. Study of seed dispersal and seedling recruitment in the planted plot with seed sampling in the plot or beneath some selected planted tree species. For this study, the 5 selected tree species showed the relation between the tree and bird from the result of seedling recruitment. The next step is to investigate the abundance and richness of seeds that really come from the seed-dispersing animal. Seed traps should be the good choice to study the seed deposition in the plot (Cottrell, 2004). Comparing the collected seed from trap and the seedling communities in plot to estimate the vegetation recovery is interesting.

2. Field work on the different groups of framework trees that produce resources to attract wildlife at the same period of time to determine the maximum attractiveness to the seed-dispersing animal and seed input as a source of regeneration. The results can be used to predict the occurrence of maximum seed input from maximum population of seed-dispersing animal in each framework tree groups. Example of some recommended tree species are the keystone species group such as Fig trees (*Ficus* spp.).

3. Combination of molecular tools and ecological field data from the field work by compared the natural recruit tree species collected from the planted plot with the tree species from the natural forest around the plantation sites can be used to find genetic relationship between the natural regenerate population in the planted sites and natural population exist in the forest. Analyses using the multilocus genotype at simple sequence repeats (SSRs) or microsatellites (Tautz, 1989) for identification of the maternal source trees of animal-dispersed seeds are recommended. Godoy and Jordano (2001) reported that endocarp microsatellites DNA from *Prunus mahaleb* seeds, dispersed by frugivores can be used to identify the maternal source tree when genotypes of the seed endocarp were compared with maternal genotypes obtained from leaf tissue of adult trees population. DNA extraction from seeds and microsatellite genotyping can be combined with regular sampling of seed rain using seed traps (Kollman and Goetze 1997; Harms *et al*., 2000).

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APPENDICES

Appendix A

Details of selected framework trees (FORRU, 2005)

1. *Erythrina subumbrans* (Hassk.) Merr.

Common name (Thai): Tawng Lahng Bah / ทองหลางป่า

Family: Leguminosae, Papilionoideae

General information and Distribution

Medium-sized, pioneer, deciduous tree, growing up to 25 m tall (DBH to 86 cm). Distribute in India, Myanmar and Indochina to Malaysia, Fiji and Samoa. In Northern Thailand, it grows sparsely in Evergreen (EGF) and Mix deciduous forests (MXF) at elevations of 500 to 1680 m.

Characteristic

Bark: soft, grey, with spine-tipped black tubercles. **Leaves:** spirally arranged, trifoliate; leaflet blades ovate, margin entire, terminal leaflet 10-14 x 8-12 mm. **Flowers:** bisexual, 4-5 cm long; petals bright red; December to March, often when leafless. **Fruits:** pods, brown, 15.5 x 1 cm; seeds smooth, dark brown, kidney shaped, 1 x 0.9 cm; March to April; pods dispersed by wind.

Potential attractiveness to wildlife

ER saplings achieve excellent survival and growth rates after planting out (>80% survival; >2.5 m tall, crowns 2.6-2.8 m across, by end of 2nd rainy season). They flower, fruit and attract nesting birds from the 4th year after planting. The vivid scarlet flowers produce nectar, which attracts many bird and squirrel species.

Appendix A (continued)

2. *Hovenia dulcis* Thunb.

Common name (Thai): Mawn Hin / หมอนหิน

Family: Rhamnaceae

General information and Distribution

Large, briefly deciduous tree, growing up to 30 m tall (DBH to 50 cm). Distribute from the Himalayas, to Northern Thailand, China, Japan and Korea. In Northern Thailand, it is a recently discovered, rare species (Maxwell, 1994) in EGF often along streams, at elevations of 1025 m to 1325 m.

Characteristic

Bark: thick, with broad, longitudinal, grey or brown ridges, separated by narrow brickred fissures. **Leaves:** spirally arranged, simple; blades, thin, ovate to elliptic, 11-14 x 5-9 cm; margin serrulate. **Flowers:** in cymes, numerous, light green and cream, small (2.5 mm); March to May. **Fruits:** fruit stalks (pedicels) very thin and curving for 2-3 mm above each fruit, but further along, swollen and fleshy, green when fruits are unripe, turning red-brown or black as fruits ripen; capsules septicidal, brown or black and drying out when ripe, 7-8.5 x 6-7.5 mm, usually 3-lobed with 1 smooth, glossy, black seed (5-6 x 5-6 mm) per locule; August to February; bird-dsipersed, particularly by pigeons (Hitchcock and Elliott, 1999).

Potential attractiveness to wildlife

HO saplings survive well (>80% by end of 2nd rainy season) and grow rapidly (>1.5 m tall) after planting out. They develop broad crowns, which effectively shade out weeds and attract nesting birds by the 4th year. HO fruits and the infructescence are very attractive to birds, but flowering does not commence <8 years after planting.

Appendix A (continued)

3. *Melia toosendan* Sieb. & Zucc.

Common name (Thai): Lien / เลี่ยน

Family: Meliaceae

General information and Distribution

Medium-sized, briefly deciduous, pioneer tree, growing up to 25 m tall (DBH to 47 cm). Distribute from Myanmar, through Northern Thailand, Indochina, Southern China and Japan. In Northern Thailand, it is characteristic of secondary growth in EGF and MXF, at elevations of 700 to 1450 m.

Characteristic

Bark: thin, grey-brown, with shallow fissures. **Leaves:** spirally arranged, doubly pinnate or tripinnate; leaflet blades ovate, 3-7 x 1-2 cm, with acuminate tip, margin often toothed. **Flowers:** inflorescences axillary and paniculate; flowers numerous, corllas white (c.10 mm); January to March. **Fruits:** drupe, yellow when ripe, 25 x 22 mm; ridged, woody pyrene contains up to 5 seeds; seeds black, 6 x 3 mm; October to March; animal-dispersed.

Potential attractiveness to wildlife

ME is one of the fastest growing tree species tested by FORRU. Planted saplings achieve survival rates of >90% and grow 5-7 m tall by end of 2nd rainy season. They develop very broad crowns (>2.5 m), which contribute substantially to forest canopy cover and suppress weed growth. Flowering occurs from the 4th year. after planting and fruiting from the 5th. Barking deer eat the fruits. This species is very attractive to birds, which are important seed-dispersers. Its fragrant flowers attract many insects.

Appendix A (continued)

4. *Prunus cerasoides* D. Don

Common name: Nang Paya Sua Krong / นางพญาเสือโคร่ง

Family: Rosaceae

General information and Distribution

Medium-sized, pioneer, deciduous tree, growing up to 16 m tall (DBH to 38 cm). Distribute From the Himalayas and Southern China to Myanmar and Northern Indochina. It is rare in EGF, MXF and EGF-PINE, of Northern Thailand often in disturbed areas, at elevations of 1040 to 2400 m.

Characteristic

Bark: shiny, red-brown, with large, raised, brown lenticels; outer layer peeling horizontally. **Leaves**: spirally arranged, simple; blades 9-12 x 3-5 cm; margin finely serrate; 1-2 dark red, stalked, glands where petiole meets blade. **Flowers**: in axillary clusters, 1-2.5 cm across, petals, 5, pink; on leafless trees December to January. **Fruits**: drupes (small cherries), ovoid, red when ripe, 1-1.5 cm, each containing a single-seeded pyrene; March to May; dispersed by birds, squirrels and other small mammals.

Potential attractiveness to wildlife

PR is an excellent framework species. Planted saplings survive very well and grow rapidly when planted out (>80% survival and >3 m tall by end of 2nd rainy season). They develop broad crowns (>2.4 m across), which effectively shade out weeds and they flower, fruit and provide bird nest sites by the 3rd year after planting. Birds such as, Sunbirds, Spiderhunters and White-eyes feed on the nectar, whilst bulbuls eat the fruits.

Appendix A (continued)

5. *Spondias axillaris* Roxb.

Common name: Ma Kak / มะกั๊ก

Family: (Anacardiaceae)

General information and Distribution

Medium-sized, deciduous tree, growing up to 25 m tall (DBH to 50 cm). From Northeast. India and China through Indochina to Southern Japan. it is common in EGF, EGF-PINE and MXF of Northern Thailand, at elevations of 700 to 1600 m.

Characteristic

Bark: grey-brown, thin, vertically cracked. **Leaves**: spirally arranged, compound, once pinnate, 25-40 cm long; leaflet blades opposite or sub-opposite, ovate to ovate-lanceolate, 4- 12 x 2-4.5 cm; apex acuminate. **Flowers**: male inflorescences 4-10 cm long; male corollas dark reddish purple, 0.4-0.5 cm; females solitary in upper leaf axils; January to March. **Fruits**: drupes, oval-shaped, with yellow leathery exocarp when ripe, 2.5-3 x 2 cm across, each containing a single pyrene with 5 locules; June to August; animal-dispersed.

Potential attractiveness to wildlife

SP is an excellent framework species. Planted saplings achieve very high survival and growth rates (>70% survival; averaging >2.5 m tall by end of 2nd rainy season). The trunks tend to fork low down, resulting in multiple crowns, which shade out weeds very effectively. Flowering and fruiting occur from the 4th year after planting. The trees support nesting birds from the 5th year after planting. The fruits are eaten by deer, wild pigs and bears.

Appendix B

Table B1 Selected framework tree sizes

Plot 1998-1	Tree label	Species	GBH (cm)	Crown width/ Plot diameter (m)
1	18/42	*Hovenia dulcis* (HO1)	15	5.5
2	005/50	*Melia toosendan* (ME1)	56	6.6
3	71/28	*Prunus cerasoides* (PR1)	53	7.2
4	66/276	*Spondias axillaris* (SP1)	103	7.4
5	317/30	*Erythrina subumbrans* (ER1)	61	6.2
Plot 1998-2	**Tree label**	**Species**	**GBH (cm)**	**Crown width/ Plot diameter (m)**
1	005/65	*Melia toosendan* (ME2)	69	7.2
2	66/55	*Spondias axillaris* (SP2)	120	7.4
3	71/74	*Prunus cerasoides* (PR2)	67	5.2
4	005/64	*Melia toosendan* (ME3)	93	5.8
5	18/008	*Hovenia dulcis* (HO2)	35	5.6
6	66/93	*Spondias axillaris* (SP3)	134	6.2
7	71/69	*Prunus cerasoides* (PR3)	69	5.6
8	317/46	*Erythrina subumbrans* (ER2)	136	5.0
9	317/50	*Erythrina subumbrans* (ER3)	153	6.8
10	18/94	*Hovenia dulcis* (HO3)	16	2.9
Plot 1998-3	**Tree label**	**Species**	**GBH (cm)**	**Crown width/ Plot diameter (m)**
1	66/84	*Spondias axillaris* (SP4)	84	5.8
2	317/66	*Erythrina subumbrans* (ER4)	86	4.4
3	317/125	*Erythrina subumbrans* (ER5)	138	5.4
4	005/50	*Melia toosendan* (ME4)	73	4.3
5	005/143	*Melia toosendan* (ME5)	66	3.8
6	66/211	*Spondias axillaris* (SP5)	64	6.8
7	18/134	*Hovenia dulcis* (HO4)	14	4.0
8	71/111	*Prunus cerasoides* (PR4)	72	3.4
9	71/117	*Prunus cerasoides* (PR5)	82	4.3
10	18/125	*Hovenia dulcis* (HO5)	22	3.4

