Effects of Forest Restoration Activities on the Bird Community of a Degraded Upland Watershed

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3805316

A special project is submitted to the biology department
in partial fulfillment of the requirements for the degree Bachelor of Science in Biology

Biology Department
Faculty of Science
Chiang Mai University
1999

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Examining Committee

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DATE 11 MONTH MAY YEAR 1999

กิตติกรรมประกาศ

ปัญหาพิเศษเล่มนี้ใช้เวลาค่อนข้างใช้เวลานานกว่าจะสำเร็จเนื่องจากความบกพร่องของผู้เขียน แต่มีอาจารย์ Dr. Stephen Elliott ผู้คอยตักเตือนในการทำงานมิให้นอกลู่นอกทาง ชี้แนะแนวทางในการทำงาน ให้ความรู้ในด้านการทำวิจัย ตลอดจนตรวจสอบและแก้ไขเนื้อหาทั้งหมดในเล่มนี้ ทางผู้เขียนขอกราบขอบพระคุณ Dr. Stephen Elliott เป็นอย่างสูง

ขอกราบขอบคุณอาจารย์ด.ร. นริทธิ์ สีตะสุวรรณ ผู้ซึ่งเป็นอาจารย์สอนดูนกของผู้เขียนคนแรกและให้คำปรึกษาในการทำงานนี้ ตลอดจนตักเตือนสั่งสอนสิ่งต่างๆ และกราบขอบคุณอาจารย์ด.ร. วิไลวรรณ อนุสารสุนทร ที่กรุณาช่วยเป็นกรรมการตรวจสอบ และกราบขอบคุณอาจารย์ทุกท่านที่เอาใจใส่ในตัวกระผมตลอดมา

กราบขอบคุณคุณพ่อและคุณแม่ผู้ซึ่งคอยตักเตือนให้ขยันหมั่นเพียรในการทำงานตลอดเวลาและคอยตักเตือนเวลาออกนอกลู่นอกทาง

ในงานภาคสนามผมอยากขอบคุณ คุณพุทธิพงษ์ คุณเชิดศักดิ์ และเจ้าหน้าที่คนอื่นใน FORRU ที่ช่วยเหลือและอำนวยความสะดวกในด้านต่างๆ

ขอขอบคุณ คุณชนิตา ลังกา ที่ช่วยอำนวยความสะดวกในด้านยานพาหนะ และเป็นกำลังใจที่สำคัญของผู้เขียนเสมอมา ขอบคุณ คุณธนวัช แก่นท้าว ผู้ซึ่งช่วยเหลือผู้เขียนอย่างมากในงานเก็บข้อมูลภาคสนาม ขอบคุณคุณอาทิตย์ นันทขว้าง ที่อำนวยความสะดวกอุปกรณ์การพิมพ์และอาหารว่าง และสุดท้ายขอบคุณเพื่อน รุ่นพี่ และรุ่นน้องของผู้เขียนทุกคนที่คอยห่วงใยและช่วยเหลือตลอดมา

วิรงค์ จันทร

SPECIAL PROJECT TITLE: -

Effects of Forest Restoration Activities on the Bird Community of a Degraded Upland Watershed

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Abstract

A survey of bird species richness was carried out in a degraded upland watershed at Ban Mae Sa Mai in Doi Suthep-Pui National Park, comparing plots where forest restoration activities had taken place with control plots. Plots undergoing forest restoration had been planted with 29 "framework" tree species in June 1998. The non-planted control plots were abandoned agricultural areas, undergoing natural regeneration. Herbaceous weeds dominated these plots. Both plots had been burnt before tree planting took place and both were surveyed for birds in December 1998. In addition, a 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 and to identify bird species typical of the later stages or climax stage of forest succession.

In the planted plots, 16 bird species were observed. 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 jocosus*). In evergreen forest, the most common species was the Black-crested Bulbul (*Pycnonotus*

melanicterus). The value of Sorensen's index of similarity, comparing planted with non-planted plots, was 0.56, indicating a 44% difference. The two communities were, therefore, moderately different.

Low bird species richness in the planted plots was probably the result of weeding activities, necessary to allow the planted trees to grow. It is expected that bird species richness will increase as the planted trees reach maturity and provide a greater variety of resources and niches.

หัวข้อปัญหาพิเศษ:-

อิทธิพลของกิจกรรมฟื้นฟูป่าต่อชุมชนของนกในเขตพื้นที่ลุ่มน้ำที่ราบสูงเสื่อมโทรม

ชื่อผู้เขียน วิรงค์ จันทร

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บทคัดย่อ

การสำรวจหา species richness ของนกในเขตพื้นที่ลุ่มน้ำที่ราบสูงเสื่อมโทรม ณ บ้านแม่สาใหม่ อุทยานแห่งชาติดอยสุเทพ-ปุย โดยเปรียบระหว่างแปลงที่มีการปลูกป่าและแปลงที่เป็นชุดการทดลองควบคุมซึ่งไม่ได้มีการปลูก แปลงที่ผ่านการปลูกป่าได้ใช้ต้นไม้ชนิดที่เป็น framework จำนวน 29 ชนิด โดยเริ่มปลูกในเดือนมิถุนายน ปีพ.ศ. 2541 แปลงที่ไม่ได้มีการปลูกเป็นพื้นที่กสิกรรมร้าง ผ่านการเปลี่ยนแปลงแทนที่โดยธรรมชาติ และถูกปกคลุมด้วยวัชพืชใบเลี้ยงเดี่ยว ทั้งสองแปลงถูกเผาก่อนปลูกและสำรวจในเดือน ธันวาคม พ.ศ. 2541 นอกจากนี้ยังทำการสำรวจนกที่กินผลไม้ในป่าไม่ผลัดใบที่สมดุล เพื่อหาชนิดของนกที่ช่วยกระจายเมล็ดมาจากป่า และชนิดที่น่าจะพบในการเปลี่ยนแปลงแทนที่อันดับท้าย

