RESTORING BAMBOO-DECIDUOUS FOREST AT PONG YAENG NORK AFTER FIRE

SUMMARY

The project aims to restore 8.4 rai of bamboo-deciduous forest at Pong Yaeng Nork, which was burnt in the 2024 dry season. It is led by FORRU-CMU in collaboration with the Doi Suthep-Pui National Park Authority and local communities, with funding from the Plant Genetic Conservation Project (RSPG-CMU). The primary goal is to enhance biodiversity recovery and test the effects of different fertilizer treatments on tree growth and survival.

Key Dates and Activities

- May 10, 2024 – Site assessment and aerial drone survey.
- June 13 & 26, 2024 – Setup of experimental plots with fertilizer treatments.
- June 29 & July 13, 2024 – Tree planting events (total 3,500 trees planted).
- July 19, 2024 – Baseline monitoring of planted trees.
- July 29, September 5, & October 16, 2024 – Site maintenance (weeding & fertilizer application).
- November 23, 2024 – End of first rainy season monitoring.

Methods

- Species Selection – Ten framework tree species were chosen for the fertilizer experiment, with 40 trees of each species planted in four treatment plots. Another 23 species were planted in the remaining area.
- Fertilizer Experiment – Four treatments were tested:
    - Control (50g), 100g, 150g, and 200g of organic fertilizer applied at planting and three times during the rainy season.
- Tree Monitoring – Growth and survival were assessed using root collar diameter (RCD), height, crown width and health scores.

Results

- Survival Rates – 93% of trees survived the first rainy season, with six species showing over 75% survival (considered excellent).
- Best-Performing Species – *Erythrina stricta* and *Balakata baccata* had the highest survival and growth rates.
- Effect of Fertilizer – Increased fertilizer dosage had little additional benefit beyond 50g and may have slightly reduced sapling growth.
- Growth Trends – Nearly all species exhibited strong growth, with no species showing negative trends.

Conclusion

The experiment demonstrated high survival and growth rates, confirming that the Framework Species Method is effective for restoring burnt bamboo-deciduous forests. Findings suggest that higher fertilizer dosages do not significantly improve outcomes, which can guide future restoration projects.

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Project Name:	Restoring Bamboo-Deciduous Forest at Pong Yaeng Nork After Fire
Project Duration :	May 2024 - November 2025
Project Organizer :	Forest Restoration Research Unit (FORRU-CMU), Department of Biology, Faculty of Science, Chiang Mai University
Prepared by :	Pornpawee Laohasom

Background

This project is to convert a burnt bamboo-deciduous plot at Pong Yang Nork, Mae Rim, Chiang mai, back into native bamboo-deciduous forest, primarily for biodiversity recovery within Doi Suthep-Pui National Park. Total area around 10 rai, the land was recently returned to the national park since 30 January 2022 by villagers, who had been using it to cultivate ginger and avocado. Fire burnt through the site in the 2024 dry season, killing most of the trees.

Figure 1 - Participants on planting day, 29th June 2024

Since the area is easily accessible by road, FORRU-CMU considered it was an ideal tree-planting location for schools participating in the unit's Young Forest Restorers project (YFR), sponsored by Keidanren Nature Conservation Foundation (KNCF) (Figure 1). The report below covers planting on 8.4 rai of the site on 29/6 and 13/7/24, in collaboration with the Doi Suthep-Pui National Park authority and Pong Yaeng Nok Village.

Objectives

1. To retore 8.4 rai of bamboo-deciduous forest, following fire, with the primary aim to recover biodiversity to meet conservation objectives of Doi Suthep-Pui National Park. This includes planting 3,500 trees in the rainy season of 2024 and maintaining the planted trees for at least two years.

2. To test the effects of fertilizer on the planted trees.

Characteristics of the restoration site, area survey and map

The 10-rai restoration site is in Pong Yaeng Nork district and lies within the boundaries of Doi Suthep-Pui National Park. The site was previously covered with bamboo-deciduous forest (*sensu* Maxwell and Elliott, 2001) at 790-800 m above sea level.

A rapid site assessment was performed on May 10th. Fire had completely removed the ground vegetation, leaving bare soil over most of the site (Figure 2). Tree cover was very sparse over most of the site, although some trees survived in the lower SW corner. There were many clumps of burnt bamboo, which had lost their foliage but were still alive.

Figure 2 - Restoration plot in Pong Yang after fire.

An aerial survey by drone (Figure 3) estimated total tree/bamboo cover across the whole site was 1.6 rai, leaving 8.4 rai requiring planting. From 10 circular sample plots of 10 m diameter, randomly placed across the site, the density of natural regenerants (saplings taller than 50 cm and live tree stumps) was estimated at 79/rai (± 2.6, 95% c.l.) (Appendix 2). Therefore, the required number of planted trees was 421/rai—totally 3,536 trees for the entire 8.4 rai. The species of trees among those surviving on site were *Mangifera indica, Oroxylum indicum*, *Croton oblongifolius, Albizia chinensis, Fernandoa adenophylla, Fagraea fragrans* and *Ficus* sp.

Two planting events were implemented. The first one, on June 29th, coincided with a training workshop for a group of Malaysian conservationists (TRCRC). The second one took place on July 13th. Schools participating in the Young Forest Restorers program.