Appendix C

Seedling Communities

Table C1 Quantity of natural tree seedlings in each selected tree plot

No.	Species	*Erythrina subumbrans*					*Hovenia dulcis*					*Melia toosendan*					*Prunus cerasoides*					*Spondias axillaris*					Total
		(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	(1)	(2)	(3)	(4)	(5)	
1	*Albizia chinensis* (Osb.) Merr.		5	1																							**6**
2	*Albizia odoratissima* (L.f.) Benth.	1																								1	**2**
3	*Aporusa octandra* (Buch.-Ham. ex D. Don)				4		1			2		1			1			3			5						**17**
4	*Aquilaria crassna* Pierre ex Lecomte.														1												**1**
5	*Archidendron clypearia* (Jack) I. C. Nielsen ssp. *clypearia* var. *clypearia*	1				1	2					6							1						1		**12**
6	*Bauhinia variegata* L.					1																					**1**
7	*Bombax anceps* Pierre var. *anceps*	1																									**1**
8	*Bridelia tomentosa* Blume var. *tomentosa*		1									1															**2**
9	*Castanopsis cerebrina* (Hickel & A. Camus) Barnett.		24	2	1								1	1	1				52						1	1	**84**
10	*Castanopsis tribuloides* (Sm.) A. DC.											1															**1**
11	*Cinnamomum caudatum* Nees.	1																									**1**
12	*Cinnamomum iners* Reinw. ex Bl															1											**1**
13	*Engelhardia serrata* Blume.				1											1											**2**
14	*Engelhardia spicata* Blume. var. *spicata*																			1							**1**
15	*Erythrina subumbrans* (Hassk.) Merr.						1													2	5						**8**
16	*Eugenia albiflora* Duth.ex Kurz.	1		1	4	1				1				1			3			5	1		2			1	**21**

Table C1 (continued)

No.	Species	*Erythrina subumbrans* (1)	(2)	(3)	(4)	(5)	*Hovenia dulcis* (1)	(2)	(3)	(4)	(5)	*Melia toosendan* (1)	(2)	(3)	(4)	(5)	*Prunus cerasoides* (1)	(2)	(3)	(4)	(5)	*Spondias axillaris* (1)	(2)	(3)	(4)	(5)	Total
17	*Ficus hirta* Vahl. var. *hirta*	1													2	2	2					2			1	1	**11**
18	*Ficus hispida* L.	1																									**1**
19	*Ficus subincisa* J.E. Sm.				3																						**3**
20	*Helicia nilagirica* Bedd.					1																					**1**
21	*Heliciopsis terminalis* Kurz.																									1	**1**
22	*Heynea trijuga* Roxb. ex Sims.		1															3	1								**5**
23	*Horsfieldia amygdalina* (Wall.) Warb.																		1					2			**2**
24	*Ixora cibdela* Craib.															1											**1**
25	*Litsea cubeba* Pers.		1																								**1**
26	*Litsea monopetala* (Roxb.) Pers.	29	4	2	12	13	1		1	3	2	7	1	1	19	6	3	1	4	8	7	6	1		7	10	**148**
27	*Litsea salicifolia* Roxb. ex Nees.	1		3															2								**6**
28	*Mallotus philippensis* (Lam.)	1		2														1									**4**
29	*Melia toosendan* Sieb. & Zucc.																		1								**1**
30	*Michelia baillonii* (Pierre) Finet & Gagnep.																1										**1**
31	*Phoebe lanceolata* (Wall. ex Nees) Nees.	2		2	3	1		2	1		1	1	1		32	3	2	2		6			1	1			**61**
32	*Prunus cerasoides* D. Don											1					2			2						1	**6**
33	*Schima wallichii* (DC.) Korth.	2				2	1					1	1		1		1	1		2	1						**13**
34	*Sterculia villosa* Roxb.				2																						**2**
35	*Tarennoidea wallichii* (Hook.f.) Tirveng. & Sastre											1															**1**
36	*Wendlandia scabra* Kurz var. *scabra*				1		1					1					1								1		**5**
	Total	***42***	***36***	***13***	***31***	***20***	***7***	***2***	***2***	***6***	***3***	***21***	***4***	***3***	***57***	***14***	***15***	***11***	***62***	***26***	***19***	***8***	***4***	***3***	***11***	***16***	***436***

Table C2 Population density and species richness of all seedlings

Tree plot	No. of seedling	No. of seedling species	Population Density (no./m^2)	Species richness (no. sp/ m^2)
Erythrina subumbrans				
ER1	42	12	1.37	0.39
ER2	36	6	1.99	0.33
ER3	13	7	0.36	0.19
ER4	31	9	2.04	0.59
ER5	20	6	0.87	0.26
Mean			***1.33***	***0.35***
Hovenia dulcis				
HO1	7	6	0.30	0.26
HO2	2	1	0.08	0.04
HO3	2	2	0.30	0.30
HO4	6	3	0.48	0.24
HO5	3	2	0.33	0.22
Mean			***0.30***	***0.21***
Melia toosendan				
ME1	21	10	0.61	0.29
ME2	4	4	0.10	0.10
ME3	3	3	0.11	0.11
ME4	57	7	3.93	0.48
ME5	14	6	1.23	0.53
Mean			***1.20***	***0.30***
Prunus cerasoides				
PR1	15	8	0.37	0.20
PR2	11	6	0.52	0.28
PR3	62	7	2.52	0.28
PR4	26	7	2.86	0.77
PR5	19	5	1.33	0.35
Mean			***1.52***	***0.38***
Spondias axillaris				
SP1	8	2	0.19	0.05
SP2	4	3	0.09	0.07
SP3	3	2	0.10	0.07
SP4	11	5	0.42	0.19
SP5	16	7	0.44	0.19
Mean			***0.25***	***0.11***

Table C3 Population density and species richness of wind-dispersed seedling

Tree plot	No. of seedling	No. of seedling species	Population Density (no./m^2)	Species richness (no. sp/ m^2)
Erythrina subumbrans				
ER1	6	5	0.20	0.16
ER2	5	1	0.28	0.06
ER3	3	2	0.08	0.06
ER4	2	2	0.13	0.13
ER5	4	3	0.17	0.13
Mean			***0.17***	***0.11***
Hovenia dulcis				
HO1	5	4	0.21	0.17
HO2	0	0	0.00	0.00
HO3	0	0	0.00	0.00
HO4	0	0	0.00	0.00
HO5	0	0	0.00	0.00
Mean			***0.04***	***0.03***
Melia toosendan				
ME1	8	3	0.23	0.09
ME2	1	1	0.02	0.02
ME3	0	0	0.00	0.00
ME4	1	1	0.07	0.07
ME5	1	1	0.09	0.09
Mean			***0.08***	***0.05***
Prunus cerasoides				
PR1	2	2	0.05	0.05
PR2	2	2	0.09	0.09
PR3	1	1	0.04	0.04
PR4	5	3	0.55	0.33
PR5	6	2	0.42	0.14
Mean			***0.23***	***0.13***
Spondias axillaris				
SP1	0	0	0.00	0.00
SP2	0	0	0.00	0.00
SP3	0	0	0.00	0.00
SP4	2	2	0.08	0.08
SP5	1	1	0.03	0.03
Mean			***0.02***	***0.02***

Table C4 Population density and species richness of animal-dispersed seedling

Tree plot	No. of seedling	No. of seedling species	Population Density (no./m^2)	Species richness (no. sp/ m^2)
Erythrina subumbrans				
ER1	36	7	1.18	0.23
ER2	31	5	1.71	0.28
ER3	10	5	0.28	0.14
ER4	29	7	1.91	0.46
ER5	16	4	0.70	0.17
Mean			***1.15***	***0.26***
Hovenia dulcis				
HO1	2	2	0.09	0.09
HO2	2	1	0.08	0.04
HO3	2	2	0.30	0.30
HO4	6	3	0.48	0.24
HO5	3	2	0.33	0.22
Mean			***0.26***	***0.18***
Melia toosendan				
ME1	13	7	0.38	0.20
ME2	3	3	0.07	0.07
ME3	3	3	0.11	0.11
ME4	56	6	3.86	0.41
ME5	13	5	1.15	0.44
Mean			***1.11***	***0.25***
Prunus cerasoides				
PR1	13	6	0.32	0.15
PR2	9	4	0.42	0.19
PR3	61	6	2.48	0.24
PR4	21	4	2.31	0.44
PR5	13	3	0.91	0.21
Mean			***1.29***	***0.25***
Spondias axillaris				
SP1	8	2	0.19	0.05
SP2	4	3	0.09	0.07
SP3	3	2	0.10	0.07
SP4	9	3	0.34	0.11
SP5	15	6	0.41	0.17
Mean			***0.23***	***0.09***

Appendix D

Percentages of ground vegetation cover and open area in each tree plot

Table D1 Percentages of ground vegetation cover and open area in each tree plot

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98.1	***Erythrina subumbrans-1***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Dianella ensifolia* (L.) DC.	Liliaceae	H	x	
3	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
4	*Eupatorium adenophorum* Spreng.	Compositae	H	10%	
5	*Flamingia sootepensis* Craib	Leguminosae, Papilionoidea	S	x	
6	*Melastoma malabathricum* L. ssp. *malabathricum*	Melastomaceae	S	x	
7	*Murdannia japonica*	Comlinaceae	H	1%	
8	*Paspalum conjugatum* Berg.	Gramineae	G	x	
9	*Scleria levis* Retz.	Cyperaceae	H	x	
10	*Smilax ovalifolia* Roxb.	Smilacaceae	C	x	
	Total			**10%**	**90%**

Remark: C = Climber, F= Fern, G = Grass, H =Herb, S = Shrub, WC = Woody Climber

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-1	***Hovenia dulcis-1***				
1	*Dioscorea alata* L.	Dioscoreaceae	H	x	
2	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
3	*Embelia subcoriacea (Cl.)*	Myrsinaceae	S	x	
4	*Eupatorium adenophorum* Spreng.	Compositae	H	1%	
5	*Imperata cylindrica* (L.) P. Baeuv. var. *major* (Nees) C.E. Hybb. Ex Hubb. & Vaughn	Gramineae	G	1%	
6	*Mussaenda parva* Wall. ex G. Don	Rubiaceae	S	x	
7	*Paspalum conjugatum* Berg.	Gramineae	G	15%	
8	*Scleria levis* Retz.	Cyperaceae	H	x	
9	*Streptocaulon juventas* (Lour.) Merr.	Asclepiadaceae	H	x	
10	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	10%	
	Total			**40%**	**60%**

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-1	***Melia toosendan-1***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Argyreia aggregata* (Roxb.) choisy	Convulvulaceae	C	x	
3	*Clerodendrum serratum* (L.) Moon var. *wallichii* Cl.	Verbenaceae	S	x	
4	*Dioscorea glabra* Roxb. var. *glabra*	Dioscoreaceae	H	x	
5	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
6	*Embelia sessiliflora* Kurz.	Myrsinaceae	WC	x	
7	*Eupatorium adenophorum* Spreng.	Compositae	H	15%	
8	*Imperata cylindrica* (L.) P. Baeuv. var. *major* (Nees) C.E. Hybb. Ex Hubb. & Vaughn	Gramineae	G	15%	
9	*Melastoma malabathricum* L. ssp. *malabathricum*	Melastomaceae	S	x	
10	*Mussaenda parva* Wall. ex G. Don	Rubiaceae	S	x	
11	*Paspalum conjugatum* Berg.	Gramineae	G	25%	
12	*Pteris biaurita L.*	Pteridaceae	F	x	
13	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	5%	
	Total			**40%**	**60%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-1	***Prunus cerasoides-1***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cissus discolor* Bl. var. *discolor*	Vitaceae	WC	x	
3	*Clerodendrum glandulosum* Colebr. ex Lindl.	Verbenaceae	S	x	
4	*Crepidium calophyllum* (Rchb.f.) Szlach.	Orchidaceae	H	x	
5	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	x	
6	*Dianella ensifolia* (L.) DC.	Liliaceae	H	x	
7	*Dioscorea glabra* Roxb. var. *glabra*	Dioscoreaceae	H	x	
8	*Eupatorium odoratum* L.	Compositae	H	x	
9	*Leea indica* (Burm. F.) Merr.	Leeaceae	S	x	
10	*Murdannia japonica*	Commelinaceae	H	x	
11	*Mussaenda parva* Wall. ex G. Don	Rubiaceae	S	1%	
12	*Paspalum conjugatum* Berg.	Gramineae	G	10%	
13	*Ravolfia verticillata* (Lour.) Baill.	Apocynaceae	S	x	
14	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	1%	
	Total			**15%**	**85%**

