PART 1

Forest Restoration – Pipe Dream or Practicality?

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Deforestation – A Threat to Life on Earth
Forest Restoration – Confronting the Crisis
The Forest Restoration Research Unit (FORRU-CMU)
Education and Training for Restoring Tropical Forest Biodiversity

"Life on Earth dates back 4,000 million years.
Modern Man is perhaps no more than 30,000 years old.
We've been here for a very short time,
but we hold the fate of every other species in our hands.
We have an enormous responsibility to our children,
to all the other species and to our planet."
– Ben Kingsley, Actor.

Education and Training for Restoring Tropical Forest Biodiversity - FORRU/EMR's Darwin Initiative Project

From 2002 to 2005, this project passed on the skills and knowledge required to restore forest ecosystems to community groups and NGOs as well as school children and their teachers. The education/training program was based on original information derived from FORRU's research and enabled local communities to start their own forest restoration initiatives, using proven techniques. This manual is enabling the experiences gained during the project to be passed on to others for many years to come.

More than 180 school events introduced 9,000 children and their teachers to forest restoration concepts and methods (above).

Nineteen workshops showed more than 500 technicians how to include biodiversity recovery in reforestation programs by applying the framework species method (above).

Young students from all over the world were taught nursery techniques (left) before participating in hands-on activities (above).


FORRU NEWSLETTER

September 2003

FORRU Forges Links in southern Thailand

To Help Save Thailand's Rarest Bird

by Stephen Elliott

All project participants were kept informed by a newsletter (left); 900 copies (Thai and English) distributed quarterly.

Forest restoration is not just about planting trees. Conservation of seed-dispersing birds is also important for biodiversity recovery. So, a bird conservation club was formed at Ban Mae Sa Mai to persuade children who usually hunt birds to appreciate and conserve them instead (left and above).

DARWIN INITIATIVE

FOREST RESTORATION – PIPE DREAM OR PRACTICALITY?

"If we continue at the current rate of deforestation and destruction of major ecosystems like rainforests and coral reefs, where most of the biodiversity is concentrated, we will surely lose more than half of all the species of plants and animals on Earth by the end of the 21st century."
- E. O. Wilson, renowned biologist who popularized the term "biodiversity".

SECTION 1 – DEFORESTATION – A THREAT TO LIFE ON EARTH

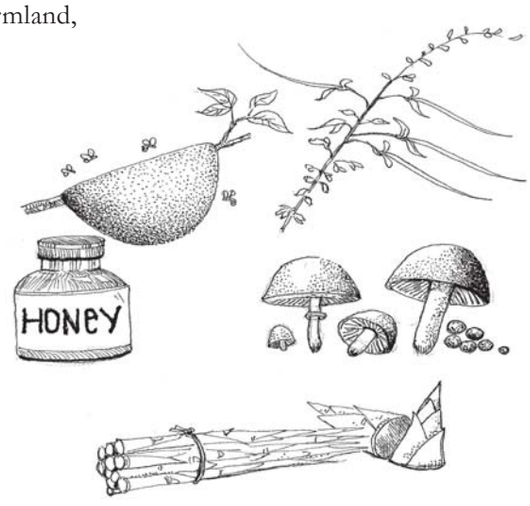
Why should I care about forest destruction ?

Ever since Humans first forged metal axes, forests have been cleared to make way for agriculture and towns and to provide timber, firewood and a host of other products. In ancient times, tree cutting rarely exceeded the natural capacity of forests to regenerate. Now, however, as the demands of an ever growing Human population have increased, forests and the wealth of species they support, are being devastated well beyond their capacity to recover.

