FOREST RESTORATION FOR WILDLIFE CONSERVATION

Editors:
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ITTO

THE FOREST RESTORATION RESEARCH UNIT

Participants visited the Forest Restoration Research Unit at the headquarters of Doi Suthep-Pui National Park on day 3 of the workshop.

After the closing ceremomy, participants assembled on the steps of the Tarin Hotel for a final photograph.

Forest Restoration
for
Wildlife Conservation

Proceedings of a Workshop
January 30th – February 4th 2000
Chiang Mai, Thailand

Forest Restoration
Research Unit

EDITORS

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BRT
Biodiversity Research & Training Program

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DEDICATION

This volume is dedicated to the memory of Dr. Apichart Kaosa-ard, who served on the steering committee of this project. He was a fine practitioner and teacher of forestry both at the Royal Forest Department and at Chiang Mai University and will be deeply missed by all those who love Thailand's trees.

Forest Restoration Research Unit

ITTO

CONTENTS

ACKNOWLEDGEMENTS

This volume presents the proceedings of a regional workshop on Forest Restoration for Wildlife Conservation held at the Tarin Hotel, Chiang Mai, Northern Thailand, from 30th January to 4th February 2000. The meeting was organized by the Forest Restoration Research Unit (FORRU), Department of Biology, Faculty of Science, Chiang Mai University.

The organizers thank the International Tropical Timber Organization for generously providing most of the financial support needed to run the workshop. The International Union for Forestry Research Organizations, the British Council, the Biodiversity Research and Training Programme, and Shell Forestry Limited also provided funding for the meeting, whilst Chiang Mai University, the Royal Forest Department and the Department of Technical and Economic Co-operation provided institutional support.

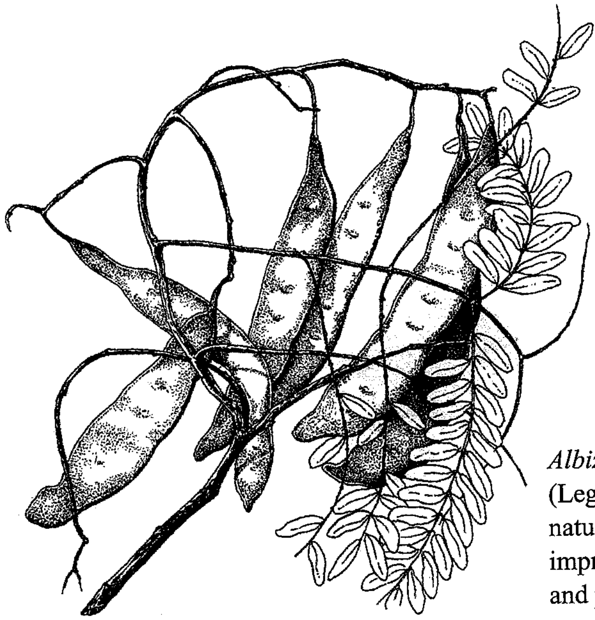
Furthermore, the organizers are grateful to the staff of the Tarin Hotel for providing excellent service during the workshop. We also thank Payong Chatwiroon, Paiboon Sawetmelanon, Apichart Kaosa-ard and Somsak Wanichacheewa for serving on the workshop steering committee. Many CMU staff and students helped with the running of the workshop and the production of these proceedings. We are especially grateful to Sudarat Zangkum, Natenapit Jitlam, Rungtiwa Bunyadod, Greuk Pakkad, Tim Rayden, Oranut Khopai, Puttipong Navakitbumrung, Cherdsak Kuarak, Thonglaw Seethong, Jumpee Bunyadit and Naeng Zeedong. The conservation committee of Ban Mae Sa Mai welcomed workshop participants to their village and we very much appreciated their hospitality.

All workshop participants contributed in some way to the words in this volume. The research agenda in Part 7 is the product of intensive discussion sessions during the workshop, in which everyone participated. The editors drafted the research proposals in Part 7 from notes taken during the discussion and feedback sessions.

