Restoration Cases Flagship Collection

Case #2:

Restoring native forest with
Ban Mae Sa Mai Village,
Chiang Mai, Thailand

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Background and context

The upper Mae Sae Valley in the northern hills of Chiang Mai Province (18˚51′46.62″N; 98˚50′58.81″E) supports lower montane evergreen tropical forest at 1200–1325 masl (Figure 2). The bedrock of the study site was granite and the soils consisted mostly of Acrisols and Cambisols (Elliott et al., 2019; Schuler, 2008). The area has a wet season (May–October) and a dry season (mean monthly rainfall below 100 mm, November–April). Average annual rainfall is 1,736 mm. The Valley lies mostly within what is now Doi Suthep-Pui National Park. Primary evergreen forest (EGF) (*sensu* Maxwell and Elliott, 2001) above 1,000 m elevation is the park's most species-rich forest type, providing habitat for >250 documented tree species, 73% of which are evergreen (Forest Restoration Research Unit, 2005).

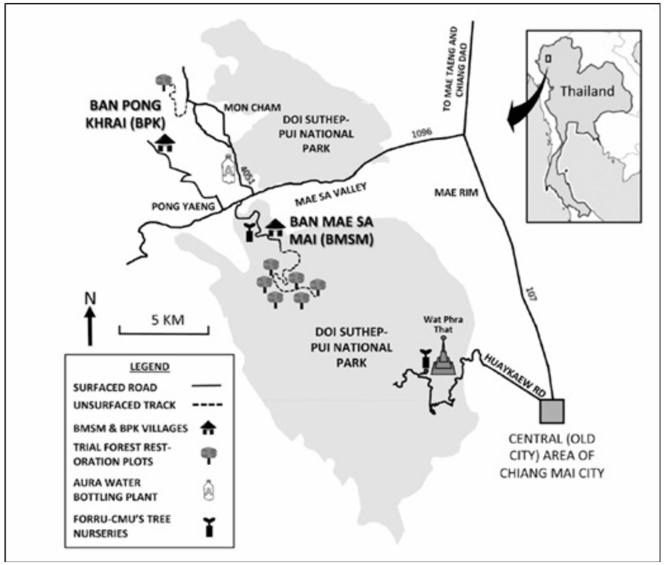

Figure 1. Project location in the upper Mae Sa Valley in northern Thailand. The grey area is the national park. Source: Elliott et al. (2018)

Two Hmong hill tribe communities (Ban Mae Sa Mai and Ban Mae Sa Noi) with a combined population around 1,800 live in the Valley. The Hmong people traditionally practiced shifting cultivation but have now adopted more sedentary forms of commercial agriculture. Although most of the villagers now have Thai citizenship, they cannot legally own land in the national park.

The political economy of northern Thailand changed dramatically after the end of World War II with government-supported production of crops, such as maize and soybeans. Landless farmers from lowlands moved up into the hills to clear and farm unclaimed land. Widespread fire claimed large areas of forest. In 1968 the government granted logging concessions on condition that the area be replanted, but many logged areas were left bare or were transformed to agricultural land. Forest cover, which accounted for about 70% of the national territory of Thailand in 1930, was reduced to approximately 15% by 2005 (Delang, 2005). Logging contributed to a massive flood in the south of Thailand in 1988, killing hundreds of people. This prompted the government to impose a logging ban in 1989 and to expand protected areas to include former logging concessions. Initial efforts to restore such areas mostly involved planting monocultures of pines and eucalypts. The Ban Mae Sa communities had settled in the Mae Sa Valley long before Doi Suthep-Pui National Park was established in 1981. The village was originally founded in 1922 at 1,300 masl, but moved down to its present location in the early 1960s (1,000 masl), after deforestation caused the village water supply to dry up, according to the village elders. To show their good faith with the National Park Authority, the villagers formed the "The Ban Mae Sa Mai Natural Resources Conservation Group" in the early 1990s. In 1996, in support of His Majesty King Bhumibol Adulyadej's Golden Jubilee, the villagers agreed to gradually phase out cultivation of cabbages, corn, and carrots in a 50-ha area in the upper watershed and reforest, while intensifying agricultural production in more fertile land in the lower valley with irrigation from spring water. The Golden Jubilee Project aimed to restore forest to over 8,000 ha of deforested land nationwide, using native forest tree species. Prior to this project, the Royal Forest Department had provided eucalypt and pine trees to plant in the upper watershed, but the villagers were disappointed with the limited species choice and the results. They wanted to plant native tree species. They also wanted to reduce conflicts with the National Park Authority and reduce the threat of eviction by demonstrating their commitment to conservation and reforestation. Meanwhile, a few kilometers down the road, Chiang Mai University's Forest Restoration Research Unit (FORRU-CMU) approached the National Park Authority to find a suitable location to establish trial plots to test the framework species method (FSM) of forest restoration. FSM is a technique for restoring forest ecosystems by densely planting open sites, close to natural forest, with a carefully selected set of woody species that are characteristic of the reference ecosystem and accelerate ecological succession (Goosem and Tucker, 1995; Elliott et al., 2003). The National Park Authority recommended the watershed above Ban Mae Sa Mai and the villagers readily agreed to accept the project in their area. A long-term partnership was born.