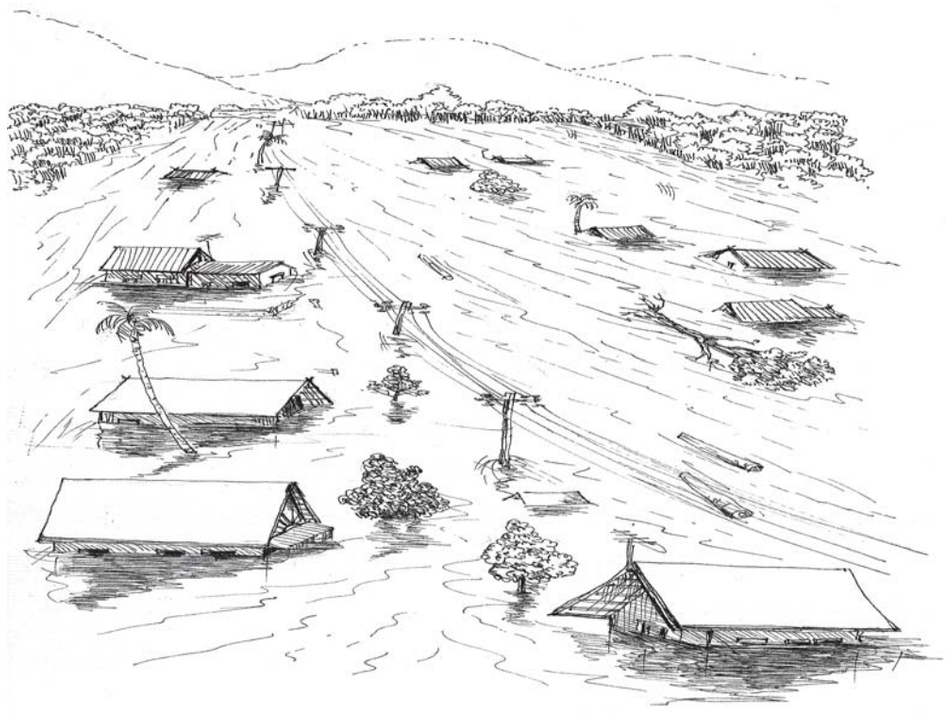
This problem is particularly serious in the tropics. Tropical and sub-tropical forests cover only 16.8 percent of Earth's land area (FAO, 2001), yet they are home to more than half the planet's plant and animal species (Wilson, 1988). Deforestation gradually reduces large forest tracts into tiny, isolated fragments, each of which is incapable of supporting viable populations of plant and animal species, especially large mammals and birds. As species start to disappear, the complex web of species interrelationships, vital for the maintenance of tropical forest biodiversity, begins to unravel. Plants loose their pollinators or seed dispersers and cannot reproduce; herbivore populations, formerly held in check by predators, expand and threaten the survival of their food plants. As key species die out, a cascade of extinctions reduces the rich biodiversity of tropical forests to a few, common weedy species that dominate the landscape. Thus, devastation of Earth's tropical forests is causing the extinction of more species now than at any time during our planet's history (Wilson, 1992).

The biodiversity of tropical forests provides a wealth of products to local communities, such as medicinal and edible plants, honey, bamboo, mushrooms and so on. Provided they are harvested sustainably, these goods can provide a valuable, long-term contribution towards the livelihoods of local people. However, because such subsistence products are not bought or sold in markets, their value is not included in indices of economic development (*e.g.* gross domestic product). Hence, their importance is largely ignored by policy makers, who sacrifice forests for conversion to other uses. Consequently, poverty worsens, when local people are forced to buy substitutes for lost forest products with cash, whilst paradoxically, economic indices show a false increase in national prosperity.

Tropical forests also provide vital ecological services that maintain environmental stability. Predators that live in forests can control pests in surrounding farmland,



Forests provide a vast array of products to local people.

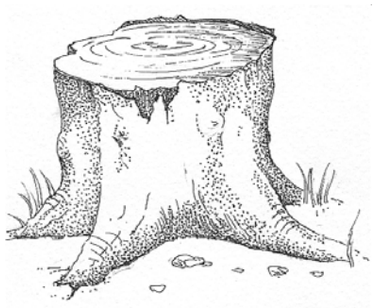


Deforestation causes soil erosion, floods and landslides.

whilst forest-dwelling bats and insects pollinate many crops, especially fruit trees. The huge quantities of leaf litter, produced by mature tropical forests, create deep organic-matter-rich soils, which store vast amounts of water per unit volume. These soils soak up water during the rainy season, preventing floods. Conversely, in the dry season, water slowly drains out of forest soils, maintaining stream flow and thus averting droughts. Furthermore, forests help to reduce global warming, by absorbing vast quantities of carbon dioxide into their canopies and converting it into wood.

