ESTABLISHING TEST PLOTS FOR ADAPTATION OF THE FRAMEWORK SPECIES METHOD OF FOREST RESTORATION FOR BIODIVERSITY RECOVERY IN DECIDUOUS FOREST ECOSYSTEMS

BRT_R 348006

Bauhinia purpurea

Ficus fistulosa and F. racemosa purpurea

Gmelina arborea- 5 months after planting

STEPHEN ELLIOTT

MARCH 2008

END-OF-PROJECT REPORT TO THE BIODIVERSITY RESEARCH AND TRAINING PROGRAM

1/9/06 – 31/3/08

Project Title

การจัดตั้งแปลงทดสอบการใช้วิธีพรรณไม้โครงสร้างสำหรับการฟื้นฟูป่าเพื่อการอนุรักษ์ในระบบนิเวศป่าผลัดใบ

"Establishing test plots for adaptation of the framework species method of forest restoration for biodiversity recovery in deciduous forest ecosystems" BRT_R 348006

Principal Investigator

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Project Duration

1 year 7 months

Commencement Date (Month/Year):	1st September 2006
Expected Completion Date (Month/Year):	31st March 2008

Scarification is the best treatment to maximize germination success and shorten dormancy of Afzelia xylocarpa seeds (left). Seedlings germinating at FORRU's lowland tree nursery should be ready for planting out in June (above).

SUMMARY

This project is establishing field trials to determine if the framework species method of forest restoration can be successfully adapted to the harsh conditions of lowland deciduous forest sites in N. Thailand. It builds on the achievements of two previous BRT-sponsored projects (BRT 240002 and 344004), which successfully adapted the framework species method to restore upland evergreen forest ecosystems.

The project provides partial support to two tree nurseries (in Chiang Mai and Phrae Provinces), which not only serve as research labs for this project but have also provided thousands of trees to the local community for planting. Germination trials were carried out to determine the most effective techniques to propagate potential framework tree species for deciduous forests. Results for 68 species are presented.

During this project a previously started plot system was expanded by 8 rai: 4 rai at the Phrae Campus of Mae Jo University and 4 rai at Huay Tung Tao, a recreational area run by the Royal Thai Army, a few kilometres north of Chiang Mai City. These plots are testing the field performance of 15 tree species and 4 fertilizer/compost application treatments to ameliorate poor soil conditions. Monitoring results at the end of the first rainy season indicated that good survival and growth rates had been achieved. Initial indications are that more intensive treatments (compost in the planting hole and high rates of fertilizer application) are likely to achieve the best results.

Data from this project were combined with those from previous experiments to create a scoring system to rank species in order of suitability as framework tree species, according to previously established criteria and standards. The 10 most suitable species for restoration of deciduous forests were: - *Eugenia fruticosa (DC.) Roxb., Ficus glaberrima Bl. var. glaberrima, Careya arborea Roxb., Actinodaphine henryi Gamb., Ficus fistulosa Reinw. ex Bl. var. fistulosa, Ficus racemosa L. var. racemosa, Terminalia chebula Retz. var. chebula, Terminalia bellirica (Gaertn.) Roxb., Ficus rumphii Bl.* and *Phyllanthus emblica L.*

The plots are now also being used as an educational resource for training various visitors in forest restoration techniques.

สรุป

โครงการวิจัยนี้มีจุดมุ่งหมายเพื่อจัดตั้งแปลงทดลองสำหรับศึกษาวิธีพรรณไม้โครงสร้างเพื่อการฟื้นฟูป่าที่สามารถปรับใช้ได้กับสภาพแห้งแล้งของป่าผลัดใบในภาคเหนือตอนบนของไทย ซึ่งเป็นการศึกษาที่ต่อเนื่องมาจากความสำเร็จของงานวิจัย 2 โครงการที่ได้รับการสนับสนุนจากโครงการพัฒนาองค์ความรู้และศึกษานโยบายการจัดการทรัพยากรชีวภาพในประเทศไทย (BRT 240002 และ 344004) ซึ่งถือเป็นความสำเร็จในการปรับใช้วิธีพรรณไม้โครงสร้างเพื่อการฟื้นฟูระบบนิเวศป่าไม่ผลัดใบในพื้นที่สูง

โครงการวิจัยนี้ได้สนับสนุนเรือนเพาะชำ 2 แห่ง (ในจังหวัดเชียงใหม่และจังหวัดแพร่) ซึ่งไม่เพียงแต่รองรับการศึกษาวิจัยเท่านั้น แต่ยังผลิตกล้าไม้กว่าพันต้นแก่ชุมชนท้องถิ่นเพื่อการปลูกอีกด้วย นอกจากนี้ยังหาวิธีการที่มีประสิทธิภาพสูงสุดในการเพาะเมล็ดเพื่อเพิ่มประสิทธิภาพแก่พรรณไม้โครงสร้างที่ใช้ในป่าผลัดใบ และได้นำเสนอพรรณไม้ 68 ชนิดในรายงานฉบับนี้

ในระหว่างโครงการนี้ได้มีการทำแปลงทดลองเพิ่มอีกจำนวน 8 ไร่ในเดือนมิถุนายน ได้แก่ แปลงทดลองจำนวน 4 ไร่ที่มหาวิทยาลัยแม่โจ้ วิทยาเขตแพร่เฉลิมพระเกียรติ และแปลงทดลอง จำนวน 4 ไร่ที่บริเวณอ่างเก็บน้ำห้วยตึงเฒ่า ซึ่งเป็นสถานที่อยู่ในความดูแลของกองทัพบก ตั้งอยู่ห่างจากตัวเมืองเชียงใหม่ไปทางทิศเหนือเพียงเล็กน้อย ซึ่งแปลงทดลองทั้ง 2 แห่งนี้ ได้มีการศึกษาวิจัยเกี่ยวกับศักยภาพของต้นไม้ 15 ชนิด และวิธีการใส่ปุ๋ย 4 วิธี เพื่อใช้ในการปรับปรุงคุณภาพของดิน รวมทั้งได้มีการติดตามประเมินผลตลอดจนการดูแลรักษาหลังการปลูกในช่วงฤดูฝนแรกของการปลูก ซึ่งข้อมูลที่ได้จากแปลงทดลองทั้ง 2 แปลง พบว่ามีอัตราการรอดสูงและการเจริญเติบโตดี จากข้อมูลเบื้องต้นแสดงให้เห็นว่าวิธีการที่เข้มข้น ดูว่าจะให้ผลลัพธ์ที่ดีกว่า (การใส่ปุ๋ยรองใต้หลุมที่ปลูกและการใช้ปุ๋ยในปริมาณมาก)

ข้อมูลจากโครงการนี้ได้ใช้ระบบการให้คะแนนแบบเป็นช่วงแก่ชนิดต้นไม้ที่ทดสอบว่ามีความเหมาะสมที่จะเป็นพรรณไม้โครงสร้างอยู่ในระดับใด ซึ่งระบบมีเกณฑ์มาตรฐานจากการเก็บรวบรวมข้อมูลจากการทดลองก่อนหน้านี้ พบว่า 10 ชนิดพรรณที่มีความเหมาะสมจะใช้ในการฟื้นฟูระบบนิเวศป่าผลัดใบประกอบด้วย หว้าขี้กวาง, เครือไทร, กระโดน, ตองลาด, มะเดื่อปล้อง, มะเดื่ออุทุมพร, สมอไทย, สมอพิเภก, โพธิ์ขี้นก และมะขามป้อม

ปัจจุบันแปลงฟื้นฟูป่ายังใช้เป็นแหล่งการเรียนรู้ให้แก่ผู้เยี่ยมชมหลากหลายกลุ่ม ที่เข้ามาเพื่อฝึกวิธีการฟื้นฟูป่า

PROJECT RATIONAL

One of the greatest threats to biodiversity in Thailand is deforestation. Logging for timber and forest clearance, to provide land for agriculture, have not only reduced the total area of wildlife habitat but these activities have also fragmented remaining forest into tiny patches, which are often incapable of supporting viable populations of wild animals and plants. To counter this threat to biodiversity, forest ecosystems must be restored to degraded or deforested areas.

Within national parks and wildlife sanctuaries, where biodiversity conservation is the main objective, tree planting should aim to restore original forest ecosystems as much as possible and to rejoin disconnected forest patches. Although it is impossible to plant all tree species that may once have been present, it is possible to restore similar levels of tree species richness and ecosystem structure and function to those originally present before deforestation. This is termed "forest restoration", in contrast to "reforestation", which refers to any kind of tree planting including establishment of commercial plantations, agro-forestry, social forestry and so on (Elliott, 2000).

The project, reported on here, is attempting to develop a framework species method to restore biodiversity in degraded deciduous forest at two contrasting sites in northern Thailand. The method involves planting 20 to 30 native forest tree species to shade out weeds and attract seed-dispersing wildlife into planted areas. Tree species are selected for rapid growth and dense spreading canopies, which enable them to "recapture" sites. Framework tree species should also provide resources for wildlife, such as fruits, nectar or roosting sites for birds or mammals, at an early age. Wildlife species, attracted into the plots, bring seeds with them from other (non-planted) forest tree species. When those seeds germinate, they gradually increase tree species diversity in the planted plots and restore the original tree species composition.

This approach was originally conceived to restore tropical forest to degraded areas within Queensland's Wet Tropics World Heritage Area (Goosem and Tucker, 1995) and has subsequently been modified, very successfully, to bring about rapid biodiversity recovery in upland evergreen forests in northern Thailand by two previous BRT projects (see reports on BRT 240002 & 344004, Elliott et al., 2003).

The research reported here is necessary because the environmental conditions in lowland deciduous forest sites are very different to those of upland evergreen forest sites. Temperatures are higher, soils tend to be more degraded and drier and human impacts are more intense. The tree species that grow under these conditions are very different from those that have proved to be successful framework species at higher elevations. Since human populations are denser at lower elevations, both environmental degradation and the demand for restoration are higher in the lowlands than in the uplands.

The first and most critical step in adapting the framework species methods to any new forest type is tree species selection. Therefore, it is first necessary to use existing data to select "candidate" or potential framework species most suited to the harsh conditions of lowland sites and then to test, with field trials, the extent to which each candidate species actually matches framework criteria. Therefore, this project is establishing experimental plots to test candidate framework tree species in two contrasting sites on degraded deciduous forest land in northern Thailand.

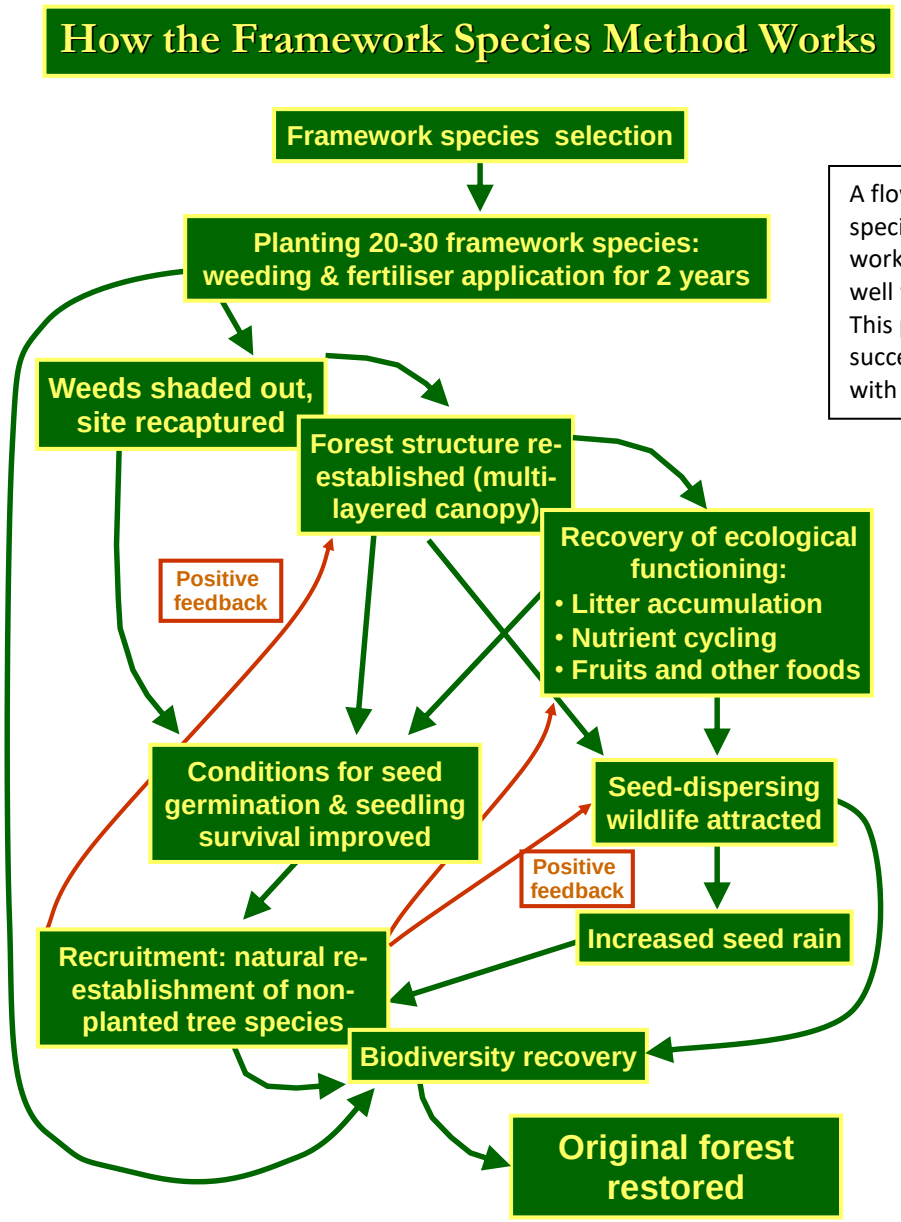
PROJECT OBJECTIVES

1. To propagate saplings of candidate framework tree species, likely to be suitable for enhancing biodiversity recovery in degraded deciduous forest ecosystems.