Actors and arrangements

FORRU-CMU was established in 1994 to develop appropriate techniques to restore tropical forest ecosystems on degraded land in protected areas for biodiversity conservation and environmental protection. Little was known regarding how to use native species in reforestation and how to grow seedlings in nurseries at that time.
In 1997, FORRU-CMU began research to adapt FSM to restore tropical EGF in the park, after training with the originators of the concept in northern Queensland, used in Australia (Goosem and Tucker, 1995).
At the request of Ban Mae Sa Mai villagers, in 1997 FORRU-CMU funded the construction of a community tree nursery in the village and trained villagers in basic tree propagation methods and nursery management. Villagers were engaged in every stage of the process from seed collection and growing indigenous trees in the community tree nursery to planting, caring for, and monitoring trees in the plots. The partnership with the village contributed to the restoration effort in three main ways:

1. villagers were a key source of indigenous knowledge about native tree species and their uses;

2. the restoration plots provided an opportunity to test practical applications of research findings;

3. villagers supplied local labor, avoiding the need to hire field workers.

Collaboration between FORRU-CMU and the village involved developing negotiation skills and sharing of both scientific and indigenous local knowledge between villagers and scientists. The restoration plot system was established over 16 years (1997–2013) (Figure 1), in close collaboration with both the National Park Authority and the villagers of Ban Mae Sa Mai.

Richemond Bangkok Ltd funded construction of the first nursery and FORRU-CMU paid for annual costs of fire prevention. Currently, FORRU-CMU continues to fund fire prevention and the village tree nursery (sponsored by Rajapruek Institute Foundation), which generates some income from tree sales to other nearby tree-planting initiatives. The unit also provides grants to students who conduct long-term studies on biodiversity recovery and carbon storage in the plot system.

Planning and engagement

Community engagement was built into this project from its origins in 1996 as a unique collaboration between local Hmong villagers, a reforestation research program, and the National Park Authority. The village conservation committee needed technical support and planting stock of diverse local native tree species. FORRU-CMU was in an excellent position to provide these. Little capacity-development was needed, as the village conservation group already had experience of tree planting. Indigenous knowledge about local tree species proved useful in the selection of potential framework tree species for testing. Villagers provided information on which tree species readily colonize abandoned fallows, which attract wildlife species, and which species of potential seed-dispersing animals live in the valley.

The objectives of villagers and the FORRU-CMU research team were closely aligned. From the perspective of FORRU-CMU, the main objective of the restoration plots was to identify and test framework tree species for restoring forest ecosystems in northern Thailand, concentrating first on EGF above 1,000 masl. The villagers, on the other hand, were most interested in planting trees for watershed protection, since most already earned sufficient income from agriculture and salaried employment. Initially, they were motivated to plant native tree species by the Golden Jubilee Project. Economic motivations for restoration were not a priority for either partner and commercial production of timber or non-timber products was illegal activity within the National Park.