All these products and ecological services represent a substantial contribution to the quality of Human life, yet all are threatened by deforestation.

A tree stump symbolises forest destruction...



How fast are tropical forests disappearing?

The Food and Agriculture Organization of the United Nations provides the most comprehensive assessments of tropical forest cover, using satellite imagery. Worldwide, the area of natural tropical forests[1] declined from 1,945 to 1,803 million hectares between 1990 and 2000 AD. Ten million hectares were converted into tree plantations, whilst 142 million hectares were converted to other land uses. Over the same period, only about 10 million hectares of deforested land regenerated into tropical forest. The net annual average reduction in natural tropical forest cover was, therefore, 14.2 million hectares (approximately 0.7 percent per year), about the same rate of decline as during the previous 10 years; 1980-90 (FAO, 2001).

In Thailand, natural forests covered 9.8 million ha (19.3 percent of the country's area) in 2000 AD. Despite a ban on commercial logging since 1989, the average annual reduction in natural forest cover (1995-2000) remained 0.26 million hectares (2.3 percent of the 1995 figure) (FAO, 1997, 2001). Overall, since 1961, Thailand has lost nearly two thirds of its forests (Bhumibamon, 1986).

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[1]Tree cover >10%, not including plantations.

SECTION 2 – FOREST RESTORATION - CONFRONTING THE CRISIS

Can tropical deforestation and the associated catastrophic losses of biodiversity be reversed? Or is merely slowing the rate of devastation the best that conservationists can realistically hope for? Fortunately, forests have a tremendous natural capacity for self-recovery. Under natural conditions, recovery can take centuries but, by understanding and enhancing the natural processes of forest regeneration, it can be completed in just a few years. The simple techniques, described in this book, show how this can be done. ***Restoration of tropical forests is no longer a pipedream but a realistically achievable goal.***

What is the difference between reforestation and forest restoration?

"Reforestation" means the re-establishment of any kind of tree cover on deforested land. It is a broad term, encompassing various forms of forestry with different objectives, such as plantations, agro-forestry, community forestry and so on. In the tropics, commercial tree plantations are the most common forms of reforestation. Asia leads the world in this type of reforestation. By 2000, 62 percent of the world's tree plantations were located there; contributing 20 percent to Asia's total tree cover. Thailand ranks 8th among countries with the largest proportion of the world's tree plantations. Nearly 5 million hectares of mostly pine, eucalypt and rubber plantations constitute about one third of Thailand's total tree cover (FAO, 2001).

Such plantations are needed to satisfy the growing demand for wood and pulp and they may reduce the need to log natural forests. However, they do not provide suitable habitat for the plant and animal species that once inhabited the forest ecosystems that plantations replace.

For environmental protection and conservation of biodiversity, "forest restoration" is more appropriate. It is defined as "re-establishment of the original forest ecosystem that was present before deforestation occurred".

Forest restoration cannot re-establish all plant and animal species that lived in the original forest in a single step, since in most areas, the complete flora and fauna of the original forest are unknown. Rather, it aims to restore former levels of ecosystem structure and functioning, by planting key tree species that played a vital role in the ecology of the original forest. The success of forest restoration can be measured in terms of the return of a multi-layered canopy; increasing numbers of returning species (particularly rare or keystone species); improved soil conditions and so on. Therefore, forest restoration is a specialized form of reforestation (Elliott, 2000).

Where is forest restoration appropriate?

Forest restoration is appropriate wherever biodiversity is one of the goals of reforestation, such as for wildlife conservation, environmental protection, eco-tourism or to supply a wide variety of forest products to local communities. It is most suitable for reforesting degraded sites within protected areas. Since the 1960's, the Royal Forest Department[1] (RFD) has declared 138 national parks or wildlife sanctuaries, covering more than 15 percent of the country (Elliott & Cubitt, 2001).