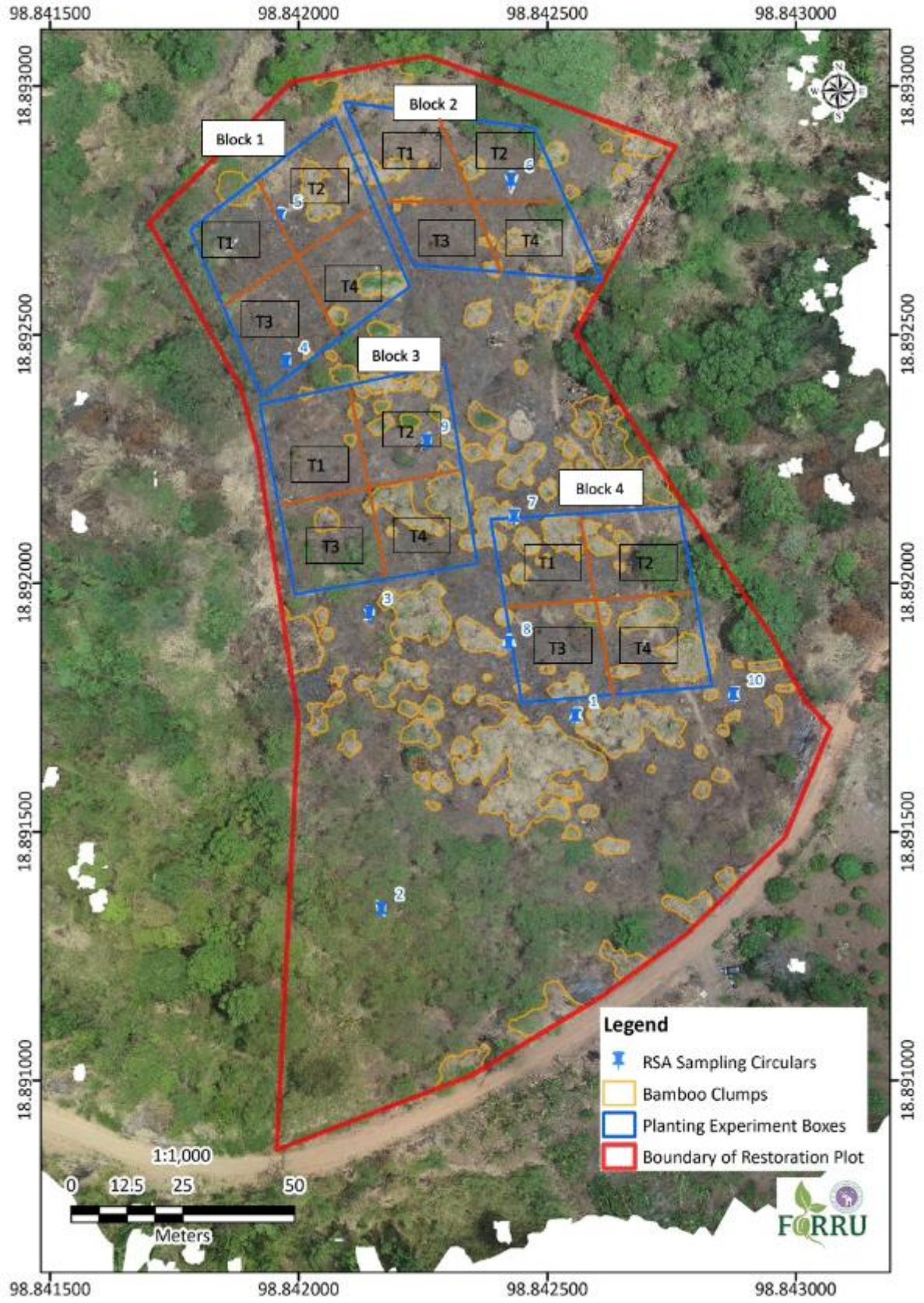


Figure 3 – Arial survey by drone

Planting Preparation

Site Preparation

It was recommended to the Doi Suthep-Pui National Park authority (DSNP) to remove large woody debris and perform weeding before the planting events, to ease access, to retain smaller debris on site for micro-habitat and nutrient retention. Due to recent burning, weed growth was initially low at this site, but weeds started to grow up rapidly shortly after the survey was completed (Figure 4). Glyphosate spraying was recommended to DSNP, but it was not allowed. Therefore manual weeding was scheduled for 24th June by DSNP staff and villagers.

Figure 4 – weed growth 5/6 – note bamboos have survived burning

Bamboo sticks were be used to mark the planting spots (1.8 m apart), as well as surviving natural regenerants. Holes. twice the size of the sapling containers (9 x 2.5-inch plastic bags). Were dug beside each pole. Planting equipment and materials were transported to the site one day before each planting day.

On June 13th and 26th the treatment plots for the fertilizer experiment were laid out with the help of GIVE volunteers (Figure 5).

Figure 5 – GIVE volunteer and FORRU staff clear weed and setup experiment plot.

Species Selection

Framework trees species, which FORRU-CMU has previously found to grow well on nearby similar bb/df sites (at Ban Meh Meh), were selected for planting at this site. The trees were sorted and labelled at FORRU's nurseries on 17th June and were transported to the site on 28th June (2024) Figure 6).

Figure 6 – FORRU staff and volunteer transfer sapling to planting site

Ten species were selected for the experiment, with 40 trees of each species planted in each of 4 x 1-rai treatment plots (totally 160 of each species) during the 1st planting event on 29th June (Table 1)

In the remaining 4.4 rai, 23 species were planted in various quantities, according to availability in nurseries – totally 1,900 trees (Table 2)

The Forest Restoration Research Unit has two active nurseries near the planting site: Ban Mae Sa Mai community tree nursery (BMSM) and Doi Suthep research nursery (DS). In addition, schools participating in the YFR project have been producing saplings from locally collected seed in their own on-campus nurseries with technical support from FORRU-CMU since April 2022. Therefore, some of their sapling are also ready for planting at this site.

5.3 Experiment design

A total of 4 blocks were used for the organic fertilizer experiments, with 4 treatments per block:

- **Treatment 1 (Control):** 50 grams of organic fertilizer (yellow poles)
- **Treatment 2:** 100 grams of organic fertilizer (red poles)
- **Treatment 3:** 150 grams of organic fertilizer (green poles)
- **Treatment 4:** 200 grams of organic fertilizer (blue poles)

All treatments were applied at the time of planting, three times during the 1st rainy season and will be repeated three times during the 2nd rainy season. Ten species were selected for the experiment, using 40 saplings per treatment per block.

Table 1 Total number and lists of species for experiment in Day 1 (4 rai)

S.no	Thai name	Species	Successional guilds	Low elevation	High elevation	Total no. of sapling	Label numbers T1 T2 T3 T4
118	มะกล่ำตาไก่	*Adenanthera microsperma*	climax	200	1,100	160	118.1-40 41-80 81-120 121-160
31	สะเดาช้าง	*Acrocarpus fraxinifolius*	Pioneer	500	1,250	160	31. 1-40 41-80 81-120 121-160
131	ตาเสือทุ่ง	Heynea trijuga	Pioneer	200	1,500	160	131. 1-40 41-80 81-120 121-160
13	มะซัก	*Sapindus rarak*	Intermediate	200	1,620	160	13. 1-40 41-80 81-120 121-160
15	สลีนก	*Balakata baccata*	Pioneer	375	1,350	160	15. 1-40 41-80 81-120 121-160
323	ทองเหลือง	*Erythrina stricta*	Pioneer	400	1,680	160	323. 1-40 41-80 81-120 121-160
4	เติม	*Bischofia javanica*	Intermediate	200	1,300	160	4. 1-40 41-80 81-120 121-160
364	เดื่อใบใหญ่	*Ficus auriculata*	climax	525	1,400	160	364. 1-40 41-80 81-120 121-160
133	มะค่าโมง	*Afzelia xylocarpa*	Climax	350	500	160	133. 1-40 41-80 81-120 121-160
12	กล้วยฤาษี	*Diospyros glandulosa*	climax	650	1,650	160	12. 1-40 41-80 81-120 121-160
						1,600	

Table 2 Total number and lists of species Day 2 (4.4 rai)