The editors thank reviewers who provided useful feedback on draft manuscripts, in particular John Parrotta, David Lamb, George Gale, Nigel Tucker, Laura Johnson and Jens Granhof.

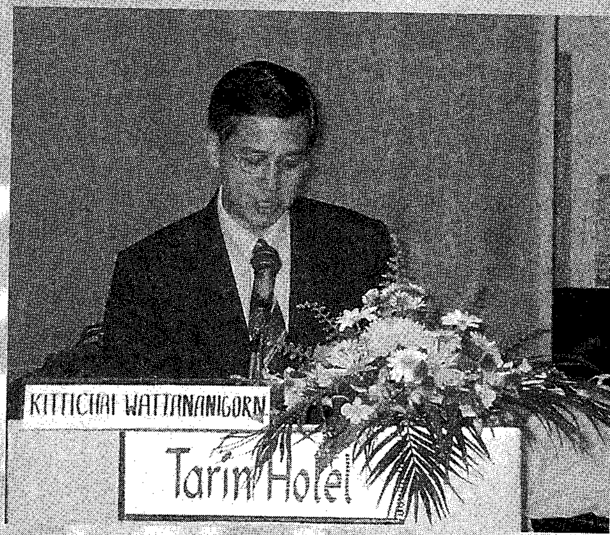
Finally, we thank Dr. Efransjah of ITTO for his helpful comments and advice throughout organization, implementation and reporting of the workshop and production of these proceedings.

S. Elliott
J. Kerby
D. Blakesley
K. Hardwick
K. Woods
V. Anusarnsunthorn



Albizia odoratissima (L.f.) Bth. (Leguminosae, Mimosoideae) – naturally colonises degraded areas; improves the soil by fixing nitrogen and provides timber, fodder and shade.

OPENING SPEECHES



Dean Kittichai Watananigorn reporting at
the opening ceremony of the workshop.

REPORT BY THE DEAN OF THE FACULTY OF SCIENCE, CHIANG MAI UNIVERSITY

Kittichai Watananigorn

The idea for this workshop arose out of the work of a small research unit in the Science Faculty, Department of Biology; the Forest Restoration Research Unit or FORRU for short. Since 1994, FORRU has been developing methods to restore natural forest ecosystems to degraded sites within conservation areas in northern Thailand, where the primary management objective is wildlife conservation. After more than 5 years research, the staff of FORRU felt that it was time to provide a forum for other researchers carrying out similar work in Southeast Asia to meet together and share experiences; to learn from each other's successes and avoid repeating each other's failures. The workshop on Forest Restoration for Wildlife Conservation was designed to provide just such an opportunity.

The workshop concentrated on the scientific and technical aspects of restoring Southeast Asia's tropical forests, with the focus primarily on biodiversity conservation. It had the very specific goal of preparing a scientific research agenda for the restoration of Southeast Asia's degraded forest ecosystems, focussing on the seasonally dry forests that are characteristic of northern Thailand and neighbouring countries. Experts involved in restoring forest ecosystems in Southeast Asia, had the difficult task of reaching a consensus on what are the most important or urgent areas for further research in this field. The research agenda, they drafted, will help to guide the future research efforts of scientists and forest managers and help to persuade funding agencies to provide more financial support to this vital area of research. The second objective of the meeting was to establish a network of people, concerned with restoring forests for wildlife conservation, so that the exchange of information begun at this workshop can continue into the future.

The organizing committee of the workshop worked tirelessly for almost a year to raise funds for this meeting and implement it successfully. The workshop was made possible through generous funding by three member countries of the International Tropical Timber Organization (ITTO): namely Japan, Australia and the United States of America. We are deeply grateful to ITTO and to the governments of those member countries. We thank The International Union of Forest Research Organizations, for supporting participants coming from developed countries and the British Council for supporting two British participants. We are also grateful to The Biodiversity Research and Training Program, an initiative of the Government of Thailand, for funding some of the field trip expenses. Shell Forestry Limited and The Science Faculty of Chiang Mai University provided additional financial and institutional support. Last but not least we thank the Headquarters of Doi Suthep-Pui National Park, under the Royal Forest Department for hosting FORRU and it's various activities since 1994.