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-1	***Spondias axillaris-1***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Camchaya eberhardtii* (Gagnep.) kit.	Compositae	H	5%	
3	*Centella asiatica* (L.) Urb.	Umbelliferae	H	x	
4	*Clausena lenis* Drake.	Rutaceae	S	x	
5	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	x	
6	*Dianella ensifolia* (L.) DC.	Liliaceae	H	x	
7	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
8	*Dioscorea glabra* Roxb. var. *glabra*	Dioscoreaceae	H	x	
9	*Dioscorea hispida* Denn. var. *hispida*	Dioscoreaceae	H	x	
10	*Eupatorium adenophorum* Spreng.	Compositae	H	5%	
11	*Globba kerrii* Craib	Zingiberaceae	H	x	
12	*Melastoma malabathricum* L. ssp. *malabathricum*	Melastomaceae	S	x	
13	*Murdannia japonica*	Commelinaceae	H	1%	
14	*Paspalum conjugatum* Berg.	Gramineae	G	5%	
15	*Polygonum chinese* L.	Polygonaceae	S	x	

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-1	***Spondias axillaris-1* (continued)**				
16	*Ravolfia verticillata* (Lour.) Baill.	Apocynaceae	S	x	
17	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	x	
18	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	1%	
19	*Urena lobata* L. spp. *lobata* var. *lobata*	Malvaceae	H	x	
	Total			**40%**	**60%**
98-2	***Erythrina subumbrans-2***				
1	*Alipinia galanga* (L.) Willd.	Zingiberaceae	H	x	
2	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
3	*Canthium parvifolium* Roxb.	Rubiaceae	S	x	
4	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	10%	
5	*Eupatorium adenophorum* Spreng.	Compositae	H	10%	
6	*Eupatorium odoratum* L.	Compositae	H	x	
7	*Paspalum conjugatum* Berg.	Gramineae	G	x	
8	*Scleria levis* Retz.	Cyperaceae	H	x	
9	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	x	
10	*Smilax corbularia* Kunth ssp. *corbularia*	Smilacaceae	C	x	
11	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
	Total			**35%**	**65%**
98-2	***Erythrina subumbrans-3***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Canthium parvifolium* Roxb.	Rubiaceae	S	x	
3	*Commelina diffusa* Burm.f.	Commelinaceae	H	10%	
4	*Cyperus laxus* Lmk. var. *laxus*	Cyperaceae	H	1%	
5	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	x	
6	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
7	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	10%	
8	*Eupatorium adenophorum* Spreng.	Compositae	H	1%	
9	*Eupatorium odoratum* L.	Compositae	H	x	
10	*Phaulopsis dorsiflora* (Retz.) Sant.	Acanthaceae	H	x	

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-2	***Erythrina subumbrans-3* (continued)**				
11	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	x	
12	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
	Total			**25%**	**75%**
98-2	***Hovenia dulcis-2***				
1	*Curculigo latifolia* Pry.ex W.T. Ait.var. *latifolia*	Amaryllidaceae	H	x	
2	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
3	*Eupatorium adenophorum* Spreng.	Compositae	H	x	
4	*Phaulopsis dorsiflora* (Retz.) Sant.	Acanthaceae	H	x	
5	*Ravolfia verticillata* (Lour.) Baill.	Apocynaceae	S	x	
	Total			**x**	**99%**
98-2	***Hovenia dulcis-3***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Curculigo latifolia* Pry.ex W.T. Ait.var. *latifolia*	Amaryllidaceae	H	x	
3	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	5%	
4	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	15%	
5	*Eupatorium adenophorum* Spreng.	Compositae	H	10%	
6	*Eupatorium odoratum* L.	Compositae	H	x	
7	*Paspalum conjugatum* Berg.	Gramineae	G	1%	
	Total			**35%**	**65%**
98.2	***Melia toosendan-2***	**Family**	**Habit**	**Cover**	**Open**
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	5%	
3	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	5%	
4	*Eupatorium adenophorum* Spreng.	Compositae	H	x	
5	*Musa* sp.	Musaceae	H	x	
6	*Mussaenda parva* Wall. ex G. DOn	Rubiaceae	S	x	
7	*Phaulopsis dorsiflora* (Retz.) Sant.	Acanthaceae	H	5%	
	Total			**15%**	**85%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-2	***Melia toosendan-3***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Clerodendrum glandulosum* Colebr. ex Lindl.	Verbenaceae	S	x	
3	*Commelina diffusa* Burm.f.	Commelinaceae	H	20%	
4	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	x	
5	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
6	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
7	*Dioscorea pentaphylla* L. var. *siamensis* Prain & Burk.	Dioscoreaceae	H	15%	
8	*Eupatorium adenophorum* Spreng.	Compositae	H	20%	
9	*Mussaenda parv*a Wall. ex G. DOn	Rubiaceae	S	x	
10	*Paspalum conjugatum* Berg.	Gramineae	G	10%	
11	*Phragmites vallatoria* (Pluk. ex. L.) Veldk.	Gramineae	G	1%	
12	*Scleria levis* Retz.	Cyperaceae	H	x	
13	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
	Total			**60%**	**40%**

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-2	***Prunus cerasoides-2***				
1	*Amorphophallus yunnanensis* Engl.	Araceae	H	x	
2	*Boehmeria thailandica* Yaha.	Urticaceaa	S	x	
3	*Curculigo latifolia* Pry.ex W.T. Ait.var. *latifolia*	Amaryllidaceae	H	1%	
4	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
5	*Eupatorium adenophorum* Spreng.	Compositae	H	15%	
6	*Eupatorium odoratum* L.	Compositae	H	x	
7	*Melastoma malabathricum* L. ssp. *malabathricum*	Melastomaceae	S	x	
8	*Paspalum conjugatum* Berg.	Gramineae	G	10%	
9	*Phragmites vallatoria* (Pluk. ex. L.) Veldk.	Gramineae	G	x	
10	*Pteridium aquilinum* L. Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try.	Dennstaedtiaceae	F	x	
11	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	x	
12	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	1%	
	Total			**25%**	**75%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-2	***Prunus cerasoides-3***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Clerodendrum glandulosum* Colebr. ex Lindl.	Verbenaceae	C	x	
3	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
4	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	1%	
5	*Eupatorium adenophorum* Spreng.	Compositae	H	10%	
6	*Eupatorium odoratum* L.	Compositae	H	5%	
7	*Imperata cylindrica* (L.) P. Baeuv. var. *major* (Nees) C.E. Hybb. Ex Hubb. & Vaughn	Gramineae	G	x	
8	*Phragmites vallatoria* (Pluk. ex. L.) Veldk.	Gramineae	G	x	
9	*Pteridium aquilinum* L. Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try.	Dennstaedtiaceae	F	x	
10	*Scleria levis* Retz.	Cyperaceae	H	x	
11	*Setaria verticillata* (L.) P. Beauv.	Gramineae	G	x	
12	*Stemona tuberosa* Lour. var. *tuberosa*	Stemonaceae	C	x	
13	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
14	*Vigna umbellata* (Wild.) Ohwi & Oha. var. *umbellata*	Leguminosae, Papilionoidea	C	x	
	Total			**30%**	**70%**

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-2	***Spondias axillaris-2***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Amorphophallus yunnanensis* Engl.	Araceae	H	x	
3	*Boehmeria thailandica* Yaha.	Urticaceaa	S	x	
4	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	x	
5	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
6	*Dioscorea pentaphylla* L. var. *siamensis* Prain & Burk.	Dioscoreaceae	H	x	
7	*Eupatorium adenophorum* Spreng.	Compositae	H	1%	
8	*Eupatorium odoratum* L.	Compositae	H	x	
9	*Mikania cordata* (Burm.f.) B.L. Rob. forma *undulata* Kast.	Compositae	C	1%	
10	*Mussaenda parv*a Wall. ex G. DOn	Rubiaceae	S	x	
11	*Paspalum conjugatum* Berg.	Gramineae	G	x	
12	*Polygonum chinese* L.	Polygonaceae	S	x	
	Total			**5%**	**95%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-3	***Spondias axillaris-3***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	x	
3	*Dianella ensifolia* (L.) DC.	Liliaceae	H	x	
4	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
5	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	1%	
6	*Eupatorium adenophorum* Spreng.	Compositae	H	10%	
7	*Eupatorium odoratum* L.	Compositae	H	5%	
8	*Millettia pachycarpa* Bth.	Leguminosae, Papilionoidea	C	x	
9	*Smilax lanceifolia* Roxb.	Smilacaceae	C	x	
10	*Smilax ovalifolia* Roxb.	Smilacaceae	C	x	
	Total			**15%**	**85%**
98-3	***Erythrina subumbrans-4***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cayratia japonica* (Thunb.) Gagnep.	Vitaceae	C	x	
3	*Dienia ophrydis* (Koen.) Orm. & Seid.	Orchidaceae	H	x	
4	*Dioscorea alata* L.	Dioscoreaceae	H	x	
5	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
6	*Eupatorium adenophorum* Spreng.	Compositae	H	25%	
7	*Mussaenda parv*a Wall. ex G. DOn	Rubiaceae	S	x	
8	*Paspalum conjugatum* Berg.	Gramineae	G	x	
9	*Phaulopsis dorsiflora* (Retz.) Sant.	Acanthaceae	H	x	
10	*Phrynium capitatum* wild.	Maranthaceae	H	x	
11	*Pteris biaurita* L.	Pteridaceae	F	x	
12	*Thelypteris subelata* (Bak.) K. lw.	Thelypteridaceae	F	x	
13	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
	Total			**30%**	**70%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-3	***Erythrina subumbrans-5***				
1	*Alipinia galanga* (L.) Willd.	Zingiberaceae	H	x	
2	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	5%	
3	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
4	*Eupatorium adenophorum* Spreng.	Compositae	H	20%	
5	*Eupatorium odoratum* L.	Compositae	H	x	
6	*Paspalum conjugatum* Berg.	Gramineae	G	x	
7	*Scleria levis* Retz.	Cyperaceae	H	x	
8	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	x	
9	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
	Total			**25%**	**75%**