การสำรวจพบนกจำนวน 16 ชนิดในแปลงปลูกป่า นกชนิดที่พบบ่อยได้แก่ นกกระจิบหญ้าอกเทา (*Prinia Hodgesonii*) และพบนกจำนวน 33 ชนิดในแปลงทดลองควบคุม นกชนิดบ่อยได้แก่ นกกระจิบหญ้าอกเทา (*Prinia Hodgesonii*) และนกปรอดหัวโขน (*Pycnonotus jocosus*) ในเขตป่าไม่ผลัดใบพบชนิดที่บ่อยได้แก่ นกปรอดเหลืองหัวจุก (*Pycnonotus melanicterus*) ความแต่งต่างของชนิดระหว่างแปลงปลูกป่าและแปลงควบคุม โดยใช้ ค่าดัชนีของ Sorensen เท่ากับ 0.56 หรือ แตกต่างกัน 44% แสดงว่ามีความแต่งกันปานกลาง

species richness ที่ต่ำในแปลงปลูกป่าน่าจะเป็นผลจากการกำจัดวัชพืช คาดว่า species richness จะเพิ่มเมื่อพืชเติบโตจนออกผลซึ่งจะให้แหล่งอาหารที่หลากหลายแก่นก

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Chapter 1 INTRODUCTION AND OBJECTIVES

In 1950, more than 60% of Thailand's area was covered in forests, but in 1992 forest cover had been reduced to about 25% of the country's area. According to the 8th National Economic and Social Development Plan, not less than 40% of Thailand should be forested (อ๐ป. 2538). It was shown the great number of forests and rapidly destroyed only forty-two years. Although there have been many Government campaigns to reforest, planted trees are often not adequately taken care of. There is a low species richness of planted trees in reforestation areas e.g. *Pinus spp.* has been planted on a large scale in degraded mountain areas. Furthermore, exotic species such as *Eucalyptus* spp. are frequently planted. As these plantations mature, biodiversity remains lower than in primary forest.

The Forest Restoration Research Unit (FORRU) was established to develop suitable methods to restore natural ecosystems in deforested areas (The Forest Restoration Research Unit, 1998). The unit has been carrying out research to develop suitable methods to restore forests by the "framework species" technique, using suites of carefully selected local forest tree species to accelerate natural succession. This method is analogous to building a house in which, once the framework has been built, the roof and furniture (e.g., in a forest the ferns, vines, orchids and animals) build themselves. The method also includes surveys of species richness or biodiversity as the forest recovers.

The properties of framework tree species are:

1. They are fast growing and can compete well with herbaceous weeds.

2. They have dense crowns, which can rapidly shade out weeds.

3. They bear fruits, which attract seed dispersing wildlifee.

According to Goosem and Tucker (1995), about 30% of planted framework tree species should be pioneer species that rapidly provide food for wildlife. They create forest structure and provide indirect advantages for birds such as creating perches. Figs (*Ficus spp.)* are also important, because they have high fecundity and provide fruits attractive to a large number of wildlife species. Other species from later successional stages such as poorly dispersed species with large fruits and seeds and endangered species are also included. It is advantageous if the forest restoration area is fairly near to remnant primary forest since this facilitates dispersal of seeds of non-planted tree species into the planted area. In Krakatoa island, Indonesia, retention time of seed in guts of birds such as *Ducula bicolor., Calcophaps indica* and *Pycnonotus aurigaster* which they can find in Doi Suthep-Pui National park is high. it can disperse seed far over the sea between islands (Whitakker & Jones 1994). In Northern Queensland Metallic Starlings (*Aplonis metallica*) and Yellow Orioles (*Oriolus flavocinotus*) can easily fly cross about 500 m. of open grasslands. The framework species method was first developed in the late 1980' s in Queensland, Australia (Goosem & Tucker, 1995; Lamb *et al.,* 1997 and Tucker & Murphy, 1997)

Tucker & Murphy (1997) reported that a small reforestation area, adjacent to remnant forest in north Queensland, that was planted with 20-30 framework tree species, accumulated up to 72 naturally establishing tree species after 7 years. Non-planted, control plots remained dominated by disclimax grasses and supported only nineteen tree species. Seed bank analysis revealed that the soil contained a large number of weed and grass seeds. This indicates that disturbance of the reforestation area would lead to re-establishment of a grass and herbaceous weed community. The study concluded that rehabilitation and vegetation recruitment in the plots planted with framework tree species were greatly accelerated compared with non-planted plots.

Although recovery of tree species diversity is the main objective during the first years after planting, using the framework method, birds were chosen for the study reported here because:

1. Birds are wildlife, which can live in deforested areas and are quite numerous.

2. Birds are easily observed and identified, using “A Guide to the Birds of Thailand” by Lekagul and Round, 1991.000

3. There are many species of birds at all trophic levels.

4. Birds are efficient seed dispersers that can disperse seeds over long distances.

The objectives of this survey were

1. To compare the species richness of bird communities in plots recently planted with 29 framework tree species with that in nearby control plots, undergoing natural regeneration.

2. To make observations about the potential of birds to disperse seeds into reforestation and grass land areas undergoing forest restoration.

Chapter 2 LITERATURE REVIEW

Tucker & Murphy (1997) suggested that in the north of Queensland, ecological succession in degraded grassland areas undergoing forest restoration by the framework tree species method might be accelerated by planting fleshy-fruited, early successional tree species. Such trees would attract key seed dispersing animals such as fruit pigeons, flying foxes, cassowaries etc. Perching or roosting sites are also important for animals to disperse seed into open habitats (Lamb *et al.,* 1997).

Doi Suthep-Pui National Park is reported as having high diversity of bird species. In 1945, Deignan reported 265 bird species on the mountain. However, between 1978-1984, 50 of the species reported by Deignan had disappeared (Round 1984), indicating that habitat degradation and hunting was diminishing the bird fauna. Both Thai and hill tribe people have been responsible for extirpating bird species, due to hunting, forest burning and logging.

In evergreen forest on Doi Suthep-Pui at an altitude similar to that of the forest restoration area, the structure of the forest canopy can be divided into 4 layers: i). the upper canopy (emergent) in which some trees may reach 35 m; ii) the main canopy; iii) the understorey, consisting of the crowns of low trees and shrubs and iv) the ground layer of tree seedlings and herbs (Beaver & Sritasuwan, 1985).