OPENING DECLARATION BY CHIANG MAI UNIVERSITY VICE PRESIDENT FOR PLANNING AND DEVELOPMENTAL AFFAIRS

Sampan Srisuwan

Distinguished guests, ladies, and gentlemen: I am honored to welcome you to Chiang Mai and officiate at the opening of this regional workshop of forest restoration for wildlife conservation. We welcome delegates from 16 countries (in alphabetical order): Australia, Bangladesh, Canada, Denmark, China, Germany, India, Indonesia, Japan, Malaysia, Myanmar, The Philippines, Thailand, United Kingdom, United States of America and Vietnam. Chiang Mai welcomes all of you.

We are glad that there is widespread interest in the problem of diminishing forests. We are glad that experts from so many countries can get together and share ideas. Our future depends on preserving biological diversity. You can help us. The problem at hand belongs to the general category of management. We can do many different things well, but we do not manage the environment well. The environment is often exploited for short-term individual interests, rather than for long-term community interests.

The early European settlers of North America tried to set up perfect societies. They set aside land where anyone could graze their animals. These lands were held in common. But did *not* have managers. There was nobody to say when the commons were full. In the absence of strong management, the commons were over-grazed and failed. This happened thousands of times. It was and is always advantageous to the individual farmer to graze one more cow even if the community suffers. Even though the last animal did not get enough, it got something. Similarly, it is always advantageous to the individual lumber company to cut down one more tree, even if it is bad for the community. Cutting trees may have ruinous consequences for biological diversity but for the timber baron, it is always advantageous to cut one more tree. The forest is a kind of common that *requires* effective management to survive.

Over-regulation, however, is unproductive. For example, the regulated economy turns out to be less efficient than the market economy. For the economy, less regulation is better. However, the environment *always* needs to be regulated. The confusion over regulation of the environment (good) and regulation of the economy (bad) is unfortunate.

Let me tell you about our experience in Thailand. Several years ago senior Government officials were concerned about the loss of forests. The Cabinet passed a resolution that all forests be closed to commercial logging. The price of lumber went up and logging therefore *increased.* This true story shows that we do not know how to close the forest. The important unsolved problems concern *management*, rather than biology. Management of forests is not well understood.

Can we identify instances of successful forest management? Perhaps polling the participants of this workshop would provide an answer to this question. It may be that the conditions for success of forest management have more to do with the salary structure of the civil service than with the botany of forest plants. My guess is that it is not possible to enforce any regulations if the regulator is not paid a living wage.

This workshop should consider the role of education in preserving forests. It may be that education is the best and only real solution to the long-term problem.

Can this workshop identify regulations that are useful and can be enforced? Participants should share information about what works. We want to recommend more research if we need information that is not available, but we should focus our resources on preserving the forest. Monocultures of economically important trees will *not* improve biological diversity, but maybe other plants can be encouraged to grow at the same time. The advice of this workshop is urgently needed. We are looking to you for new ideas. I hope that this workshop produces realistic and useful recommendations.

We in Thailand are fortunate to have a King who loves the forest and promotes the right kind of policies for protecting the forests that remain and restoring the forests that have been lost.

It is my pleasure to declare this workshop open.

STATEMENT BY THE REPRESENTATIVE OF THE INTERNATIONAL TROPICAL TIMBER ORGANIZATION (ITTO)

Dr. Efransjah[1]

Mr. Vice President of the Chiang Mai University,
Mr. Dean of Faculty of Sciences,
Distinguished participants, Ladies and Gentlemen...

It is indeed my pleasure to come back to the beautiful city of Chiang Mai after successfully concluding the International Tropical Timber Council Sessions held here, last May 1999. This workshop was approved and funded by the ITTC during the Chiang Mai Session of the Council. Allow me to bring to this distinguished gathering, greetings from the Executive Director of ITTO, Dr. Manoel Sobral Filho. He sends his sincere wishes to all of you for the success of this workshop. We are deeply honored to extend a warm welcome to dignitaries from the Royal Thai Forest Department and other Government Agencies who have found time to be with us and contribute in our deliberations.