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-3	***Hovenia dulcis*-4**				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cayratia japonica* (Thunb.) Gagnep.	Vitaceae	C	x	
3	*Clerodendrum disparifolium* Bl.	Verbenaceae	S	x	
4	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
5	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
6	*Eupatorium adenophorum* Spreng.	Compositae	H	5%	
7	*Eupatorium odoratum* L.	Compositae	H	x	
8	*Globba kerri*	Zingiberaceae	H	x	
9	*Imperata cylindrica* (L.) P. Baeuv. var. *major* (Nees) C.E. Hybb. Ex Hubb. & Vaughn	Gramineae	G	x	
10	*Mussaenda parv*a Wall. ex G. DOn	Rubiaceae	S	x	
11	*Oplismenus compositus* (L.) P. Beauv.	Gramineae	G	x	
12	*Pteris biaurita* L.	Pteridaceae	F	x	
13	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	5%	
	Total			**15%**	**85%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-3	***Hovenia dulcis*-5**				
1	*Amorphophallus yunnanensis* Engl.	Araceae	H	x	
2	*Canthium parvifolium* Roxb.	Rubiaceae	S	x	
3	*Cayratia japonica* (Thunb.) Gagnep.	Vitaceae	C	x	
4	*Cochlianthus gracilis* Bth.	Leguminosae, Papilionoidea	H	x	
5	*Embelia sessiliflora* Kurz.	Myrsinaceae	C	x	
6	*Eupatorium adenophorum* Spreng.	Compositae	H	x	
7	*Eupatorium odoratum* L.	Compositae	H	x	
8	*Mussaenda parv*a Wall. ex G. DOn	Rubiaceae	S	x	
9	*Paspalum conjugatum* Berg.	Gramineae	G	x	
10	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
11	*Urena lobata* L. spp. *lobata* var. *lobata*	Malvaceae	H	x	
	Total			**1%**	**99%**
98-3	***Melia toosendan-4***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cayratia japonica* (Thunb.) Gagnep.	Vitaceae	C	x	
3	*Cochlianthus gracilis* Bth.	Leguminosae, Papilionoidea	H	1%	
4	*Digitaria violascens* Link	Gramineae	G	x	
5	*Dioscorea alata* L.	Dioscoreaceae	H	x	
6	*Eupatorium odoratum* L.	Compositae	H	15%	
7	*Polygonum chinense* L.	Polygonaceae	S	15%	
8	*Pteris biaurita* L.	Pteridaceae	F	x	
	Total			**30%**	**70%**
98-3	***Melia toosendan-5***				
1	*Cayratia japonica* (Thunb.) Gagnep.	Vitaceae	C	x	
2	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	15%	
3	*Dioscorea alata* L.	Dioscoreaceae	H	x	
4	*Panicum notatum* Retz.	Gramineae	G	1%	
5	*Polygonum chinese* L.	Polygonaceae	S	x	
6	*Pteris biaurita* L.	Pteridaceae	F	x	
7	*Scleria levis* Retz.	Cyperaceae	H	x	
	Total			**15%**	**85%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-3	***Prunus cerasoides-4***				
1	*Alipinia galanga* (L.) Willd.	Zingiberaceae	H	x	
2	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
3	*Cayratia japonica* (Thunb.) Gagnap	Vitaceae	C	1%	
4	*Clerodendrum disparifolium* Bl.	Verbenaceae	S	x	
5	*Coclianthus gracilis* Bth.	Leguminosae, Papilionoidea	H	1%	
6	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	x	
7	*Dienia ophrydis* (Koen.) Orm. & Seid.	Orchidaceae	H	x	
8	*Dioscorea bulbifera* L.	Dioscoreaceae	H	x	
9	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
10	*Eupatorium adenophorum* Spreng.	Compositae	H	10%	
11	*Eupatorium odoratum* L.	Compositae	H	x	
12	*Maclura fruticosa* (Roxb.) Corn.	Moraceae	C	x	
13	*Paspalum conjugatum* Berg.	Gramineae	G	x	
14	*Scleria levis* Retz.	Cyperaceae	H	x	
15	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	1%	
16	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
	Total			**20%**	**80%**

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-3	***Prunus cerasoides-5***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cayratia japonica* (Thunb.) Gagnep.	Vitaceae	C	x	
3	*Clerodendrum disparifolium* Bl.	Verbenaceae	S	x	
4	*Coclianthus gracilis* Bth.	Leguminosae, Papilionoidea	H	x	
5	*Dienia ophrydis* (Koen.) Orm. & Seid.	Orchidaceae	H	x	
6	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
7	*Eupatorium odoratum* L.	Compositae	H	1%	
8	*Scleria levis* Retz.	Cyperaceae	H	x	
9	*Thysanolaena latifolia* (Roxb.ex Horn.)	Gramineae	G	x	
	Total			**5%**	**95%**

Table D1 (continued)

Plot	Tree plots/ ground species	Family	Habit	Cover	Open
98-3	***Spondias axillaris-4***				
1	*Amorphophallus yunnanensis* Engl.	Araceae	H	x	
2	*Cyrtococcum accrescens* (Trin.) Stapf	Gramineae	G	5%	
3	*Dioscorea glabra* Roxb. var. *glabra*	Dioscoreaceae	H	x	
4	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
5	*Eupatorium adenophorum* Spreng.	Compositae	H	x	
6	*Fluggea virosa* (Roxb. ex Willd.) Baill.	Euphorbiaceae	H	x	
7	*Mussaenda parv*a Wall. ex G. DOn	Rubiaceae	S	x	
8	*Paspalum conjugatum* Berg.	Gramineae	G	x	
9	*Polygonum chinese* L.	Polygonaceae	S	x	
10	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	x	
11	*Vernonia divergens* (DC.) Edgew.	Compositae	H	x	
	Total			**15%**	**85%**
98-3	***Spondias axillaris-5***				
1	*Alipinia malaccensis* (Burm.f.) Rosc.	Zingiberaceae	H	x	
2	*Cayratia japonica* (Thunb.) Gagnep.	Vitaceae	C	x	
3	*Clausena lenis* Drake.	Rutaceae	S	x	
4	*Dienia ophrydis* (Koen.) Orm. & Seid.	Orchidaceae	H	x	
5	*Dioscorea alata* L.	Dioscoreaceae	H	x	
6	*Dioscorea prazeri* Prain & Burk.	Dioscoreaceae	H	x	
7	*Eupatorium adenophorum* Spreng.	Compositae	H	x	
8	*Eupatorium odoratum* L.	Compositae	H	x	
9	*Maclura fruticosa* (Roxb.) Corn.	Moraceae	C	x	
10	*Mussaenda parv*a Wall. ex G. DOn	Rubiaceae	S	x	
11	*Panicum notatum* Retz.	Gramineae	G	x	
12	*Paspalum conjugatum* Berg.	Gramineae	G	20%	
13	*Scleria levis* Retz.	Cyperaceae	H	x	
14	*Setaria palmifolia* (Koen.) Stapf var. *palmifolia*	Gramineae	G	x	
	Total			**20%**	**80%**

Remark: C = Climber, F= Fern, G = Grass, H =Herb, S = Shrub, WC = Woody Climber

Appendix E

Light intensity (Lux/m^2) in each tree plot

Table E1 Plot 1998-1 Time 8.00-12.00 5 /Jul/ 07

		Measuring time (Lux / Fc)										
TreeLabel	Tree plots	1	2	3	4	5	6	7	8	9	10	Mean
317/30	*Hovenia dulcis*	1013	1232	1538	1193	2170	2570	1570	799	986	1110	**1418.1**
18/42	*Melia toosendan*	2200	2540	2190	1554	1576	1824	1820	1910	2790	1900	**2030.4**
5/50	*Prunus cerasoides*	3460	2760	2060	2250	2280	2300	2750	4370	4070	2610	**2891**
71/28	*Spondias axillaris*	1818	1639	1104	1835	3240	1611	1504	1728	1828	1855	**1816.2**
66/276	*Erythrina subumbrans*	2400	2360	1587	2100	1495	1128	624	1011	900	712	**1431.7**

Table E2 Plot 1998-1 Time 13..00-18.00 5 /Jul/ 07

		Measuring time (Lux / Fc)										
Tree Label	Tree plots	1	2	3	4	5	6	7	8	9	10	Mean
317/30	*Erythrina subumbrans*	291	437	439	231	540	285	525	790	410	552	**450**
18/42	*Hovenia dulcis*	530	443	425	474	606	524	549	630	414	600	**519.5**
5/50	*Melia toosendan*	980	675	655	693	676	673	784	737	1049	1382	**830.4**
71/28	*Prunus cerasoides*	375	358	355	354	246	378	534	390	254	249	**349.3**
66/276	*Spondias axillaris*	394	361	367	316	332	335	268	261	322	312	**326.8**

Table E3 Plot 1998-1 Time 8.00-12.00 23 /Aug/ 07

TreeLabel	Tree plots	Measuring time (Lux / Fc) 1	2	3	4	5	6	7	8	9	10	Mean
317/30	*Hovenia dulcis*	727	577	890	734	657	1092	1276	1348	1225	1216	**974.2**
18/42	*Melia toosendan*	832	859	1017	462	540	477	529	427	431	400	**597.4**
5/50	*Prunus cerasoides*	995	973	720	702	766	815	869	826	717	743	**812.6**
71/28	*Spondias axillaris*	1228	1192	1228	1251	1122	1230	1096	753	363	993	**1045.6**
66/276	*Erythrina subumbrans*	779	702	677	727	667	939	1053	589	879	972	**798.4**

Table E4 Plot 1998-1 Time 13.00-18.00 23 /Aug/ 07

Tree Label	Tree plots	Measuring time (Lux / Fc) 1	2	3	4	5	6	7	8	9	10	Mean
317/30	*Erythrina subumbrans*	1254	1330	2450	1050	1978	1855	2210	984	882	950	**1494.3**
18/42	*Hovenia dulcis*	866	530	427	522	774	760	742	681	596	588	**648.6**
5/50	*Melia toosendan*	1460	1842	2005	1214	1055	988	1098	964	942	950	**1251.8**
71/28	*Prunus cerasoides*	776	821	583	1121	1172	1224	856	872	886	850	**916.1**
66/276	*Spondias axillaris*	1105	760	842	850	764	1156	732	645	622	658	**813.4**

Table E5 Plot 1998-2 Time 8.00-12.00 5 /Jul/ 07

		Measuring time (Lux / Fc)										
Tree Label	Tree plots	1	2	3	4	5	6	7	8	9	10	Mean
317/46	*Erythrina subumbrans*	780	1070	1030	776	1002	709	637	739	526	953	**822.2**
317/50	*Erythrina subumbrans*	1836	2100	1857	2340	3060	2580	1478	2200	2080	2220	**2175.1**
18/8	*Hovenia dulcis*	591	475	291	909	1182	729	820	836	725	326	**688.4**
18/94	*Hovenia dulcis*	1345	1207	1132	1238	1065	971	962	1466	833	733	**1095.2**
5/65	*Melia toosendan*	607	579	1533	741	1316	1923	1097	1738	768	646	**1094.8**
5/64	*Melia toosendan*	977	653	428	1145	1032	1815	1322	11383	996	703	**2045.4**
71/74	*Prunus cerasoides*	1077	888	548	1681	1034	2570	1775	1793	1105	502	**1297.3**
71/69	*Prunus cerasoides*	1198	1022	876	1736	2540	1651	1388	1859	1078	642	**1399**
66/55	*Spondias axillaris*	1105	789	603	1997	1635	2040	1924	2710	985	598	**1438.6**
66/93	*Spondias axillaris*	1294	854	1754	1549	1314	1737	2100	2250	1318	578	**1474.8**

Table E6 Plot 1998-2 Time 13.00-18.00 5 /Jul/ 07

		Measuring time (Lux / Fc)										
Tree Label	Tree plots	1	2	3	4	5	6	7	8	9	10	Mean
317/46	*Erythrina subumbrans*	727	807	926	1122	1000	994	781	731	687	592	**836.7**
317/50	*Erythrina subumbrans*	652	506	637	795	862	800	834	806	758	695	**734.5**
18/8	*Hovenia dulcis*	654	440	586	803	1130	957	938	939	727	468	**764.2**
18/94	*Hovenia dulcis*	2300	1560	2290	3010	2920	2310	2810	1460	2240	3090	**2399**
5/65	*Melia toosendan*	669	689	764	471	886	870	1536	1240	1974	1899	**1099.8**
5/64	*Melia toosendan*	1857	1359	1071	948	1124	1236	1281	1560	1535	3050	**1502.1**
71/74	*Prunus cerasoides*	2260	2310	2220	2860	2140	4040	3270	7230	1590	2350	**3027**
71/69	*Prunus cerasoides*	535	662	640	718	784	561	474	512	469	672	**602.7**
66/55	*Spondias axillaris*	2100	1860	1583	842	621	872	689	425	264	451	**970.7**
66/93	*Spondias axillaris*	628	896	1004	1128	1842	2550	4760	1930	3400	3290	**2142.8**