Such forest supports the highest bird species richness in the National park. Beaver and Sritasuwan (1985) reported ninety species. This can be the expected bird species richness of forest restoration areas in the future, if restoration activities are successful. A study comparing bird communities among several deforested areas, which had undergone various degrees of disturbance in Doi Suthep-Pui National Park at 1,050-1,100 above sea level, found 74 species in undisturbed evergreen forest, 67 species in moderately disturbed evergreen forest and 58 species in highly disturbed evergreen forest (Portigo, 1994)

Howe (in Murray 1986) defined some terms relating to seed dispersal:

- Frugivore: an animal that eats fruits
- Dispersal: departure of seed from the parent; *secondary dispersal* is further movement of seeds following their initial departure
- Dispersal system: a plant species and the animals that eat its fruits
- Dispersal agent: an animal that moves viable seed from one location to another
- Seed predator: an animal that eats a seed or part(s) of a seed, usually killing the embryo

Janzen & Connell (Irvine & Harrington, pers com.) developed the hypothesis that "seedling numbers would be greatest some distance away from the parent tree, since heavy seed predation is more likely to occur where fruit is abundant near the parent tree and that such predation would result in low seedling density". This process could contribute towards wide spacing between conspecific trees and high tree species richness in tropical forests

Frugivorous birds can be divided into three groups according to their feeding habits (Jordano 1992)

1. Dispersers, which eat whole fruits and defecate or regurgitate seeds.
2. Pulp predators, which tear off the pulp of fruits and ingest only the pulp, by working seed out.
3. Seed predators, which crack seeds and/or ingest them or swallow whole fruits and digest both pulp and seeds.

Groups 1 and 2 are frugivores which transport seeds without destroying them. Group 3 are granivores which destroy seeds.

The seed-processing behavior of birds affects plant distribution. There are two general types of these behaviors: 1) rapid processing of seeds by frugivores that mash or spit out the seeds, resulting in short-distance dispersal of seeds and highly clumped distribution near the parent tree and 2) seed processing involving a longer retention time. This behavior brings about a more scattered distribution or random distribution and dispersal of seeds further away from parent trees. In addition, the faeces of birds with longer retention times will contain seeds of several species, resulting in aggregated distribution of several species. Such feeding behavior helps forest to extend quickly and generates high biodiversity (Jordano 1992).

There is much evidence demonstrating co-evolution or mutualism between plants and the birds that disperse their seeds. Howe *et al*. (1985) demonstrated that large birds such as Guans (*Penelope purpurascens*) and Toucans (*Ramphastos spp.*) in South America, can disperse seeds of the tree *Virola surinamensis* more than 20 m. from tree base. The tree benefits from such dispersal, since the seeds escape seed and seedling predators, such as curculionid weevils. Nearly all seeds falling under the crown of the parent tree die. There is a 44-fold advantage for seed and seedling survival when the distance from tree increases to 45 m. Six bird species take 77% of seeds handled by animals. The fruit of *Virola surinamensis* has arillate seeds and animals remove 65.5% of mature fruits. Toucans (*Ramphastos swainsomii*) play an important role in seed dispersal. Fruit-eating animals (birds) prefer to eat small seeds and favor trees with high aril-to-seed ratios. These birds do not scarify seeds whilst seeds are being removed or handled. If not ingested by birds, seed germination is zero (N=30), whilst 26 and 9 seeds germinated after regurgitation by Toucans or defecated from Guans respectively (Howe & Kerckhove, 1979). The tree benefits from removal of the aril. All arillate seeds were rotten 8 weeks after planting by infection by fungi (Howe & Kerckhove 1981). Some bird such as Contigas (*Tityra semifasciata*) are too small to swallows seeds of *Virola surinamensis* and eat only the aril but they do not disperse seeds.

Howe (1977) suggested that the Masked Tityra (*Tityra semifasciata*) was an important seed-disperser of the tree *Casearia corymbosa* in Costa Rican rain forest for the following reasons:

1. It can regurgitate viable seeds.

2. It is a common and regular visitor throughout the season.

3. It has a high feeding rate that shows competitive effectiveness. This high rate might indicate interdependence (mutualism) between the tree and the bird.

4. It does not drop seeds under the tree crown and can disperse seeds far away from the tree.

5. The bird depends on this tree species, rather than other plants fruiting at the same time.

However, some fruit-eating birds such as the two parrots, *Amazona autumnalis* and *farinosa* are not good seed dispersers because they strip arils with their bills and drop all seeds under the crowns of the parent trees. *Casearia corymbosa* fruits when most other trees in the forest are not producing fruits. It is a good example of how the extinction of one species would affect the whole community. If this tree species becomes extirpated from the area, the bird *Tityras semifasciata* would also disappear. There might also be additional local extinction of trees, whose seeds are dispersed by this bird. Moreover, it may affect toucans and cause their extirpation because they must eat these fruits when other fruits are scarce. This would consequently affect Toucan-dispersed plants such as *Virola surinamensis*. From this evidence, we should maintain every species for sustainable biodiversity of forest.

Birds help pollination in many plants for example in Indonesia, *Aethopygamystacalis* and *Anthreptes malacensis* (Family: nectarinidae), which are both species found in the south of Thailand pollinate *Loranthus sp., Hibiscus sp.* and *Musa acuminata* (Whittaker & Jones, 1994)

Birds probably also disperse some plant species indirectly, for example through the collection of materials for nest lining. It is postulated that *Galium tomentosum* disperses its seeds by this method. Dispersal in this way is employed by seeds with a cottony covering or indehiscent fruits on wooly branches or peduncles (Dean *et al.,* 1990).

Whittaker & Jones 1994 reported that some frugivorous bird species in Malaysia and also in Northern Thailand for example *Chalcophaps spp.* and *Terron spp* have grit-containing muscular gizzards but *Dicular spp*. have thinner walled gizzards and do not use grit. It is supposed that *Dicular spp* are more effective dispersal agents. The species can be an effective catalyst for forest regeneration.

