CHAPTER 2

LITERATURE REVIEW

Understanding natural regeneration is very important to improve ANR techniques (Parrotta, 2000). Every step of the process must be studied, such as the seed rain, seed deposition, seed germination, seedling recruitment (Hardwick *et al.*, 1997). My study focused on the effects of remnant trees on seedling establishment in deforested areas. The most important background knowledge for this study concerns seed dispersal, especially by birds, the role of remnant trees, and seedling establishment.

Importance of the seed rain on deforested sites

A main problem that limits forest regeneration in disturbed areas is the lack of a soil seed bank (McClanahan and Wolfe, 1993). Many species of forest plants do not develop persistent seed banks (Ng, 1980). This agrees with the Forest Restoration Research Unit (FORRU, unpublished data). FORRU studied seed germination of native tree species in Doi Suthep-Pui National Park since 1995 at FORRU's nursery, next Doi Suthep-Pui National Park Headquarters. Seeds were sown in modular trays in forest soil without fertilizer. Numbers of seeds germinated were recorded weekly. The results indicated that many tree species lose viability rapidly in the soil seed bank. About 39% of the total species tested (337 species) were non-viable within a month and up to 67% in two months (Figure 1). Therefore, seed banks have a limited value in reforestation (van der Valk and Pederson, 1989). An important factor for the recovery of forests is seed dispersal from sources outside the deforested site. Seeds are dispersed in many ways, by wind, water, and animals (Willson, 1992; Jordano, 1992; Stiles, 1992).

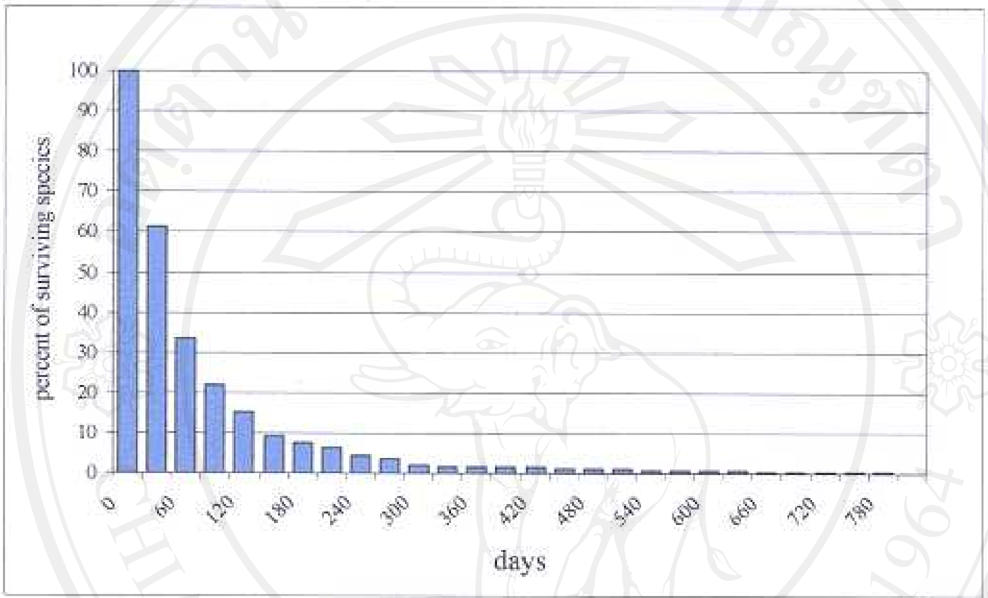

Figure 1 The loss of viability of tree seeds from the seed bank shows that most trees tested have no dormancy

Source: unpublished data, Forest Restoration Research Unit

Seed dispersal

Forster and Janson (1985) compared seed masses of mature tropical forest tree species with different light gap requirements for establishment in Peru. They reported that the species that become established beneath a closed canopy or in small gaps have higher mean seed masses than those that require large gaps. Furthermore, the seed mass of mature forest species is significantly larger than that of pioneer species.