However, even these conservation areas often contain large deforested sites, logged by former concessionaires or cleared for agriculture by former inhabitants. If they are to fulfill their role as the last refuges for Thailand's wildlife, forest restoration, as defined above, is urgently needed.

...but some tree stumps can spring back to life.

[1]Now the Department of National Parks and Wild Plants and Animals (DNP)

Anyone can enjoy the satisfaction of planting trees...

Is tree planting essential to restore forest ecosystems?

A lot can be achieved by studying how forests regenerate (see Part 3). The factors that limit regeneration can be identified and consequently, various interventions can be implemented to overcome them. These can include weeding and adding fertilizer around natural tree seedlings, preventing fire, removing cattle and so on.

This is termed "accelerated natural regeneration" or ANR (see Part 4). ANR is simple and cost-effective, but it usually operates on trees that are already present. These usually represent only a small fraction of the total tree species that comprise mature tropical forests. Therefore, for full recovery of biodiversity, some tree planting is usually necessary. It is not feasible to plant all the many hundreds of trees that may formerly have grown in the original forest and, fortunately, it is also unnecessary.

What is the framework species method of forest restoration?

Planting a few, carefully selected tree species can rapidly re-establish forest ecosystems with high biodiversity. First developed in Queensland, Australia (Goosem and Tucker, 1995; Lamb *et al.*, 1997; Tucker and Murphy, 1997; Tucker, 2000), the framework species method involves planting mixtures of 20-30 indigenous forest tree species that rapidly re-establish forest structure and ecosystem functioning. Wild animals, attracted by the planted trees, disperse the seeds of additional tree species into planted areas, whilst the cooler, more humid and weed-free conditions, created by the planted trees, favor seed germination and seedling establishment (see Part 5).

Excellent results were achieved with this method in Australia (Tucker and Murphy, 1997), but could this success be replicated in Thailand? Chiang Mai University's Forest Restoration Research Unit was founded in 1994 to address this question.

...but it is also important to monitor the performance of planted trees, to learn from mistakes and improve techniques year by year.

SECTION 3 - THE FOREST RESTORATION RESEARCH UNIT

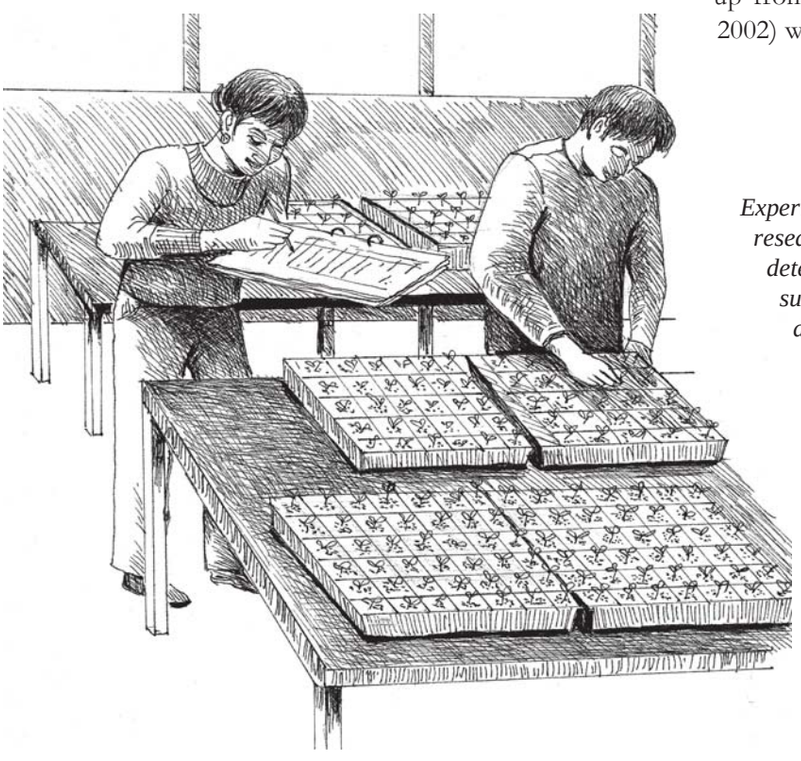
In 1994, a few members of staff and students of the Biology Department, in Chiang Mai University's (CMU) Science Faculty, started to investigate the possibility of restoring forests on degraded sites in northern Thailand, by adapting the framework species method to local conditions. With a founding grant from Riche Monde (Bangkok) Ltd., and technical assistance from Bath University, U.K. (sponsored by The British Council), a research facility was established in collaboration with Doi Suthep-Pui National Park authority (under the DNP) and named the Forest Restoration Research Unit (FORRU-CMU). It now consists of an office and research tree nursery at the park headquarters, a community nursery and field plots at Ban Mae Sa Mai and an education unit, in the Herbarium Building of CMU's Biology Department.