Chapter 3 STUDY SITE, MATERIALS AND METHODS

Site Descriptions

Reforestation Area

The study site where reforestation activities were taking place was in the north of Doi Suthep-Pui National Park, about 2 km above the Hmong village of Ban Maesa Mai. Three replicate plots, each of 4 rai (totalling 12 rai), were within a degraded water catchment area at 1,207-1,310 m elevation (see figure 3.1), dominated by herbaceous weeds. The whole area had been deforested about 20 years ago, subsequently cultivated for cabbages, potatoes, etc., then further degraded by frequent fires.

The 3 replicate plots, 98.1, 98.2, 98.3 had been planted with 29 framework tree species (see appendix) in June 1998. By each planted plot, there were also control areas, which had not been planted with trees, for comparison. The whole area had been burnt in March-April, before planting. Each planted plot covered about 3 rai (1,600 m^2 per rai) and each control plot was about 1 rai in area (for this study, non-planted areas around the edges of the planted plots were also included). All planted plots were weeded on September 2^{nd}, October 7^{th} and December 11^{th}. Immediately after weeding, fertiliser was applied according to the treatments.

By December, planting had increased the density of saplings more than 1 m tall by 182% from 297/ha (for naturally established saplings) to 838/ha i.e., an average spacing of about 3.5x3.5m. In contrast, the density of naturally established saplings taller than 1 m in control plots averaged 509/ha. Sapling density was considerably increased compared with the pre-planting survey (212 saplings/ha), due to recovery of saplings after fire in March-April 1998 (pers. com., Elliott.1999).

Weeding operations significantly altered the character of the ground vegetation. Non-planted control plots, where natural succession was occurring, were dominated by

grasses *Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. ex Hubb. & Vaugh. and *Thysanolaena latifolia* (Roxb. ex Horn.) Honda (both Gramineae), whilst planted plots became dominated by bracken (*Pteridium aquilinum* (L.) Kuhn (Dennstaedtiaceae)) and herbs, especially *Bidens pilosa* L. var. *minor* (Bl.) Sherf, *Ageratum conyzoides* L., *Eupatorium odoratum* L. and *E. adenophorum* Spreng. (all Compositae) and *Commelina diffusa* Burm. F. (Commelinaceae).

Climax Evergreen Forest

The area around Doi-Suthep-Pui Headquarters, 1,000-1,150 m above sea level, was also surveyed to determine which birds might be ingesting tree seeds in primary evergreen forest. The forest canopy was about 30 m tall. Frugivorous bird species and their feeding behaviour were observed for comparison with the degraded areas where forest restoration was in progress. Most importantly, the study attempted to identify which species of birds might disperse seeds from the forest into open degraded areas.

Methods

Survey in forest restoration area.

Bird species were recorded by direct observation, using 8x40 binoculars, noting the time when observed, the bird species name and their distinct behaviour. In addition, specimens of food plants were collected for identification at Chiangmai University Herbarium. The survey was done from December until January in the mornings at about 6:30-10:00 and during the late afternoon at 15:00-18:00. This is the time when birds are most active. Each day, every replicate planted plot and non planted plot was observed for 1-hour totaling 60 hours of observation time.

The species list method developed by MacKinnon (1981) was adapted, using lists of ten species to estimate the number of species not seen at each plot. A list of the first ten different species was made. After that a new list of the next ten different species was

made and so on until ten lists were compiled. No species was entered twice in same list, but the same species could be entered on several separate lists.

A graph of log number of species vs. number of lists (on which that number of species occurs) was plotted and extrapolated back to zero to estimate the number of species occurring on zero lists (i.e., the number of species present, but not observed, during the survey).

Sorensen's index (Odum 1971) was used to show the degree of similarity of the bird communities between the planted and non-planted areas.

Sorensen's Index: $2C/A+B$

A= number of species which found in habitat A

B= number of species which found in habitat B

C= number of species which found both in habitat A and B

$$\frac{\text{Number of migrant species}}{\text{Number of resident species}} = \text{(M/R) value}$$

M/R value is used to estimate the habitat competition. The resource is enough for species that live in each habitat, usually enough for resident birds in that place. However, in migration seasons, migration birds come to share limit resource due to competition between resident and migration birds. If M/R value high, it will mean that there is high competition between two groups.

Survey in evergreen forest

In July-October 1998, four species of fruiting trees i.e., *Ilex umbellulata, Antidesma montanum, Nyssa javanica and Ficus sp* were observed for frugivorous birds. Bird species were recorded by direct observation, using 8x40 binoculars, noting the time

observed, number of bird species and their distinct behaviour. The survey was done by sitting near the tree and observing for 50 minutes at each tree, in the morning at about 6:30-11:00 am.

Chapter 4 RESULTS

A total of 35 bird species were observed during the survey of forest restoration plots and nearby control plots. Non-planted plots supported a substantially more species-rich bird community than planted plots. In non-planted subplots, a total of 33 bird species were observed, compared with only 16 in planted plots. Two species were observed uniquely in non-planted plots, whilst 19 species were observed uniquely in non-planted plots. More species of both migrants and residents were observed in non-planted plots than in planted plots (Table 4.1).

Table 4.1 Comparison of the numbers of bird species between the planted and non-planted plots

	Planted plots	Non-planted plots
Total bird species	16	33
Migrant species	8	13
Resident species	9	20
Uniquely in area	2	19

Using Mackinnon's method (Mackinnon, 1981) to estimate the numbers of unobserved species, yielded estimates of 5 undiscovered species in the planted plots and 8 in the non-planted plots. Figs 4.2 and 4.3 show plots of the log numbers of species recorded on 1, 2, 3…etc lists vs. number of lists. The y-axis intercept indicates the log number of species occurring on zero lists (i.e., the number of unobserved species). The curves should follow a linear regression equation. A typical linear equation is $y=mx+C$, where y and x are the plotted variables, m is slope of the graph and c is the y-axis intercept value. The value of C in the non-planted plots was 0.8678, indicating 8 undiscovered species (Fig. 4.2) and in the planted plots it was 0.5521, indicating 5 undiscovered species (Fig. 4.3). Values of R^2, which indicate closeness of fit between the data and the linear regression equation, were 0.52 and 0.53 ($p>0.05$), indicating low correlation. The

value of R^2 ranges from 0, which indicates no fit, and 1, which represents the highest closeness of fit. Therefore, the estimates of unobserved species cannot be regarded as very reliable.