Table E7 Plot 1998-2 Time 8.00-12.00 23 /Aug/ 07

Tree Label	Tree plots	Measuring time (Lux / Fc) 1	2	3	4	5	6	7	8	9	10	Mean
317/46	*Erythrina subumbrans*	552	608	508	603	500	485	760	878	900	794	**658.8**
317/50	*Erythrina subumbrans*	774	743	870	810	803	874	706	572	508	517	**717.7**
18/8	*Hovenia dulcis*	358	360	332	392	377	295	277	293	289	409	**338.2**
18/94	*Hovenia dulcis*	318	388	394	279	261	319	424	406	393	349	**353.1**
5/65	*Melia toosendan*	501	454	503	281	128	173	244	447	525	490	**374.6**
5/64	*Melia toosendan*	246	252	190	196	180	165	216	213	192	207	**205.7**
71/74	*Prunus cerasoides*	418	387	304	269	300	269	359	412	339	360	**341.7**
71/69	*Prunus cerasoides*	631	705	732	606	550	475	560	609	521	497	**588.6**
66/55	*Spondias axillaris*	423	354	303	293	257	331	296	137	179	231	**280.4**
66/93	*Spondias axillaris*	782	455	617	537	639	644	664	828	989	607	**676.2**

Table E8 Plot 1998-2 Time 13.00-18.00 23 /Aug/ 07

Tree Label	Tree plots	Measuring time (Lux / Fc)										
		1	2	3	4	5	6	7	8	9	10	Mean
317/46	*Erythrina subumbrans*	601	480	380	475	544	573	759	466	588	671	**553.7**
317/50	*Erythrina subumbrans*	767	683	695	869	691	688	933	572	566	629	**709.3**
18/8	*Hovenia dulcis*	549	372	783	835	820	686	718	653	667	906	**698.9**
18/94	*Hovenia dulcis*	827	884	901	750	638	537	758	546	770	602	**721.3**
5/65	*Melia toosendan*	766	570	448	414	326	471	797	1520	526	450	**628.8**
5/64	*Melia toosendan*	297	317	365	275	277	424	466	394	415	384	**361.4**
71/74	*Prunus cerasoides*	508	352	429	317	360	486	575	490	434	472	**442.3**
71/69	*Prunus cerasoides*	1343	1447	3200	1114	1079	1141	1165	1663	1470	1800	**1542.2**
66/55	*Spondias axillaris*	594	574	333	208	298	407	324	541	644	522	**444.5**
66/93	*Spondias axillaris*	1291	1207	1325	1371	1760	671	741	734	690	861	**1065.1**

Table E9 Plot 1998-3 Time 8.00-12.00 5 /Jul/ 07

		Measuring time (Lux / Fc)										
Tree Label	Tree plots	1	2	3	4	5	6	7	8	9	10	Mean
317/66	*Erythrina subumbrans*	1846	1584	1052	329	286	946	1068	3080	1210	1864	**1326.5**
317/125	*Erythrina subumbrans*	2580	2130	1600	385	689	1381	1648	3460	3000	3420	**2029.3**
18/134	*Hovenia dulcis*	1900	1670	710	972	728	495	424	433	631	898	**886.1**
18/125	*Hovenia dulcis*	890	840	528	209	241	250	445	514	883	801	**560.1**
005/50	*Melia toosendan*	1464	1883	2650	559	592	691	1219	1051	1040	1521	**1267**
5/143	*Melia toosendan*	1621	1787	822	360	644	439	407	1050	1960	867	**995.7**
71/111	*Prunus cerasoides*	1111	1526	1101	410	423	754	867	762	724	1560	**923.8**
71/117	*Prunus cerasoides*	947	779	488	326	275	436	649	450	511	625	**548.6**
66/84	*Spondias axillaris*	1432	1096	964	221	257	479	1350	1380	1063	3270	**1151.2**
66/211	*Spondias axillaris*	1469	907	468	999	436	484	416	816	1014	744	**775.3**

Table E10 Plot 1998-3 Time 13.00-18.00 5 /Jul/ 07

Tree Label	Tree plots	Measuring time (Lux / Fc)										
		1	2	3	4	5	6	7	8	9	10	Mean
317/66	*Erythrina subumbrans*	1086	1543	1524	1565	1393	1273	1479	1361	1410	1421	**1405.5**
317/125	*Erythrina subumbrans*	1689	1748	808	679	1139	1062	1460	1508	1769	1092	**1295.4**
18/134	*Hovenia dulcis*	872	1036	1130	957	681	656	745	951	1052	763	**884.3**
18/125	*Hovenia dulcis*	721	447	478	408	792	845	1052	1407	1124	746	**802**
005/50	*Melia toosendan*	1013	954	814	557	809	183	685	854	989	1502	**836**
5/143	*Melia toosendan*	567	548	612	668	839	708	616	679	683	931	**685.1**
71/111	*Prunus cerasoides*	1025	1171	1108	1322	1144	1697	1711	2180	2180	2120	**1565.8**
71/117	*Prunus cerasoides*	1080	951	1434	776	662	479	749	744	767	752	**839.4**
66/84	*Spondias axillaris*	1038	1295	897	895	1035	1090	1163	961	1160	952	**1048.6**
66/211	*Spondias axillaris*	898	874	861	834	681	1917	869	917	729	601	**918.1**

Table E11 Plot 1998-3 Time 8.00-12.00 23 /Aug/ 07

Tree Label	Tree plots	Measuring time (Lux / Fc)										
		1	2	3	4	5	6	7	8	9	10	Mean
317/66	*Erythrina subumbrans*	1148	1339	1100	1064	947	1058	1106	1174	1136	902	**1097.4**
317/125	*Erythrina subumbrans*	1192	1532	1418	1147	931	1292	1675	1574	1660	1488	**1390.9**
18/134	*Hovenia dulcis*	814	649	730	721	593	600	990	1075	977	891	**804**
18/125	*Hovenia dulcis*	446	413	318	609	839	529	837	572	389	806	**575.8**
005/50	*Melia toosendan*	1896	1342	1051	881	1019	1153	1266	1426	1606	1362	**1300.2**
5/143	*Melia toosendan*	910	748	853	1299	1358	838	1229	1096	915	715	**996.1**
71/111	*Prunus cerasoides*	1413	1612	1836	1934	1722	1817	1941	1300	1395	1603	**1657.3**
71/117	*Prunus cerasoides*	785	743	739	627	517	676	601	744	824	675	**693.1**
66/84	*Spondias axillaris*	561	679	893	537	445	570	695	724	982	968	**705.4**
66/211	*Spondias axillaris*	721	618	644	651	858	708	591	500	597	612	**650**

Table E12 Plot 1998-3 Time 13.00-18.00 23 /Aug/ 07

		2000 Lux / Fc										
Tree Label	Tree plots	1	2	3	4	5	6	7	8	9	10	Mean
317/66	*Erythrina subumbrans*	7940	2210	2090	3730	2500	1850	1850	1872	2100	2220	**2836.2**
317/125	*Erythrina subumbrans*	3080	3150	1940	1812	1970	4100	4130	3280	3100	3280	**2984.2**
18/134	*Hovenia dulcis*	2060	1911	1728	1487	1091	1298	1734	1617	1753	1814	**1649.3**
18/125	*Hovenia dulcis*	1205	1086	725	1045	1198	1344	1221	1163	1107	726	**1082**
005/50	*Melia toosendan*	4180	2860	1220	1760	1184	2150	3440	4260	3670	3180	**2790.4**
5/143	*Melia toosendan*	1195	1052	1448	1849	2200	2080	1650	1436	1237	1205	**1535.2**
71/111	*Prunus cerasoides*	1850	2480	2720	3120	2850	2860	3140	2330	2100	2580	**2603**
71/117	*Prunus cerasoides*	1697	1953	1512	1204	1826	1361	1364	1535	1975	1363	**1579**
66/84	*Spondias axillaris*	1641	1096	1140	1232	1145	1331	1977	1175	1214	1392	**1334.3**
66/211	*Spondias axillaris*	1825	1670	1288	1380	1578	1531	2720	1862	2190	2430	**1847.4**

Appendix F

Birds

Table F1 List of bird species observed in each planted plot (Lekagul and Round, 1991; Kopkate, 1998-2001)

No.	Scientific name	Species of bird	Diets	Plot that birds were observed		
				1998-1	1998-2	1998-3
1	*Phylloscopus borealis*	Arctic Warbler	Insectivore	√	√	√
2	*Terpsiphone paradisi*	Asian Paradise-Flycatcher	Insectivore	-	-	√
3	*Hemixos flavus*	Ashy Bulbul	Omnivore	-	-	√
4	*Dicrurus leucophaeus*	Ashy Drongo	Insectivore/Nectarivore	-	√	√
5	*Irena puella*	Asian Fairy Bluebird	Omnivore	√	-	-
6	*Megalaima* sp.	Barbet sp.	Omnivore	√	-	-
7	*Hemipus picatus*	Bar-winged Flycatcher-Shrike	Insectivore	√	-	√
8	*Pycnonotus melanicterus*	Black-crested Bulbul	Omnivore	√	√	√
9	*Hypothymis azurea*	Black-naped Monarch Flycatcher	Insectivore	√	-	√
10	*Aethopyga saturata*	Black-throated Sunbird	Nectarivore	√	√	√
11	*Megalaima asiatica*	Blue-throated Barbet	Omnivore	√	√	√
12	*Phylloscopus reguloides*	Blyth's Leaf-Warbler	Insectivore	-	-	√
13	*Cisticola exilis*	Bright-capped Cisticola	Insectivore	√	-	-
14	*Dicaeum ignipectus*	Buff-bellied Flowerpecker	Omnivore	√	-	-
15	*Pycnonotus* sp.	Bulbul sp.	Omnivore	-	√	-
16	*Lanius collurioides*	Burmese Shrike	Carnivore	-	√	√
17	*Timalia pileata*	Chestnut-capped Babbler	Omnivore	√	√	-
18	*Aegithina tiphia*	Common Iora	Insectivore	-	-	√

Table F1 (continued)

No.	Scientific name	Species of bird	Diets	Plot that birds were observed		
				1998-1	1998-2	1998-3
19	*Coracina* sp.	Cuckoo-Shrike sp.	Omnivore	-	-	√
20	*Orthotomus atrogularis*	Dark-necked Tailorbird	Insectivore	-	√	-
21	*Phylloscopus fuscatus*	Dusky Warbler	Insectivore	-	-	√
22	*Pycnonotus flavescens*	Flavescent Bulbul	Omnivore	-	√	√
23	*Dicaeum* sp.	Flowerpecker sp.	Omnivore	√	-	-
24	*Seicercus valentini*	Golden-spectacled Warbler	Insectivore	-	√	√
25	*Parus major*	Great Tit	Omnivore	-	√	-
26	*Phaenicophaeus tristis*	Green-billed Malkoha	Omnivore	√	-	√
27	*Culicicapa ceylonensis*	Grey-headed Flycatcher	Insectivore	√	√	√
28	*Dicrurus hottentottus*	Hair-crested Drongo	Insectivore/Nectarivore	-	√	-
29	*Cyornis banyumas*	Hill Blue Flycatcher	Insectivore	√	√	√
30	*Upupa epops*	Hoopoe	Omnivore	-	√	-
31	*Phylloscopus inornatus*	Inornate Warbler	Insectivore	√	-	-
32	*Zosterops japonicus*	Japanese White-eye	Omnivore	√	-	√
33	*Ficedula westermanni*	Little Pied Flycatcher	Insectivore	-	√	-
34	*Arachnothera longirostra*	Little Spiderhunter	Insectivore/Nectarivore	√	-	-
35	*Pericrocotus* sp.	Minivet sp.	Insectivore	√	-	-
36	*Cyornis banyumas*	Olive-backed Pipit	Insectivore	-	-	√
37	*Chloropsis hardwickii*	Orange-bellied Leafbird	Omnivore	√	-	√
38	*Zosterops palpebrosus*	Oriental White-eye	Omnivore	√	√	-