For those who are not familiar with ITTO, I would like to briefly highlight that ITTO is an intergovernmental organization created under the auspices of the United Nations Conference on Trade and Development (UNCTAD) with the mandate of ensuring the implementation of the International Tropical Timber Agreement, being the only convention now in existence on forests. The ITTO is headquartered in Yokohama, Japan and at present ITTO has 54 members of producing and consuming countries including the European Union, which together represent 95 percent of the world trade in tropical timber and 75 percent of the world's tropical forests.

The principal objective of the International Tropical Timber Agreement is to offer a forum for cooperation and policy dialogue between countries that produce and countries that consume tropical timber, in order to encourage expansion and diversification of the international tropical timber trade, to improve forest management and sustainable use of tropical forests. Unequivocally entrenched in the International Tropical Timber Agreement, the ITTO is mandated to strike a balance between the rational utilisation of tropical forest resources and their secure resource base through conservation and sustainable management. For those of you wishing to find out more about ITTO, I would refer you to ITTO's home page web site at http://www.itto.or.jp/

[1] Dr. Efransjah is Project Manager, managing ITTO-financed projects on reforestation and forest management in the Asia and Pacific region.
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Our Workshop attempts to address forest restoration and wildlife conservation and it has identified two broad constraints as reflected in the background paper. They are: inadequate social and institutional mechanisms and a lack of scientific knowledge and technical expertise. We are delighted to learn that an array of credible speakers and experts from various disciplines and institutions are gathered here to contribute meaningfully to the discussions at this workshop. The issues and the real challenges facing us are on the ground. They cannot be solved by organizations or in laboratories, journals or in meetings and conferences, no matter how good these may be. Those who work in the forest and those who live in and around the forests, ultimately have a vital role to play. Through incentives and other appropriate measures, let us therefore also secure the co-operation of local communities who are close to and dependent on forest resources for their livelihoods. Equally, the network of institutional infrastructure in various agencies in many countries in the region must be mobilised more effectively to enable better forest restoration and rehabilitation. Although all strategic information could be analysed in this important meeting, and it should not be neglected, we should not forget the human resources on the ground.

Touching upon the technical aspect, I wish to share with you some of ITTO's supported projects at the field level. In the Philippines, starting in 1995, ITTO and the Forest Management Bureau initiated an experimental demonstration area, where twenty different methods of plantation establishment, consisting of a combination of nursery techniques, soil fertilisation regimes and land preparation methods were tested in the field. This project was implemented in marginal grasslands in Bayombong, Nueva Viscaya, Philippines. After three-years of consistent measurements, a follow-up project which expanded the experimental plantations to 1500 hectares, based on the most successful treatments, also gained ITTO support. Equally important, during the course of implementation of this project, significant gains were attained by securing the support and a positive relationship between the project and the local populations living in, or adjacent to the forestry project area. Before implementing the project, the area was regularly burned, either to open up patches of land for shifting cultivation by local people, or to provide fresh forage for cattle. This resulted in the inability of forest regeneration to take hold and develop. The project now continues to progress, involving the local government and support from a Japanese chain of department stores, Ito Yokado. The lessons learnt in this project may be used to address the two constraints identified by the Workshop.

In 1993, ITTO started to support implementation of a project in Hainan Island, China aimed at establishing a demonstration area of 2000 hectares for afforestation of the tropical region of China. This project uses advanced technology involving a modern nursery producing 3 million trees per year and the establishment of a 800 hectares plantation for demonstration purposes. The project, equipped with a training centre, remains the largest ITTO's demonstration plantation in the region.