Johnson *et al.* (1985) reported that seed shadows depend upon both seed size and bird species carrying out dispersal. Hedge *et al.* (1991) investigated the relationship of seed size in the bird-dispersed tree *Santalum album* L. (Santalaceae) in India. They found that dispersal efficiency is favoured in small seeds, while establishment of seedlings is favoured with larger ones.

Jordano (1995) studied the association between type of seed dispersers (birds, mammals, and mixed dispersers) and fruit phenotypic traits by analyzing the information available on the fleshy fruit characteristics of 910 angiosperm species in tropical and sub-tropical Asia. Fruit phenotypic traits were not entirely correlative to type of seed dispersers. He found that the type of disperser was limited by fruit size.

Sharp (1995) studied seed dispersal and predators in Doi Suthep-Pui National Park, Thailand. Small, flat, light-weight, and usually winged fruits/seeds could disperse farther into gaps, while bigger ones could spread only a few meters from the parent trees. Furthermore, the species diversity of fruits/seeds declined with distance from forest edges.

Wunderle (1997) investigated the role of animal seed dispersal in accelerating native forest regeneration on degraded tropical lands. He concluded that the efficacy of animal seed dispersal to restoration sites can be limited by the degree of isolation from a seed source, absence of animal seed dispersers in the region, and by large seed size.

Corlett (1998b) investigated seed dispersal by vertebrates in the Indomalayan Region. He reported that small fruits and large, soft fruits that have many small seeds are eaten by a wide range of seed dispersal agents. Larger seeds and fruits are eaten by fewer dispersers and most depend on a few species of mammals and birds, which are highly vulnerable to hunting, fragmentation, and habitat loss.

Dalling *et al*. (1998) studied patterns of seed rains, seed abundance in the soil, and seed mortality of two common pioneer trees, *Miconia argentea* DC. (Melastomataceae) and *Cecropia insignis* Liebm. (Moraceae), on Barro Colorado Island, Panama. The below-crown seed bank in the top soil (up to 3 cm deep) accounted for only 23% of seed rain for *Miconia*, and only 2% for *Cecropia*. Seed densities of both species in the seed bank decline with distance from the crown. The annual loss of *Miconia* seeds was >90% below the crown and declined to 65% at 30 m from the crown. The annual loss of *Cecropia* was >90% at all distances. They concluded that seed losses in the seed bank could largely be attributed to mortality from pathogenic fungi.

Hamann and Curio (1998) studied interactions between frugivores and fleshy fruit trees in a Philippine rainforest. They grouped tree species into early-, mid-, and late-successional species. Early-successional tree species were visited by a wide range of frugivores, but mid- and late-successional tree species were mostly visited by hornbills and pigeons. Consequently, late-successional tree species are the most specialized with respect to dispersers and most sensitive to extinction.

Traveset (1998) reviewed the effects of different seed dispersers (42 bird species, 28 non-flying mammals, 10-15 bats, 12 reptiles, and 2 fishes) on seed germination of nearly 200 plant species after passage through the digestive tract of these animals. She found that seed dispersers commonly have an effect on the germinability of seeds and the rate of germination in about 50% of the plant species they consume. Enhancement of germination occurred about twice as often as inhibition.

Martínez-Garza and González-Montagut (2002) studied the spatial distribution of fleshy-fruited species that disperse to tropical pastures at different distances from forest border in Mexico. They collected a total of 12,647 seeds from 38 fleshy-fruited species which are dispersed to pastures, 30% (32 species) were bird-dispersed seeds only, 20% (3 species) were bat-dispersed seeds, and 50% (3 species) were dispersed by both birds and bats.

Frugivorous birds

Seed dispersal agents have been widely studied, but most interesting is seed-dispersal by birds. Frugivorous birds are known to be important seed dispersers, facilitating regeneration of degraded natural forests (Elliott *et at.*, 1997). Many authors have described the benefits of frugivorous birds on forest restoration over other seed dispersal agents (Howe, 1986). Frugivorous birds benefit the plants by 1) dispersing many seeds into gaps, 2) by increasing the diameter of the seed shadow over that effected gravity, and 3) by increasing the probability that seeds will be deposited at the site of a future treefall gap (Hoppes, 1988).