Fig 4.1 Graph of log frequency (Y-axis) vs number of lists (X-axis) in non-planted plots

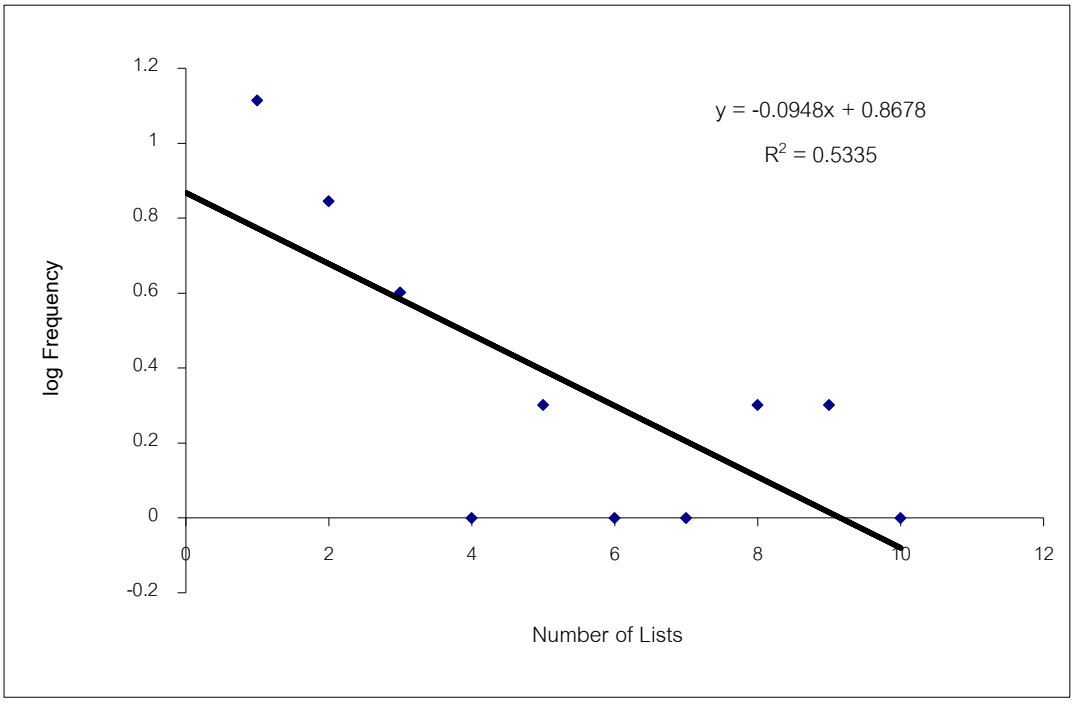
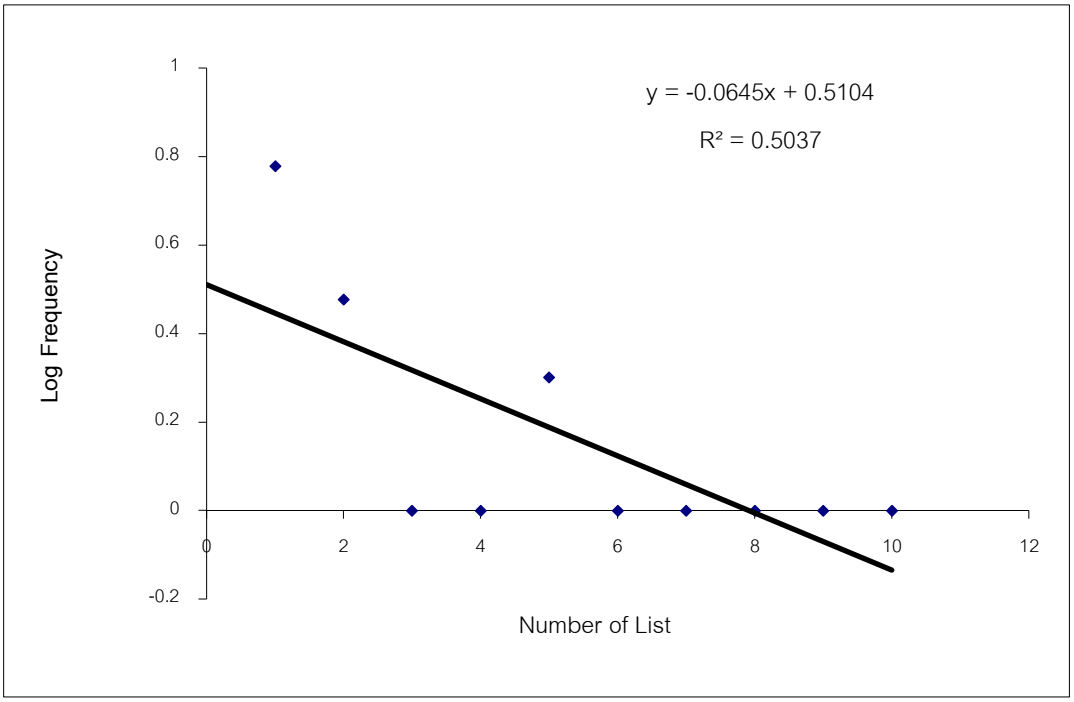


Fig 4.2 Graph of log frequency (Y-axis) vs number of lists (X-axis) in planted plots



Birds usually feed on variety of foods, and are rarely obligate to one type of foods. When I surveyed, Grey In this survey, birds can be divided into 4 groups from author's experiences: frugivore, insectivore, seed predator and carnivore. The percent of each group compared between the two habitats: planted and non-planted plots were a few different. Frugivorous birds are effective species for vegetation recruitment. In planted and non-planted plots, only 12% and 15% were observed (Table. 4.2).

Table 4.2 The percent of birds with different feeding characteristics in planted and non-planted plots.