Within the 50-ha area allocated for restoration with the approval of the National Park Authority, specific locations of trial plots were selected during walks around the project area with the villagers and National Park officers. Practical considerations, such as ease of access and de facto land occupation were more important than ecological factors in determining plot locations. FORRU-CMU guided the experimental design of the restoration plots, while villagers planted trees, in exchange for support of various community development projects. Villagers were paid individually for monitoring and maintenance work including fertilizer application. FORRU-CMU also supported fire prevention with payments for food and transport for fire patrols and cutting fire breaks. FORRU-CMU staff supervised these activities.

Costs, funding and other support

The active engagement and volunteer labor provided by villagers and students greatly reduced implementation costs. FORRU-CMU was the main fund-raiser for the project. The Science Faculty of Chiang Mai University provided small annual grants, office space, and logistical support, but research and fieldwork had to be funded by project and research grants from government and private sectors and by donations. FORRU-CMU secured funding from a broad variety of sources, including private-sector CSR funds, from both Thai companies (e.g., Riche Monde (Bangkok) Ltd., King Power Duty Free) and foreign companies (e.g., Shell International Renewables, Guinness PLC). The Thai government contributed towards the research in the form of grants from the Biodiversity Research and Training Program. Several non-government organizations directly supported tree planting and the community tree nursery (e.g., WWF-Thailand, Plant a Tree Today Foundation, Rajapruek Institute Foundation). A local company, CityLife Magazine, sponsored one of the plots, to voluntarily offset their carbon footprint. Visits by media celebrities raised the public profile of the project (Figure 2).

Figure 2. Celebrity TV presenter of Tee Nee Mo-Chit, Doo helps his son to plant a tree in the 2008 plot, with pop idol Beam from D2B (WWF's youth ambassador) Photo credit: FORRU-CMU.

Implementation

Trial plots were established on land that had been cleared from the 1950s to the early 1980s for the cultivation of cabbages, potatoes, and other cash crops. Baseline data, collected prior to establishing restoration plots in 1997, included ground flora, soil conditions, and an inventory of tree species in the target EGF ecosystem.

Teams of FORRU-CMU staff and village volunteers worked together to establish forest restoration plots every year during the rainy season using the FSM. In March–April, about two months before the beginning of the rainy season, circular plots of 5 m radius were surveyed to estimate the density of naturally occurring regeneration (e.g., remnant mature seed trees, live tree stumps capable of coppicing, tree saplings and seedlings above 50 cm height). The number of tree seedlings to be planted per hectare was calculated to yield a total density of 3100 individuals (planted plus natural regenerants). Individual plots ranged in size from 1.4 to 3.2 ha, with 0.48 to 6.4 ha planted each year. In mid-June, about a month after the rainy season began, each plot was planted with varied combinations of 20–30 candidate framework tree species in the Upper Mae Sa Valley (1,300 masl) of Doi Suthep-Pui National Park.

The species planted were varied each year to compare performance among species. In total, 57 framework tree species were planted over 16 years. Planting protocols were also changed each year to test for the effects of various treatments, including spacing, fertilizer types and dosages, weeding frequency, pruning trees before planting, bare-rooted vs. containerized planting stock, and the use of cardboard mulch mats. The timing of planting was chosen to allow the maximum time for root growth for seedling access to soil moisture in lower soil layers before the onset of their first dry season. Weeding by hand and fertilizer application were applied to both planted trees and natural regenerants three times in both the first and second rainy seasons after planting, to accelerate growth and canopy closure.

The village committee declared tree-planting to be a community activity, so every household in the village was obliged to send one family member to join the work (or pay a fine to the community fund). Following each planting event, FORRU-CMU made a donation to the village community development fund. These donations were mostly used to improve the water system and roads in the village.

Aspect, slope, and land use history varied among the plots over the years. All plots were former evergreen forest, above 1,300 masl, with severe forest degradation and natural regenerants absent or sparsely present at densities well below those needed to close the canopy within 3 years. Framework species were selected from species in the EGF above 1,000 masl, since these forests have the highest conservation value among forests in the region, with the highest number of rare and habitat-restricted vascular plant species (Maxwell and Elliott, 2001).