What kind of research has FORRU-CMU carried out?

The techniques and recommendations described in this book are derived from 10 years of research, carried out by both FORRU staff and research students of CMU's Biology Department.

FORRU's first task was to screen some of the more than 660 tree species that are indigenous to the national park (Maxwell and Elliott, 2001) for their ability to act as framework species. Forest restoration begins with seed collection, so FORRU's researchers labeled trees of more than 100 species in the forest around the research station and observed them every 3 weeks, over four years for flowering and fruit production. This study revealed seasonal patterns of fruiting, enabling seed collection schedules to be devised.

The success of any forest restoration project depends on the production of top quality planting stock. Therefore, in the nursery, experiments were designed to develop horticultural practices that optimize seed germination and seedling vigor and health (Blakesley *et al.*, 2000). Germination trials were carried out on more than 400 native forest tree species (Blakesley *et al.*, 2002). Some species germinated easily, whilst others proved difficult. So various treatments to break dormancy were tested, including scarification, heat treatments and soaking in water and acid (Kopachon, 1995; Singpetch, 2001; Vongkamjan, 2003). For those species that proved difficult to grow from seed, vegetative propagation from cuttings (Vongkamjan, 2003) and the nurturing of seedlings dug up from the forest (Kuarak, 2002) were also investigated.



Experiments at FORRU's research nursery have determined the effects of sun and shade on seed dormancy and germination of more than 400 indigenous forest tree species.

FORRU's researchers follow seedling performance from seed germination to planting.

Experiments were then conducted to determine the best container types and media for seedling growth and survival (Zangkum, 1998; Jitlam, 2001). Various methods of fertilizer application and pruning were also tested.

Different tree species produce seeds at different times of the year and seedling growth rates also vary among species, yet all species must grow big enough for planting by the beginning of the rainy season. Therefore, one of the main aims of research in the nursery was to identify treatment combinations that produce trees of a plantable size and quality by the first or second planting season after seed collection (see Part 6).

This led to the development of production schedules for many tree species, which can be used by nursery managers to formulate effective nursery production programmes for mixed crops of framework tree species (Kuarak *et al.*, 2000; Elliott *et al.*, 2002; Blakesley *et al.*, 2000).

Trees were planted out in field trials to assess the relative performance of various "potential" framework species (Elliott *et al.*, 2003). Survival and growth were monitored, as well as ability to shade out weeds and resilience to fire. Various silvicultural treatments, to enhance performance of the planted trees were also tested. These included different weeding methods, mulching and fertilizer application regimes (Elliott *et al.*, 2000) (see Part 7).

An essential characteristic of framework tree species is attractiveness to seed-dispersing wildlife. Therefore, planted trees were checked regularly for production of any resources that might attract birds or mammals (*e.g.* fruits, flowers *etc.*). Surveys to assess the species richness and composition of the ground flora (Khopai, 2000) and bird and mammal communities were also carried out ((Chantong, 1999; Toktang 2005; Thaiying, 2003).

One of the most important outcomes of FORRU's research has been identification of species that can rapidly restore forest structure and function (Elliott *et al.*, 2003), whilst enhancing forest regeneration and biodiversity recovery. Part 9 describes such framework species and explains how to grow them.

Tree growing techniques developed by FORRU's research program are tested for practicability in a community nursery by local people.