Howe and Kerckhove (1979) observed feeding assemblages of birds in a Costa Rican dry-forest population of *Casearia corymbosa* H.B.K. (Flacourtiaceae). The Yellow-green Vireo (*Vireo flavoviridis*) was the most reliable disperser throughout the season, accounting for 65% of the arillate seeds removed. Other common visitors were the Streaked Flycatcher (*Myiodynastes maculatus*) 12%, Golden-fronted Woodpecker (*Melanerpes aurifrons*) 9%, Pale-throated flycatcher (*Myiarchus nuttingi*) 8%.

Howe and Kerckhove (1981) observed birds and mammals visiting individual plants in a Panamanian population of the rainforest tree *Virola surinamensis* (Rol.) Warb. (Myristicaceae) (wild nutmeg). They found that consistent differences in seed size could result in dramatic differences in dispersal. Food selection will alternatively favor small seed size and high dispersability in years when frugivores are abundant and large seed size and enhanced seedling vigor in the parental stand, when fruit-eating birds are scarce. Small-seeded plants are likely to colonize new sites whereas large-seeded individuals are likely to produce offspring that fare well in competition with other seedlings near parent trees.

Pratt and Stiles (1983) showed that diet, courtship, and breeding behavior of frugivorous birds influence how long they spend among fruiting plants. Furthermore, the correlation between fruit type and frugivorous birds has implications for seed dispersal. Their results showed that fruit pigeons (Superb fruit dove, White-breasted fruit dove, and Mountain pigeon) and bowerbirds (Black-eared catbird, MacGregor's bowerbird) excrete more seeds beneath parent trees than birds of paradise (Lawes's parotia, Trumpet manucode, Superb bird of paradise, Magnificent bird of paradise, and Blue bird of paradise). The fruit pigeons and bowerbirds make long visits to the plants and the birds of paradise make short visits.

Howe *et al.* (1985) demonstrated that large birds, such as Guans (*Penelop purpurascens*) and toucans (*Ramphastos sulfuratus* and *R. swainsonii*) in South

America can disperse seeds of the rainforest tree *Virola surinamensis* (Rol.) Warb. (Myristicaceae) more than 20 meters. Furthermore, dispersal by these large birds is more favorable for seedling survival than by smaller birds, such trogons (*Trogon massena*) and motmots (*Baryphthengus martii*), which regurgitate seeds under or near the tree crown.

This agrees with the report of Johnson *et al.* (1985), who reported that regurgitated seeds generally spent less time in a bird than defecated seeds, facilitating more rapid dispersal. Smaller birds defecate only small seeds and regurgitate some small seeds as well as all large ones, whereas larger birds defecate all small seeds and many larger ones.

Hoppes (1988) investigated spatial patterns of seedfall for several species of bird-dispersed plant in an Illinois (USA) maple-hackberry woodland. He found that around individual fruiting plants, seedfall declined with distance from the seed source. Small seeds were dispersed farther and were much more likely to be dispersed into adjacent treefall gaps than large ones. Furthermore, natural seedfall around a treefall gap was highest at the edge of the gap, lower in the center of the gap, and lowest in undisturbed forest.

Dean *et al.*, (1990) found that although, birds dispersed seeds by feeding, many birds dispersed seeds as nest material. They studied the dispersal of seeds as nest material by birds and found that seeds of 55 plant species are incorporated into the nests of 31 common bird species in semiarid shrubland of the southern Karoo, South Africa. Nest lining and structural materials include many viable seeds. Furthermore, they postulated that seeds with cottony coverings on indehiscent fruits on woolly or branched peduncles are adapted for direct dispersal by birds as nest material.

Robinson and Handel (1993) investigated forest restoration in New York, USA by planting trees and shrubs of 17 species to attract avian seed dispersers. One year after planting the plantation spread and increased in diversity, with 20 additional species. They found a total of 1,079 woody seedlings, of which 95% came from sources outside the plantation. Most seedlings (71%) were fleshy fruits, dispersed by birds from nearby woodland fringes. The density of new recruits of each species is dependent on the distance from the nearest potential seed source.