FORRU-CMU employed one family in the village to collect seeds and grow planting stock. Close proximity of the nursery to the planting sites reduced costs of transporting trees for planting. It has also provided an ideal testbed, where villagers provided feedback on the practicality of species choices and tree growing techniques, developed by the research program. The nursery is still in operation, employing two staff that grow about 20,000 saplings per year for nearby restoration projects (Elliott et al, 2018).

The planting of framework tree species complements pre-existing natural regeneration to accelerate biomass accumulation and recovery of forest structure, biodiversity, and ecological functioning, above that which would occur by natural regeneration alone. It involves planting 20–30 tree species, characteristic of the reference forest ecosystem, selected for their tolerance of exposed conditions, ability to inhibit herbaceous weeds and attractiveness to seed-dispersing wildlife. With a planting density of 3,100 trees/ha, the method achieved canopy closure within 2–3 years of planting in the Mae Sa Valley, relying on animals to disperse seeds from nearby forest remnants, to gradually re-establish the tree species composition of EGF. Framework species are selected for their ability to attract seed-dispersing animals and pollinators by producing fleshy fruits, nectar-rich flowers, and nesting, roosting, or perching sites at a young age.

The success of the FSM relies on selecting high-performing species and applying effective silvicultural treatments. Through establishing the experimental restoration plots, high-performing framework tree species were successfully identified, along with evaluation of silvicultural treatments that maximized survival and growth rates (Elliott et al., 2003; Elliott et al., 2000). Site preparation was important. Before planting, the plots were cleared of weeds by slashing and spraying with glyphosate, taking care not to damage any existing natural regeneration. Trees were planted randomly across the plots, averaging 1.8 m apart. Seedlings were 30–50 cm tall at planting. Various fertilizer, mulching, and weeding regimes were applied as experimental treatments during the first two rainy seasons after planting. Fire breaks were cut every January and fire prevention patrols worked throughout the dry season. Planted trees were monitored just after planting and annually thereafter, to determine survival and growth rates as well as attractiveness to seed-dispersing wildlife.

Studies of the timing of fruit availability were undertaken by FORRU-CMU to determine optimal seed collection times. About 5–10 individuals of each of 100 species were identified and labelled along footpaths in relatively undisturbed EGF adjacent to the unit's research nursery. Selected trees were observed at 3-week intervals from 1995 to 1998 for flowering and fruiting events, and they also served as the initial trees for seed collection (Elliott and Kuaraksa, 2008). Seeds were collected from as many trees as possible and bulked before sowing, to ensure maximum genetic diversity in the planting stock and adaptation of trees to local conditions.

Seed collection was conducted throughout the year, as seeds of the various species come into season. Despite species variation in seed collection time, length of dormancy and seedling growth rates, all species must be ready for planting at the beginning of the rainy season (May–June in northern Thailand). Substantial research was conducted to develop methods for dealing with complexities of native seedling production, including germination experiments, methods to break seed dormancy, seed storage experiments, and seedling growth trials (Blakesley et al., 2002).

In the nursery, seedlings were grown in polybags (9 x 2 ½ inches). Containers are usually placed on the ground, with manual root pruning carried out if needed. Root pruning encourages root branching and removes the risk of transplantation shock during planting. Forest soil is a critical ingredient of the potting mix because it contains mycorrhizal fungi and possibly other microbes that are necessary to promote seedling growth (Elliott and Kuaraksa, 2008).

A plot-monitoring strategy was carefully designed by FORRU-CMU to provide data for testing the framework species model and to evaluate survival and growth of the planted trees. As a research unit, monitoring data was a key focus. Monitoring of 20–50 trees per species per replicate was carried out within 2 weeks of tree planting (to provide baseline data) and was repeated at the end of the first, second, and sometimes third rainy seasons. Villagers were the primary data collectors. The root collar diameter of the young saplings was measured by Vernier calipers. As trees grew larger, tape measures were used to record the girth at breast height. Tree height was measured by tape measures and telescopic measuring poles. Simple subjective scoring was used to record tree health, weed cover (in a 1 m circle around the base of each tree), and shade (over the tree) (subjective scores on scales of 0 to 3). Data were analyzed to calculate rates of survival and growth and combined to derive performance indices. Plots planted in 1998, 1999, and 2000 were also monitored over 6 years for age at first flowering/fruiting and attractiveness to wildlife. The oldest plots were recently resurveyed for long-term survival, growth, and above-ground biomass in relation to functional traits (Elliot et al., 2019).