Feeding type	Planted plots	non-planted plots
% frugivore	12	15.2
% Insectivore	75	72.7
% carnivore	6.3	3
% seed predator	6.3	9

Fig 4.3 Overlap diagram demonstrating the degree of difference in bird communities between planted and non-planted plots. The areas of the squares are proportional to the number of species.

With a total of 33 species found in the non-planted plots, 16 in the planted plots and 14 shared by both habitats, Sorensen's index was calculated as:

$$\frac{2\,x(14)}{16+33} = 0.57$$

In evergreen forest, during observations, a total of 12 bird species were observed feeding in fruiting trees (see table 4.3). Of these, only five species, including three bulbuls (*Pycnonotus jocosus, Pycnonotus aurigaster* and *Pycnonotus flavescens*), a barbet (*Megalamia asiatica*) and the Common Tailorbird (*Orthotomus sutorius*) were also observed in the control plots of the forest restoration area. All except the Common Tailorbird are probable dispersers of small to medium-sized seeds. Two of the bulbuls, *Pycnonotus jocosus* and *Pycnonotus aurigaster*, were observed in the planted plots.

Table 4.3 Frequency of birds in fruiting trees in evergreen forest in twenty hours observation

No. Common name	Scientific name	Total frequency	*Ilex umbellulata* (in 1 hrs.)	*Antidesma montanum* (in 11 hrs.)	*Nyssa javanica* (in 2 hrs.)	*Ficus sp.* (in 2 hrs.)
1. Black-crested Bulbul	*Pycnonotus melanicterus* (F)	26	3	20	-	3
2. Mountain Bulbul	*Hyssipetes mcclellandii* (F)	7	1	4	1	1
3. Puff-throated Bulbul	*Criniger palidus*(F)	15	0	13	1	1
4. Ashy Bulbul	*Hyssipetes flavala*(F)	4	-	3	0	1
5. Blue-throated Barbet	*Megalamia asiatica*(F)	10	-	8	-	2
6. Red-whiskered Bulbul	*Pycnonotus jocosus*(F)	2	1	1	-	-
7. Soothy-headed Bulbul	*Pycnonotus aurigaster* (F)	4	-	4	-	-
8. Asian fairy Bluebird	*Irena puella*(F)	3	-	3	-	-
9. Flavescent Bulbul	*Pycnonotus flavescens* (F)	6	1	5	-	-
10. Blue-winged Leafbird	*Chloropsis cochinchinensis*(F)	5	-	4	1	-
11. Common Tailorbird	*Orthotomus sutorius*(I)	1	-	-	1	-
12. Blacked-naped Monarch	*Hypothymis azurea*(I)	1	-	-	1	-

Birds are catalyst that can accelerate rehabilitation and vegetation recruitment (Tucker & Murphy 1977). Birds which can live in both forest and degraded areas were focused on. They might disperse seeds from remnant forests to degraded areas. There was very little difference between planted and non-planted plots in the percentage of forest-dwelling bird species observed (12% and 15% respectively) (see Table 4.3).

Table 4.4 Percent of species seen in the planted and non-planted plots which can probably disperse seeds and which also live in forest

Treatment	Forest-dwelling species	Seed-dispersing Species	
		Frugivores	Insectivores
planted	50%	12%	31%
non-planted	61%	15%	39%

CHAPTER 5 DISCUSSION

Thirty-three bird species were observed in the non-planted plots. An additional eight species were predicted by the MacKinnon method, making a total of 41 species. In the planted plots, 16 species were observed. An additional five species were predicted by the MacKinnon method, making a total of 21 species. Therefore, predicted total bird species richness in the planted plots was about 49% lower than that in the non-planted plots. Values of R^2 in both plots were intermediate, indicating that predictions of additional non-observed species are not reliable.

Probably the main reason why fewer bird species were found in the planted plots was that frequent weeding was necessary to ensure the survival of the planted trees. This reduced the biomass of the vegetation in the planted plots, niche space and food resources for birds. This meant that fewer bird species could survive in the simpler habitat created after weeding and tree planting. Most of the birds observed were insectivores e.g., the Long-tailed Shrike and Pied Bushchat (*Saxicola caprata*) (Table 4.2). As the weeds provide food for insects, the birds that eat these insects will be reduced where weeding is taking place. Some birds used shrubs in the planted plots for resting. Another reason for the low species richness in the planted plots might be that they were quite open and provided little cover from predators, since many birds habitually need cover to avoid predation (Howe and Kerckhove, 1981).

Frugivores did not form a large percentage of the bird species in both planted and non-planted plots, probably due to the absence of fruiting trees. From Fig 4.3, it might be concluded that rate of recruitment of bird-dispersed plants is probably similar in both planted and non-planted plots, since frugivorous birds are scarce and they are therefore not yet able to act as catalytic agents.

It is expected that, as the forest recovers, bird species richness will increase in the long term. The growing forest will provide greater niche space, as the canopy develops several layers. In addition, the trees will provide food resources, such as fruit, nectar, perches and nesting sites. Under such circumstances it is expected that

frugivorous birds will become more common. It is known that the species diversity of fruit seed rain declines with increase distance from forest (Sharp, 1995). Thus, birds will help vegetation recruitment by dropping seed from regurgitation or defecation when they perch in planted trees or fly across area.

The differences in the composition of the bird communities, between the two habitats, as shown by the value of Sorensen's index, was probably also due to the effects of weeding on habitat structure and availability of food resources, as mentioned above.

In the planted plots, the most common bird species, based on frequency of observations, was the Grey-breasted Prinia (*Prinia hodgsonii).* In non-planted plots, the most common species were the Red-whiskered Bulbul (*Pycnonotus jocosus)* and Grey-breasted Prinia (*Prinia hodgsonii*). In the non-planted plots, Grey-breasted Prinias fed together in flocks of about 5-10. They foraged for insects amongst the fronds of bracken fern (*Pteridium aquilinum*), not more than 1.5 m above the ground. In planted plots, this species was found only at the edges of plots. It seems that the species is well able to live in open grassland areas. However, it is unlikely that the species contributes much to forest restoration, since it is insectivores and does not live in forests.