Debussche and Isenmann (1994) studied the composition and spatial patterns of the seed rain, produced by bird dispersers, in patchy Mediterranean vegetation in France. They collected the seeds of 38 fleshy-fruited plants. Twenty-five species were dispersed by the bird *Sylvia atricapilla*, which disperses the most diverse and mixed seed rain of the various bird dispersers. The species richness of the seed rain increased with seed density, ranging from 3-21 species per 0.25 m^2. The maximum density (up to 829 per 0.25 m^2) of seeds was observed under the canopy of isolated trees and saplings in old fields, which are favoured perching places for the dispersers. The minimum density (down to 12 per 0.25 m^2) was observed outside of the canopy of these same trees and saplings. The bird dispersers thus trigger dynamic processes initiated by pioneer woody plants in Mediterranean old field successions. Furthermore, dispersal of fleshy-fruited plants by birds was more significant in the mid-stages of succession, when both have homogeneous structure.

Whittaker and Jones (1994) studied the role of frugivorous bats and birds in the rebuilding of a tropical forest on Krakatau Island, Indonesia, which was devastated by a volcanic eruption in 1883. They found that 124 species of plant had been introduced endogenously by birds and bats from a total of 137 zoochorous species. Besides, birds have a dispersal role for a more diversity of plants than do bats, for which available records indicated a restriction largely to trees and shrubs.

Parrotta (1995) studied the influence of overstory composition on understory colonization by native species in a plantation of the exotic trees *Casuarina equisetifolia* L. (Casuarinaceae), *Eucalyptus robusta* Sm. (Myrtaceae), and *Leucaena leucocephala* (Lam.) de Wit (Leguminosae, Mimosoideae), on a degraded tropical site in Puerto Rico. He found that 19 secondary forest species established in the plantation understories. Most of these species (90%) and the total seedling population (97%) are zoochorous, indicating the importance of frugivorous bats and particularly birds as facilitators of secondary forest species colonization. Understory species richness and seedling densities are affected by overstory composition.

Nepstad *et al.* (1996) compared tree establishment in abandoned pastures and mature forest in eastern Amazonia. They found that tree seed deposition in abandoned pastures was higher beneath trees (999 m^{-2} yr^{-1}). Tree seed deposition by birds was low in the open vegetation of the abandoned pastures (2 m^{-2} yr^{-1}).

Corlett (1996) studied the characteristics of vertebrate-dispersed fruits in Hong Kong. He concluded that bird-dispersed species cover the full range of fruit characteristics, except for fruits that are too large to swallow and too hard to peck. This agrees with the report of Tucker and Murphy (1997), who concluded that fruit size and type suggest that birds are responsible for most of the effective seed dispersal in Queensland.

Corlett (1998a) observed birds feeding in Hong Kong shrubland and recorded 42 bird species (22 residents, 20 migrants) eating fruits. At least 92 fruiting species were eaten by birds, the most important seed-dispersal agents being the Red-whiskered Bulbul (*Pycnonotus jocosus*), the Light-vented Bulbul (*P. sinensis*), and the Japanese White-eye (*Zosterops japonicus*).

Remnant trees in deforested areas

The role of remnant trees in disturbed areas has been widely discussed. Many studies have shown the benefits of such trees for accelerated natural regeneration (ANR) by attracting seed dispersers (Wunderle, 1997). These trees are associated with higher seed deposition and seedling beneath their crowns than in open areas.

Guevara *et al.* (1986) determined the role of remnant forest trees in tropical secondary succession in Mexico. They found that remnant large forest trees form "regeneration nuclei", because passing and resident frugivorous birds use them as perching sites. They recorded 29 woody species and 2 climbers beneath 7 remnant trees, and 86% of those plants are bird dispersed.