In 1989, ITTO launched an initiative to identify different ways of rehabilitating forests that had been affected by the fires that struck East Kalimantan during 1983-1985. In 1992, a project to establish a demonstration plot for restoration of forests affected by fire was implemented in East Kalimantan, Indonesia. The project aimed to develop a methodology to rehabilitate forest damaged by fire, study natural succession, and establish a demonstration area for research and training purposes. Although upon its completion the area was devastated again by fire, the project has generated valuable information, which includes:

- **detailed experimental design** of forest inventory for areas affected by fire and related classification of degree of degradation of burned over forests
- **technical guidelines** on proposed silvicultural options for rehabilitating forests devastated by fire depending upon the degree of forest degradation
- **detailed data recorded** on growth and yield of the stands after various silvicultural treatments
- **systematic analysis** of volumes and distribution of natural and planted species in the forest areas affected by fire.

In Thailand, ITTO also supported the Thailand Environment Institute (TEI) in developing a buffer zone concept attempting to reduce pressure on wildlife sanctuaries by introducing community approaches in the rural areas adjacent to the natural forest reserves.

These are some of the relevant experiences of ITTO's work on the subjects to be discussed in this workshop and which I am willing to share with you.

Let me take the opportunity to inform you that ITTO, in collaboration with the Department of the Environment and Natural Resources of the Philippines, will convene at the International Conference on Timber Plantations" in Manila, by the end of this year.

In connection with forest restoration, wildlife conservation is another key element to be discussed during this Workshop. We understand that the issue is an integral part of conservation of flora and fauna and ecosystems under the Convention on Biodiversity. As you may be aware, at the policy level, based on a productive dialogue among 54 ITTO Member Countries, ITTO has adopted several guidelines relevant to the issues of forest restoration and wildlife conservation. They are:

- ITTO Guidelines for the Conservation of Biological Diversity in Tropical Production Forest (1993)
- ITTO Guidelines for the Establishment and Sustainable Management of Planted Tropical Forest (1993)
- ITTO Guidelines on Fire Management in Tropical Forests (1997)

We are also at the final stage of finalising an important publication entitled: "State-of-the-art Review on Conservation of Forest Tree Species" and "Technical Guidelines for the Establishment and Management of *in-situ* and *ex-situ* Conservation Stands of Selected Species" prepared by Regional Institute of Forest Management based in FRIM, Malaysia. These publications are expected to be available by June, this year.

This Workshop has set the production of a "research agenda" as its focal target. At the international level, it has been clearly identified that there are some inadequacies in existing systems for mobilising resources, setting priorities and achieving coherence for forest research, as discussed at the Intergovernmental Forum on Forests (IFF). There is a strong call for financial and technical assistance programmes as well as examination of new ways of mobilising funding for forest research. In this regard, I wish to share with you ITTO's potential involvement. Projects are an important aspect of the Organization's work and a primary means of assisting member countries to implement policy initiatives. Members may submit project proposals to the Council for approval and financing if found to be consistent with an agreed project cycle. Examples include pilot and demonstration projects, human resource development projects, and research and development projects. All projects are funded by voluntary contributions from member countries. Since it became operational in 1987, the ITTO has funded nearly 400 projects at a total cost of approximately US$200 million. A special funding mechanism, called the Bali Partnership Fund, has also been established to provide ITTO's producer member countries with assistance through international co-operation. As may be expected, enhanced levels of such co-operation and assistance will be needed if sufficient resources are to be made available.

The ITTO offers its hand of partnership and co-operation to work together with all relevant organizations to promote the conservation, management and sustainable development of tropical forests. It is within these perspectives that the existing opportunities and challenges of tropical forests should be examined. I am therefore most delighted to see many friends at this meeting, with whom ITTO has been working closely.

Let me now conclude my remarks by paying tribute to our host, FORRU of Faculty of Science, Chiang Mai University under whose patronage this initiative is being implemented with the support of ITTO and other sponsors., such as the British Council and the Shell Forestry Limited. I wish also to extend my appreciation to the dedicated experts and staff of the project led by co-directors, Dr. Vilaiwan Anusarnsunthorn and Dr. Steve Elliott. At this juncture, I should not fail to acknowledge with the deep gratitude the collaboration and support demonstrated here by other national and international agencies and our close partners including FAO and IUFRO to attain the objective of this Workshop.

It is on this note that I wish to conclude, and to thank you for your kind indulgence.