S.no	Thai name	Species	Successional guilds	Low elevation	High elevation	Total no. of sapling
310	ราชพฤกษ์	*Cassia fistula*	climax	400	900	40
204	แคหางค่าง	*Markhamia stipulata*	climax	575	1,275	40
36	มะขามป้อม	*Phyllanthus emblica*	Pioneer	60	1,700	50
13	มะซัก	*Sapindus rarak*	Intermediate	200	1,620	200
301	กางหลวง	*Albizia chinensis*	Pioneer	450	1,600	50
317	ทองหลาง	*Erythrina subumbrans*	Pioneer	200	1,680	50
425	มะห้อ	*Spondias lakonensis*	Pioneer	450	850	40
161	ฝาละมี	*Alangium kurzii*	climax	600	1,400	50
320	เสี้ยวดอกแดง	*Bauhinia purpurea*	Pioneer	350	900	100
4	เติม	*Bischofia javanica*	Intermediate	200	1,300	50
364	เดื่อใบใหญ่	*Ficus auriculata*	climax	525	1,400	150
41	กัลปพฤกษ์	*Cassia bakeriana*	Pioneer	1,000	1,350	100
492	มะกล่ำตาควาย	*Adenanthera parvonina*				150
241	หว้าขี้กวาง	*Eugenia fruticosa*	climax	200	1,525	90
438	หาดหนุน	*Artocarpus lakoocha*	climax	650	1,100	50
487	แคบิด	*Fernandoa adenophylla*		200	850	40
365	มะเดื่ออุทุมพร	*Ficus racemosa*	climax	60	650	20
218	อบเชย	*Cinnamomum inners*	climax	350	1,900	100
450	ยางโอน	*Polyalthia viridis*	climax	500	800	150
296	อวบดำ	*Chionanthus ramiflorus*	climax	550	850	150
53	ปอมื่น	*Colona floribunda*	Pioneer	650	1,250	80
66	มะกัก	*Spondias axillaris*	Pioneer	460	1,600	50
376	กะเหรี่ยง	*Ficus capillipes*	climax	1,050	1,100	100
						1,900

Planting Events

Planting spots and any surviving natural regenerants were marked with bamboo poles and holes dug twice the size of the containers (approx. 1.8 m apart on average). Participants were instructed to use a knife to cut open the sapling bag area to remove the saplings from the bag in an attempt not to affect the root system. The saplings were then planted in the holes and soil added from back fill and firmly pressed down. Outside the experimental area, 50 g of organic fertilizer was applied in a circle 20 cm from the stem around each sapling. Within the experimental area the fertilizer dosage was according to the experimental treatments.

Planting equipment

1. Baskets for sapling transport across the site
2. Hoe
3. Box cutters to open plastic bags
4. Gloves
5. Fertilizer, bucket for fertilizer and measuring cup
6. Bamboo poles
7. First aid supplies

On the first planting day on 29th July (Figure 7), the experiment blocks were planted: a total of 10 species, 1,600 saplings, with Varee School, Dara Academy and Satit Chiang Mai School (participants in the YFR project). In addition, participants from Doi Suthep National Park Authority, local villagers, the Tropical Rainforest Conservation & Research Centre (TRCRC) and FORRU staff also joined the event: totally 106 people.

A supplementary planting event took place on 11th July with SIG company (30 people) and the Rajapruek Foundation planted 400 sapling (around 1 rai). The remainder - 3.4 rai - was planted with 1,500 saplings on 13th July with YFR schools (Varee, Chiang Mai Christian and Mae Ho Pra school), National Park staff and FORRU staff.

Figure 7– Planting day

Site Maintenance

Weeding and fertilizer application were done 3 times in the first rainy season: on 29th July, 5th September and 16th October (2024) (Figure 8) and will be repeated 3 times in the second rainy season at approximately 6-8 weeks intervals, depending on rate of weed growth. On each occasion, weeds were hand-pulled in a radius of about 50 cm around each tree and 50 g of organic fertilizer applied as above (or as specified within the experimental area).

Figure 8 – FORRU volunteers help weeding and fertilizing.

Tree Monitoring

Monitoring of tree survival and growth was performed with YFR schools and volunteers, supervised by FORRU-CMU staff, shortly after planting (baseline data) on 19th July and at the end of the first rainy season (R1 monitoring) on 23rd November (Figure 9). FORRU-CMU staff analyzed the data and results are presented below. Measurements included tree height and root collar diameter (RCD) to assess tee growth. For the small trees, Vernier calipers were used to measure RCD at the widest point. Tape measures were used to measure tree height from the root collar to the highest shoot tip and to measure crown width at the widest point. A simple health score of 0 to 3 was assigned to each tree and a descriptive note made of any health problems observed. The same scoring system was applied to weed cover (within 1 m of the tree stem) and for shade over the planted trees. Monitoring will be repeated, using the same methods at the end of the second rainy season, to calculate survival and relative growth rates and to detect any differences between the experimental treatment.

Figure 9 FORRU staff and volunteer do baseline and R1 monitoring

Results

Post-planting baseline (BL)

Eighteen trees not found in both the BL and R1 surveys were assigned the status of "not planted" (NP), as there was no evidence that they had been planted in the experimental area. They may have been planted outside the experimental area, not labelled, or left in the nursery. This reduced the overall cohort size to 1,582. Slight reductions in the species cohort sizes were taken into account when calculating survival per cent.

Only four saplings were recorded as having died between the planting date and June 19th (baseline monitoring – BL), probably due to rough handling or trampling. Thus, the BL overall survival rate was 99.8% for all trees planted in the fertilizer experiment area. Species-specific survival rates are shown in Figure 10.

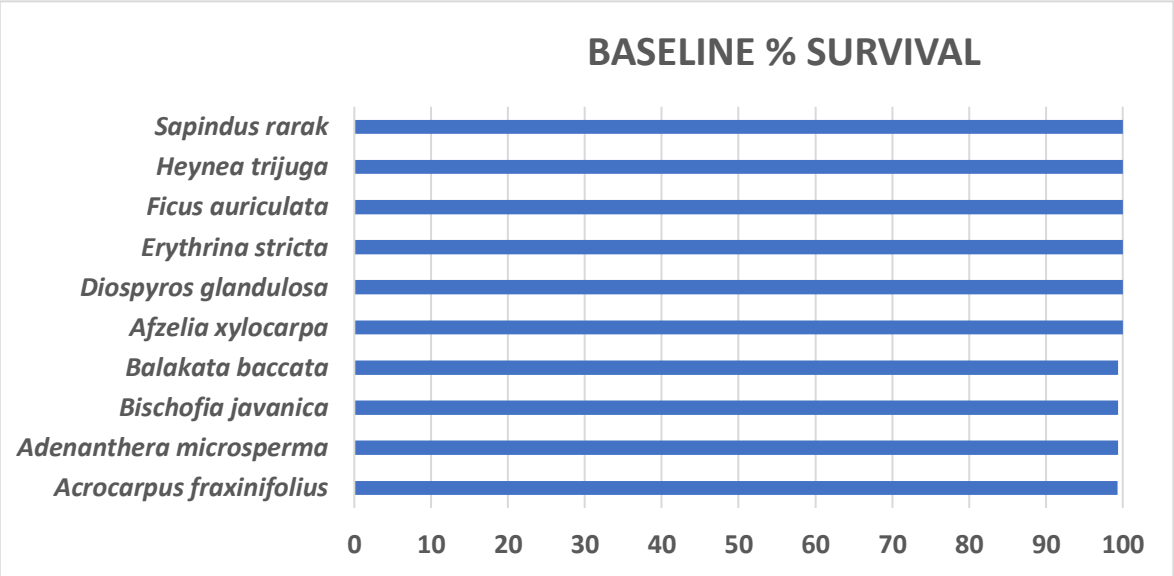


Figure 10 Species-specific survival between planting and baseline survey 19th July