CMU students and villagers were trained in seed collection, nursery methods, tree planting, maintenance of plantings, and monitoring tree growth. Experiences and protocols developed from FORRU-CMU's extensive research program were compiled in a technical manual (FORRU, 2008), to support development of research programs to apply the FSM to other forest ecosystems and socio-economic circumstances. FORRU-CMU's research nursery is also used for training and education of groups outside of the local village. Workshops and other education events were carried out for various target groups, including school children and their teachers, villagers, and government officials. FORRU-CMU supported establishment of tree nurseries in many communities in northern, western, and southern Thailand and published training manuals in several regional languages to enable adaptation of generic techniques to local conditions and forest types in Cambodia, Vietnam Lao PDR, Vietnam, Indonesia, and China (Yunan).

In 2006, WWF-Thailand Program and King Power Duty-free sponsored the planting and maintenance of framework forest plots over three years and construction of a new nursery/education facility near the village (Figure 3).

A hugely important outcome of the project was an evidence-based set of techniques for restoring tropical EGF on abandoned agricultural fields. Only 8 years after planting 29 framework species in 4 ha, more than 70 non-planted tree species recolonized naturally, herbaceous weeds were eliminated, humus had accumulated, a multi-level canopy had developed, and biodiversity recovery was underway (Sinhaseni, 2008). The project demonstrated the effectiveness of the FSM in harnessing natural regeneration mechanisms to restore EGF on moderately degraded sites and it generated a set of generic protocols to develop similar restoration practices for other tropical forest countries.

Figure 3. Officials from WWF, King Power, and the sub-district administration opening the new nursery at Ban Mae Sa, 2007. Photo credit: FORRU-CMU

Over 16 years, a total of 33 ha of forest was restored within the experimental planting sites (Figure 4). Including the 57 framework tree species planted in the sampled plots, the total tree species richness recorded in this study amounted to 130 species, constituting 63% of the total tree flora of EGF at 1,300 m elevation. Most of the tree species recorded germinated from seeds dispersed from nearby forest by birds (particularly bulbuls), fruit bats, and civets (Elliott et al., 2012). Bird species richness increased from 30 species before planting to over 80 species within 6 years, representing about 54% of bird species recorded in nearby mature forest (Toktang, 2005). The species richness of mycorrhizal fungi and lichens increased dramatically, often exceeding that of natural forest (Nandakwang et al., 2008; Phongchiewboon, 2008).

Tree growth in the plots contributed net inputs of carbon into the soil from litterfall, resulting in overall accumulation of soil organic carbon and rapid accumulation of above-ground tree biomass. Carbon stored in tree biomass returned to levels that are typical of old-growth natural forest within 14–21.5 years (Kavinchan et al., 2015; Jantawong et al., 2017). Within 14 years of implementing the FSM, the understory environment supported regeneration of a wide range of tree species, with rates of two-year seedling survival exceeding 70% (Sangsupan et al., 2021).