The Red-whiskered Bulbul (*Pycnonotus jocosus)* is a frugivore. The species is common in pairs and groups in areas inhabited by man such as gardens and in agricultural fields (Portigo, 1994). This species was also observed in evergreen forest but not very frequently. This bird species is undoubtedly an important seed disperser, transporting seeds from forest edge into deforested areas.

Long-tailed Shrikes (*Lanius shach*) were frequently observed perching on shrubs, about 1.5 m above the ground and on the bamboo sticks, used to mark the position of planted saplings. This behaviour was probably a display to mark their feeding territory. This was this reason why this species was not considered to be a dominant species, even though it was frequently observed. Due to each individual protect theirs feeding territory and the same individual might be found in same place. Swifts and swallows (Family

Apodidae and Hirundinidae) were commonly observed flying around both planted and non-planted plots. They catch insects whilst flying. In non-planted plots, swifts and swallows were seen more frequently than in the planted plots, presumably because the non-planted plots provided better habitat for insects. Insectivorous birds help to control insect populations that might infest planted trees.

Birds of prey, such as common buzzard (*Buteo buteo*) and changeable-hawk eagle (*Spizaetus cirrhayus*) were also observed over both planted and non-planted plots. They were probably looking for prey such as small rodents and possibly hares, since a Siamese hare (*Lepus peguensis*) was observed in the non-planted plots, as well as faeces in the planted plots. Planted plots are probably quite attractive to birds of prey because, due to their open nature, prey is easily visible. Therefore, planted plots seem capable of supporting all trophic levels.

Some bird species observed in the non-planted plots were characteristic of secondary forest or evergreen forest (Lekagul and Round 1991), such as the Ashy Drongo (*Dricurus leucophaeus*) and Green-billed Malkoha (*Centropus sinensis*), Velvet-fronted Nuthatch (*Sitta frontalis*), Hill Blue Flycatcher (Cyornis *banyumas*), because a few big trees still remained. Such trees provided microhabitats isolated from the grassland habitat. Species of birds perching in the large trees, give some indication of which bird species might eventually colonise the planted areas, once the trees have grown up.

Most birds do not rely only on fruit for food and several insectivores eat fruit some of the time. It is therefore possible that some insectivores might also act as seed dispersers. For example, the Grey Bushchat, which is an insectivore, was observed to eat fleshy utricle, *Debregeasia longifolia* can probably be assumed that this species is partially frugivore because I saw that whole fruits were eaten. So many bird species can help to disperse seeds into planted areas.

The Flavescent bulbul (*Pycnonotus flavescens*), Brown-breasted Bulbul (*P. xanthorrhous*), Red-whiskered Bulbul (*P. jocosus*), Sooty-headed Bulbul (*P. aurigaster*)

and Blue throated Barbet (*Megalamia asiatica*) are probably good seed dispersers. In evergreen forest in Doi Suthep-Pui National Park headquarters, these species (except *P. xanthorrhous* and *P. jocosus*) were frequently observed to eat large amounts of fruits. The Black-crested Bulbul (*Pycnonotus melanicterus*) and Puff-throated Bulbul (*Ciniger pallidus*) were observed many times, but only in evergreen forest. The Black-crested Bulbul is a most common species in this forest type. Once trees in planted plots have grown tall, this bird species will probably be found in reforested areas. *M. asiatica* is an efficient seed disperser, because it can eat more fruits than the other species. The Blue-winged Leafbird (*Chloropsis cochinchinensis*) is probably not a good seed disperser, since it thoroughly "chews" fruits to separate the pulp from the seeds before ingestion. This damages the seeds by breaking the seed coat and through excessive mechanical scarification, etc. (Jordano 1992). The evergreen survey might not be comparable with the survey in the forest restoration plots since it was carried out in different season. Bird community will change in winter, some frugivore winter migrants arrive such as Thrushes and the species richness will be higher than at the other times of the year.

The common Rosefinch (*Carpodacus erythrinus*) eats mostly grass seeds such as the grain of *Pennisetum polystachiyon* and is probably not a good disperser of grass seeds, since it tends to crush them during eating. The Chestnut Bunting (*Emberiza rutila*) and Cresting Bunting (*Melophus lathami*) were also included to this group.

The total number of bird species observed in this study (35) was exactly the same as the number of bird species observed by Hitchcock (1998) during a survey in the same area in May-June 1998, using the same methods, before planting was carried out and shortly after fires had substantially reduced vegetation cover over the entire area. As he was surveying the area before planting took place, he did not distinguish between planted and non-planted plots. He observed 35 bird species, with an additional 20 species predicted by the MacKinnon method, making a total of 55 species for the whole area. However, the actual species observed were different. In particular, a higher percentage of migrant species (43%) was recorded in December, compared with only 31% recorded by Hitchcock in May-June. When the ratio of resident species to migrants (M/R value) was

calculated, the value was 0.46 in May-June, compared with 0.89 and 0.65 in planted and non-planted plots respectively.

The bird community in the planted plots was only 73 %, and 55% in non-planted plots, calculated by Sorensen's index different to that reported by Hitchcock. It can be hypothesized that weed control in planted plots maintained the openness of the area similar to that found after fire, when Hitchcock carried out his survey. Hitchcock's list included only 11 migrant species (since May-June is not the main migration season). The study reported here recorded 15 migrant species (8 in the planted plots and 14 in the non-planted plots), since the cool season is the main migration season.

Suggested reasons why the study reported here recorded fewer resident bird species than Hitchcock (1988) include:

1. The habitat structure had altered the observability of birds. When Hitchcock carried out his survey, the area had recently been burnt. Lack of thick vegetation allowed birds to be easily seen.

2. It is postulated that there was competition between migrant species and resident species. Since the M/R value is suggested to show the succession and competition due to restriction of habitat resources and niche space between migrant and resident species. Consequently, the resident species which can live in ecotone between grassland and forest, maybe migrant to feed in evergreen forest for decreasing competition. M/R value is 0.46, 0.89 and 0.65 in the May-June survey, planted plots and non-planted plots in this survey. The M/R value were higher in any experiment plots, probably indicating in habitat migration of ecotone species from open area to forest or forest edge when having competition with winter visitor birds.