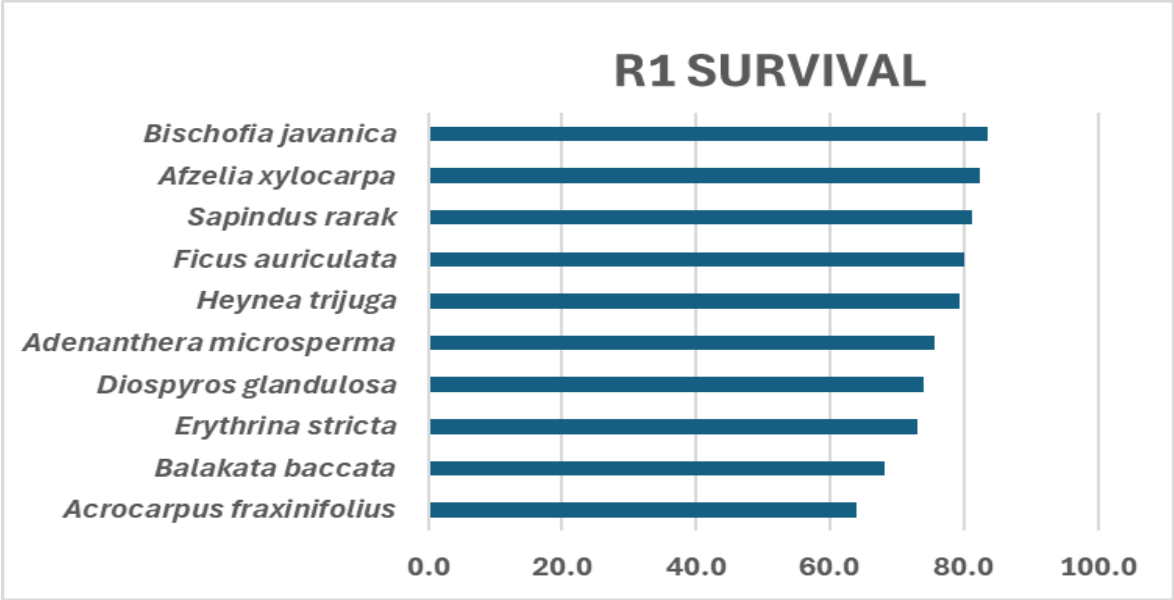


Figure 11 Species-specific survival end first rainy season

R1 – End first rainy season results

A total of total of 1,470 trees were recorded as alive (or NFPA), resulting in an overall estimated survival rate of 93%. Species-specific survival rates are shown in Figure 11. *Adenanthera microsperma, Heynea trijuga, Ficus auriculata, Sapindus rarak, Afzelia xylocarpa* and *Bischofia javanica* all maintained survival rates higher than 75%, which is considered "excellent" compared to FORRU-CMU's previous experiments (Elliott et al., 2003).

The growth metric used was relative growth rate of root collar diameter (RGR-RCD), calculated for all saplings for which RCD measurements were made during both the BL and R1 surveys. The formula used was Hoffman and Poorter's (2002) "estimator 2"[1], with the size variables being log transformed, before averaging within species and treatments, to avoid bias:

$$RGR\ (days^{-1}) = \frac{(\ln(Size2) - (\ln(Size1))}{(t2 - t1)\ (days)}$$

… where Size1 is the initial value of a size variable (in this case RCD), measured on date t1. Size2 is the subsequent value of the size variable, measured on date t2, with (t2-t1) being the time interval in days between the two measurements The equation calculates daily growth, proportional to the average plant size over the time interval. We further standardized the result by multiplying it by 365, to produce an annualized figure, and converted the unitless proportion into a percentage by multiplying it by 100, to express RGR as a standardized per cent per year.

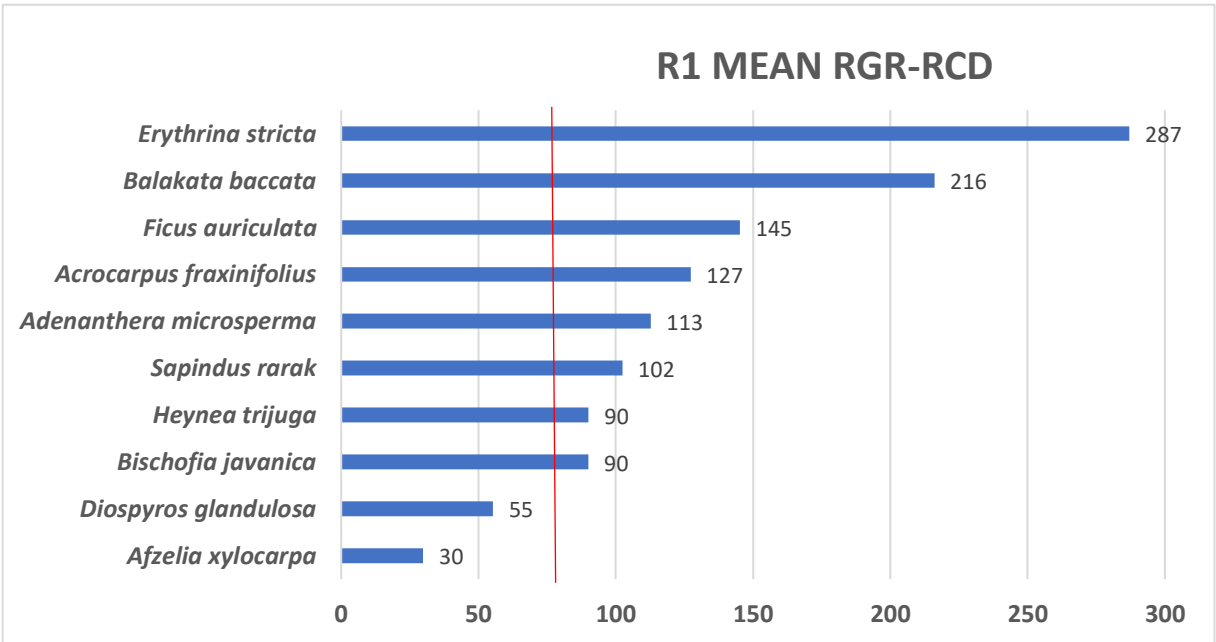


Figure 12 Species-specific mean relative growth rates of root-collar diameter from planting to the R1 survey (23/11/24). The red line is the RGR value that equates to an annual doubling in size.

[1] Hoffmann, W.A., Poorter, H., 2002. Avoiding bias in calculations of relative growth rate. Annals of Botany, 90 (1), 37-42.

Caution must be exercised when interpreting the per cent results, since it represents growth as a per cent of the *average* plant size (not the *initial* plant size). For example, a doubling in RCD from 1 to 2 cm results in an RGR (%/y) of 69% (as a percent of the average RCD of 1.44 cm)— not 100% (based on initial size), might be expected intuitively. Negative values indicate that a species is dying out and is not suited to the prevailing site conditions.

No species exhibited negative RGR-RCD and only two: *Diospyros glandulosa* and *Afzelia xylocarpa*, exhibited RGR-RCD values slowly than that required to double in size annually (69%). Overall, growth of nearly all species on this site was exceptionally high (Figure 12), probably reflecting the fact that three of the four fertilizer treatments applied were higher than the regular fertilizer dosages.