McClanahan and Wolfe (1993) investigated accelerated forest succession in a fragmented landscape by birds using perches as bird-attracting structures, in Florida, USA. They recorded more seeds and a higher diversity beneath perches (340 seeds m^{-2} yr^{-1}), which was 150 times greater than in sites without perches, however less than 0.06% of the dispersed seeds survived to become seedlings. Perches attracted birds and increased seed deposition, but the harsh conditions and/or high predation on seeds appeared to reduce seedling recruitment. Nonetheless, abundance and diversity of bird-dispersed plants was higher under perches. Therefore, perch structures have a limited ability to enhance plant diversity in secondary successions.

Verdú and García-Fayos (1996) also demonstrated that perches, trees, and shrubs not only attract seed-dispersing birds, but also produce favourable micro-environmental conditions for seed germination and seedling establishment. Soil moisture content after rainfall is always greater beneath trees, providing favourable water potentials for seed germination maintained for a longer time.

Toh *et al*. (1999) studied the role of isolated trees in a degraded sub-tropical rainforest in southern Queensland, Australia. They reported that low trees (<3 m high) act as the initial focus for the activities of seed-dispersing birds, while taller trees (>6 m high) act as bird perches. There was no relationship between remnant tree size and seedling density beneath their crowns. The diversity of tree seedlings beneath the trees increases with both the height and crown area of the trees. Most seedlings can establish around remnant trees, but only some of these can survive through to maturity.

Hau (1999) studied tree seed dispersal on degraded hillsides in Hong Kong. He collected a total of 2,417 tree seeds (17 species), 10,097 shrub seeds (14 species), 132 climber seeds (5 species), and 78 herb seeds (5 species). Most seeds (>94%) collected by seed traps under treelets are dispersed by frugivorous birds.

Galindo-González *et al.* (2000) investigated the seed rain under isolated fig trees in pastures in a tropical rainforest in Mexico. They reported that the seed rain is dominated by zoochorous species (89%). Birds and bats are important seed dispersers in pastures because they disperse seeds of pioneer and primary species connect forest fragments, and maintain plant diversity. They assist to restore woody vegetation in disturbed areas in tropical forests.

Carrière *et al.* (2002a) studied the seed rain beneath remnant trees in a slash-and-burn agricultural system in southern Cameroon. They found that the seed rain beneath remnant trees is 25 times higher than in open areas, 10 m away from the edges of their crowns, while mean species richness of the monthly seed rain is three times higher. Both fleshy-fruited and wind-dispersed species of remnant trees attracted seed-dispersing animals, which greatly raised the seed rain. The attraction did not depend only on presence of fleshy fruits.

Carrière *et al.* (2002b) investigated this site further and found that plant diversity around all age classes (3-20 years) of remnant trees was not significantly different between the positions, beneath and away from their crowns. Most individuals of naturally establishing trees belonged to species with animal-dispersal seeds. These accounted for a larger proportion of recruits beneath remnant trees (75%) than away from remnant trees (64%). In contrast, wind-dispersed species comprised a smaller proportion of recruits beneath remnant trees (11.7%) than away from them (23.6%). They concluded that increased seed rain by attraction of perching animals influences regeneration patterns. Furthermore, the regeneration beneath remnant trees of an animal-dispersed (*Pycnanthus angolensis* (Welw.) Warb., Myristicaceae) and a wind-dispersed (*Triplochiton scleroxylon* K. Schum., Sterculiaceae) species was similar.

Seedling establishment

Post-dispersal processes such as seed predation, seed germination, and seedling establishment are dependent and affect seedling distribution (Verdú and García-Fayos, 1998). For seedling establishment, research has concentrated an various factors, such as competition with herbaceous weeds, seed size, and nutrient availability. The probability of survival varies significantly among species, between habitat, forest type, and fruit types (Osunkoya, 1994). In addition, much research has indicated a higher abundance of seedlings, especially of animal-dispersed plants, under tree crowns than in open areas.

Maguire and Forman (1983) studied the effects of herbs on tree seedling distribution patterns in West Virginia, USA. They concluded that herb patches have a major influence in determining the density and distribution of seedlings of common tree species. However, the distribution of the herb patches is controlled by both the tree canopy and other herb patches.