Table F1 (continued)

No.	Scientific name	Species of bird	Diets	Plot that birds were observed		
				1998-1	1998-2	1998-3
39	*Dicaeum concolor*	Plain Flowerpecker	Omnivore	√	-	-
40	*Cacomantis merulinus*	Plaintive Cuckoo	Omnivore	-	-	√
41	*Pellorneum ruficeps*	Puff-throated Babbler	Omnivore	√	√	√
42	*Ficedula parva albicilla*	Red-throated Flycatcher	Insectivore	√	√	-
43	*Pycnonotus jocosus*	Red-whiskered Bulbul	Omnivore	√	√	√
44	*Stachris rufifrons*	Rufous-fronted Babbler	Omnivore	-	√	-
45	*Pericrocotus flammeus*	Scarlet Minivet	Insectivore	√	√	√
46	*Accipiter badius*	Shikra	Carnivore	-	-	√
47	*Oriolus tenuirostris*	Slender-billed Oriole	Omnivore	-	-	√
48	*Pycnonotus aurigaster*	Sooty-headed Bulbul	Omnivore	-	√	√
49	*Picumnus innominatus*	Speckled Piculet	Insectivore	√	√	√
50	*Arachnothera magna*	Streaked Spiderhunter	Insectivore/Nectarivore	√	√	√
51	Unknown sp.	Sunbird sp.1	Nectarivore	-	-	√
52	Unknown sp.	Sunbird sp.2	Nectarivore	√	-	-
53	*Phylloscopus trochiloides plumbeitarsus*	Two-barred Warbler	Insectivore	-	√	-
54	Unknown sp.1	Unknown sp. 1	-	-		√
55	Unknown sp.2	Unknown sp. 2	-	-	√	-
56	Unknown sp.3	Unknown sp. 3	-	-	√	-
57	*Sitta frontalis*	Velvet-fronted Nuthatch	Omnivore	-	√	-
58	*Sasia ochracea*	White-browed Piculet	Insectivore	-	-	√

Table F1 (continued)

No.	Scientific name	Species of bird	Diets	Plot that birds were observed		
				1998-1	1998-2	1998-3
59	*Pomatorhinus schisticeps*	White-browned Scimitar-Babbler	Insectivore	√	√	-
60	*Pteruthius flaviscapis*	White-browned Shrike-Babbler	Omnivore	-	√	-
61	*Garrulax leucolophus*	White-crested Laughingthrush	Omnivore	-	√	-
62	*Copsychus malabaricus*	White-rumped Shama	Omnivore	√	√	√
63	*Rhipidura albicollis*	White-throated Fantail	Insectivore	√	-	√
64	*Pomatorhinus schisticeps*	Yellow-streaked Warbler	Insectivore	-	-	√

Table F2 Number of birds observed in each selected tree

No.	Species of bird	*Erythrina subumbrans*					
		ER1	ER2	ER3	ER4	ER5	Total
1	Arctic Warbler	-	1	-	-	-	1
2	Barbet sp.	1	-	-	-	-	1
3	Bar-winged Flycatcher-shrike	-	-	-	2	-	2
4	Black-crested Bulbul	-	-	-	1	1	2
5	Black-throated Sunbird	-	-	-	1	-	1
6	Blue-throated Barbet	-	-	-	1	-	1
7	Common Iora	1	-	-	-	-	1
8	Golden Spectacle Warbler	-	1	-	-	-	1
9	Hill Blue Flycatcher	-	-	-	-	1	1
10	Japanese White-eye	3	-	-	-	-	3
11	Puff-throated Babbler	-	-	-	1	-	1
12	Red-whiskered Bulbul	-	2	4	-	-	6
13	Scarlet Minivet	-		1	-	1	2
14	Sooty-headed Bulbul	-	2	2	-	-	4
15	Speckled Piculet	1	-	-	-	1	2
16	Streak Spiderhunter	-	1	1	-	-	2
17	Sunbird sp. (female)	-	-	-	-	1	1
18	White-crested Laughingthrush	-	-	4	-	-	4
19	White-rumped Shama	1	-	-	-	2	3
	Total	***7***	***7***	***12***	***6***	***7***	***39***

No.	Species of bird	*Hovenia dulcis*					
		HO1	HO2	HO3	HO4	HO5	Total
1	Arctic Warbler	-	1	-	-	-	1
2	Barbet sp.	1	-	-	-	-	1
3	Bar-winged Flycatcher-shrike	-	-	-	2	-	2
4	Black-crested Bulbul	-	-	-	1	1	2
5	Black-throated Sunbird	-	-	-	1	-	1
6	Blue-throated Barbet	-	-	-	1	-	1
7	Common Iora	1	-	-	-	-	1
8	Golden Spectacle Warbler	-	1	-	-	-	1
	Total	***7***	***7***	***12***	***6***	***7***	***39***

Table F2 (continued)

No.	Species of bird	*Melia toosendan*					
		ME1	ME2	ME3	ME4	ME5	Total
1	Arctic Warbler	-	-	-	2	-	2
2	Ashy Drongo	-	-	-	-	1	1
3	Bar-winged Flycatcher-shrike	2	-	-	1	3	6
4	Buff-bellied Flowerpecker	-	-	-	1	-	1
5	Bulbul sp.	2	-	-	-	-	2
6	Common Iora	1	-	-	-	-	1
7	Great Tit	-	-	1	-	-	1
8	Grey-headed Flycatcher	-	2	-	-	-	2
9	Hill Blue Flycatcher	-	1	-	-	1	2
10	Japanese White-eye	4	-	-	-	-	4
11	Little Pied Flycatcher	-	1	-	-	-	1
12	Little Spiderhunter	-	-	1	-	-	1
13	Oriental White-eye	-	-	2	-	-	2
14	Red-whiskered Bulbul	1	-	-	1	-	2
15	Scarlet Minivet	7	-	-	-	-	7
16	Sooty-headed Bulbul	2	-	-	-	-	2
17	Speckled Piculet	-	1	-	-	-	1
18	Streaked Spiderhunter	1	-	-	1	-	2
19	Two-barred Warbler	-	-	2	-	-	2
20	Unknown sp. 1	-	-	-	-	1	1
21	Unknown sp. 3	-	-	1	-	-	1
22	White-rumped Shama	-	1	1	-	2	4
23	White-throated Fantail	-	-	-	1	-	1
	Total	***20***	***6***	***8***	***7***	***8***	***49***

Table F2 (continued)

No.	Species of bird	*Prunus cerasoides*					
		PR1	PR2	PR3	PR4	PR5	Total
1	Arctic Warbler	1	1	-	-	-	2
2	Black-crested Bulbul	1	-	-	2		3
3	Black-throated Sunbird	-	-	2	1	5	8
4	Blyth's Leaf-Warbler	-	1	-	1	-	2
5	Buff-bellied Flowerpecker	-	-	-	-	2	2
6	Common Iora	-	-	1	-	-	1
7	Dark-necked Tailorbird	-	2	-	-	-	2
8	Flavescent Bulbul	-	-	-	3	1	4
9	Great Tit	-	1	4	-	-	5
10	Grey-headed Flycatcher	-	-	-	2	-	2
11	Hill Blue Flycatcher	1	1	-	-	1	3
12	Hoopoe	-	-	1	-	-	1
13	Japanese White-eye	3	-	-	3	-	6
14	Olive-backed Pipit	-	-	-	2	1	3
15	Oriental White-eye	2	2	-	-	-	4
16	Plain Flowerpecker	1	-	-	-	-	1
17	Plaintive Cuckoo	-	-	-	-	1	1
18	Red-throated Flycatcher	1	1	-	-	-	2
19	Red-whiskered Bulbul	-	-	-	1	-	1
20	Speckled Piculet	-	1	-	-	-	1
21	Streaked Spiderhunter	-	1	1	-	-	2
22	Two-barred Warbler	-	-	1	-	1	2
23	White-browed Piculet	-	-	-	1	1	2
24	White-browned Scimitar-Babbler	-	1	-	-	-	1
25	White-rumped Shama	2	3	-	-	-	5
	Total	***12***	***15***	***10***	***16***	***13***	***66***

Table F2 (continued)

No.	Species of bird	*Spondias axillaris*					
		SP1	SP2	SP3	SP4	SP5	Total
1	Arctic Warbler	-	1	1	-	2	4
2	Ashy Drongo	-	-	-	1	-	1
3	Bar-winged Flycatcher-shrike	2	-	-	-	-	2
4	Black-crested Bulbul	2	-	1	-	3	6
5	Black-throated Sunbird	-	-	-	1	-	1
6	Blyth's Leaf-Warbler	-	1	-	-	2	3
7	Burmese Shrike	-	-	1	-	-	1
8	Dusky Warbler	-	-	-	-	1	1
9	Flavescent Bulbul	-	-	2	-	-	2
10	Great Tit	-	1	1	-	-	2
11	Green-billed Malkoha	-	-	-	-	1	1
12	Hill Blue Flycatcher	-	1	-	-	-	1
13	Hoopoe	-	1	-	-	-	1
14	Oriental White-eye	-	3	-	-	-	3
15	Puff-throated Babbler	1	-	-	-	-	1
16	Red-throated Flycatcher	1	1	1	-	-	3
17	Red Whiskered Bulbul	-	3	4	-	-	7
18	Scarlet Minivet	-	-	-	2	-	2
19	Sooty-headed Bulbul	4	-	-	-	-	4
20	Streaked Spiderhunter	-	-	-	1	-	1
21	Sunbird sp. (female)	-	-	1	-	-	1
22	Two-barred Warbler	-	1	-	-	-	1
23	Unknown sp. 2	-	-	1	-	-	1
24	Velvet-fronted Nuthatch	1	-	-	-	-	1
25	Warbler sp.	-	-	-	-	1	1
26	White-browned Shrike-Babbler	-	2	-	-	-	2
27	White-rumped Shama	1	1	2	1	2	7
28	White-throated Fantail	1	-	-	-	-	1
	Total	***13***	***16***	***15***	***6***	***12***	***62***

Table F3 Population density and species richness of all birds

Tree plot	No. of seedling	No. of seedling species	Population Density (no./m^2)	Species richness (no. sp/ m^2)
Erythrina subumbrans				
ER1	42	12	1.37	0.39
ER2	36	6	1.99	0.33
ER3	13	7	0.36	0.19
ER4	31	9	2.04	0.59
ER5	20	6	0.87	0.26
Mean			***1.33***	***0.35***
Hovenia dulcis				
HO1	7	6	0.30	0.26
HO2	2	1	0.08	0.04
HO3	2	2	0.30	0.30
HO4	6	3	0.48	0.24
HO5	3	2	0.33	0.22
Mean			***0.30***	***0.21***
Melia toosendan				
ME1	21	10	0.61	0.29
ME2	4	4	0.10	0.10
ME3	3	3	0.11	0.11
ME4	57	7	3.93	0.48
ME5	14	6	1.23	0.53
Mean			***1.20***	***0.30***
Prunus cerasoides				
PR1	15	8	0.37	0.20
PR2	11	6	0.52	0.28
PR3	62	7	2.52	0.28
PR4	26	7	2.86	0.77
PR5	19	5	1.33	0.35
Mean			***1.52***	***0.38***
Spondias axillaris				
SP1	8	2	0.19	0.05
SP2	4	3	0.09	0.07
SP3	3	2	0.10	0.07
SP4	11	5	0.42	0.19
SP5	16	7	0.44	0.19
Mean			***0.25***	***0.11***