A performance index was calculated by multiplying % survival and standardized RGR-RCD (converted to a scale of 0-100%) – giving equal weight to both variables.

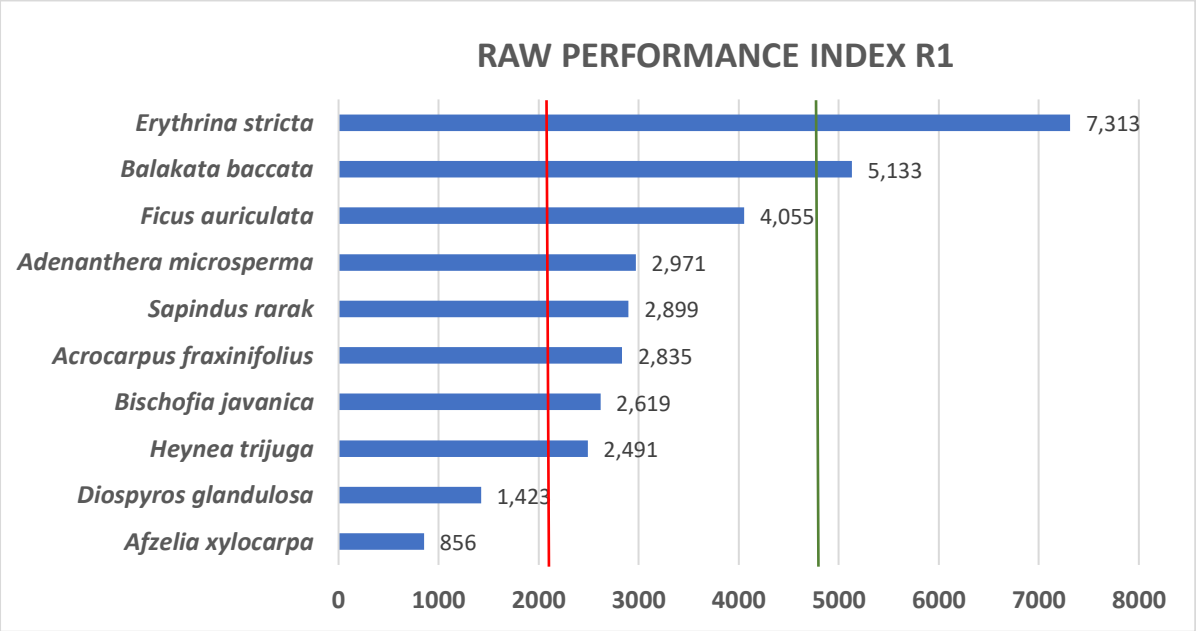


Figure 13 Species-specific performance index values from planting to the R1 survey (23/11/24). The red and green lines are the acceptable and excellent guidelines respectively.

Erythrina stricta and *Balakata baccata*, both exhibited outstanding performance at this site. The other species were ranked as acceptable (the acceptable guideline being >50% survival x >50% annual size increase (i.e. RGR-RCD> 40.5%)=2,025). Only *Diospyros glandulosa* and *Afzelia xylocarpa* failed to achieve acceptable performance levels (Figure 13).

The fertilizer treatments had negligeable effects on overall mean survival averaged across species.

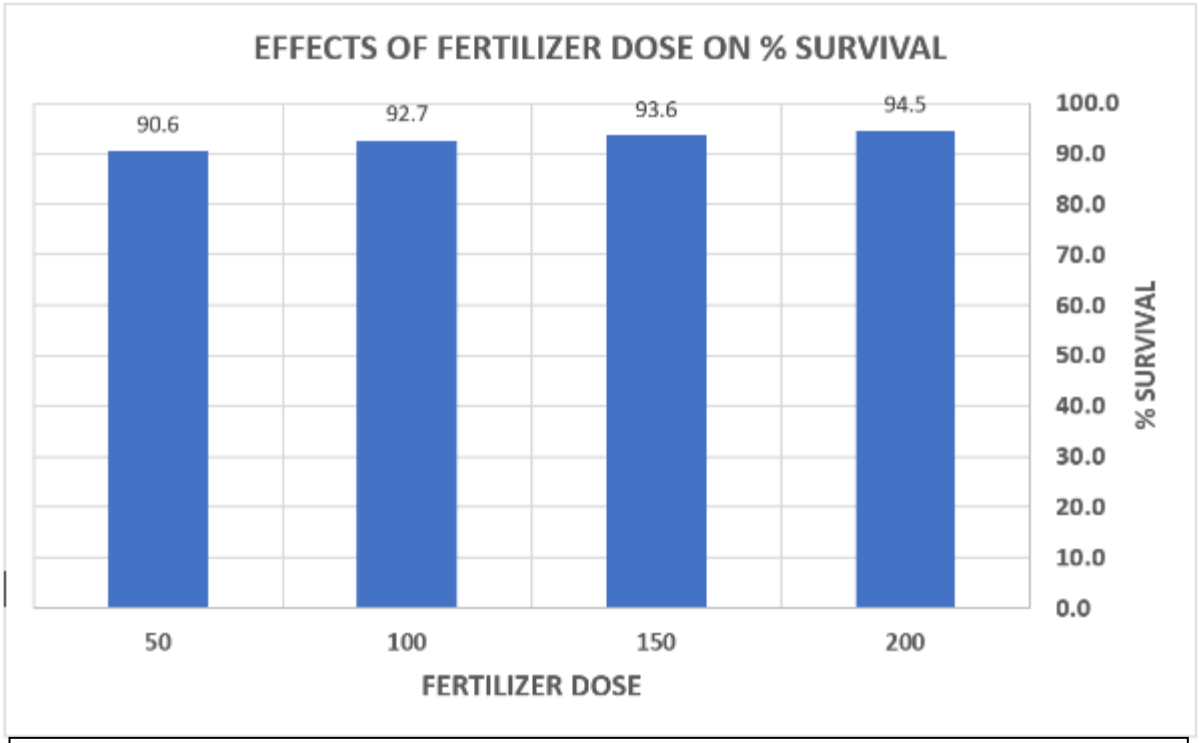


Figure 14 Mean survival averaged across species for each treatment

Higher than standard fertilizer dosages appeared to reduce sapling growth over the first rainy season (Figure 18).