PART ONE

OVERVIEWS

Editor

Stephen Elliott

Forest restoration means restoring forest ecosystems to their original condition for all plants and animals, as well as humans – planting indigenous tree species is just the first step.

Balakata baccata (Roxb.) Ess. (Euphorbiaceae) – a fast-growing tree species that rapidly shades out weeds. Its fruit can attract animals into forest restoration sites.

DEFINING FOREST RESTORATION FOR WILDLIFE CONSERVATION

Stephen Elliott[1]

Deforestation in the tropics is now widely accepted as one of the greatest threats to wildlife on Earth. The last decade of the 20th century saw rapid changes in attitudes towards this problem and some innovative attempts to devise solutions. In many parts of Southeast Asia, producing timber by logging natural forests is rapidly becoming a thing of the past, not only because forest areas where logging remains economically viable are diminishing, but also due to growing public opposition. Some countries, such as Thailand, have completely banned commercial logging in natural forest, whilst others have imposed stricter controls, in an attempt to achieve sustainable timber production. With the traditional logging industry under pressure, more timber plantations are being established. The hope is that vast plantations of eucalypts, pines, teak etc. will meet the increasing demand for timber, paper, fuel-wood etc. Although these plantations will become essential to provide wood products, they do not provide suitable habitat for the millions of plant and animal species that formerly inhabited the forest ecosystems they are replacing. Within conservation areas, such as national parks and wildlife sanctuaries, reforestation should meet the needs of wildlife, rather than those of the timber industry. Southeast Asia has an extensive system of protected areas (KASHIO, 2000). Many of these areas, however, encompass large deforested or degraded sites that require forest restoration, primarily for wildlife conservation and environmental protection.

Forest restoration is one particular form of reforestation. Whereas the term **reforestation** covers the re-establishment of any kind of tree cover, including plantations and agro-forestry, the term **forest restoration** is confined to the re-establishment of entire forest ecosystems, as similar as possible to the original forest ecosystems that were present before deforestation occurred. If strictly applied, this definition makes forest restoration almost impossible to achieve. Quite often, it is not known exactly which tree species were present in any particular area before deforestation occurred. Consequently, it is difficult to know which species to plant. Furthermore, tropical forests contain so many different tree species, it would be impractical to grow them all in nurseries and plant them. It would also be unrealistic to expect that seeds of all the original tree species would be dispersed into deforested sites and re-establish themselves naturally. Rather than quibble over the exact species composition aimed for by any particular forest restoration project, forest restoration should aim to match original levels of species diversity, ecosystem structure and ecosystem function, whilst planting or encouraging tree species that are known to have been originally present. The success of forest restoration programmes could therefore be assessed in terms of gradually increasing levels of the following attributes: species richness and diversity indices of plants and

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animals; diversity of life forms; presence of keystone species; biomass and primary productivity; soil organic matter content and moisture holding capacity.

The term **wildlife** also requires some clarification. Common usage of this term is sometimes restricted to mean only large vertebrates. For the purposes of the workshop, however, "wildlife" was used to mean *all* animal *and plant* species indigenous to areas undergoing forest restoration. The term included plant or animal species still present, or those that had become extirpated, due to deforestation, requiring re-introduction. In recent years, the term **biodiversity** has almost superseded the term wildlife. However, biodiversity includes genetic diversity of domestic or exotic plants or animals. In order to focus attention on indigenous forest plants and animals, the term wildlife was preferred.

Forestry research in Southeast Asia is quite advanced. For example, in Thailand, the ASEAN Seed Centre, the FORGENMAP project (PEDERSEN, 2000) and the Silviculture Division of the Royal Forest Department have all undertaken excellent research on genetics, propagation and planting, mostly of commercial tree species. On campus at Chiang Mai University, the Multiple Cropping Centre and the International Centre for Research on Agro-forestry (ICRAF) both carry out research to support agro-forestry. However, most of the current forestry research concentrates on establishing plantations for economic or commercial objectives, rather than reconstructing complex forest ecosystems. When it comes to restoring forests to provide habitat for wildlife, wide gaps in knowledge remain. Many thousands of tree species grow in the Southeast Asian region – species that may have no immediate economic value but which are vital in maintaining ecological stability. It is not known how to grow, plant or take care of most of these species. Thus, the main focus of the workshop was on forests for wildlife, rather than for economic or commercial purposes.