2. To establish field trial plots at two locations in northern Thailand to assess for each planted tree species i) the degree to which they meet the criteria of framework species for restoration of deciduous forest ecosystems and ii) their responses to various silvicultural treatments.

3. To create an educational and research resource that can be used to encourage forest restoration projects for biodiversity recovery in northern Thailand and neighbouring regions.

4. To collect baseline data on biodiversity levels that will enable biodiversity recovery to be monitored in subsequent studies.



A flowchart of how the framework species method of forest restoration works in theory. The method works well with upland evergreen forest. This project is testing whether successful results can be achieved with lowland, deciduous forest.

RESULTS AND ACHIEVEMENTS

Nursery Support and Training

Part of the project budget has been used to provide partial support to two tree nurseries to produce seedlings of a wide range of candidate framework species, suitable for planting in lowland deciduous forests. The two tree nurseries are i) FORRU's tree nursery at Doi Suthep, which, supplied trees for planting at the Mae On and at the Huay Tung Tao field plots sites and ii) an additional small nursery at the Phrae campus of Maejo University, which produces trees for planting in the forestry demonstration plot area there.

In Chiang Mai, the project partly supported the salary of Nursery Manager, Kuhn Cherdsak Kuaraksa and Nursery Technician, Kuhn Thonglaw Seethong. At Maejo University, Phrae Campus, Ach. Lamthai Asanok manages seedling production with Kuhn Piyaphong Meepanya as nursery technician. In addition to working on seedling production Kuhn Piyaphong also carried out monthly surveys of flowering and fruiting of 71 tree species for comparison with a similar study carried out previously in Chiang Mai and to determine geographical variability in optimal seed collection times.

During this project period, training of Kuhn Piyaphong was provided by the FORRU team at Chiang Mai University for 6 weeks from April till mid-May 2007. During that time, Kuhn Piyaphong was trained in seed collection techniques, germination experiments, nursery production procedures, planting, maintenance and monitoring techniques.

Furthermore during the course of this project, these nurseries donated about 21,000 trees to various community tree planting projects and to the DNP/RFD, resulting in a substantial input of indigenous forest tree species into the local landscape. From the CMU nursery, 100 seedlings of 3 species were donated to Wat Maesai for planting around the temple grounds; 1,500 seedlings to the Royal Project (Doi Om Pine, Mae Jam); 10,000 seedlings to Doi Suthep-Pui National Park and 500 seedlings to Ban Kad School. More recently, 1,800 seedlings of 30 species provided to two communities in N. Thailand under the Eden Project (Pong, Pa Yao Province and Mae Jam, Chiang Mai); 500 seedlings were provided to the 3rd Army for planting at Huay Tung Tao (in addition to those planted by FORRU); 500 seedlings were donated to Doi Inthanon National Park; 300 seedlings to Mae Sa Mai Royal Project; 2,000 seedlings to the Animal Rescue foundation at Doi Tao, Chiang Mai; 1,000 seedlings to Doi Suthep Pui National Park and 300 seedlings to Ban Mae Sa Mai School. In the past 6 months 600 seedlings were provided to the RFD nursery at Mae On; 100 seedlings to Temples in Chiang Mai and Chiang Rai; 60 seedlings to Prem International Centre, for planting around the school campus to support World Environment Day; 1,000 seedlings to EGAT, Chiang Mai; 200 seedlings to the Saun Tawan NGO, Mae Rim, Chiang Mai and 200 seedlings to the DNP for planting in Phrae and Chiang Mai.

The Mae Jo university nursery in Phrae province contributed trees to Wat Pha Wiveakaram on late October 2007, about 500 seedlings of 10 species, which were planted on degraded land around the temple by MJU students.

Seedling production at the MJU Phrae Campus; project partner Mr Lamthai Asanok (left) and nursery technician Kuhn Piyphong (right).

Growing the Trees

All trees were grown from seeds collected locally from remnant forest patches or isolated surviving forest trees. Monthly trips were made to inspect likely seed trees and collect seeds from those found in fruit. Since "ease of propagation" is one of the framework criteria, seeds were subjected to various treatments to determine the most effective way to germinate them. The aim was to maximize germination percentage and shorten the length of dormancy, to allow seedlings to attain a plantable size as quickly as possible, whilst minimizing consumption of nursery space and resources. The treatments applied to each species depended on the seed structure, as well as both local knowledge and available literature. Each germination experiment consisted of a control (no treatment) and one or more treatments, replicated three times. Treatments tested included i) soaking in cold water for 24 hours; ii) soaking in cold water for 48 hours; iii) soaking in hot water and left to cool overnight; iv) acid and v) scarification (chipping away at a hard seed coat (large seeds) or abrasion with sand paper (small seeds)). These treatments were designed to i) make the seed covering more permeable to allow water and oxygen to penetrate more rapidly to the embryo and/or ii) dissolve out chemical inhibitors of germination.

The most effective treatments identified for each species test are presented in Table 1. During this project, 51 species were tested at the FORRU-CMU nursery and 30 at MJU; a total of 68 species (since some species were tested at both nurseries).

Seasonal cycles of seed availability (reflected by numbers of species collected each month) and germination were clearly visible in the data. Seed availability peaked at the beginning of the dry season November (13 species), gradually declining to 0 by the middle of the rainy season (August). In contrast, median germination month peaked sharply at the end of the hot, dry season (March) and declined during the rainy season.

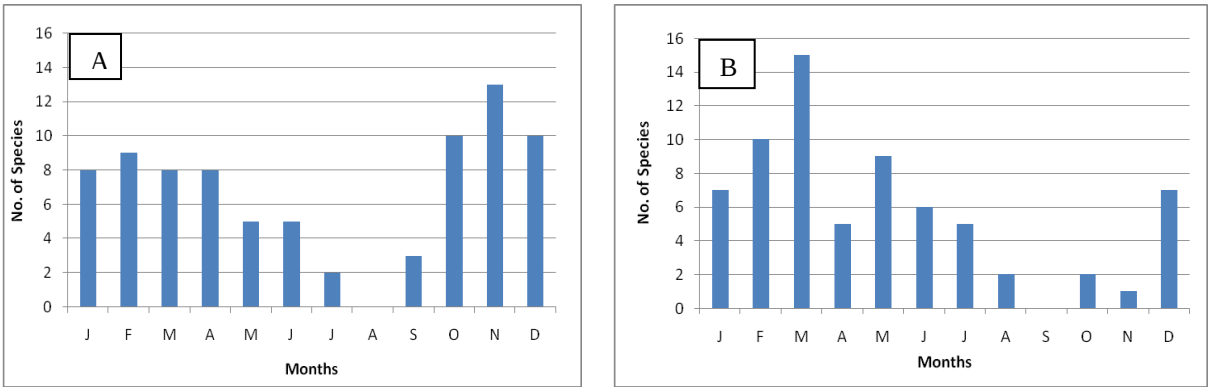


Figure 1. A: Numbers of species collected each month (reflecting seed availability) and B: Numbers of species with median date of germination falling in each month.

A tendency for seed of forest tree species to germinate at the beginning of the rainy season allows maximum time during the rainy season for root systems to develop deep enough to supply trees with moisture during the dry season. Dormancy was remarkably short (compared with our data for evergreen forest tree species) and showed no obvious season cycle. The average MLD ranged from 20 to 40 days for seeds collected November to August, with a minimum value for seeds collected in September (average of 18 days) and a maximum value for seeds collected in October (49 days). The shortness of the seed dormancy periods is probably due to the high efficiency of the treatments that were applied.

Table 1 – Results of germination tests at FORRU-CMU and MJU tree nurseries

Species	Date Seed Collection	Most effective treatment	Sowing Date	Maximum % Germination Achieved	Median Germination date	Median Length of Dormancy (days)	CMU/ MJU
Acacia catechu	7 Mar 07	Soaking overnight	5 Mar 07	72	3 Apr 07	30	M
Adenanthera microsperma	25 Oct 06	Soaking 2 nights	1 Nov 06	67	3 Dec 06	33	C
Adenanthera microsperma	12 Feb 07	Hot water	5 Mar 07	79	3 May 07	60	M
Aegle marmelos	24 Jul 07	Soaking 1 night	28 Jul 07	22	19 Aug 07	22	C
Afzelia xylocarpa	19 Apr 07	Scarification	3 May 07	65	22 May 07	19	C
Afzelia xylocarpa	7 Nov 07	Scarification	21 Jan 08	80	18 Feb 08	29	M
Albizia lebbeck	25 Feb 07	Scarification	28 Feb 07	96	3 Mar 07	3	C
Albizia lebbeck	12 Nov 07	Hot water	10 Jan 08	11	25 Jan 08	15	M
Albizia lebbeckoides	7 Mar 07	Hot water	14 Mar 07	72	12 Apr 07	30	M
Albizia lucidior	10 Jan 08	Ongoing	19 Jan 08	Ongoing	Ongoing	Ongoing	C
Alstonia scholaris	26 Feb 07	Control	28 Feb 07	62	14 Mar 07	14	C
Alstonia scholaris	7 Mar 07	Soaking overnight	14 Mar 07	78	22 Apr 07	40	M
Aphanamixis polystachya	27 Feb 07	Control	28 Feb 07	91	9 Mar 07	9	C
Artocarpus lakoocha	27 May 07	Control	29 May 07	92	19 Jun 07	21	C
Bauhinia purpurea	25 Feb 07	Control	28 Feb 07	85	14 Mar 07	14	C
Bauhinia saccocalyx	4 Jan 07	Control	10 Jan 07	72	8 Feb 07	30	M
Bauhinia variegata	10 Oct 07	Hot water	6 Feb 08	94	27 Feb 08	22	M
Bridelia retusa	10 Jan 08	Ongoing	19 Jan 08	Ongoing	Ongoing	Ongoing	C
Butea monosperma	19 Apr 07	Control	22 Apr 07	57	3 May 07	11	C
Canarium subulatum	19 Sep 07	Control	10 Jan 08	83	14 Feb 08	36	M
Careya arborea	27 May 07	Control	4 Jun 07	69	18 Jun 07	14	C
Cassia bakeriana	8 Feb 07	Acid	15 Feb 07	17	23 Apr 07	67	C
Cassia bakeriana	11 Jun 07	Hot water	15 Jun 07	22	20 Jul 07	36	M
Cassia fistula	11 Jun 07	Soaking overnight	15 Jun 07	20	14 Jul 07	30	M
Dalbergia oliveri	3 Nov 06	Hot water	6 Nov 06	85	25 Dec 06	50	M
Dalbergia cultrata	3 Nov 06	Hot water	6 Nov 06	75	5 Dec 06	30	M
Dalbergia nigrescens	6 Nov 06	Soaking overnight	14 Nov 06	55	2 Jan 07	50	M
Dillenia parviflora	11 May 07	Soaking 1 night	14 May 07	45	24 Jun 07	41	C
Dillenia pentagyna	19 Apr 07	Control	25 Apr 07	8	31 Jul 07	97	C
Diospyros ehretioides	23 Nov 06	Control	25 Nov 06	6	24 Feb 07	91	C
Diospyros mollis	24 Apr 07	Hot water	30 Apr 07	45	28 Jun 07	60	M
Diospyros mollis	4 Dec 06	Control	12 Dec 06	59	9 Mar 07	87	C
Erythrina subumbrans	30 Nov 06	Hot water	12 Dec 06	76	25 Jan 07	45	M
Eugenia cumini	21 Jun 07	Soaking 1 night	23 Jun 07	84	14 Jul 07	21	C
Eugenia fruiticosa	23 May 07	Control	26 May 07	98	18 Jun 07	23	C
Ficus annlata	12 Dec 07	Soaking overnight	7 Feb 08	66	28 Feb 08	22	M
Ficus benghalensis	20 Dec 06	Control	4 Jan 07	42	21 Jan 07	17	C
Ficus benjamina	20 Feb 08	Ongoing	27 Feb 08	Ongoing	Ongoing	Ongoing	C