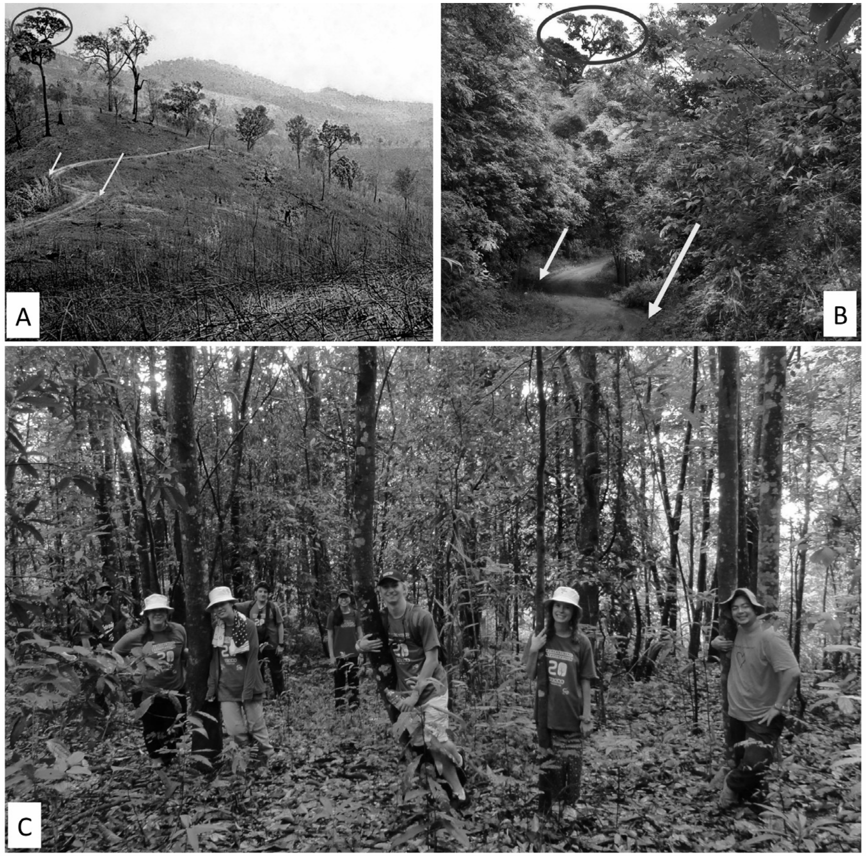

Figure 4. A. Upper Mae Sa Valley, May 1998 before restoration; B. same site, left of the track, restored forest 15 years old, planted 2001; right, 9 years old restored forest, planted 2007 (photo September 2016). C. Inside the restored forest (10 years old), a dense understorey develops beneath the canopy of the planted trees, with up to 70 recruit tree species represented by seedlings and saplings in the ground layer.

Conversion of forest to agriculture was restricted within the national park. FORRU-CMU invested heavily in annual fire protection and sponsored cutting of fire breaks around the village. They paid for eight people to watch for fires during the dry season and the whole village contributed to fire control. There were no fires in the area during 1998–2014, but fires swept through about a third of the plots in 2015 and 2016 (Elliott et al., 2018). Most trees survived the damage or resprouted. After these fires there was an attempt to revive fire prevention activities in all the villages in the region and they made a public pledge to forest conservation and protection. The villagers hope that their continued collaboration with reforestation and forest protection will bolster their claim to remain living within the national park.

Questionnaires and interviews conducted during 2005–2007 revealed strong satisfaction with most aspects of life in the village and high awareness of FORRU-CMU's activities (Elliott et al., 2012). The majority of villagers were highly satisfied with tree planting and forest fire prevention activities. Around 80% of respondents agreed that the project had helped to reduce internal social conflicts over natural resource shortages and improved the community's relationships with outside organizations (particularly the Forest

Department and National Park Authority, with which the villagers had previously been in conflict). Villagers appreciated that the project had improved the public image of the village through media coverage (Figure 2).

The villagers received economic benefits, such as direct monetary payments in the forms of salaries for work in the nursery and for plot maintenance as well as support provided by FORRU-CMU for community development (improving road access, water supply, fire prevention work and religious ceremonies). The development of ecotourism in the village also benefited from the project programs, since many ecotourists began to visit the village after learning about the forest restoration project there. Ecotourism is generating revenue for the village from rental of bungalows and provision of meals for visitors. Several villagers acknowledged that FORRU's support had enabled them to receive other forms of local support (e.g., "matching funds") from the Sub-district Administration Organization and from local units of Royal Project and the National Park Authority. In addition, the community tree nursery stimulated a few villagers to produce trees for sale.