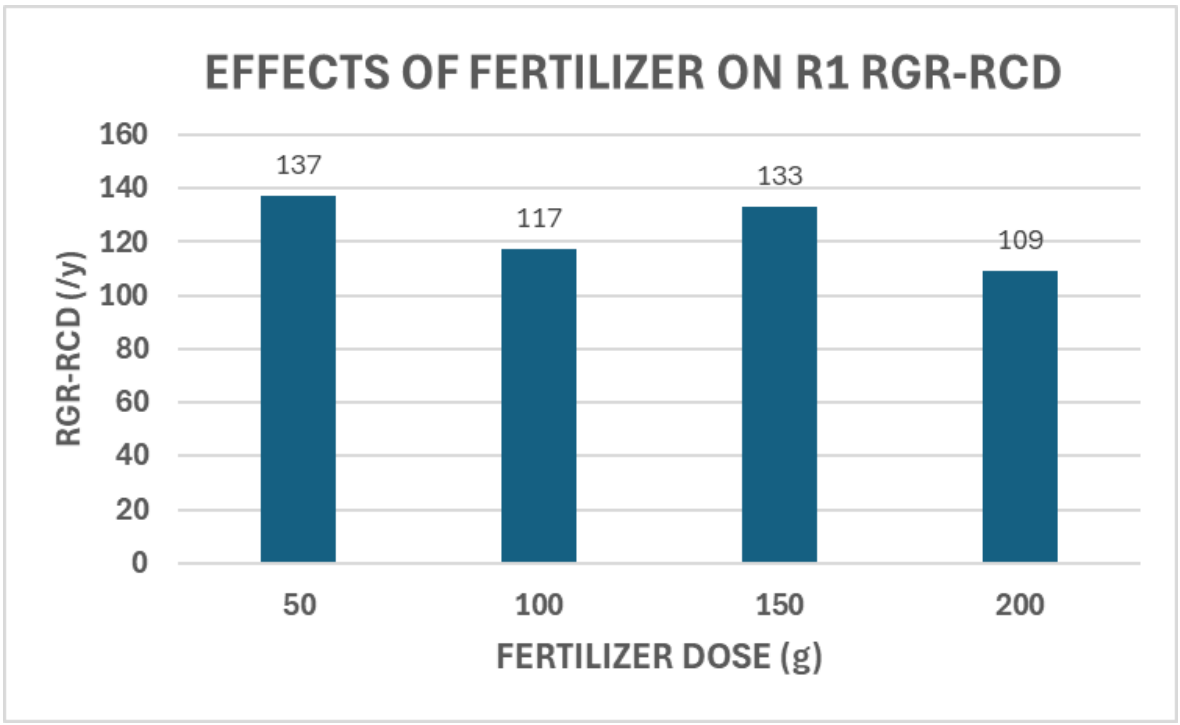
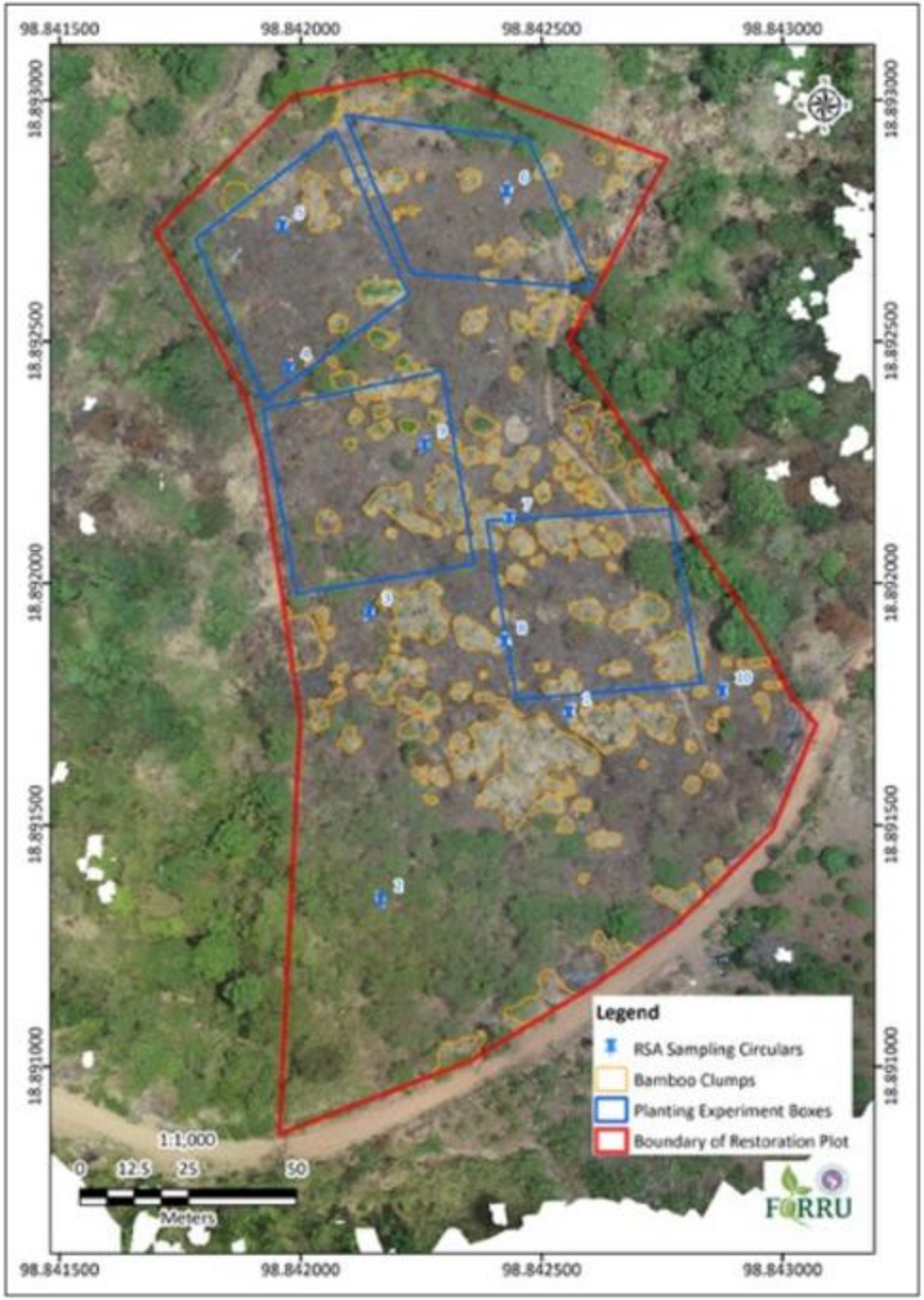


Figure 15 Species-specific performance index between baseline to R1 survey 23rd November.