Nepstad *et al.* (1990) studied tree seedling establishment in a highly degraded pasture in Brazil. They found that establishment is limited by a lack of seed dispersal, predation of seeds and seedlings, and seasonal drought. Bats and birds disperse small seeds of pioneer trees, but leaf-cutter ants and small rodents eat most of them. Furthermore, if the seeds germinate, seedling predators or drought eliminates most of them.

Debussche and Isenmann (1994) studied the composition and spatial patterns of the seedlings of fleshy-fruited plants in patchy Mediterranean vegetation in France. Their results indicated that establishment of fleshy-fruited plants is favored when seeds are deposited under pioneer woody plants rather than in open areas.

Leishman and Westoby (1994) studied the role of seed size on seedling establishment on dry soils in Australia. Their results indicated that seed size is positively associated with survival time of seedlings under dry conditions. Large seeds provide an advantage for seedling establishment when soil moisture is low, such as in deforest sites. Furthermore, Leishman *et al.* (1995) suggested that seed size is more important than environmental conditions for seedling establishment.

Huante *et al.* (1995) determined nutrient availability and growth rates of 34 woody species in a deciduous forest in Mexico. They recorded the highest relative growth rate (RGR) in the high nutrient treatment. Relationship between RGR and seed biomass among the species was weak. Under both low and high nutrients, RGR was highly correlated with specific leaf area (SLA), suggesting the importance of both the total leaf area produced and leaf morphological characteristics in determining the RGR.

Nepstad *et al.* (1996) compared tree establishment in abandoned pasture and mature forest in the eastern Amazonia. They found that tree seedlings and sprout emergence was 20 times lower in the abandoned pasture than in forest understory and forest gaps.

Adhikari (1996) found a relationship between tree seedling establishment and herbaceous vegetation in degraded areas of Doi Suthep-Pui National Park, northern Thailand. He reported that tree seedling diversity is highest in *Eupatorium adenophorum* Spreng. (Compositae)-dominated sites, followed by *Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. *ex* Hubb. & Vaugh. (Gramineae)-dominated sites and *Pteridium aquilinum* (L.) Kuhn ssp. *aquilinum* var. *wightianum* (Ag.) Try. (Dennstaedtiaceae)-dominated sites. Furthermore, the *Eupatorium* sites had lowest seedling mortality (21.7% over 10 months) followed by the *Pteridium* sites (25.7%) and the *Imperata* sites (30%). Most tree seedling species had better growth rate in the *Eupatorium* sites. There were no significant associations between any of the tree seedling species found in both of the *Imperata* sites and the *Pteridium* sites. Seedlings of three species (*Castanopsis diversifolia* (Kurz) King *ex* Hk. f., Fagaceae; *Leea indica* (Burm. f.) Merr., Leeaceae; and *Phoebe lanceolata* (Wall. *ex* Nees) Nees, Lauraceae) showed significant association with the *Eupatorium*-dominated site. He suggested that the dominant ground flora does not provide a reliable indication of the tree seedling community or of soil conditions.

Previous research at the study site

In the study site, a deforested area above Mae Sa Mai village, previous research has focused on reforestation.

Elliott *et al.* (1997) surveyed naturally established seedlings or saplings (>30 cm tall, gbh < 10 cm) in 1,600 m^2 of plots in this deforested area. They found 174 natural seedlings of 36 species and a density of 0.12 seedlings / m^2.