Villagers also benefited through access to non-timber forest products; 90% of the interviewees said that they gather some products from the forest for daily use in the family. Forest restoration contributed to increased production of bamboo shoots and stems, banana leaves and flowers, edible leafy vegetables (mostly young leaf shoots from trees); other flowers and fruits (mostly from trees) and some mushrooms. Yet, despite these social and economic benefits, the Hmong villagers still have no legal rights to the forest and face potential eviction along with thousands of other hill tribe communities.

Using the Upper Mae Sa Valley plot system as a model, FORRU-CMU began collaborating with the IUCN and Thailand's Supreme Command to restore EGF on 1,440 ha at Doi Mae Salong, with eight communities of various ethnic groups. A FORRU was also established by the Elephant Conservation Network in Kanchanaburi to restore mixed evergreen deciduous forest for elephant conservation and to restore lowland EGF in the southern province of Krabi, as habitat for Gurney's Pitta, one of Thailand's most endangered bird species. Following workshops at the Ban Mae Sa Mai demonstration site, various government agencies and conservation organizations have now planned to replicate the FORRU model in China, Cambodia and Indonesia. Since 2015, the nearby Thai community of Ban Pong Khrai has also embraced the framework species method, to restore the watershed above their village (Elliott et al., 2018).

Key challenges

The particularities of the special collaboration among FORRU-CMU, the Hmong villagers, and the National Park Authority created challenges largely due to the inability for policy reform on land tenure. The villagers still fear eviction from the National Park. The National Park Authority does not seem to take into consideration the community's considerable contribution towards conservation and restoration of the upper watersheds since 1996 and has lately increased efforts to prevent agriculture and ecotourism ventures within the park, making it difficult for the villagers to earn a living. In the words of Stephen Elliott, one of FORRU-CMU's founders: "Working with a local community is like riding a roller coaster. You have to hold on tight."

Another major challenge has been generational change in the community. The project evolved successfully during 1997–2013, which is a noteworthy track record. Early on, the most engaged villagers were strongly committed to the project's ideals of restoring the forest. These were the founders of the Ban Mae Sa Mai Natural Resources Conservation Group back in 1996. The new generation is more focused on material benefits from ecotourism agriculture, so enthusiasm for forest restoration fluctuates. Ban Mae Sa Mai split into two villages in 2014, to take advantage of government funding opportunities. So, now agreement must be sought from two village heads whenever activities are planned. Since 2014, FORRU-CMU has not initiated any new restoration plantings in this area, but has actively continued monitoring, research, and fire protection. Having established an effective method to restore tropical EGR on Thailand's northern mountains, their scientific work has shifted to look more closely at biodiversity recovery, long-term forest dynamics (particularly survival and growth of incoming tree species), and carbon storage in restored forests (Jantawong et al., 2017).

A further challenge was maintaining project momentum and stability based on short-term grants. Since the restored forest was in a national park, there was no prospect of the project becoming self-sustaining financially through sale of non-timber forest products. The project advanced from one grant cycle to another, making long-term strategic planning impossible. Each year, decisions were made regarding where to locate new plantings, based on casual walks and recommendations from villagers based on avoiding conflicts with areas under cultivation. It was not possible to use spatial planning tools to optimize restoration outcomes or benefits.

Fire is the greatest challenge facing the long-term survival of the experimental plots. With increasing drought and other effects of climate change, fire prevention and active involvement of villagers are essential to allow these plots to continue on their trajectory of recovery. “Project fatigue” now also threatens the project’s long-term sustainability through encroachment, fire, tree felling, improved road access, and tourism developments (Elliott et al., 2019).

Enabling factors and innovations

A fundamental driver of this project’s success was the participation by all stakeholders at every stage of the project, from site and species selection to planting and taking care of planted trees, as well as monitoring. Stakeholders have included the Hmong villagers from Ban Mae Sa Mai, educational institutes (particularly Chiang Mai University), government (Doi Suthep-Pui National Park), non-governmental organizations (the Forest Resources Management Unit of WWF Greater Mekong Thailand Country Program), and the business sector (King Power Duty Free Co.).