Species	Date Seed Collection	Most effective treatment	Sowing Date	Maximum % Germination Achieved	Median Germination date	Median Length of Dormancy (days)	CMU/ MJU
Ficus collosa	20 Nov 06	Control	26 Nov 06	97	7 Dec 06	11	C
Ficus fistulosa	20 Mar 07	Control	29 Mar 07	64	21 Jun 07	84	C
Ficus fistulosa	12 Nov 07	Control	7 Feb 08	24	6 Mar 08	28	M
Ficus hispida	8 Jun 07	Control	22 Jun 07	90	6 Jul 07	14	C
Ficus maclellandii	12 Dec 07	Hot water	14 Feb 08	62	20 Mar 08	35	M
Ficus microcarpa	29 Dec 06	Control	8 Jan 07	90	30 Jan 07	22	C
Ficus racemosa	9 Jan 08	Ongoing	17 Jan 08	Ongoing	Ongoing	Ongoing	C
Ficus racemosa	12 Nov 07	Control	7 Feb 08	69	14 Feb 08	8	M
Ficus rumphii	9 Jan 08	Ongoing	17 Jan 08	Ongoing	Ongoing	Ongoing	C
Flacourtia indica	21 Sep 06	Control	24 Sep 06	69	12 Oct 06	18	C
Garuga pinnata	4 Jul 07	Control	11 Jul 07	35	20 Aug 07	39	C
Gmelina arborea	19 Apr 07	Control	25 Apr 07	39	11 May 07	16	C
Holoptelea intergrifolia	5 Mar 07	Control	8 Mar 07	84	18 Mar 07	10	C
Ilex umbellulata	16 Sep 07	Not germinated	16 Sep 07	0	-	-	C
Irvingia malayana	26 Oct 07	Control	3 Nov 07	64	18 Jan 08	76	C
Lagerstroemia calyculata	9 Apr 07	Hot water	20 Apr 07	27	30 May 07	41	M
Lagerstroemia speciosa	15 Mar 07	Control	18 Mar 07	38	1 May 07	44	C
Melia azedarach	10 Oct 07	Control	15 Feb 08	63	21 Mar 08	35	M
Melia toosendan	25 Dec 07	Ongoing	9 Jan 08	Ongoing	Ongoing	Ongoing	C
Microcos paniculata	1 Dec 07	Ongoing	14 Dec 07	Ongoing	Ongoing	Ongoing	C
Millettia leucantha	30 Nov 06	Soaking overnight	12 Dec 06	92	10 Jan 07	30	M
Oroxylum indicum	2 Jan 08	Soaking overnight	4 Jan 08	89	1 Feb 08	40	M
Oroxylum indicum	8 Feb 07	Control	10 Feb 07	94	22 Feb 07	12	C
Phyllanthus emblica	26 Jan 07	Scarification	1 Feb 07	84	3 Mar 07	31	C
Phyllanthus emblica	10 Oct 07	Soaking overnight	10 Jan 08	85	7 Feb 08	32	M
Protium serratum	15 Oct 07	Control	16 Oct 07	40	14 Nov 07	29	C
Pterocarpus macrocarpus	25 Feb 07	Scarification	1 Mar 07	25	18 Mar 07	17	C
Pterocarpus macrocarpus	6 Nov 06	Soaking overnight	14 Nov 06	40	14 Dec 06	30	M
Quercus kerrii	15 Oct 07	Control	17 Oct 07	74	28 Oct 07	11	C
Schleichera oleosa	25 Jun 07	Ongoing	29 Jun 07	Ongoing	Ongoing	Ongoing	C
Shorea roxburghii	19 Apr 07	Control	20 Apr 07	57	7 May 07	17	C
Sindora siamensis	4 Dec 06	Hot water	12 Dec 06	72	26 Dec 06	14	C
Sindora siamensis	23 Dec 06	Scarification	10 Jan 07	47	10 Mar 07	60	M
Spondias pinnata	22 Nov 07	Ongoing	1 Dec 07	Ongoing	Ongoing	Ongoing	C
Spondias pinnata	14 Dec 07	Control	14 Feb 08	40	13 Mar 08	28	M
Styrax benzoides	14 Oct 06	Control	15 Oct 06	65	14 Mar 07	150	C
Terminalia bellerica	10 Mar 07	Soaking 2 nights	14 Mar 07	90	19 Apr 07	36	C
Terminalia bellerica	4 Oct 07	Control	21 Jan 08	92	17 Mar 08	56	M
Terminalia chebula	9 Jan 08	Ongoing	14 Jan 08	Ongoing	Ongoing	Ongoing	C
Vitex peduncularis	28 Oct 07	Control	1 Nov 07	60	16 Dec 07	45	C
Wrightia arborea	6 Apr 07	Soaking overnight	20 Apr 07	64	19 May 07	30	M
Xantolis burmanica	29 Mar 08	Ongoing	31 Mar 08	Ongoing	Ongoing	Ongoing	C
Xylia xylocarpa	9 May 07	Control	10 May 07	76	22 May 07	12	C

Plot Establishment

In June 2007, 4 rai of experimental plots were established at MJU Campus, Phrae Province and 4 rai at Huay Thung Tao, Chiang Mai Province, to i) evaluate field performance of candidate framework tree species and ii) test various treatments to ameliorate the harsh soil conditions, typical of lowland deciduous forest land. The previously established plot system at Mae Ow, Lampang Province, had to be abandoned due to forest fire. Under this project, those plots were useful only for determining survival of planted tree species following fire.

Huay Thung Tao Site Description

New plots were planted at Huay Tung Tao, about 10 km north of Chiang Mai city, where fire prevention is easier. The land is under the control of the Royal Thai Army and trees were planted as part of celebrations marking the 80th birthday of His Majesty the King. The site is adjacent to boundary of Doi Suthep-Pui National Park, and lies at an elevation of 360 m, about 10 km north of Chiang Mai city. This highly degraded, ex-deciduous dipterocarp-oak forest site had almost no tree cover. The area planted formed a riparian strip along both banks of a small stream, running from the forested lower slopes of Doi Suthep-Pui National Park between two reservoirs, where bird populations become concentrated. The area is known for its high species diversity of birds and is being developed as a bird sanctuary by the army and the Lanna Bird Club. Ground covered consisted mostly of scattered clumps of grasses interspersed with bare soil. The soil was degraded, with top soil and leaf litter largely absent. The site was planted on June 9th 2007.

MJU Phrae Campus Site Description

Experimental plots were established in a demonstration area for community forestry on the university campus. There were very few stunted remnant trees on the including *Memecylon scettellatum, Cratoxylum formosum* and *Strychnos nux-vomica* etc., all indicative of heavy browsing by cattle in the past. Ground cover was also very sparse, with a few grasses and *Eupatorium adenophorum*. The condition of the soil was also poor, containing a high density of rocks and gravel. The plots were positioned between secondary forest and teak plantation, at an elevation of 250 m above sea level.

Aerial view of community forest area at MJU Phrae campus, within which the plots are located

Soil Conditions

Soil analysis was completed in the first project period. New analyses of the soil are currently being undertaken with soil from the Huay Thung Tao site. We are awaiting results from the laboratory. Five-kilogram combined soil samples were collected from each site. These samples underwent analysis at the laboratory of Faculty of Agriculture, Chiang Mai University for texture, pH, organic matter, available N, P and K and field capacity. The results are present in Table 2 below.

Table 2 – Soil Properties at the field sites

	Mae Ow	MJU-Phrae
Sand (%)	65.32	59.66
Silt (%)	14.50	29.62
Clay (%)	20.18	10.72
Texture	Sandy loam	Sandy loam
pH	6.23	5.85
OM (g/100g)	4.05	2.94
Total N (g/100g)	0.15	0.05
P (mg/kg)	7.93	6.31
K (mg/kg)	165.98	34.12

This project included monitoring of plots planted at Mae Ow in 2006, as well as the more recent Huay Thung Tao plots (planted 2007).

2006 Plots - Experimental Design

The same experimental design was adopted at both sites. Four rai were planted with 300 tree saplings of 15 species (20 individuals per species, table 3) and one rai was demarcated as a non-planted control plot for comparison. Different treatments were applied in each of the four planted rais, designed to address the problem of poor soil condition and nutrient status:-

Rai 1 Fill + 100 g fertilizer + 2 times during rainy season
Rai 2 No fill + 100 g fertilizer + 2 times during rainy season
Rai 3 No fill + 100 g fertilizer + 4 times during rainy season
Rai 4 No fill + 200 g fertilizer + 2 times during rainy season

“Fill” refers to filling half of each planting hole with commercial nursery-grade compost (Din Lamduan brand composed of rice husk, burnt husk, composted weeds, coconut husk, sand and soil) and mixing it 50:50 with the local soil before planting each sapling into the mix and applying fertilizer. The fertilizer used was the locally produced, organic Pho Karuna brand (N P K, bat, chicken and cow dung, sugarcane, cassava, rice and green bean, mycorrhizae and rhizobium). After planting, fertilizer was applied in a ring 10-20 cm away from the stems of the saplings; a circular mulch mat (40-60 cm in diameter) was laid around

each sapling and pegged in place with a bamboo pole. Finally each tree was watered with about 3-4 litres. The work program followed to establish the plots is presented in table 3.

Table 3 - Work plan for 2006 plots (established under previous BRT project)

Events	Mae Ow (Lamphun)	Mae Jo (Phrae)
Field trip to plan establishment of experimental plots	2 MAY 2006	9 MAY 2006
Lay out plots (4 rais + 1 rai of CONTROL) & collect soil sample for analysis	20 MAY 2006	7 JUL 2006
Transfer seedlings to sites	12 JUL 2006	4 JUL 2006
Digging the holes	12 JUL 2006	8 JUL 2006
Planting days	15 JUL 2006	8 JUL 2006
1st Monitoring after planting	7 AUG 2006	25-27 JUL 2006
Weeding and fertilizer applications (1)	1 SEP 2006	4 AUG 2006
Weeding and fertilizer applications (2)	29 SEP 2006	1 SEP 2006
Weeding and fertilizer applications (3)	27 OCT 2006	29 SEP 2006
Weeding and fertilizer applications (4)	24 NOV 2006	27 OCT 2006
2nd Monitoring after rainy season	7th DEC 2006	16th DEC 2006

Monitoring of 2006 plots – end first rainy season

Mortality

To determine mortality during the first rainy season after planting out, monitoring of the planted trees was completed at Mae Ow on 7th December 2006 by FORRU staff and at MJU-Phrae on 16th December 2006 by agro-forestry students of Mao Jo University. Mortality rates are presented in Tables 4 and 5.

At Mae Ow, survival averaged about 80% across species and treatments, which was higher than expected, considering the very poor soil conditions of the site. Highest overall survival was achieved with the fill treatment + 100 g fertilizer. Previously published standards classified species with >70% as “excellent” and 50-69.9% as “acceptable” (Elliott et al., 2003). All species achieved the basic standard and the majority (11 out of 15) were on track to be ranked as “excellent”.

In contrast at Mae Jo, mortality rates were much higher. This was due to flooding of the site, shortly after planting, which waterlogged the soil, particularly in rai nos. 1 and 2. In addition the soil nutrients were much lower at this site (see table 2). Therefore, at the Mae Jo site, only four species could be ranked as “excellent” (*Gmelina arborea, Holoptelea intergrifolia, Phyllanthus emblica* and *Terminalia bellirica*). In addition, four species failed to meet the 50% survival target, although those same species were ranked as excellent at the Mae Ow site (*Afzelia xylocarpa, Irvingia malayana, Eugenia fruticosa* and *Albizia lebbeck*). Perhaps the latter were unable to cope with waterlogged soil conditions during the flood.

Table 4 – Per cent mortality after 1st rainy season by species and treatment at Mae Ow

Species	Survival Class*	Rai 1 Fill + 100x2	Rai 2 No fill +100x2	Rai 3 No fill +100x4	Rai 4 No fill +200x2	Species Average
Adenanthera microsperma Teijsm. & Binn	E	15	10	10	10	11.2
Afzelia xylocarpa (Kurz) Craib	E	5	5	10	5	6.2
Albizia lebbeck (L.) Bth.	E	20	10	10	5	11.2
Bauhinia purpurea L.	E	0	10	15	25	12.5
Eugenia fruticosa DC.	E	10	30	40	35	28.7
Gardenia obtusifolia Roxb. ex Kurz	E	23	30	20	10	20.9
Gmelina arborea Roxb.	A	50	15	70	20	38.7
Holoptelea integrifolia (Roxb.) Planch.	E	30	25	30	15	25.0
Irvingia malayana Oliv. Ex Benn.	E	35	20	35	20	27.5
Lithocarpus polystachyus (A. DC.) Rehd.	A	20	50	50	20	35.0
Phyllanthus emblica L.	A	40	20	40	20	30.0
Pterocarpus macrocarpus Kurz	E	15	5	10	20	12.5
Sindora siamensis Teysm. ex Miq. var *siamensis*	E	5	5	0	15	6.2
Strychnos nux-vomica L.	A	15	35	55	20	31.2
Terminalia bellirica (Gaertn.) Roxb.	E	15	10	10	5	10.0
Treatment Average>>>		16.3	27.0	18.7	19.9	20.3

*E=excellent; A=acceptable; M=marginal; R=rejected

Table 5 – Per cent mortality after 1st rainy season by species and treatment at Mae Jo.