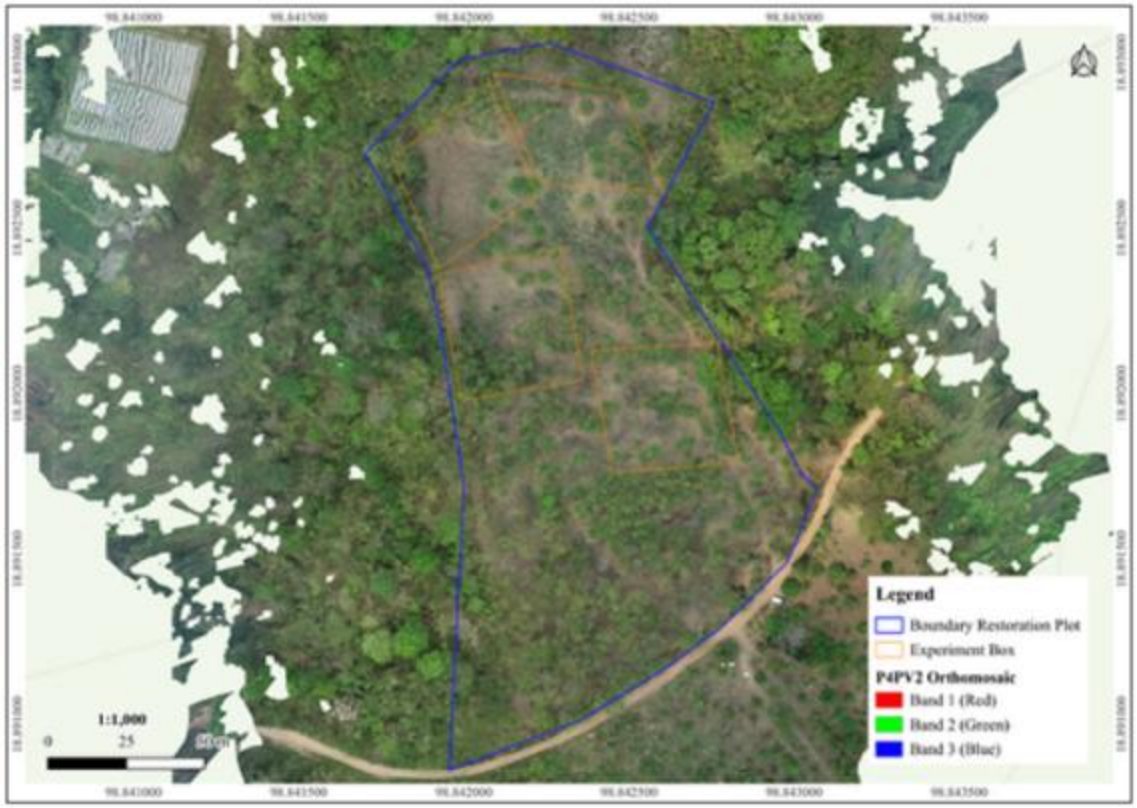


Figure 16 Map from drone surveys of the site before planting on 10th May 2024 (Left).

Figure 17 Map models from drone surveys of the site after planting on 4th April 2025, R1 monitor (Right).

Conclusions

Overall the high survival and growth of most of the species planted on this burnt bamboo-deciduous forest sites were exceptionally high compared with other FORRU plots in the same forest type. Increasing the fertilizer dose appeared to have little additional benefit.

References

Maxwell, J. F. & S. Elliott, 2001. Vegetation and Vascular Flora of Doi Sutep–Pui National Park, Chiang Mai Province, Thailand. Thai Studies in Biodiversity 5. Biodiversity Research & Training Programme, Bangkok. 205 pp.

Appendix 1 – Schedule of Tasks (those in grey have been achieved)

May 10, 2024	Rapid site assessment and drone survey	FORRU
May 16 2024	Planting planning meeting – species selection	FORRU
June 13, 2024	Site preparation before planting (mowing and handling wood chips) – demarcate experimental plots	FORRU and GIVE volunteers
June 17, 2024	Tagging each sapling used in restorative planting	FORRU and volunteers
June 22, 2024	Site preparation (weeding, removing big wood).	FORRU and Villager
June 26, 2024	Site preparation (settle bamboo stake and digging planting holes)	FORRU and Volunteer
June 28, 2024	Transfer saplings, equipment to the 1st planting area and settle and distribute sapling to each hole	FORRU
June 29, 2024	Transfer fertilizer to planting site Planting Day 1 Area 4 Rai	FORRU and everyone
July 9,2024	Site preparation (Bamboo poling to the 2nd planting area)	FORRU
July 11,2024	Site preparation (digging planting hole) and 1 rai planting	Villagers, FORRU, and SIG company
July 12,2024	Transfer saplings, equipment to the 1st planting area and settle and distribute sapling to each hole	FORRU and Volunteers
July 13, 2024	Planting Day 2 Area 3.4 Rai	FORRU and everyone
July 19, 2024	Baseline Monitoring in experimental plots	FORRU and volunteers.
July 29, 2024	1st Site Maintenance	FORRU
September 5, 2024	2nd Site Maintenance	FORRU
October 16, 2024	3rd Site Maintenance	FORRU
November 23, 2024	The end of 1st rainy season monitoring	FORRU
January 31, 2025	Report for the end of 1st Rainy season	FORRU
February 2025 to April 2025	Fire Prevention	FORRU
Rainy season 2025	4th Site Maintenance	FORRU
Rainy season 2025	5th Site Maintenance	FORRU
Rainy season 2025	6th Site Maintenance	FORRU
Late November – Early December 2025 (after the 6th maintenance of the site)	The end of 2nd rainy season monitoring	FORRU
December 2025	Report for the end of 2nd Rainy season	FORRU