A major factor responsible for the destruction of forests and their biodiversity is forest fire, caused mostly by local people, when they burn their fields to prepare for cultivation. In the area where forest fire is frequent, some sensitive bird species which live in intact forest, with large trees or lush undergrowth, such as trogons, some woodpeckers,

broadbills and ground Thrushes (*Zoothera sp.*) will disappear. Hunting is another important problem. There used to be five species of Hornbill on Doi Suthep: *Ptilolaemus tickelli, Aceros nipalensis, Rhyticeros undulatus, Anthra coceros albirostris* and *Buceros bicornis,* but now they have been extirpated by hunting (Round 1984). Hornbills are very good seed dispersers, because they have a wide gape and can swallow large fruits and seeds, without damaging them (โอภาส 2541). They fly long distances and, due to their large body size, they do not fear birds of prey and can feed on fruits year-round (Howe 1977). This is similar to Toucans (*Ramphastos* spp.) in S. America which help seed to escape from seed and seedling predators under tree crowns (Howe, *et al.,* 1985) It is possible that some large-seeded tree species might become extirpated, due to the extirpation of hornbills and other large frugivores on Doi Suthep.

However, the bird species richness in this National Park is not be as high as in 1945 and 1981 surveys (Round 1984), since some species have become extirpated already. Hence, it is important to maintain the habitat area and restore degraded area first, increasing resources for upper trophic-level organisms. Then later, re-introducing extirpated species and studying their adjustment for sustaining forest ecosystems.

It can be concluded that restoration forest did not increase bird species richness within the first year after tree planting. Bird species richness was lower than in evergreen forest (Portigo,1994), There were few frugivorous birds which will help to accelerated forest etc. However, future will show the efficiency of the method in this area. The next survey should be done when the trees bear fruit. Only then we can know if they will attract forest frugivores and help succession occur naturally or not.

Chapter 6 CONCLUSIONS

The main conclusion of this study is that forest restoration activities, especially weeding, initially reduces bird species richness of degraded, open grassland areas. The bird species found in plots where forest restoration activities are carried out do not constitute a different bird community to that found in adjacent non-planted plots. Rather they are mostly a smaller subset of the bird species in non-planted areas. The 6–7-month period between tree planting and this survey of the bird communities was not long enough for the planted trees to have a significant effect on the bird community, whilst weeding did have an immediate effect on the bird community, by removing food resources. It is expected that, as the planted trees mature, and begin to provide food and habitat resources, the bird community will increase in diversity and will gradually become similar to that of climax forest. Further surveys are therefore essential to determine whether these hypothesized changes in the bird community actually occur.

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Chapter 8 APPENDICES

Table 8.1 Abundant of Bird species seen during this study and by Hitchcock (1998) in the same area,migration status and feeding habits.

No.	Bird species	Planted plots frequency	Non-planted plots frequency	Also observed by Hitchcock (1998)	Migrant or resident	Frugivore, Insectivore etc*	Also seen in evergreen forest ? (Y/N)	Living in forest habitat?(y/n)
1	*Prinia hodgesonii*	7	9	Y	R	Insectivore	N	N
2	*Hirundo rustica*	3	2	N	M	Insectivore	N	N
3	*Cypsiurus balasiensis*	1	0	Y	R	Insectivore	N	N
4	*Ficedula parva*	5	2	N	M	Insectivore	N	Y
5	*Pycnonotus Aurigaster*	1	3	Y	R	Frugivore	Y	Y
6	*Lanius schach*	8	7	Y	R	Insectivore	N	N
7	*Buteo buteo*	1	0	Y	M	Carnivore	N	Y
8	*Saxicola caprata*	2	8	Y	R	Insectivore	N	N
9	*Pycnonotus jocosus*	1	9	Y	R	Frugivore	Y	Y
10	*Saxicola ferrea*	4	8	N	R	Insectivore	N	N
11	*Delichon dasypus*	2	3	N	M	Insectivore	N	Y
12	*Phylloscopus inornatus*	5	5	N	M	Insectivore	N	Y
13	*Carpodus eryhrinus*	1	2	N	M	Seed predator	N	N
14	*Phylloscopus schwarz??*	1	5	Y	M	Insectivore	N	Y
15	*Chrysomma sinensis*	2	3	Y	R	Insectivore	N	N
16	*Orthotomus sutorius*	1	1	N	R	Insectivore	Y	Y
17	*Centropus sinensis*	0	3	N	R	Insectivore	N	N
18	*Emberiza rutila*	0	2	N	M	Seed predator	N	Y
19	*Spizaetus cirrhatus*	0	1	Y	R	Carnivore	N	Y
20	*Melophus lathami*	0	2	N	M	Seed predator	N	N
21	*Hirudo daurica*	0	1	Y	M	Insectivore	N	Y
22	*Pycnonotus xanthorrhous*	0	6	N	R	Frugivore	N	N
23	*Dicrurus leucophaeus*	0	4	N	R	Insectivore	N	Y
24	*Phaenicophaeus tristis*	0	1	N	R	Insectivore	N	Y
25	*Sitta frontalis*	0	1	N	R	Insectivore	N	Y
26	*Cyornis banyumas*	0	1	N	R	Insectivore	N	Y

Table 8.1 (continued)

27	*Timalia pileata*	0	1	Y	R	Insectivore	N	N
28	*Muscicapa dauurica*	0	2	N	M	Insectivore	N	Y
29	*Lanius collurioides*	0	1	Y	M	Insectivore	N	N
30	*Prinia atrogularis*	0	1	Y	R	Insectivore	N	N
31	*Pycnonotus Flavescens*	0	2	N	R	Frugivore	Y	Y
32	*Megalaima aiatica*	0	1	N	R	Frugivore	Y	Y
33	*Luscinia calliope*	0	1	N	M	Insectivore	N	N
34	*Seiccrcus burkii*	0	1	N	M	Insectivore	N	Y
35	*Orthotomus atrogularis*	0	1	N	R	Insectivore	N	Y

* Some insectivorous bird also eat fruits and might therefore disperse seeds.

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