Species	Survival Class*	Rai 1 Fill + 100x2	Rai 2 No fill +100x2	Rai 3 No fill +100x4	Rai 4 No fill +200x2	Species Average
Adenanthera microsperma Teijsm. & Binn	A	60	25	5	5	23.8
Afzelia xylocarpa (Kurz) Craib	R	85	60	75	70	72.5
Albizia lebbeck (L.) Bth.	R	95	65	55	60	68.8
Bauhinia purpurea L.	A	25	30	30	20	26.3
Eugenia fruticosa DC.	R	95	75	50	70	72.5
Gardenia obtusifolia Roxb. ex Kurz	A	35	45	10	20	27.5
Gmelina arborea Roxb.	E	35	25	5	15	20.0
Holoptelea integrifolia (Roxb.) Planch.	E	5	15	5	10	8.8
Irvingia malayana Oliv. Ex Benn.	R	100	100	100	15	78.8
Lithocarpus polystachyus (A. DC.) Rehd.	A	25	30	15	100	42.5
Phyllanthus emblica L.	E	5	15	15	10	11.3
Pterocarpus macrocarpus Kurz	A	60	55	35	40	47.5
Sindora siamensis Teysm. ex Miq. var *siamensis*	A	100	20	5	5	32.5
Strychnos nux-vomica L.	A	50	50	35	25	40.0
Terminalia bellirica (Gaertn.) Roxb.	E	25	5	15	25	17.5
Treatment Average>>>		53.3	41.0	30.3	32.7	39.3

*Badly affected by flooding shortly after planting

Table 6 – Mean sapling heights at end of first rainy season at Mae Ow

Species	Survival Class*	Rai 1 Fill + 100x2	Rai 2 No fill +100x2	Rai 3 No fill +100x4	Rai 4 No fill +200x2	Species Average
Adenanthera microsperma Teijsm. & Binn	R	48.5	37.9	41.3	44.3	43.00
Afzelia xylocarpa (Kurz) Craib	A	62.3	54.2	59.8	60.3	59.16
Albizia lebbeck (L.) Bth.	A	68.7	62.3	64.7	76.1	67.92
Bauhinia purpurea L.	E	111.9	94.5	89.6	91.8	96.97
Eugenia fruticosa DC.	A	58.2	54.0	61.6	58.2	58.02
Gardenia obtusifolia Roxb. ex Kurz	R	39.9	39.7	39.6	43.5	40.67
Gmelina arborea Roxb.	A	63.1	51.7	50.2	61.4	56.59
Holoptelea integrifolia (Roxb.) Planch.	A	62.3	56.4	58.6	56.7	58.52
Irvingia malayana Oliv. Ex Benn.	M	38.8	46.1	50.6	48.9	46.11
Lithocarpus polystachyus (A. DC.) Rehd.	A	53.9	57.2	58.4	52.9	55.60
Phyllanthus emblica L.	E	83.6	72.8	68.2	71.4	74.03
Pterocarpus macrocarpus Kurz	M	50.7	50.9	56.6	40.6	49.71
Sindora siamensis Teysm. ex Miq. var *siamensis*	A	59.2	59.0	62.8	60.7	60.44
Strychnos nux-vomica L.	R	27.5	27.0	26.3	25.6	26.60
Terminalia bellirica (Gaertn.) Roxb.	A	52.4	53.3	58.1	59.4	55.81
Treatment Average>>>		58.74	54.47	56.43	56.80	

*E=excellent; A=acceptable; M=marginal; R=rejected

Table 7 – Mean sapling heights at end of first rainy season at Mae Jo

Species	Growth Class	Rai 1 Fill + 100x2	Rai 2 No fill +100x2	Rai 3 No fill +100x4	Rai 4 No fill +200x2	Species Average
Adenanthera microsperma Teijsm. & Binn	R	47	54	46	14	40.4
Afzelia xylocarpa (Kurz) Craib	M	45	44	53	54	48.9
Albizia lebbeck (L.) Bth.	A	66	68	53	57	61.1
Bauhinia purpurea L.	A	80	75	45	69	67.1
Eugenia fruticosa DC.	A	71	79	50	66	66.3
Gardenia obtusifolia Roxb. ex Kurz	R	36	47	28	40	37.5
Gmelina arborea Roxb.	A	29	53	100	72	63.5
Holoptelea integrifolia (Roxb.) Planch.	R	68	50	30	26	43.4
Irvingia malayana Oliv. Ex Benn.	R	0	0	0	45	11.3
Lithocarpus polystachyus (A. DC.) Rehd.	A	74	85	62	0	54.9
Phyllanthus emblica L.	R	5	40	19	25	22.1
Pterocarpus macrocarpus Kurz	R	37	34	28	29	32.1
Sindora siamensis Teysm. ex Miq. var *siamensis*	R	0	26	36	14	18.9
Strychnos nux-vomica L.	A	66	71	59	60	64.2
Terminalia bellirica (Gaertn.) Roxb.	A	65	30	52	55	50.5
Treatment Average>>>		45.9	50.4	44.0	41.6	45.5

* Badly affected by flooding shortly after planting

Monitoring of 2006 plots – end of second rainy season

Protection of the plots from fire became a major problem in 2007. Despite project support for cutting of fire breaks around the plots and providing support for local forest officers to maintain fire prevention patrols, fire swept through the Mae Ow plots in Feb 2007. This meant that mortality of the trees planted in June 2006 was very high. Those trees that survived had to re-grow from root collar buds, so growth was knocked back as well. However, this event provided an opportunity to assess relative resilience of the various species planted after fire. We scheduled extra monitoring activities to assess that and the results for the fire resilience study are presented in the next section. Results presented here are for the standard end-of-second-rainy-season monitoring, used to evaluate species concurrence with framework standards. Second monitoring at Mae Jo was not carried out since so few trees survived.

Fire resulted in no tree species achieving acceptable survival rates (Table 8). Lowest mortality rate was for *Sindora siamensis*, but it was still >50%, which is considered unacceptable for framework species. However, the species listed in Table 8 should not all be rejected as potential framework species, since their survival rates would obviously be higher in the absence of fire. Since fire had burnt back the shoots of trees, mean root collar diameter was used instead of tree height to compare tree size among species. Species with highest growth included *Afzelia xylocarpa Albizia lebbeck Bauhinia purpurea Gardenia obtusifolia Gmelina arborea, Sindora siamensis* and *Terminalia bellirica.* Mean growth across species was higher with the high fertilizer treatments (Rai 3 & 4)

Despite protecting the Mae Ow plots with fire breaks and fences, they eventually had to be abandoned due to burning and cattle invasion, which caused unacceptably high mortality of the planted trees and distorted data on survival and growth of the tested species.

However, the fires did provide an opportunity to collect data on the ability of each tree species to recover after burning - an important framework characteristic.

Table 8 – Percent mortality after 2nd rainy season by species and treatments at Mae Ow

	Rai 1	Rai 2	Rai 3	Rai 4	
Species	**Fill + 100x2**	**No fill +100x2**	**No fill +100x4**	**No fill +200x2**	**Species Means**
Adenanthera microsperma	55	85	60	70	67.5
Afzelia xylocarpa	95	75	90	80	85
Albizia lebbeck	60	80	65	90	73.7
Bauhinia purpurea	60	65	80	70	68.7
Eugenia fruiticosa	30	85	80	75	67.5
Gardenia obtusifolia	50	100	75	60	71.2
Gmelina arborea	70	65	90	85	77.5
Holoptelea intergrifolia	45	60	90	85	70.0
Irvingia malayana	90	50	95	70	76.2
Lithocarpus polystachyus	65	100	90	75	82.5
Phyllanthus emblica	50	80	95	75	75.0
Pterocarpus macrocarpus	35	80	90	75	70.0
Sindora siamensis	25	55	75	70	56.2
Strychnos nux-vomica	60	100	95	65	80.0
Terminalia bellirica	75	65	55	80	68.7
Treatment means	58	76	82	75	72.0

Table 9 - Mean sapling root collar diameter (RCDmm) after 2nd rainy season by species and treatments at Mae Ow

	Rai 1	Rai 2	Rai 3	Rai 4	
Species	**Fill + 100x2**	**No fill +100x2**	**No fill +100x4**	**No fill +200x2**	**Species Average**
Adenanthera microsperma	3.9	5.4	5.9	5.6	5.1
Afzelia xylocarpa	8.0	11.9	8.2	10.1	9.7
Albizia lebbeck	8.4	12.0	10.8	9.2	10.0
Bauhinia purpurea	7.7	8.8	7.3	10.7	8.6
Eugenia fruiticosa	6.4	10.2	7.6	8.5	7.6
Gardenia obtusifolia	7.4	-	12.3	11.3	9.8
Gmelina arborea	7.6	8.6	10.8	13.6	9.3
Holoptelea intergrifolia	4.9	6.0	6.9	7.6	5.7
Irvingia malayana	6.1	5.3	5.4	6.5	5.7
Lithocarpus polystachyus	3.4	-	6.0	4.3	4.1
Phyllanthus emblica	4.9	8.4	4.8	6.6	6.0
Pterocarpus macrocarpus	6.2	8.3	10.9	8.3	7.4
Sindora siamensis	8.3	9.1	10.6	7.8	8.7
Strychnos nux-vomica	3.3	0.0	3.2	3.2	3.3
Terminalia bellirica	7.5	6.7	8.9	8.6	7.9
Treatment means	6.27	6.71	7.97	8.13	7.26

Resilience after fire

After the March 2007 fire event, mentioned above, on 4th to 5th April 2007, all burnt trees were assessed for health and root collar diameter. These burnt trees were assessed again in mid-November 2007 for survival, re-sprouting and health. This survey included trees planted in 2005 in an adjacent plot, which were 21 months old, larger and presumably more resilient to fire than the trees planted in 2006 which were 8 months old. Even in the first post-fire survey in April, some of the larger trees planted in 2005 had already begun re-shooting. Those with the highest survival rates (20-30%) were *Albizia lebbeck, Spondias pinnata, Sindora siamensis, Careya arborea, Artocarpus lakoocha* and *Diospyros mollis.*

Of those tree species planted in 2005, those that showed highest resilience after fire were *Careya arborea, Diospyros mollis* and *Shorea roxburghii* (the latter being the dominant naturally occurring tree of the area). These species were classed as "excellent" in terms of fire resilience. Some individuals of these species as small at 1-3 mm RCD could re-sprout after burning and grow quite well. Other species classed as acceptable included, *Eugenia fruticosa, Ficus rumphii, Irvingia malayana, Sindora siamensis and Spondias pinnata.*

Trees planted in 2006 did not do so well, since they were younger and smaller at the time of the fire. Burnt trees mostly died with no trees exceeding 70% survival after fire and only 3 species achieving an acceptable survival percentage of >50% (*Phyllanthus emblica, Sindora siamensis* and *Terminalia bellerica*). In general, the data show that some trees as small as 3-5 mm RCD can survive a moderate ground cover burn, but for most trees to survive a fire event an RCD of >15 mm is required and that this required more than 2 years of growth for most species.

Table 10 – Survival of 21-month old trees after burning in March 2007 (survey November 2007) at Mae Ow.

					RCD (mm)	
Species	**Fire Resilience Class**	**No of Burnt Trees**	**No. trees which survived**	**Percent survival**	**Largest tree which died**	**Smallest surviving tree**
Afzelia xylocarpa	R	16	7	43.8	14	3
Albizia lebbeck	M	23	11	47.8	10	2
Artocarpus lakoocha	R	18	2	11.1	4	2
Careya arborea	E	18	16	88.9	4	3
Diospyros mollis	E	18	18	100.0	10	1
Eugenia fruticosa	A	14	7	50.0	10	2
Ficus benjamina	R	14	1	7.1	12	11
Ficus hispida	R	9	3	33.3	8	3
Ficus microcarpa	R	11	2	18.2	5	3
Ficus rumphii	A	10	6	60.0	10	2
Flacourtia indica	R	10	2	20.0	5	3
Irvingia malayana	A	12	6	50.0	6	1
Mangifera caloneura	R	9	2	22.2	12	13
Melia toosendan	R	10	4	40.0	11	3
Shorea roxburghii	E	9	9	100.0	8	3
Sindora siamensis	A	20	13	65.0	8	2
Spondias pinnata	A	20	10	50.0	5	2
Xantolis burmanica	R	17	4	23.5	6	3