Table F4 Population density and species richness of non-frugivorous birds

Tree plot	No. of seedling	No. of seedling species	Population Density (no./m^2)	Species richness (no. sp/ m^2)
Erythrina subumbrans				
ER1	42	12	1.37	0.39
ER2	36	6	1.99	0.33
ER3	13	7	0.36	0.19
ER4	31	9	2.04	0.59
ER5	20	6	0.87	0.26
Mean			***1.33***	***0.35***
Hovenia dulcis				
HO1	7	6	0.30	0.26
HO2	2	1	0.08	0.04
HO3	2	2	0.30	0.30
HO4	6	3	0.48	0.24
HO5	3	2	0.33	0.22
Mean			***0.30***	***0.21***
Melia toosendan				
ME1	21	10	0.61	0.29
ME2	4	4	0.10	0.10
ME3	3	3	0.11	0.11
ME4	57	7	3.93	0.48
ME5	14	6	1.23	0.53
Mean			***1.20***	***0.30***
Prunus cerasoides				
PR1	15	8	0.37	0.20
PR2	11	6	0.52	0.28
PR3	62	7	2.52	0.28
PR4	26	7	2.86	0.77
PR5	19	5	1.33	0.35
Mean			***1.52***	***0.38***
Spondias axillaris				
SP1	8	2	0.19	0.05
SP2	4	3	0.09	0.07
SP3	3	2	0.10	0.07
SP4	11	5	0.42	0.19
SP5	16	7	0.44	0.19
Mean			***0.25***	***0.11***

Table F5 Population density and species richness of frugivorous birds

Tree plot	No. of seedling	No. of seedling species	Population Density (no./m^2)	Species richness (no. sp/ m^2)
Erythrina subumbrans				
ER1	42	12	1.37	0.39
ER2	36	6	1.99	0.33
ER3	13	7	0.36	0.19
ER4	31	9	2.04	0.59
ER5	20	6	0.87	0.26
Mean			***1.33***	***0.35***
Hovenia dulcis				
HO1	7	6	0.30	0.26
HO2	2	1	0.08	0.04
HO3	2	2	0.30	0.30
HO4	6	3	0.48	0.24
HO5	3	2	0.33	0.22
Mean			***0.30***	***0.21***
Melia toosendan				
ME1	21	10	0.61	0.29
ME2	4	4	0.10	0.10
ME3	3	3	0.11	0.11
ME4	57	7	3.93	0.48
ME5	14	6	1.23	0.53
Mean			***1.20***	***0.30***
Prunus cerasoides				
PR1	15	8	0.37	0.20
PR2	11	6	0.52	0.28
PR3	62	7	2.52	0.28
PR4	26	7	2.86	0.77
PR5	19	5	1.33	0.35
Mean			***1.52***	***0.38***
Spondias axillaris				
SP1	8	2	0.19	0.05
SP2	4	3	0.09	0.07
SP3	3	2	0.10	0.07
SP4	11	5	0.42	0.19
SP5	16	7	0.44	0.19
Mean			***0.25***	***0.11***

Table F6 Minutes observed of bird in each tree plots of each selected framework tree

No.	Species of bird	No. of bird	*Erythrina subumbrens*					Total	Average Min /bird
			ER1	ER2	ER3	ER4	ER5		
1	Arctic Warbler	1	-	0.45	-	-	-	0.45	0.45
2	Barbet sp.	1	0.22	-	-	-	-	0.22	0.22
3	Bar-winged Flycatcher-Shrike	2	-	-	-	0.11	-	0.11	0.06
4	Black-crested Bulbul	2	-	-	-	0.18	-	0.18	0.09
5	Blue-throated Barbet	1	-	-	-	0.38	-	0.38	0.38
6	Blyth's Leaf-Warbler	1	-	-	-	0.32	-	0.32	0.32
7	Common Iora	1	0.10	-	-	-	-	0.10	0.10
8	Golden Spectacle Warbler	1	-	-	0.10	-	-	0.10	0.10
9	Hill Blue Flycatcher	1	-	-	-	-	0.08	0.08	0.08
10	Japanese White-eye	3	0.18	-	-	-	-	0.18	0.06
11	Puff-throated Babbler	1	-	-	-	0.02	-	0.02	0.02
12	Red-whiskered Bulbul	6	-	0.48	-	-	-	0.48	0.08
13	Scarlet Minivet	2	-	-	0.10	-	0.10	0.20	0.10
14	Sooty-headed Bulbul	4	-	0.07	0.11	-	-	0.18	0.05
15	Speckled Piculet	2	0.26	-	-	-	0.12	0.38	0.19
16	Streaked Spiderhunter	2	-	0.05	0.03	-	-	0.08	0.04
17	Sunbird sp. (female)	1	-	-	-	-	0.08	0.08	0.08
18	White-crested Laughingthrush	4	-	-	0.50	-	-	0.50	0.13
19	White-rumped Shama	3	1.00	-	-	-	0.16	1.16	0.39
	Total	39	2.07	1.45	1.24	1.41	0.54	7.53	0.15

Table F6 (continued)

No.	Species of bird	No. of bird	*Hovenia dulcis*					Total	Average Min/bird
			HO1	HO2	HO3	HO4	HO5		
1	Bar-winged Flycatcher-Shrike	1	-	-	-	0.03	-	0.03	0.03
2	Black-throated Sunbird	1	0.12	-	-	-	-	0.12	0.12
3	Blyth's Leaf-Warbler	3	-	0.48	-	-	-	0.48	0.16
4	Great Tit	2	-	1.40	-	-	-	1.40	0.35
5	Hill Blue Flycatcher	1	-	0.03	-	-	-	0.03	0.03
6	Puff-throated Babbler	1	-	-	-	2.20	-	2.20	2.20
7	White-rumped Shama	2	1.38	-	-	-	-	1.38	0.49
8	Inornate Warbler	1	0.02	-	-	-	-	0.02	0.02
	Total	12	1.52	2.31	0.00	2.23	0.00	6.46	0.43

Table F6 (continued)

No.	Species of bird	No. of bird	*Melia tosendan* ME1	ME2	ME3	ME4	ME5	Total	Average Min/bird
1	Arctic Warbler	2	-	-	-	0.15	-	0.15	0.08
2	Ashy Drongo	1	-	-	-	-	1.30	1.3	1.30
3	Bar-winged Flycatcher-Shrike	6	0.06	-	-	0.08	0.10	0.24	0.04
4	Bulbul sp.	1	0.29	-	-	-	-	0.29	0.29
5	Buff-bellied Flowerpecker	2	-	-	-	0.04	-	0.04	0.02
6	Common Iora	1	0.1	-	-	-	-	0.1	0.10
7	Great Tit	1	-	-	0.49	-	-	0.49	0.49
8	Grey-headed Flycatcher	2	-	0.11	-	-	-	0.11	0.06
9	Hill Blue Flacatcher	2	-	0.14	-	-	0.02	0.16	0.08
10	Japanese White-eye	4	0.32	-	-	-	-	0.32	0.08
11	Little Pied Flycatcher	1	-	0.19	-	-	-	0.19	0.19
12	Little Spiderhunter	1	-	-	0.09	-	-	0.09	0.09
13	Oriental White-eye	2	-	-	0.22	-	-	0.22	0.11
14	Red-whiskered Bulbul	2	0.12	-	-	0.05	-	0.17	0.09
15	Scarlet Minivet	7	2.34	-	-	-	-	2.34	0.33
16	Sooty-headed Bulbul	2	0.12	-	-	-	-	0.12	0.06
17	Speckled Piculet	1	-	3.21	-	-	-	3.21	3.21
18	Streaked Spiderhunter	2	0.04	-	-	0.05	-	0.09	0.05
19	Two-barred Warbler	2	-	-	1.04	-	-	1.04	0.52
20	Unknown sp. 1	1	-	-	0.08	-	-	0.08	0.08
21	Unknown sp. 3	1	-	-	0.04	-	-	0.04	0.04
22	White-rumped Shama	4	-	0.07	0.04	-	0.12	0.23	0.06
23	White-throated Fantail	1	-	-	-	0.12	-	0.12	0.12
	Total	49	4.10	4.12	2.40	0.49	1.54	13.42	0.32

Table F6 (continued)

No.	Species of bird	No. of bird	*Prunus cerasoides* PR1	PR2	PR3	PR4	PR5	Total	Average Min /bird
1	Arctic Warbler	2	3.35	0.15	-	-	-	3.50	2.15
2	Black-crested Bulbul	3	0.11	-	-	0.07	-	0.18	0.06
3	Black-throated Sunbird	8	0.48	-	0.22	-	0.34	1.04	0.13
4	Blyth's Leaf-Warbler	2	-	0.38	-	0.05	-	0.43	0.22
5	Buff-bellied Flowerpecker	2	-	-	-	-	0.05	0.05	0.03
6	Common Iora	1	-	-	1.45	-	-	1.45	1.45
7	Dark-necked Tailorbird	2	-	-	0.44	-	-	0.44	0.22
8	Flavescent Bulbul	4	-	-	-	2.39	0.54	3.33	1.23
9	Great Tit	5	-	1.22	2.47	-	-	4.09	1.22
10	Grey-headed Flycatcher	2	-	-	-	0.16	-	0.16	0.08
11	Hill Blue Flycatcher	3	3.20	0.10	-	-	0.24	3.54	1.18
12	Hoopoe	1	-	-	0.08	-	-	0.08	0.08
13	Japanese White-eye	6	0.38	-	-	1.05	-	1.43	0.24
14	Olive-backed Pipit	3	-	-	-	0.35	0.12	0.47	0.16
15	Oriental White-eye	4	0.22	0.27	-	-	-	0.49	0.12
16	Plain Flowerpecker	1	0.13	-	-	-	-	0.13	0.13
17	Plaintive Cuckoo	1	-	-	-	-	3.42	3.42	3.42
18	Red-throated Flycatcher	2	0.20	1.12	-	-	-	1.32	1.06
19	Red-whiskered Bulbul	1	-	-	-	0.04	-	0.04	0.04
20	Speckled Piculet	1	-	1.24	-	-	-	1.24	1.24
21	Streaked Spiderhunter	2	-	0.04	0.02	-	-	0.06	0.03
22	Two-barred Warbler	2	-	-	0.25	-	0.19	0.44	0.22
23	White-browed Piculet	2	-	-	-	-	0.06	0.06	0.03
24	White-browned Scimitar-Babbler	1	-	0.09	-	-	-	0.09	0.09
25	White-rumped Shama	5	0.24	0.43	-	-	-	1.07	0.21
	Total	66	9.51	5.24	6.13	4.51	6.16	32.55	0.60

Table F6 (continued)