Does FORRU-CMU work with local communities?

The ultimate test of FORRU's work is whether local people can accept and use the new techniques developed by the project. As well as sound techniques, based on scientific research, forest restoration requires considerable sustained commitment in terms of time, labour and financial inputs from all those involved. Forest restoration programs can only succeed if local authorities and communities understand the benefits of ecosystem recovery and are motivated to maintain their commitment over several years.

To investigate these aspects of forest restoration, FORRU-CMU developed a close partnership with a local community, Ban Mae Sa Mai, the largest community of Hmong hill-tribe people in northern Thailand. FORRU-CMU worked with the villagers to establish experimental field trials in the watershed above the village. The story of how FORRU-CMU and the extraordinary community of Ban Mae Sa Mai combined the needs of science with those of local people is told in Part 8.

FORRU-CMU helped the villagers to build and manage their own tree nursery. As well as producing all the trees needed for forest restoration within the Mae Sa Valley, this nursery also serves as a test bed, where villagers with no scientific background, test the new propagation techniques developed by FORRU's research.

By developing this model with a local community, FORRU-CMU has been able to gain valuable insights into the logistics of implementing forest restoration projects. Much of that knowledge is presented in Part 8.

Furthermore, the nursery and plots at Ban Mae Sa Mai are providing a valuable demonstration model for training and education. As news of the project's success spread, a growing stream of visitors came to learn from the results. FORRU's research staff soon became overwhelmed by the burgeoning demand for education and training services, so a new branch of the project was created to implement a comprehensive education program.

In 2001, FORRU-CMU, the villagers of Ban Mae Sa Mai and local RFD staff won an award for good tree care from the Royal Forest Department.

SECTION 4 - EDUCATION AND TRAINING FOR RESTORING TROPICAL FOREST BIODIVERSITY

In 2002, FORRU-CMU and its UK partner, East Malling Research (EMR, formerly Horticulture Research International), were awarded a grant by the U.K.'s Darwin Initiative to run a 3-year project entitled "Education and training for restoring tropical forest biodiversity". This enabled employment of a full-time team of educators to disseminate FORRU's research results through a schools program, workshops and extension services. This manual is one of the outputs of that project.

It makes available, to all those interested in restoring forest ecosystems, techniques that have been scientifically developed by FORRU-CMU and tested for their practicability in a local community. Draft copies were trialed and improved by NGO's, government agencies, school teachers and community groups at several workshops run during the project.

What are the aims of this manual?

It presents the basic principles and techniques of forest restoration in an accessible format for all organizations committed to restoring tropical forest ecosystems. In particular, it explores the development of the framework species method in northern Thailand, and describes confirmed framework species for that region (see Part 9). However, this manual is not solely for Thai organizations. The approach that FORRU-CMU has developed can be adapted and applied to other regions.

Whilst many publications have been produced on the various forms of economic forestry, they often ignore the role of forests as repositories of biodiversity and providers of ecological services. This manual aims to redress this deficiency. Its central theme is the restoration of natural forest ecosystems, primarily for biodiversity conservation and environmental protection. However, it does not ignore the economic value of forest resources. Much of its content is applicable to economic forestry such as community forestry, agro-forestry and so on. The methods described in Parts 6 & 7 should encourage more efficient tree husbandry for all forms of forestry. Many of the framework species, described in Part 9, also have uses in agro-forestry or community forestry. Several have exceptionally high growth rates and should be further investigated for their potential as plantation species. Even where commercial objectives are paramount; the concepts and methods described here provide a means to integrate biodiversity conservation into forest management plans, particularly the diversification of plantation forestry.

A common view is that forest destruction is the inevitable consequence of human population growth and economic development. We fundamentally disagree with this pessimistic outlook. ***Deforestation can be reversed*** with better technical expertise, greater understanding of the value of forests and more incentives to encourage forest restoration.

We, therefore, hope that this text will contribute towards a more optimistic outlook for the world's tropical forests.

FORRU's nursery in Doi-Suthep-Pui National Park serves as a classroom, as well as a research facility.