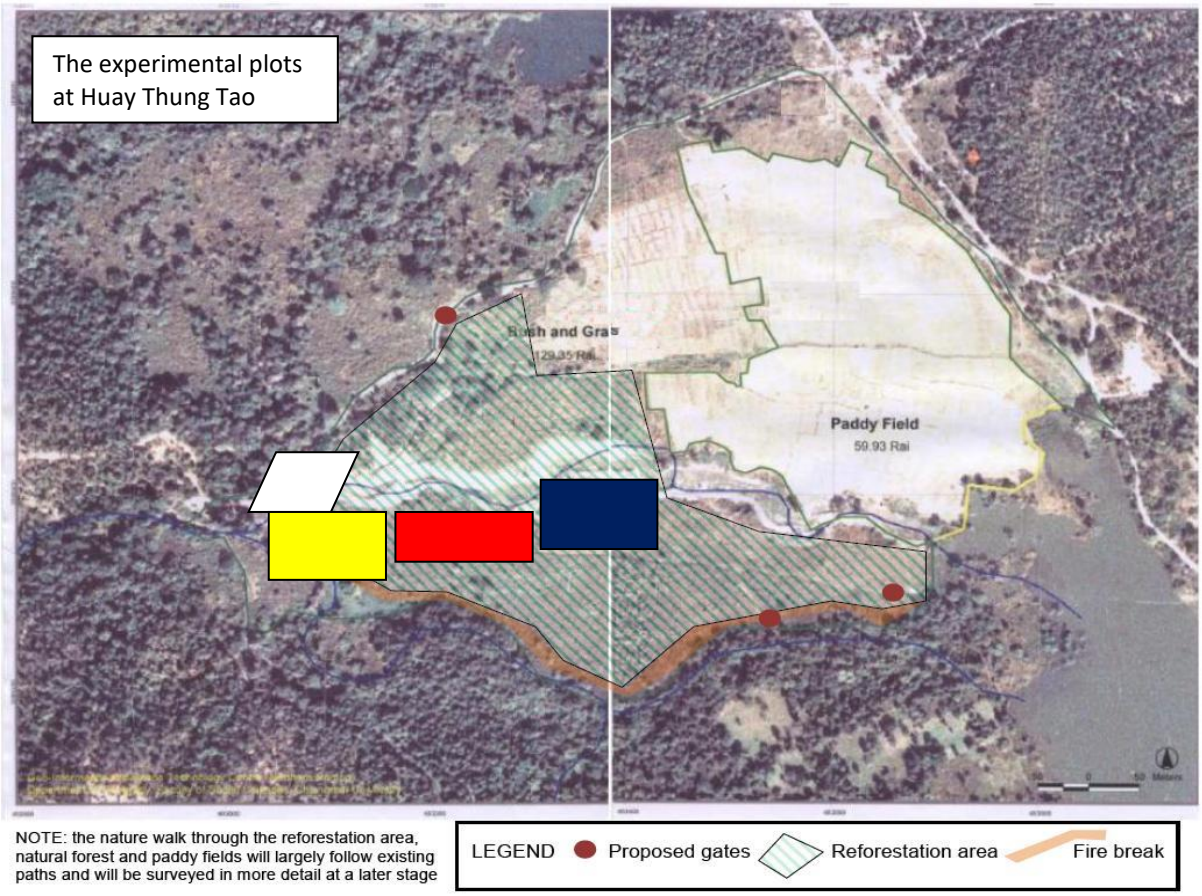
Table 11 - Survival of 8-month old trees after burning in March 2007 (survey November 2007) at Mae Ow.

					RCD (mm)	
Species	**Fire Resilience Class**	**No of Burnt Trees**	**No. trees which survived**	**Percent survival**	**Largest tree which died**	**Smallest surviving tree**
Adenanthera microsperma	R	71	13	18.3	8	2.3
Afzelia xylocarpa	R	73	11	15.1	9	4
Albizia lebbeck	R	73	12	16.4	10.5	5
Bauhinia purpurea	R	70	20	28.6	7	5
Eugenia fruiticosa	R	56	16	28.6	6.7	4
Gardenia obtusifolia	R	63	12	19.0	9	4
Gmelina arborea	R	49	20	40.8	10.1	5
Holoptelea intergrifolia	R	60	13	21.7	6.5	4
Irvingia malayana	R	57	12	21.1	6	3.5
Lithocarpus polystachyus	R	52	14	26.9	8	3
Phyllanthus emblica	A	54	35	64.8	7.5	3
Pterocarpus macrocarpus	R	70	17	24.3	7	3.1
Sindora siamensis	A	74	41	55.4	7	5
Strychnos nux-vomica	R	56	17	30.4	4	2
Terminalia bellirica	A	72	44	61.1	8	3

2007 plots - Experimental Design

In June 2007 the plots system was expanded at MJU and new plots were established at Huay Thung Tao. The same experimental design was adopted at both sites. Each 1-rai plot was planted with tree saplings of 15 species (20 individuals per species). The species planted were: *Afzelia xylocarpa, Alangium salvifolium, Albizia lebbeck, Alstonia scholaris, Bauhinia purpurea, Careya arborea, Cassia fistula, Dalbergia oliveri, Eugenia cinerea, Ficus fistulosa, Ficus racemosa, Gmelina arborea, Oroxylum indicum, Phyllanthus emblica* and *Terminalia bellirica.* Different treatments were applied in each of the four planted rais at both sites, designed to address the problem of poor soil condition and nutrient status:-

Rai 1 1 litre of compost mixed into the planting hole plus 100 g organic fertilizer plus cardboard mulch.
Rai 2 No compost. 100 g fertilizer + cardboard mulch.
Rai 3 1 litre compost + 200 gm fertilizer + cardboard mulch.
Rai 4 No compost. 200 gm fertilizer + cardboard mulch.



The compost mixed into the planting hole was commercial nursery-grade compost (Din Kui Pai brand), composed of soil, rice husk, burnt husk, composted weeds, coconut husk, sand and soil. It was mixed 50:50 with the soil in each planting hole before planting each sapling into the mix and applying fertilizer. The organic fertilizer used was the locally produced, Kai Nai Dao (chicken in star) brand (soil, rice husk, burnt husk, N P K, coconut husk, composted mushroom, composted weeds and lime compound). After planting, fertilizer was applied in a ring 10-20 cm away from the stems of the saplings; a circular mulch mat (40-60 cm in diameter) was laid around each sapling and pegged in place with a bamboo pole. Finally each tree was watered with about 3-4 litres. The work program followed to establish the plots is presented in table 12.

Planting day at Huay Thung Tao – June 2007

Table 12 – Details of work carried out to establish experimental plots

Activity	Huay Thung Tao	Mae Jo (Phrae)
Planning establishment of experimental plots	25 April 2007 (with army)	20 April 2007
Laid out the plots.	1 June 2007	9 June 2007
Transferred seedlings to sites	4-6 June 2007	12 June 2007
Digging the holes	4 June 2007	16 June 2007
Site preparation	Not needed	20 June 2007
Planting	9 June 2007	23 June 2007
1st Monitoring after planting	16 July 2007	20 July 2007
Weeding and fertilizer applications (1)	11 July 2007	28 July 2007
Weeding and fertilizer applications (2)	29 August 2007	31 August 2007
Weeding and fertilizer applications (3)	15 October 2007	30 October 2007
Weeding (4)	21 November 2007	-
End of 1st rainy season monitoring	29 November 2007	30 September 2007
Fire break cutting	30 January 2008	12 March 2008

Monitoring of 2007 plots – end first rainy season

Mortality

To determine mortality during the first rainy season after planting out, monitoring of the planted trees was completed at Huay Thung Tao on 29th November 2007 and at MJU Phrae on 30th September 2007.

At Huay Thung Tao, mortality rates of all species were very low in the first rainy season after planting. Survival was well above the 70% required to class all species as "excellent" for this framework criterion. Survival was especially high for the fig species, since their dense root systems enable them to grow well under very harsh soil conditions. There were no significant differences in survival among the treatments tested.

At Mae Jo, mortality rates were slightly higher than at Huay Thung Tao, probably due to harsher soil conditions there (see Table 2). However, only one species fell below the 70% survival standard for framework species in the first year (*Eugenia cinerea*).

Growth

Growth rates at HTT were generally much higher than those previously recorded at Mae Ow after 1 growing season (compare Table 13 with Table 6), indicating a general improvement in techniques and sapling quality as the project has progressed. Growth exceeding more than 1 m in the 1st rainy season represents a more than doubling in sapling size, which is considered excellent. Four species exceeded this standard: *Phyllanthus emblica*, *Gmelina arborea*, *Bauhinia purpurea* and *Ficus racemosa*. Flowering and fruiting at

a young age after planting out is also considered to be an important framework species characteristic, since flowers and fruits attract seed-dispersing animals into planted plots. Flowering and fruiting within one year of planting is exceedingly rare (we recorded it previously for only one species (*Ficus subincisa*) in evergreen forest) but in the HTT plots, several *Bauhinia purpurea* trees flowered and fruited in January 2008, just 7 months after planting.

At Mae Jo, growth rates were much lower, possibly a result of harsher soil conditions. No species exceeded the 1-m-standard (although *Gmelina arborea* came close at 86 cm). The data suggest that the most intensive treatment (fill plus 200 g fertilizer doses) is the most effective in the harsher conditions at Mae Jo.

Plots at Huay Thung Tao – Mar 08. Many trees have now grown above head height in less than 1 year.

Bauhinia purpurea flowering and fruiting just 7 months after planting.

Table 13 – Percent mortality after the 1st rainy season by species and treatments at Huay Thung Tao

Species	Fill+100 g	No fill+100 g	Fill+200 g	No fill+200 g	Species Averages
Afzelia xylocarpa	15	5	0	5	6.2
Alangium salvifolium	15	15	10	5	11.2
Albizia lebbeck	15	0	5	20	10.0
Alstonia scholaris	5	0	5	5	3.7
Bauhinia purpurea	10	0	15	0	6.2
Careya arborea	10	0	5	10	6.2
Cassia fistula	15	20	5	5	11.2
Dalbergia oliveri	5	15	5	10	8.7
Eugenia cinerea	15	10	20	5	12.5
Ficus fistulosa	10	0	0	0	2.5
Ficus racemosa	10	5	5	0	5.0
Gmelina arborea	5	5	15	10	8.7
Oroxylum indicum	15	5	5	0	6.2
Phyllanthus emblica	30	0	15	10	13.7
Terminalia bellirica	5	15	10	0	5.0
Treatment means	12.0	6.3	8.0	5.7	7.8

Table 14 – Per cent mortality after 1st rainy season by species and treatment at Mae Jo

Species	Fill+100 g	No fill+100 g	Fill+200 g	No fill+200 g	Species Average
Afzelia xylocarpa	5	0	0	0	1.2
Alangium salvifolium	10	5	5	35	13.7
Albizia lebbeck	5	0	5	0	2.5
Alstonia scholaris	20	0	10	10	10.0
Bauhinia purpurea	15	5	5	15	10.0
Careya arborea	10	0	0	0	2.5
Cassia fistula	0	10	0	10	5.0
Dalbergia oliveri	20	10	15	45	22.5
Eugenia cinerea	45	35	50	25	38.7
Ficus fistulosa	10	25	10	20	16.2
Ficus racemosa	25	0	0	15	10.0
Gmelina arborea	20	15	5	30	17.5
Oroxylum indicum	20	20	15	40	23.7
Phyllanthus emblica	15	5	15	5	10.0
Terminalia bellirica	10	0	20	10	10.0
Treatment means	15.3	8.7	10.3	17.3	12.9

Table 15 – Mean sapling heights after 1st growing season by species and treatment at Huay Tung Tao

Species	Fill+100 g	No fill+100 g	Fill+200 g	No fill+200 g	Species Average
Afzelia xylocarpa	57.12	54.35	58.15	67.26	59.22
Alangium salvifolium	47.65	48.59	59.88	57.37	53.37
Albizia lebbeck	56.06	59.70	65.60	67.25	62.15
Alstonia scholaris	81.24	78.60	70.84	90.79	80.37
Bauhinia purpurea	108.89	93.20	126.35	152.90	120.34
Careya arborea	46.06	37.30	54.16	54.11	47.91
Cassia fistula	41.06	38.00	39.53	42.74	40.33
Dalbergia oliveri	59.83	63.29	67.26	86.78	69.29
Eugenia cinerea	82.18	61.42	77.88	77.05	74.63
Ficus fistulosa	73.56	78.65	56.95	77.85	71.75
Ficus racemosa	141.39	132.79	127.63	172.45	143.56
Gmelina arborea	100.89	103.89	105.18	123.44	108.35
Oroxylum indicum	60.32	62.16	70.11	80.55	68.28
Phyllanthus emblica	113.14	88.45	125.59	103.83	107.75
Terminalia bellirica	60.53	63.94	60.17	69.40	63.51
Treatment means	75.33	70.95	77.68	88.25	78.05

Table 16 – Mean sapling heights after 1st growing season by species and treatment at Mae Jo

Species	Fill+100 g	No fill+100 g	Fill+200 g	No fill+200 g	Species Average
Afzelia xylocarpa	74.87	31.62	65.03	60.57	58.02
Alangium salvifolium	26.96	17.45	37.45	23.75	26.40
Albizia lebbeck	54.20	30.10	36.09	35.55	38.99
Alstonia scholaris	39.24	18.16	47.97	38.50	35.97
Bauhinia purpurea	42.65	17.19	45.07	32.34	34.31
Careya arborea	25.26	23.37	25.69	23.24	24.39
Cassia fistula	31.11	18.55	31.17	30.92	27.94
Dalbergia oliveri	33.39	20.09	39.66	23.75	29.22
Eugenia cinerea	14.48	3.70	19.00	22.05	14.81
Ficus fistulosa	27.47	6.36	42.15	25.22	25.30
Ficus racemosa	19.22	14.77	26.94	27.91	22.21
Gmelina arborea	26.79	17.05	272.16	28.93	86.23
Oroxylum indicum	20.38	14.98	25.13	14.12	18.65
Phyllanthus emblica	30.10	26.70	50.78	49.77	39.34
Terminalia bellirica	62.07	22.75	77.03	64.16	56.50
Treatment Means	35.21267	18.856	56.088	33.38533	35.88533

Fig trees are proving to be excellent framework species for restoring deciduous forest. Left – *Ficus fistulosa* and right *F. racemosa*, 5 months after planting.