No.	Species of bird	No. of bird	*Spomdias axillaris* SP1	SP2	SP3	SP4	SP5	Total	Average Min /bird
1	Arctic Warbler	4	-	0.20	0.11	-	0.32	1.03	0.26
2	Ashy Drongo	1	-	-	-	0.33	-	0.33	0.33
3	Bar-winged Flycatcher-Shrike	2	0.10	-	-	-	-	0.1	0.05
4	Black-crested Bulbul	6	0.08	-	0.31	-	0.14	0.53	0.09
5	Black-throated Sunbird	1	-	-	-	0.11	-	0.11	0.11
6	Blyth's Leaf-Warbler	3	-	0.24	-	-	1.02	1.26	0.42
7	Burmese Shrike	1	-	-	0.18	-		0.18	0.18
8	Dusky Warbler	1	-	-	-	-	1.05	1.05	1.05
9	Flavescent bulbul	2	-	-	0.18	-	-	0.18	0.09
10	Great Tit	2	-	1.24	0.45	-	-	2.09	1.05
11	Green-billed Malkoha	1	-	-	-	-	0.38	0.38	0.38
12	Hill Blue Flycatcher	1	-	0.34	-	-	-	0.34	0.34
13	Hoopoe	1	-	0.16	-	-	-	0.16	0.16
14	Oriental White-eye	3	-	0.06	0.12	-	-	0.18	0.06
15	Puff-throated Babbler	1	0.16	-	-	-	-	0.16	0.16
16	Red-throated Flycatcher	3	0.12	0.31	0.10	-	-	0.53	0.18
17	Red Whiskered Bulbul	7	-	0.24	0.15	-	-	0.39	0.06
18	Scarlet Minivet	2	-	-	-	0.06	-	0.06	0.03
19	Sooty-headed Bulbul	4	1.12	-	-	-	-	1.12	0.28
20	Streaked Spiderhunter	1	-	-	-	0.04	-	0.04	0.04
21	Sunbird (female)	1	-	-	0.06	-	-	0.06	0.06
22	Two-barred Warbler	1	-	0.32	-	-	-	0.32	0.32
23	Unknown sp. 2	1	-	-	0.03	-	-	0.03	0.03
24	Velvet-fronted Nuthatch	1	0.10	-	-	-	-	0.1	0.10
25	Warbler sp.	1	-	-	-	-	0.09	0.09	0.09

Table F6 (continued)

No.	Species of bird	No. of bird	*Hovenia dulcis* HO1	HO2	HO3	HO4	HO5	Total	Average Min/bird
26	White-browned Shrike-Babbler	2	-	0.05	-	-	-	0.05	0.03
27	White-rumped Shama	7	0.21	0.09	0.12	0.21	3.25	4.28	1.01
28	White-throated Fantail	1	0.34	-	-	-	-	0.34	0.34
	Total	***62***	***3.03***	***4.45***	***3.01***	***1.15***	***7.05***	***19.06***	***0.26***

Table F7 Bird behaviors observed from each selected framework tree

No.	Species of bird	Diets	Behavior observed from each tree species				
			ER	HO	ME	PR	SP
1	Arctic Warbler	non-frugivores	P	-	P,FI	P,FI	P,FI
2	Ashy Drongo	non-frugivores	-	-	P,FI	-	P
3	Barbet sp.	frugivores	P	-	-	-	-
4	Bar-winged Flycatcher-shrike	non-frugivores	P	P	P	-	P
5	Black-crested Bulbul	frugivores	P	-	-	P	P
6	Black-throated Sunbird	non-frugivores	P,FN	P	-	P,FN	P
7	Blue-throated Barbet	frugivores	P	-	-	-	-
8	Blyth's Leaf-Warbler	non-frugivores	-	P	-	P,FI	P
9	Buff-bellied flowerpecker	frugivores	-	-	P	P	-
10	Bulbul sp.	frugivores	-	-	P	-	-
11	Burmese Shrike	non-frugivores	-	-	-	-	P
12	Common Iora	non-frugivores	P	-	P	P	-
13	Dark-necked Tailorbird	non-frugivores	-	-	-	P,FI	-
14	Dusky Warbler	non-frugivores	-	-	-	-	P,FI
15	Flavescent Bulbul	frugivores	-	-	-	P,FF	P
16	Golden-spectacled Warbler	non-frugivores	P	-	-	-	-
17	Great Tit	frugivores	-	P	P	P	P
18	Green-billed Malkoha	frugivores	-	-	-	-	P
19	Grey-headed Flycatcher	non-frugivores	-	-	P,FI	P,FI	-
20	Hill Blue Flycatcher	non-frugivores	P	P	P,FI	P,FI,DE	P
21	Hoopoe	non-frugivores	-	-	-	P,FF	P
22	Inornate Warbler	non-frugivores	-	P	-	-	-

Table F7 (continued)

No.	Species of bird	Diets	Behavior observed from each tree species				
			ER	HO	ME	PR	SP
23	Japanese White-eye	frugivores	P	-	P	P,FN	-
24	Little Pied Flycatcher	non-frugivores	-	-	P	-	-
25	Little Spiderhunter	non-frugivores	-	-	P	-	-
26	Olive-backed Pipit	non-frugivores	-	-	-	P,FI	-
27	Oriental White-eye	frugivores	-	-	P	P,FN	P
28	Plain Flowerpecker	frugivores	-	-	-	P	-
29	Plaintive Cuckoo	non-frugivores	-	-	-	P	-
30	Puff-throated Babbler	frugivores	P	P,FI	-	-	P
31	Red-throated Flycatcher	non-frugivores	-	-	-	P,FI	P
32	Red-whiskered Bulbul	frugivores	P	-	P	P	P
33	Scarlet Minivet	non-frugivores	P	-	P	-	P
34	Sooty-headed Bulbul	frugivores	P	-	P	-	P,DE
35	Speckled Piculet	non-frugivores	P	-	P		-
36	Streaked Spiderhunter	non-frugivores	P,FN	-	P	P,FN	P
37	Sunbird sp. (female)	non-frugivores	P	-	-	-	P
38	Two-barred Warbler	non-frugivores	-	-	P,DE	P	P
39	Unknown sp. 1	unknown	-	-	P	-	-
40	Unknown sp. 2	unknown	-	-	-	-	P
41	Unknown sp. 3	unknown	-	-	P	-	-
42	Velvet-fronted Nuthatch	frugivores	-	-	-	-	P,FI
43	Warbler sp.	non-frugivores	-	-	-	-	P
44	White-browed Piculet	non-frugivores	-	-	-	P	-

Table F7 (continued)

No.	Species of bird	Diets	Behavior observed from each tree species				
			ER	HO	ME	PR	SP
45	White-browned Scimitar-Babbler	frugivores	-	-	-	P	-
46	White-browned Shrike-Babbler	non-frugivores	-	-	-	-	P
47	White-crested Laughingthrush	frugivores	P	-	-	-	-
48	White-rumped Shama	non-frugivores	P	P,FI	P,FI	P,FI,DE	P,FI
49	White-throated Fantail	non-frugivores	-	-	P	P	P

Remark: FF=feeding on fruit, FN=feeding on nectar, FI=feeding on insects and DE=defecation

Table F8 Bird using sites and their numbers observed in each selected framework tree

No.	Species of bird	Diets	Bird using sites and their numbers observed in each tree species				
			ER	HO	ME	PR	SP
1	Arctic Warbler	non-frugivores	UU(1)	-	UU(2)	UU(2)	UU(4)
2	Ashy Drongo	non-frugivores	-	-	CU(1)	-	CU(1)
3	Barbet sp.	frugivores	CU(1)	-	-	-	-
4	Bar-winged Flycatcher-shrike	non-frugivores	CU(2)	CU(1)	CU(6)	-	CU(2)
5	Black-crested Bulbul	frugivores	CU(2)	-	-	CU(3)	CU(6)
6	Black-throated Sunbird	non-frugivores	CU(1)	CU(1)	-	CU(3),UU(5)	CU(1)
7	Blue-throated Barbet	frugivores	CU(1)	-	-	-	-
8	Blyth's Leaf-Warbler	non-frugivores	-	UU(3)	-	UU(2)	UU(3)
9	Buff-bellied Flowerpecker	frugivores	-	-	UU(1)	UU(2)	-
10	Bulbul sp.	frugivores	-	-	CU(2)	-	-
11	Burmese Shrike	non-frugivores	-	-	-	-	CU(1)
12	Common Iora	non-frugivores	CU(1)	-	CU(1)	CU,UU(1)	-
13	Dark-necked Tailorbird	non-frugivores	-	-	-	UU(2)	-
14	Dusky Warbler	non-frugivores	-	-	-	-	GU(1)
15	Flavescent Bulbul	frugivores	-	-	-	CU(4)	CU(2)
16	Golden-spectacled Warbler	non-frugivores	UU(1)	-	-	-	-
17	Great Tit	frugivores	-	UU(2)	UU(1)	UU(5)	UU(2)
18	Green-billed Malkoha	frugivores	-	-	-	-	CU(1)
19	Grey-headed Flycatcher	non-frugivores	-	-	UU(2)	UU(2)	-
20	Hill Blue Flycatcher	non-frugivores	UU(1)	UU(1)	UU(2)	UU(3)	UU(1)
21	Hoopoe	non-frugivores	-	-	-	GU(1)	UU(1)
22	Inornate Warbler	non-frugivores	-	UU(1)	-	-	-

Table F8 (continued)

No.	Species of bird	Diets	Bird using sites and their numbers observed in each tree species				
			ER	HO	ME	PR	SP
23	Japanese White-eye	frugivores	CU(3)	-	CU(4)	CU(4),UU(2)	-
24	Little Pied Flycatcher	non-frugivores	-	-	UU(1)	-	-
25	Little Spiderhunter	non-frugivores	-	-	CU,UU(1)	-	-
26	Olive-backed Pipit	non-frugivores	-	-	-	GU(3)	-
27	Oriental White-eye	frugivores	-	-	CU(2)	CU(2),UU(2)	CU(3)
28	Plain Flowerpecker	frugivores	-	-	-	UU(1)	-
29	Plaintive Cuckoo	non-frugivores	-	-	-	UU(1)	-
30	Puff-throated Babbler	frugivores	GU(1)	GU(1)	-	-	GU(1)
31	Red-throated Flycatcher	non-frugivores	-	-	-	UU(2)	UU(3)
32	Red-whiskered Bulbul	frugivores	CU(6)	-	CU(2)	CU(1)	CU(7)
33	Scarlet Minivet	non-frugivores	CU(2)	-	CU(7)	-	CU(2)
34	Sooty-headed Bulbul	frugivores	CU(4)	-	CU(2)	-	CU(4)
35	Speckled Piculet	non-frugivores	UU(2)	-	UU(1)	UU(1)	-
36	Streaked Spiderhunter	non-frugivores	CU(2)	-	CU(1),UU(1)	CU(1),UU(1)	CU,UU(1)
37	Sunbird sp. (female)	non-frugivores	CU,UU(1)	-	-	-	UU(1)
38	Two-barred Warbler	non-frugivores	-	-	UU(2)	UU(2)	UU(1)
39	Unknown sp. 1	unknown	-	-	UU(1)	-	-
40	Unknown sp. 2	unknown	-	-	-	-	UU(1)
41	Unknown sp. 3	unknown	-	-	UU(1)	-	-
42	Velvet-fronted Nuthatch	frugivores	-	-	-	-	UU(1)
43	Warbler sp.	non-frugivores	-	-	-	-	UU(1)
44	White-browed Piculet	non-frugivores	-	-	-	UU(2)	-

Table F8 (continued)

No.	Species of bird	Diets	Bird using sites and their numbers observed in each tree species				
			ER	HO	ME	PR	SP
45	White-browned Scimitar-Babbler	frugivores	-	-	-	UU(1)	-
46	White-browned Shrike-Babbler	non-frugivores	-	-	-	-	CU(2)
47	White-crested Laughingthrush	frugivores	UU(4)	-	-	-	-
48	White-rumped Shama	non-frugivores	UU(2),GU(1)	UU,GU(1)	UU(3),GU(1)	UU(4),GU(1)	UU(6),GU(1)
49	White-throated Fantail	non-frugivores	-	-	UU(1)	-	UU(1)

Remark: US= Crown user; UU= Understorey user; UG= Ground user

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