Several pre-existing conditions contributed to project success. First, villagers had already decided to plant trees when the project started, so there was no need to persuade them of the value of the activity. Second, the village was large and highly organized. There was a strong sense of community and an effective village committee, supported by the majority of the population. Third, the villagers had little need to exploit the forest for material needs. Agriculture for cash crops was already well-developed, firewood was mostly provided from pruning lychee orchards, and timber for construction was largely being replaced with concrete. And fourth, the villagers were used to working with other organizations on projects. Being situated about one hour's drive from Chiang Mai, this village has hosted many projects implemented by both Thai and international organizations over the years, establishing lines of communication and negotiation mechanisms.

The project has initiated or led to two novel contributions that set it apart. First, FORRU-CMU invested significant effort in outreach and education, providing practical guides (FORRU, 2006), teaching materials, training materials for practitioners, and materials for school groups and children. They recently produced a cartoon book for children entitled, "Grow a Forest with Lin and Sai." Second, the project has innovated the use of drones in forest restoration and community engagement (Elliott, 2019). Drones are being used to map plot boundaries, assess canopy closure, and detect fires. They could potentially be used to plant seeds and monitor seedling growth in remote areas. They give villagers "eyes in the sky." An international workshop on the applications of drones in forest restoration was held in Chiang Mai in 2015 and has stimulated great interest within the local community and around the world (Elliott, 2016).

- Make restoration pay. It is important to develop social, economic, and political systems that acknowledge the value of the forest and provide benefits to those who restore and protect the forest. Forest restoration should not be implemented at somebody's expense. Otherwise, those that are disadvantaged can retaliate and destroy it.

- Elevate restoration to the level of a livelihood. Declaring "I am a forest restorer" should be just as valued as "I am a farmer."

- The sustainability of restoration can never be guaranteed. Rural populations grow and aspirations and expectations change. Project goals and values need to adjust to these changing realities.

- Use restoration projects as an opportunity to conduct controlled and replicated experiments. Results will provide the evidence for developing good practices and are vital for adaptive management.

- Communities and villages are not single entities, but are composed of diverse members with different perspectives and needs. To engage villages and communities the diverse skills and interests of community members should be harnessed.

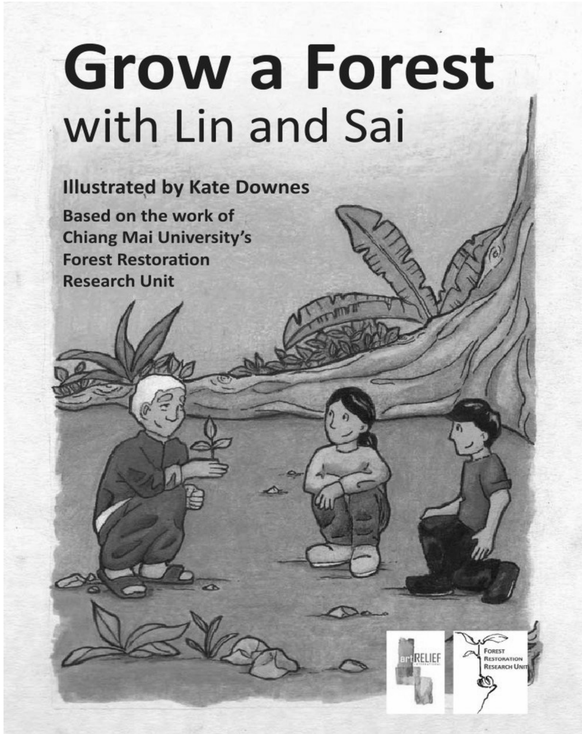

Figure 5: The cartoon book for children "Grow a Forest with Lin and Sai" can be downloaded here *for free.*

Further information and resources

Chiang Mai Forest Restoration Unit website: https://www.forru.org/

Video, "FORRU AT 20 (English): https://www.youtube.com/watch?v=Skz7DlxPFlc&t=609s

FORRU-CMU publications: https://www.forru.org/library

How to Plant a Forest Manual (available in 7 languages)

Outreach and Educational Materials

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