Determining Suitable "Candidate" Framework Species for Lowland Deciduous Forests

A review of all available information about tree species of lowland deciduous dipterocarp-oak forest was carried out at the beginning of the project, in order to determine which species are most likely to act as framework tree species and thus help to determine which tree species to propagate in nurseries. Information sources included the work of Pakkad (1996) and Wong (1992) on fruit types and seed dispersal mechanisms of deciduous forest tree species, as well as habitat information and phenology data stored in the CMU Herbarium database. In addition, field performance data of trees planted in previously established pilot plots were reviewed (FORRU, unpub. data and Kasemsuk, 2005) and ease of propagation was judged from work undertaken under this project as well as FORRU's previous research on seed germination under nursery conditions. As the project progressed and information from the nursery and field experiments became available, data were added to the table and species were ranked according to a scoring system designed to reflect the extent to which each species met previously published standards for framework species criteria (Elliott et al. 2003, and 2006). The scoring system and updated tables are presented in Appendix 1.

The *ad hoc* suitability scoring system was based both on data and subjective assessments of the main characteristics that define framework species (Elliott et al., 2006) e.g. field performance (in previous as well as the present study); fleshy, animal-dispersed fruits likely to attract wildlife; suitability to lowland deciduous forest habitats; ease of propagation in nurseries (high germination rate and short dormancy) and evergreen habit. Species in Appendix 1 are divided into two lists. The first list includes all those species, for which field trial data are available. Species scoring above 50% are recommended for planting now in mixtures of 15-30 species per plot. The second list includes those species, for which field trials have yet to be carried out, but which score highly in the other framework species characteristics. In list 2, species coring higher than 50% are recommended for growing in nurseries and inclusion in future trials for to assess field performance, after which they may be moved to list 1.

These lists are very much working documents, based on the best data currently available and will be continually modified as gaps in knowledge are filled by nursery and future field results. It not only helps to direct immediate seed collecting programs for growing trees in nurseries for field trials, but it will also help to focus future student project-work on gaps in knowledge.

Biodiversity Monitoring

Monitoring of vegetation and birds has been delayed due to the change in project field site. These activities are now scheduled for the end of the rainy season 2008.

Educational Use of the plots

By working closely with the Royal Thai Army, local NGO's and schools, the plots at HTT are now beginning to fulfil their secondary role as educational facilities for forest restoration. The site was used a venue for the field trip of the workshop "The Future of Forest Restoration Research in Indochina" held in March 12-14th 2008. About 50 international delegates were able to observe the high growth rates. In addition, CMU and the Royal Thai Army have worked on a proposal to manage this area as a bird corridor, adjoining Doi Suthep Pui National Park. Plans are underway to create more bird habitats in this area, increase forest cover and create educational trails and signs for visiting students. The bird sanctuary proposal is copied in the appendix. Furthermore, about 40 children from Prem International Centre joined in the planting event as part of their environment group's extracurricular activities. Several interns (university students) at FORRU-CMU have joined in the maintenance and monitoring activities at the plots.

The demonstration plots at MJU Phrae Campus have also been used for class work for about 200 students, for forest restoration lessons and field labs work. The plots were visited by teachers from Vietnam and local villagers also received training in tree propagation methods at the nursery.

Conclusions

Devising a framework species system to restore deciduous forests in northern Thailand has become a far more challenging task than expected. In evergreen forest, framework species were easy to identify, and we had identified a functional range of species and achieve impressive demo plots within 3-4 years after starting nursery and field work. This was probably because i) there are more species to choose from in evergreen forest; ii) conditions for tree growth are much better above 1,000 m elevation than in the lowlands and iii) human disturbance, especially cattle and fire, was less intense.

In deciduous forest, the main problem has been fire and cattle destroying the planted trees before completion of field trials, despite considerable expenditure on fire break cutting and employment of local people for fire prevention and suppression. The situation is much better, now we have shifted the field trial plot system to Huay Thung Tao, under the protection of the Royal Thai Army, so we will expand the field trial plot system there this year (dependent on further funding).

Another problem has been maintenance at quality control of experiments, at a distance, at MJU Phrae campus. Fewer germination trials were completed there and results from field

trials were consistently lower than at the FORRU-CMU sites. Whilst this may be attributed in part to the poorer environmental conditions at the MJU plots, lack of adequate supervision and training may have played a part, causing inconsistent or missing application of treatments to ameliorate soil conditions at the required times. We attempted to remedy the situation by training Mr. Piyaphong for 6 weeks in early 2007 at the FORRU-CMU's facilities, but an inspection of the MJU work in December still found very little work ongoing in the nursery. Therefore in the future, we would like to concentrate efforts at achieving consistently high results in Chiang Mai Province with FORRU-CMU staff, first, before seeking project partners in other provinces and establishing a comprehensive training program for them, to enable them to replicate our results.

However, we believe that List 1 in the appendix is a sound basis for restoration of lowland deciduous forests at this time and that List 2 provides an excellent point, from which to progress with research on more species. Our new plots at Huay Thung Tao are doing very well and have now started to be used for education as well as research. With another, 2-3 years work, I believe that we will have developed a field trial plot system there which is as good as our evergreen forest plot system in Doi Suthep-Pui National Park.

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APPENDIX 1

Candidate Framework Tree Species - with rank scores predicting suitability for restoring deciduous forest ecosystems, based on best currently available data.

E/D = evergreen (E) or deciduous (D) (source: CMU Herbarium Database)

ABUNDANCE recorded for Doi Suthep-Pui National Park (CMU Herbarium Database):

0	Probably extirpated
1	Down to a few individuals, in danger of extirpation
2	Rare
3	Medium abundance
4	Common, but not dominant
5	Abundant (source: CMU Herbarium Database)

HABITAT recorded for Doi Suthep-Pui National Park (CMU Herbarium Database):

deciduous dipterocarp/oak	dof
pine dipterocarp	do/pine
bamboo/deciduous forest	bb/df
mixed deciduous/evergreen	mxf
evergreen forest	egf
evergreen with pine	eg/pine
disturbed areas, roadsides	da
secondary growth	sg

ELEVATION RANGE recorded for Doi Suthep-Pui National Park (CMU Herbarium Database): metres above mean sea level.

FRUITING MONTHS recorded for Doi Suthep-Pui National Park (CMU Herbarium Database):- ja = January; fb = February; mr = March; ap = April; my = May; jn = June; jl = July; ag = August; sp = September; oc = October; nv = November; dc = December.

FRUIT CLASS (Pakkad, 1996; Wong 1992): FIG = fig; F = fleshy; DD = dry dehiscent; DI = dry indehiscent.

GERMINATION PERCENT (FORRU data): E = excellent (>75%); A = acceptable (50-75%); M = marginal (25-50%) R = rejected (<25%).

MLD (FORRU data): median length of dormancy (days)

DISPERSAL (Pakkad, 1996; Wong, 1992): A = animal-dispersed; W = wind-dispersed.

FIELD PERFORMANCE (FORRU data) survival and growth in first growing seasons and fire resilience: E = excellent; A = acceptable; M = marginal; R = rejected.

SUITABILITY SCORE: 0-100, percentage of maximum possible score with available data, based on field performance (6 points); ease of propagation (4); fire resilience (4); animal-dispersed (3); fleshy fruits (3); habitat suitability (3) and evergreen habit (1.5).

List (1) - Species with known high field performance scores and overall suitability scores of >50% (in descending order of suitability) - recommended species for planting and further field tests (species marked in grey should be rejected).

SPECIES	FAMILY	E/D	ABUN-DANCE	HABITAT	ELEVATION RANGE	FRUITING MONTHS	FRUIT CLASS	GERMIN-ATION %	MLD (DAYS)	DISPER-SAL	FIELD PERFOR-MANCE	FIRE RESIL-IENCE	SUITABILITY SCORE
Eugenia fruticosa (DC.) Roxb.	Myrtaceae	E	2	eg/pine dof bb/df	350-1525	my-jl	F	E	23-35	A	E	A	96
Ficus glaberrima Bl. var. glaberrima	Moraceae	E	4	streams rocks in bb/df mxf egf	450-1200	all year	FIG	E	22-40	A	E		95
Careya arborea Roxb.	Lecythidaceae	D	3	dof bb/df	350-850	my jn	F	E	14-18	A	E	E	94
Actinodaphine henryi Gamb.	Lauraceae	E	3	mxf egf	650-1425	ap my	F	E	75	A	E		90
Ficus fistulosa Reinw. ex Bl. var. fistulosa	Moraceae	ED	3	da open bb/df mxf egf sg	350-1400	all year	FIG	A	16-84	A	E		90
Ficus racemosa L. var. racemosa	Moraceae	D	3	mxf often along streams	350-500	nv-jl	FIG	E	8-27	A	E		88
Terminalia chebula Retz. var. chebula	Combretaceae	D	3	dof bb/dg mxf	350-850	nv-fb	F	A	60	A	E		88
Terminalia bellirica (Gaertn.) Roxb.	Combretaceae	D	3	bb/df mxf	350-1150	oc-fb	F	E	36-56	A	E	A	88
Ficus rumphii Bl.	Moraceae	D	2	bb/df streams	450-550	ap my	FIG	E	65	A	E	A	86
Phyllanthus emblica L.	Euphorbiaceae	D	4	da sg da bb/df mxf	600-1620	sp-mr	F	E	17-40	A	E	A	86
Ficus microcarpa L. f. var. microcarpa forma microcarpa	Moraceae	E	3	dof bb/df mxf egf eg/pine	350-1050	all year	FIG	E	17-25	A	E	R	84
Eugenia grata Wight	Myrtaceae	E	4	streams dof bb/df	400-900	jn jl	F	A	18-32	A	A		80
Irvingia malayana Oliv. ex Benn.	Irvingiaceae	E	3	mxf	350-750	sp-nv	F	A	76	A	A	A	80
Casearia grewiifolia Vent. var. grewiifolia	Flacourtiaceae	D	3	mxf egf	350-500	jn jl	F	E	12	A	A		78
Ficus altissima Bl.	Moraceae	E	3	bb/df mxf	350-1050	all year	FIG	E	25-58	A	M		78
Strychnos nux-vomica L.	Loganiaceae	D	3	dof bb/df	350-900	dc-my	F	A	38-53	A	A	R	78
Gmelina arborea Roxb.	Verbenaceae	D	3	dof bb/df mxf egf eg/pine	350-1475	mr-jn	F	E	16-25	A	E	R	78
Ficus benjamina L. var. benjamina	Moraceae	E	3	mxf egf	350-1400	all year	FIG	E	22-67	A	A	R	73
Gardenia obtusiflia Roxb. Ex Kurz	Rubiaceae	D	3	dof	400-750	sp-mr	F			A	E	R	73
Ficus hispida L. f. var. hispida	Moraceae	E	3	da in bb/df sg	350-1525	all year	FIG	E	14-18	A	A	R	71
Sindora siamensis Teysm. ex Miq. var. siamensis	Leguminosae, Caesalpinioideae	D	2	dof streams bb/df	350-460	(jn) dc-ja	DD	E	14-15	W	E	A	65

SPECIES	FAMILY	E/D	ABUN-DANCE	HABITAT	ELEVATION RANGE	FRUITING MONTHS	FRUIT CLASS	GERMIN-ATION %	MLD (DAYS)	DISPER-SAL	FIELD PERFOR-MANCE	FIRE RESIL-IENCE	SUITABILITY SCORE
Dalbergia oliveri Gamb. Ex Pain	Leguminosae, Papilionoideae	D	3	dof bb/df mxf	350-1500	jn-ag	DD	E	50	W	E		63
Lithocarpus polystachyus (A.DC.) Rehd.	Fagaceae	E	3	dof bb/df	550-1300	sp-dc	DI	A	258	A	A	R	63
Afzelia xylocarpa (Kurz) Craib	Leguminosae, Caesalpinioideae	D	2	bb/df	350-500	jn-fb	DD	E	19-29	A?	E	R	61
Alstonia scholaris (L.) R. Br. var. scholaris	Apocynaceae	D	3	mxf egf	350-1200	fb mr ap	DD	E	14-40	W	E		61
Rhus chinensis Mill.	Anacardiaceae	D	3	eg/pine bb/df mxf da sg	500-1550	ja fb	F	R	28-73	A	A		59
Adenanthera microsperma Teijm & Binn.	Leguminosae, Mimosoideae	D	3	dof bb/df	350-700	(my) sp-nv	DD	E	33-60	A	A	R	57
Albizia lebbeck	Leguminosae, Mimosoideae	D	3	bb/df sg	350-500	ja-ap	DI	E	3-15	W	E	M	57
Bauhinia purpurea L.	Leguminosae, Caesalpinioideae	ED	3	dof da	350-930	jl-ap	DD	E	14	W	E	R	57
Cassia fistula L.	Leguminosae, Caesalpinioideae	D	4	dof bb/df mxf	400-1050	oc-mr	DI	A	13-38	W	A		56
Oroxylum indicum (L.) Kurz	Bignoniaceae	D	3	bb/df mxf	350-1400	ja-mr	DD	E	12-40	W	A		51
Terminalia alata Hey. ex Roth	Combretaceae	D	3	dof bb/df	350-900	ag-mr	DI	R	17	W	E		49
Holoptelea integrifolia (Roxb.) Planch	Ulmaceae	D	2	bb/df mxf sg	350-850	mr-ap	DI	E	10	W	A	R	47
Albizia chinensis (Osb.) Merr.	Leguminosae, Mimosoideae	D	3	mxf da in egf and eg/pine	450-1325	ja fb	DI	R	116	W	E		46
Pterocarpus macrocarpus Kurz	Leguminosae, Papilionoideae	D	4	bb/df egf	350-1400	sp oc nv mr	DD	R	17-30	W	A	R	27