Kuarak and Hitchcock (1998) compared the number of bird dispersed seedlings beneath the canopies of remnant trees (14 individual trees, 9 species) and in control plots, away from their crowns. They found that *Schima wallichii* (DC.) Korth. (Theaceae) and *Albizia chinensis* (Obs.) Merr. (Leguminosae, Mimosoideae) were the most important remnant trees that promoted seed dispersal by birds, there were abundant bird-dispersed tree seedling beneath their crowns over in control plots. Furthermore, they observed birds feeding on 17 fruiting trees species in mature forest. They found that only 8 species, *Bischofia javanica* Bl., *Macaranga denticulata* (Bl.) M.-A. (both Euphorbiaceae), *Eugenia fruticosa* (DC.) Roxb. (Myrtaceae), *Eurya acuminata* DC. var. *wallichiana* Dyer (Theaceae), *Ficus altissima* Bl., *Ficus glaberrima* Bl. var. *glaberrima, Ficus microcarpa* L. f. var. *microcarpa forma microcarpa* (Moraceae), and *Hovenia dulcis* Thunb. (Rhamnaceae) are clearly attractive to birds. The most important bird visitors were Black-crested Bulbul *Pycnonotus melanicterus* and Striated Yuhina *Yuhina castaniceps*, which had the longest visits to fruiting trees.

Chanthorn (1999) observed birds from December 1997 to January 1998 in the reforested area at this study site. In 60 hours of the observations he recorded 35 bird species (33 species in non-planted plots and 16 species in planted plots). Most of the birds were insectivores, such as Grey breasted Prinia, Long-tailed Shrike, and Pied Bushchat. There was a low proportion of frugivorous birds, of which the Red-whiskered Bulbul was the most abundant. Furthermore, 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) during July-October 1998 in evergreen forest of Doi Suthep-Pui

National Park. In twenty hours, a total of 12 bird species were recorded, Black-crested Bulbul, Mountain Bulbul, Puff-throated Bulbul, Ashy Bulbul, Blue-throated Barbet, Red-whiskered Bulbul, Soothy-headed Bulbul, Asian fairy Bluebird, Flavescent Bulbul, Blue-winged Leafbird, Common Tailorbird, and Blacked-naped Monarch. Of these, only five species (Red-whiskered Bulbul, Soothy-headed Bulbul, Flavescent Bulbul, Blue-throated Barbet, and Common Tailorbird) were also found in the reforested area at the study site.

Khopai (2000) studied effects of forest restoration activities on the species diversity of ground flora and tree seedlings in the reforested site. She reported a total of 49 species of naturally established trees (> 1 m in height) in her research plots. The most abundant species were *Litsea cubeba* (Lour.) Pers. var. *cubeba* (Lauraceae), *Acacia megaladena* Desv. var. *megaladena*, *Albizia chinensis* (Osb.) Merr. (Leguminosae, Mimosoideae), *Antidesma acidum* Retz., *Glochidion sphaerogynum* (M.-A.) Kurz (both Euphorbiaceae), *Gmelina arborea* Roxb. (Verbenaceae), and *Markhamia stipulata* (Wall.) Seem. *ex* K. Sch. var. *kerrii* Sprague (Bignoniaceae).

Scott *et al.* (2000) studied the effects of artificial perches and local vegetation on bird-dispersed seed deposition in regenerating sites. They found that the species richness and density of bird-dispersed seeds are significantly higher below perches than in control plots, which lack perches. The majority of bird-dispersed tree seeds were *Antidesma acidum* Retz. (Euphorbiaceae). During 72 hours of bird observations, they recorded a total of 8 bird species visiting perches (29 visits). They were largely insectivorous birds (Grey Bushchat, Grey-breasted Prinia, Olive-backed Pipet, Pied Bushchat, Asian Brown Flycatcher, and Yellow-eyed Babbler) and some frugivorous birds (Sooty-headed Bulbul and Red-whiskered Bulbul). The total species richness of birds visiting perches was higher in the naturally regenerating plots. They suggested that perches are a useful technique to increase seed deposition by birds. Furthermore, the absence of nearby forest and the presence and specific characteristics of fruiting trees have a significant impact on attractiveness to seed-dispersing birds.

These research projects produced an understanding of natural succession and knowledge for ANR. Although much research has indicated the benefits of remnant trees to reforestation in assisting seed dispersal by animals, there are many gaps in this knowledge, such as the effects of different remnant tree species on seedling establishment. This study will help provide a more detailed idea of the role of remnant trees and their role in helping improve ANR techniques.