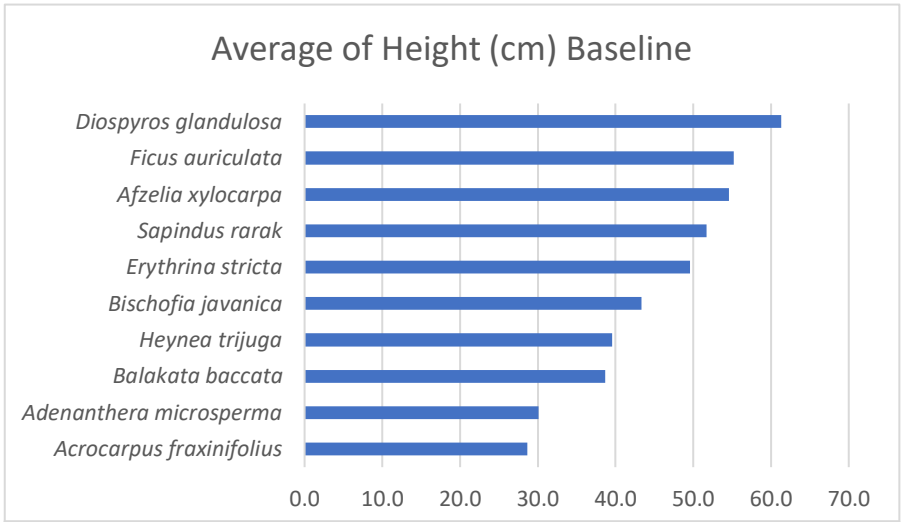
Appendix 2

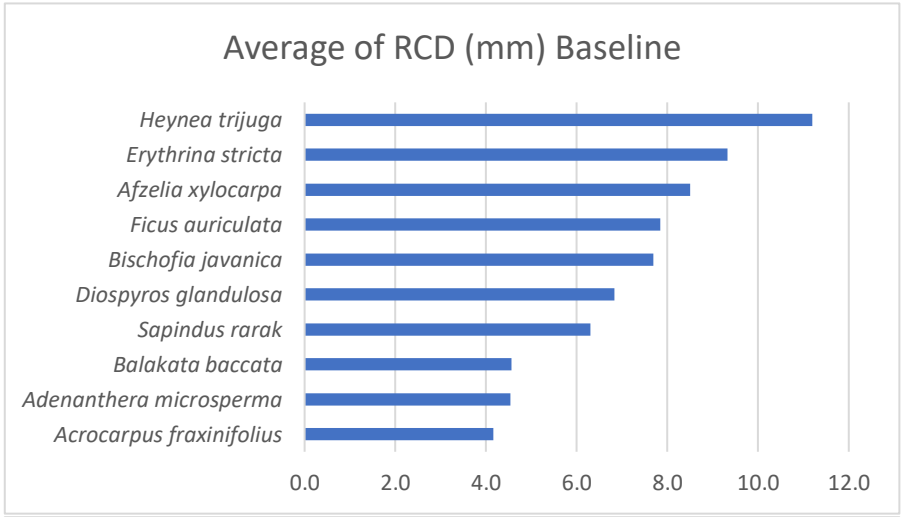
Rapid site assessment

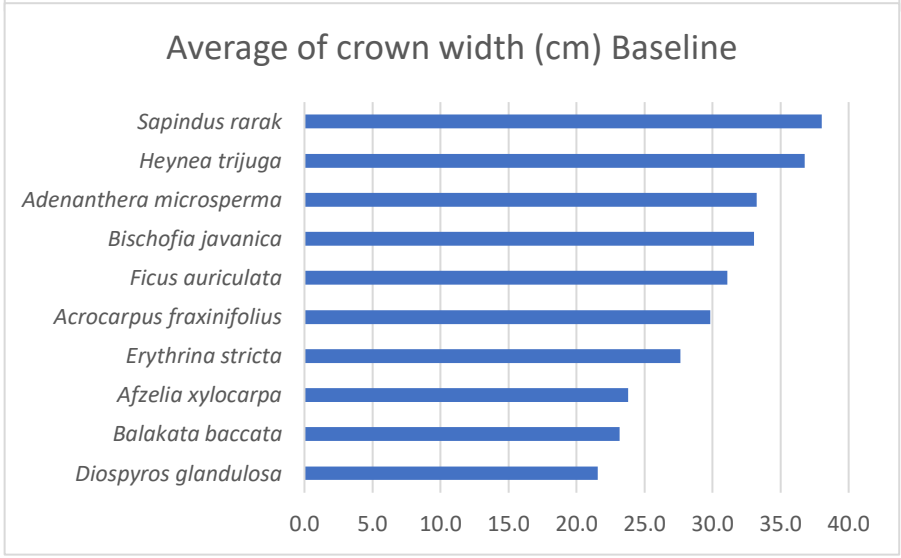
RAPID SITE ASSESSMENT									
Site: PYN 2024						Recorder: Bee		Date: 2024 May, 10th	
Circle	**Latitude (N)**	**Longitude (E)**	**Livestock signs**	**Fire signs**	**Weeds - %cover/mean height/ ± tree saplings**	**No. trees >50 cm tall (<30 cm gbh)**	**No. live tree stumps**	**No. trees>30 cm gbh**	**"Total No. regenerants"**
1	18.891810	98.846280	NONE	Found	0% cover	0	0	0	0
2	18.891340	89.842167	NONE	Found	5% cover, 0.20 m.	1	1	10	12
3	18.891935	98.842143	Found	Found	10% cover, 0.5 m.	4	0	1	5
4	18.892440	98.841975	NONE	Found	0% cover	6	0	0	6
5	18.892733	98.841963	NONE	Found	5% cover, 0.20 m.	1	0	0	1
6	18.892806	98.842428	NONE	Found	0% cover	0	0	0	0
7	18.892129	98.842434	NONE	Found	0% cover	0	0	2	2
8	18.891874	98.842423	NONE	Found	20% cover	4	0	0	4
9	18.892281	98.842258	NONE	Found	0% cover	0	0	3	3
10	18.891771	98.842875	NONE	Found	0% cover	0	0	6	6
					TOTALS	16	1	22	39
"Site description Deforested then reclaimed by the park . Not too slope, mostly burnt, bamboo dominant."							(= total/10)	Mean	3.9
							(= mean x 1,600/78.5)	"Average /Rai"	79.5
							95% c.l.		2.9
							จำนวนที่ต้องปลูก/ไร่(500-Average/Rai)		421

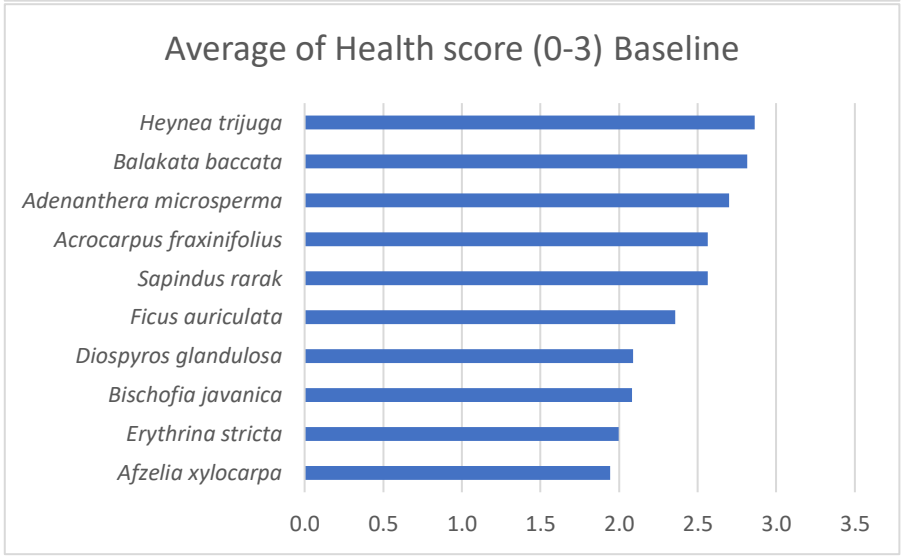
Appendix 3

TREE MONITORING DATA


Average of Height (cm) Baseline
Diospyros glandulosa
Ficus auriculata
Afzelia xylocarpa
Sapindus rarak
Erythrina stricta
Bischofia javanica
Heynea trijuga
Balakata baccata
Adenanthera microsperma
Acrocarpus fraxinifolius
0.0
10.0
20.0
30.0
40.0
50.0
60.0
70.0


Average of RCD (mm) Baseline
Heynea trijuga
Erythrina stricta
Afzelia xylocarpa
Ficus auriculata
Bischofia javanica
Diospyros glandulosa
Sapindus rarak
Balakata baccata
Adenanthera microsperma
Acrocarpus fraxinifolius
0.0
2.0
4.0
6.0
8.0
10.0
12.0


Average of crown width (cm) Baseline
Sapindus rarak
Heynea trijuga
Adenanthera microsperma
Bischofia javanica
Ficus auriculata
Acrocarpus fraxinifolius
Erythrina stricta
Afzelia xylocarpa
Balakata baccata
Diospyros glandulosa
0.0
5.0
10.0
15.0
20.0
25.0
30.0
35.0
40.0


Average of Health score (0-3) Baseline
Heynea trijuga
Balakata baccata
Adenanthera microsperma
Acrocarpus fraxinifolius
Sapindus rarak
Ficus auriculata
Diospyros glandulosa
Bischofia javanica
Erythrina stricta
Afzelia xylocarpa
0.0
0.5
1.0
1.5
2.0
2.5
3.0
3.5

R1 SURVEY DATA