List (2) - Species with unknown field performance scores but overall suitability scores >50% (in descending order of suitability) - recommended for seed collection and field trials (low scoring species marked in grey probably do not warrant further attention)

SPECIES	FAMILY	E/D	ABUN-DANCE	HABITAT	ELEVATION RANGE	FRUITING MONTHS	FRUIT CLASS	GERMIN-ATION %	MLD (DAYS)	DISPER-SAL	FIELD PERFOR-MANCE	FIRE RESIL-IENCE	SUITABILITY SCORE
Aphanamixis polystachya (Wall.) R. Parker	Meliaceae	E	3	egf and streams in mxf	375-1300	ja-my	F	E	9	A			93
Vaccinium sprengelii (D. Don) Sleum.	Ericaceae	E	4	da dof bb/df max eg/pine	600-1650	mr-jn	F			A			90
Canarium subulatum Guill.	Burseraceae	D	3	dof da in egf	373-1300	jn-ag	F	E	36	A			90
Ficus semicordata B.-H. ex J.E. Sm. var. semicordata	Moraceae	D	3	sg da in bb/df egf eg/pine	350-1550	fb-my	FIG	E	38-52	A			86
Grewia eriocarpa Juss.	Tiliaceae	D	3	dof bb/df	350-1020	jn-sp	F			A			86
Morinda tomentosa Hey. ex Roth	Rubiaceae	D	3	dof	400-600	jl-sp	F			A			86
Euonymus similis Craib	Celastraceae	ED	3	dof mxf egf	450-1525	sp-ja	F	A	133	A			83
Vitex peduncularis Wall. ex Schauer	Verbenaceae	D	3	dof bb/df mxf	350-900	my-ag	F	A	34-45	A			83
Phyllanthus columnaris M.-A.	Euphorbiaceae	D	3	bb/df sg	350-600	my-fb	F			A			81
Styrax benzoides Craib	Styracaceae	E	4	eg/pine da bb/df mxf egf	600-1650	jl ag sp oc (ja)	F	A	150	A			79
Scleropyrum wallichianum (A. DC.) Arn. var. siamensis H. Lec.	Santalaceae	E	4	streams in dof bb/df mxf egf	425-1325	jl-sp	F	A	V.LONG	A			76

SPECIES	FAMILY	E/D	ABUN-DANCE	HABITAT	ELEVATION RANGE	FRUITING MONTHS	FRUIT CLASS	GERMIN-ATION %	MLD (DAYS)	DISPER-SAL	FIELD PERFOR-MANCE	FIRE RESIL-IENCE	SUITABILITY SCORE
Quercus kerrii	Fagaceae	D	4	dof	350-850	mr-jn	DI	E	11-13	A			76
Memecylon plebejum Kurz	Melastomataceae	E	3	dof bb/df mxf eg/pine	400-1650	dc-my	F	R	23	A			72
Anneslea fragrans Wall.	Theaceae	ED	4	dof mxf egf eg/pine do/pine	400-1650	mr-my	F	R	19-26	A			69
Dillenia parviflora Griff. var. kerrii (Craib) Hoogl.	Dilleniaceae	D	4	dof	375-1000	ap	F	M	41	A			69
Symplocos racemosa Roxb.	Symplocaceae	D	3	dof	450-875	mr ap	F	M	42	A			69
Diospyros ehretioides Wall. ex G. Don	Ebenaceae	D	3	dof bb/df	350-900	jl-ja	F	M	70-126	A			69
Garcinia cowa Roxb.	Guttiferae	D	3	dof mxf mx/pine	400-1500	(sp) fb-my	F	M	53-60	A			69
Dalbergia cultrata Grah. ex Bth.	Leguminosae, Papilionoideae	D	4	da dof bb/df mxf eg/pine egf	350-1400	jl ag sp oc nv dc ja fb mr	F	E	30	W			69
Millettia pubinervis Kurz	Leguminosae, Papilionoideae	D	3	eg/pine dof bb/df egf	375-1500	sp-nv	DI			A			67
Antidesma ghaesembilla Gaertn.	Euphorbiaceae	D	3	dof	600-750	(ag) nv-ja	F	M	247	A			66
Aporosa villosa (Lindl.) Baill.	Euphorbiaceae	D	4	dof bb/df mxf eg/pine	500-1500	mr-my	F	R	25-32	A			62
Dillenia pentagyna Roxb.	Dilleniaceae	D	3	dof bb/df	425-925	ap my	F	R	97	A			62
Premna latifolia Roxb. var. latifolia	Verbenaceae	D	3	dof	375-725	jn-ag	F	R	254-485	A			62
Aegle marmelos (L.) Corr.	Rutaceae	D	2	bb/df	350-650	ja-ap	F	R	28	A			59

SPECIES	FAMILY	E/D	ABUN-DANCE	HABITAT	ELEVATION RANGE	FRUITING MONTHS	FRUIT CLASS	GERMIN-ATION %	MLD (DAYS)	DISPER-SAL	FIELD PERFOR-MANCE	FIRE RESIL-IENCE	SUITABILITY SCORE
Garuga pinnata Roxb.	Burseraceae	D	3	bb/df mxf eg/bb	350-1350	ap my jn jl ag	F	R	39	A			59
Rhus rhetsoides Craib	Anacardiaceae	D	3	mxf egf eg/pine	650-1550	sp-ja	DI	A	24-31	A			59
Lithocarpus lindleyanus (Wall.) A. Camus	Fagaceae	D	3	dof mxf eg/pine	650-1400	sp oc	DI	A	168-238	A			55
Xylia xylocarpa (Roxb.) Taub. var. kerrii (Craib & Hutch.) Niels.	Leguminosae, Mimosoideae	D	4	dof bb/df mxf	375-1000	nv dc ja fb mr	DD	E	12	W			48
Castanopsis argyrophylla King ex Hk. f.	Fagaceae	ED	3	dof	350-1180	sp oc	DD	R	144-179	A			48
Mitragyna hirsuta Hav.	Rubiaceae	D	3	dof da in egf	350-1100	oc-mr	DD	E	27-28	W			48
Aporosa wallichii Hk. f.	Euphorbiaceae	D	4	dof bb/df mxf eg/pine	500-1400	ap my	DD	M	17	A			48
Butea monosperma (Lmk.) Taub.	Leguminosae, Papilionoideae	D	3	da dof	350-400	jn-jl	DD	A	11	W			41
Lophopetalum wallichii Kurz	Celastraceae	D	2	dof	400-880	mr ap	DD	A	21	W			41
Kydia calycina Roxb.	Malvaceae	D	3	dof bb/df	350-1000	dc-ap	DI			W			38
Erythrina subumbrans (Hassk.) Merr.	Leguminosae, Papilionoideae	D	3	mxf egf	500-1680	mr ap	DD	E	45	W			38
Protium serratum (Wall. ex Colebr.) Engl.	Burseraceae	D	3	mxf egf	350-1500	jn jl ag sp oc	F	R	29	W			38
Wrightia arborea (Dennst.) Mabb.	Apocynaceae	D	3	bb/df	350-500	jl-sp	DD	A	30	W			38
Bauhinia variegata L.	Leguminosae, Caesalpinioideae	D	3	bb/df mxf egf	650-1250	mr-my	DD	E	22	W			34
Albizia garrettii Niels.	Leguminosae, Mimosoideae	D	2	dof eg/pine	400-1475	dc-fb	DD			W			29

SPECIES	FAMILY	E/D	ABUN-DANCE	HABITAT	ELEVATION RANGE	FRUITING MONTHS	FRUIT CLASS	GERMIN-ATION %	MLD (DAYS)	DISPER-SAL	FIELD PERFOR-MANCE	FIRE RESIL-IENCE	SUITABILITY SCORE
Hiptage benghalensis (L.) Kurz ssp. candicans (Hk. f.) Siri.	Malpighiaceae	D	2	dof bb/df	450-950	mr ap	DD	M	13-18	W			28
Bauhinia racemosa Lmk.	Leguminosae, Caesalpinioideae	D	2	bb/df	350-550	mr sp oc	DD	M	V LONG	W			24
Sterculia villosa Roxb.	Sterculiaceae	D	2	dof mxf egf eg/pine	600-1575	mr ap	DD	M	10	W			24
Terminalia mucronata Craib & Hutch.	Combretaceae	D	4	bb/df mxf egf	450-1250	jl-ja	DI	R	35-41	W			24
Cratoxylum cochinchinense (Lour.) Bl.	Guttiferae	D	3	dof	500-700	(ja) ap-my	DD	M	56-126	W			21

โครงร่างงานวิจัยเพื่อเสนอต่อกองบัญชาการกองทัพบก

สถานที่

อ่างเก็บน้ำห้วยตึงเฒ่า และบริเวณใกล้เคียงโดยรอบ เป็นพื้นที่ที่อยู่ในความดูแลของมณฑลทหารบกที่ 33 ตั้งอยู่ในอำเภอแม่ริม จังหวัดเชียงใหม่

ความเป็นมาของพื้นที่

ในช่วงต้นปี พ.ศ 2550 คุณไนเจล ปาร์กเกอร์ ซึ่งเป็นชาวต่างประเทศที่อาศัยอยู่ในเมืองไทยเป็นระยะเวลานาน และเป็นสมาชิกของชมรมอนุรักษ์นกล้านนา ได้มีโอกาสหารือกับทางพันเอกกมล เพิ่มกำลังพล ผู้จัดการสำนักงานส่งเสริมการท่องเที่ยวอ่างเก็บน้ำห้วยตึงเฒ่า(ในขณะนั้น) ซึ่งหน่วยงานของท่านได้มีหน้าที่ดูแลรับผิดชอบในบริเวณพื้นที่อ่างเก็บน้ำห้วยตึงเฒ่า และท่านได้มีโครงการที่จะจัดทำบริเวณพื้นที่นี้ให้เป็นแหล่งอนุรักษ์พันธุ์นกและเขตอนุรักษ์ป่าทางธรรมชาติ จำนวน 200 ไร่ ซึ่งจะประกอบไปด้วยพื้นที่ทำนา และบริเวณพื้นที่โดยรอบที่อยู่ทางด้านเหนือของอ่างเก็บน้ำ นอกจากนี้ท่านยังได้ให้ข้อมูลเพิ่มเติมว่าในบริเวณนี้(ซึ่งเป็นบริเวณที่อยู่ใกล้กับอุทยานแห่งชาติดอยสุเทพ-ปุย) มีจำนวนชนิดของนกที่พบมากกว่า 250 ชนิด และในบริเวณพื้นที่นี้ยังมีห้วยหนอง คลองบึงขนาดเล็กๆ ซึ่งเป็นที่อยู่อาศัยของสัตว์นานาชนิดที่อพยพมาอาศัยอยู่ในช่วงฤดูแล้ง เช่น สัตว์เลื้อยคลาน สัตว์ครึ่งบกครึ่งน้ำ นก และแมลง เป็นต้น เนื่องด้วยความสำคัญของพื้นที่นี้ ทางพันเอกกมล เพิ่มกำลังพล และ ผู้บังคับบัญชาของท่าน คือ พลตรีศุภอักษร สังประกุล ผู้บัญชาการมณฑลทหารบกที่ 33 (ในขณะนั้น) จึงมีความเห็นชอบให้จัดทำโครงการศึกษาวิจัยดังกล่าว และได้มอบหมายให้ทางพันเอกธีรวุธ อินทรไข่ ผู้จัดการสำนักงานส่งเสริมการท่องเที่ยวอ่างเก็บน้ำห้วยตึงเฒ่า(คนปัจจุบัน) เป็นผู้รับผิดชอบดำเนินงาน และทางพันเอกธีรวุธ ได้เสนอให้ทางหน่วยวิจัย จัดทำโครงร่างงานวิจัยฉบับนี้ขึ้นเพื่อขออนุญาตในการใช้พื้นที่อ่างเก็บน้ำห้วยตึงเฒ่าในการทำงานวิจัย รวมทั้งการเสนอขอการสนับสนุนอย่างเป็นทางการต่อทางกองบัญชาการกองทัพบก (สำนักงานใหญ่ ซึ่งตั้งอยู่ที่กรุงเทพ) ได้เป็นผู้พิจารณาให้การอนุเคราะห์ในโอกาสต่อไป

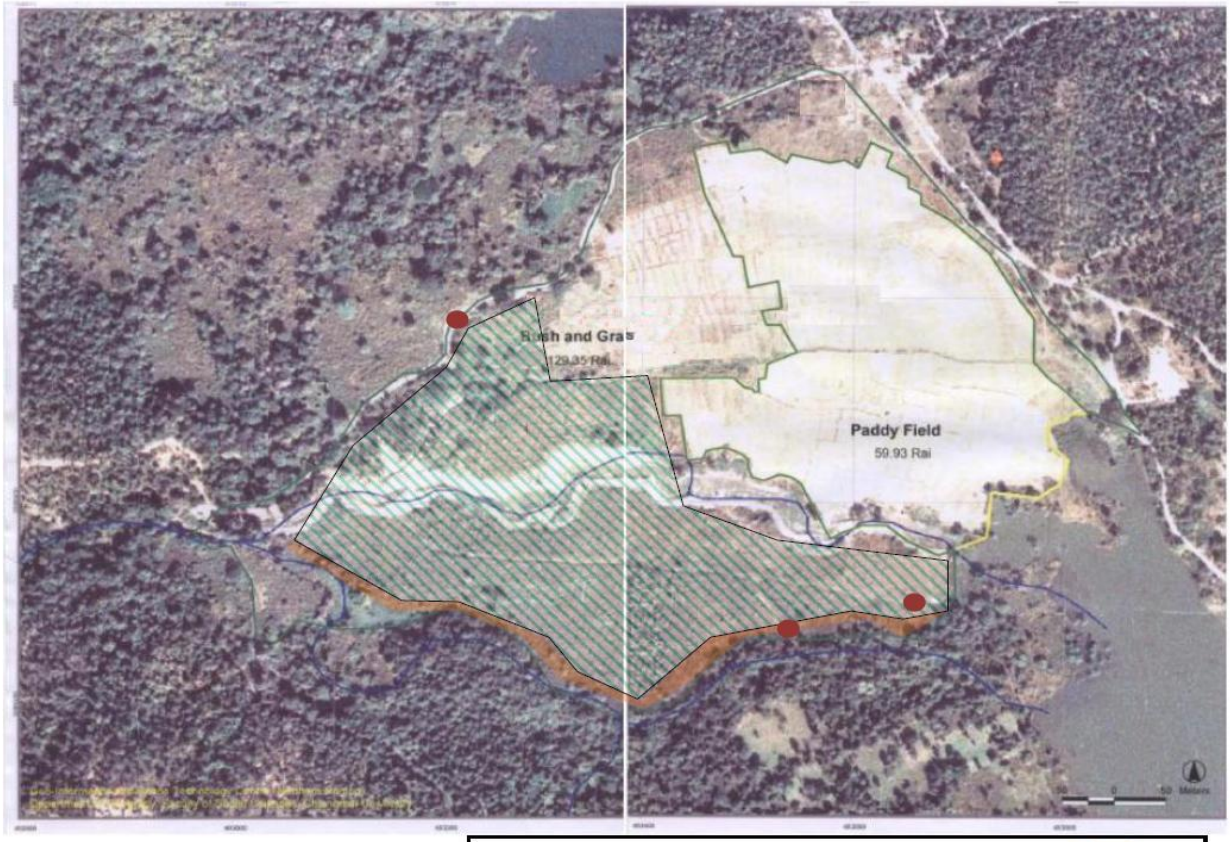
จุดมุ่งหมายของการจัดตั้งเขตรักษาพันธุ์นก และเขตป่าอนุรักษ์ในพื้นที่อ่างเก็บน้ำห้วยตึงเฒ่า

การจัดตั้งจัดตั้งเขตอนุรักษ์พันธุ์นก และเขตป่าอนุรักษ์ในพื้นที่อ่างเก็บน้ำห้วยตึงเฒ่า จะทำให้เกิดประโยชน์หลายประการ ดังนี้

- เป็นการอนุรักษ์และปรับปรุงถิ่นที่อยู่อาศัยของสัตว์ป่าและพรรณไม้ในท้องถิ่น
- เป็นการปรับปรุงคุณภาพของน้ำที่จะไหลผ่านไปยังอ่างเก็บน้ำห้วยตึงเฒ่า
- เป็นการปรับปรุงภูมิทัศน์โดยรอบบริเวณอ่างเก็บน้ำเพื่อเป็นแหล่งศึกษาเรียนรู้ธรรมชาติของนักเรียนในพื้นที่ และนักท่องเที่ยว
- เป็นการส่งเสริมให้บริเวณนี้กลายเป็นแหล่งท่องเที่ยวเชิงอนุรักษ์ที่น่าสนใจต่อไปในอนาคต โดยเฉพาะสำหรับผู้ที่ชื่นชอบการดูนกเป็นพิเศษ

สภาพพรรณไม้ที่ค่อนข้างเสื่อมโทรมที่ขึ้นอยู่บริเวณโดยรอบอ่างเก็บน้ำห้วยตึงเฒ่า

ภาพถ่ายทางอากาศบริเวณอ่างเก็บน้ำห้วยตึงเฒ่า อ.แม่ริม จ.เชียงใหม่



ข้อมูลทั่วไปของพื้นที่ บริเวณพื้นที่อ่างเก็บน้ำห้วยตึงเฒ่าในอดีตเป็นพื้นที่ทำการเกษตร โดยเฉพาะการทำนาแบบขั้นบันได รวมทั้งการล่าสัตว์ และมีการใช้ประโยชน์จากไม้ในพื้นที่โดยรอบนั้นด้วย ดังนั้นจึงถือได้ว่าในบริเวณนี้เป็นป่าผลัดใบในระดับล่างที่มีสภาพเสื่อมโทรมในระดับปานกลางถึงมาก รวมทั้งในพื้นที่ยังปกคลุมไปด้วยวัชพืช

กิจกรรมวันปลูกป่าในเดือนมิถุนายน 2550 โดยความร่วมมือของทหารจากมณฑลทหารบกที่ 33 และหน่วยวิจัยการฟื้นฟูป่า และหน่วยงานต่างๆ ในจังหวัดเชียงใหม่

ได้มีการริเริ่มปลูกป่าในบริเวณในบริเวณฟื้นฟูป่าหลายครั้งโดยทางมณฑลทหารบกที่ 33 และหน่วยงานอื่นๆ รวมทั้งหน่วยวิจัยการฟื้นฟูป่ามหาวิทยาลัยเชียงใหม่(FORRU-CMU) เป็นหน่วยงานล่าสุดที่สนใจเข้ามาฟื้นฟูป่าในบริเวณนี้ โดยในเดือนมิถุนายน 2550 ทางหน่วยวิจัยได้ปลูกต้นไม้ท้องถิ่น จำนวน 1,200 ต้น ในพื้นที่ 4 ไร่ เพื่อเป็นการศึกษาเปรียบเทียบวิธีในการปลูกต้นไม้โดยวิธีการต่างๆ กัน เพื่อหาวิธีการที่เหมาะสมที่สุดในการฟื้นฟูป่าระดับล่างในพื้นที่ป่าธรรมชาติ

การดำเนินงานในโครงการวิจัย – กิจกรรมต่าง ๆในระยะที่ 1

จะต้องมีการจัดตั้งคณะกรรมการหลักในการดำเนินโครงการ ซึ่งจะต้องประกอบไปด้วยตัวแทนจาก ทางกองบัญชาการกองทัพบก องค์กรที่เกี่ยวข้องกับการอนุรักษ์นก นักวิชาการจากมหาวิทยาลัยเชียงใหม่ และองค์กรอื่นๆในท้องถิ่น ซึ่งจะมีขั้นตอนในการดำเนินงานดังต่อไปนี้

1. จัดทำแผนการจัดการด้านสิ่งแวดล้อมสำหรับพื้นที่บริเวณอ่างเก็บน้ำห้วยตึงเฒ่า
2. การประชาสัมพันธ์โครงการ เช่น การจัดให้มีเวทีเสวนาแลกเปลี่ยนความคิดเห็นเกี่ยวกับโครงการตลอดจนการ

ประชาสัมพันธ์โครงการผ่านทางสื่อมวลชนต่างๆเพื่อให้ประชาชนทั่วไปได้ทราบรายละเอียดของโครงการ

3. ติดตามตรวจสอบการดำเนินกิจกรรมต่างๆของโครงการ
4. การจัดเตรียมโครงร่างงานวิจัยเพื่อเสนอของบประมาณในการสนับสนุนการทำวิจัยไปยังแหล่งทุนต่างๆ ที่

เกี่ยวข้องเพื่อนำงบประมาณสนับสนุนมาดำเนินกิจกรรมต่างๆของโครงการ และการบริหารจัดการโครงการ

นอกจากนี้ ยังมีข้อเสนอแนะเพิ่มเติมในการจัดทำกิจกรรมต่างๆ ในการดำเนินงานของโครงการวิจัยในระยะที่ 1 ดังนี้

1. การปรับปรุงและพัฒนาเส้นทางศึกษาธรรมชาติตลอดเส้นทางเดินเท้าให้กว้างขวงและสะดวกมากขึ้นในเส้นทาง

ที่เชื่อมต่อระหว่างบริเวณพื้นที่อนุรักษ์ และบริเวณพื้นที่จัดทำพิเศษสำหรับดูนก รวมทั้งการจัดทำป้ายบอกทางสัญลักษณ์ต่างๆ และป้ายแนะนำสถานที่ให้มีความชัดเจนมากขึ้น เพื่อจะเป็นประโยชน์ในการให้ความรู้แก่นักเรียนและนักศึกษาที่เข้ามาใช้พื้นที่ ตลอดจนประชาชนโดยทั่วไปที่เข้ามาเยี่ยมชมสถานที่แห่งนี้

2. การสร้างแหล่งที่อยู่อาศัยของนกให้มีความหลากหลายมากขึ้น เช่น การสร้างหนองน้ำหรือบึงขนาดเล็ก เพื่อให้

นกชนิดต่างๆได้มาอาศัยและหากินในบริเวณนี้ได้ แต่ในขณะเดียวกันก็จะต้องมีการอนุรักษ์ป่าไม้ในพื้นที่ไปพร้อมๆกันด้วย

3. จะต้องมีการควบคุมทำกิจกรรมต่างๆในบริเวณนี้ที่อาจส่งผลกระทบต่อถิ่นที่อยู่อาศัยของนก หรือกิจกรรมที่จะ

ส่งผลเสียต่อสิ่งแวดล้อม เช่น การจัดทำประตูทางเข้า-ออก เป็นต้น

การเข้ามามีส่วนร่วมในโครงการของทางกองบัญชาการกองทัพบก

ทางหน่วยงานใคร่ขอให้ทางกองทัพบกได้พิจารณาแบบเสนอโครงร่างงานวิจัยฉบับนี้ รวมไปถึงการพิจารณาในการให้การสนับสนุนอย่างเป็นทางการสำหรับโครงการในการจัดทำเขตอนุรักษ์พันธุ์นกในบริเวณอ่างเก็บน้ำห้วยตึงเฒ่าในระยะที่ 1 นี้ รวมทั้งการอนุญาตให้เข้าไปทำงานวิจัยในพื้นที่ที่อยู่ในความดูแลของท่าน นอกจากนี้ทางหน่วยวิจัย จะใคร่ขอให้ทางกองบัญชาการกองทัพบกได้เสนอชื่อบุคคลที่เหมาะสมที่จะเป็นตัวแทนของทางกองทัพบกในการเข้าร่วมเป็นคณะกรรมการดำเนินงานโครงการนี้ รวมไปถึงการมีส่วนร่วมในการดำเนินกิจกรรมต่างๆ ในโครงการวิจัยนี้

ทางหน่วยวิจัยใคร่ขอขอบพระคุณอย่างสูง มา ณ โอกาสนี้ ที่ทางกองบัญชาการกองทัพบกได้กรุณาให้ความอนุเคราะห์ในการพิจารณาโครงร่างงานวิจัยฉบับนี้ และหวังเป็นอย่างยิ่งว่าจะได้รับการสนับสนุนจากทางกองบัญชาการกองทัพบกเป็นอย่างดียิ่ง

ACTION PLAN

Project Name: ***"Establishing test plots for adaptation of the framework species method of forest restoration for biodiversity recovery in deciduous forest ecosystems"***

Activities	Year 1		Year 2 (7 months)	Expected outputs
	Sep 06 – Feb 07	Mar – Aug 07	Sep 07 – Mar 08	
1. Updating list of candidate framework tree species	Done	Done	Done	A list of candidate tree species likely to meet basic framework criteria
2. Nursery production of candidate tree species	In progress	In progress	51 Species	At least 30 candidate tree species.
3. Site preparation		Done		Plots cleared ready for planting
4. Planting of trial plots		Done		10 rai of trial demonstration plots.
6. Post-planting monitoring of planted trees	Done	Done	Done	Baseline data for performance monitoring
7. Monitoring of ground flora and natural trees	Done (previous)		TBD – end rainy season 08	Baseline data to determine future flora recovery
8. Monitoring of birds	Done (previous)		TBD – end rainy season 08	Baseline data to determine future effects of tree planting on recovery of the bird community
9. Soil Analysis	Done		Awaiting lab results	Baseline data to determine future recovery of soil fertility.
7. Data analysis and reporting	Done		Done	Biannual reports to BRT with recommendations on tree propagation techniques.
Monitoring survival of burnt trees		Done	Done	Unexpected extra activity