Although the science of restoring tropical forests for wildlife conservation is very new, various approaches, requiring different levels of input are being tested. Perhaps the simplest approach is **assisted or accelerated natural regeneration** (ANR). This method usually involves no or minimal tree-planting, but instead encourages the natural processes of forest succession (HARDWICK *ET AL.*, 2000). Existing naturally-established trees are protected and nurtured, by weeding, mulching or application of fertiliser. Seed dispersal into restored areas is encouraged and fire prevention measures are implemented. The method requires very low inputs and is simple to implement at low cost (DUGAN, 2000). However, ANR can only work with the trees that are already established in deforested areas. Most tree species capable of colonising such areas tend to be fast-growing pioneer trees with small easily dispersed seeds: a small subset of the tree species that comprised the original forest ecosystem. Rapid restoration of a more complete forest tree community usually requires some tree planting, at least to ensure early representation of large-seeded, climax forest tree species.

This has led to the development of more intensive (and more expensive) systems of forest restoration, involving tree planting, such as the **Miyawaki method** (MIYAWAKI, 1993; ALIAS *ET AL.*, 2000). In Malaysia ALIAS *ET AL.* (2000) experimented with direct planting of up to 42 climax forest tree species, to return the forest to its primary condition as quickly as possible. In other systems both climax and pioneer tree species are planted. In Queensland, Australia, the **framework species method** (TUCKER, 2000) uses a mixture of 20-30 pioneer and climax species planted in a single step. The framework species are selected for their ability to shade out competing weeds and attract wildlife into planted areas. The planted trees re-establish basic forest structure and function, whilst birds and bats add diversity to the forest by dispersing seeds of non-planted trees into the planted areas. This method is now being adapted for use in northern Thailand, with promising results (FOREST RESTORATION RESEARCH UNIT, 1998 & 2000). In Vietnam, forest succession is mimicked by the "**accelerated pioneer-climax series**" or APCS method (SÔÛ, 2000). With this method, pioneers are planted first and are later interplanted with climax tree species.

An alternative technique is to make plantations of commercial tree species more attractive to wildlife. This is the so-called "**plantations as catalysts**" approach discussed by PARROTTA (2000). Establishment of almost any kind of tree cover tends to accelerate natural forest regeneration, by ameliorating the harsh environment of open degraded areas and creating cover for seed-dispersing wildlife, thus providing suitable conditions for the natural establishment of native trees. The degree of this effect depends on the tree species planted, the silvicultural management applied, site conditions, the position of the site relative to remaining forest and many other factors. Further research is needed to determine how the catalytic effects of plantations could be enhanced. Another important question is how can such plantations be harvested without destroying the native trees and wildlife that may have colonised them?

Most experiments to test the methods outlined above are less than 10 years old and are generating more questions than answers. There is, therefore, considerable scope for further research. The workshop provided an opportunity for proponents of the various forest restoration techniques currently being developed to showcase their latest findings, whilst discussion groups developed new ideas for further research.

Once the different techniques of forest restoration have been tested in experimental plots, the next problem will be how to scale up planting to cover larger areas. Enlisting the support of government agencies and local communities will be vital for this (MUNEZ, 2000). In recent years, training programmes and seminars, such as those organized by the Regional Community Forestry Training Centre (or RECOFT), based in Bangkok (SUKWONG, 2000), have propelled the concept of community or social forestry from obscurity to wide acceptance throughout the region. Some of the strongest incentives for local people to become involved in forest restoration projects are the links between healthy forest ecosytems and the provision of resources, especially water (LAL, 2000; SVASTI, 2000; DUGAN, 2000). The need for better understanding of the factors that motivate local people to become involved in forest restoration activities was a recurrent theme throughout the workshop.

The workshop also focused on the seasonally dry tropical forests characteristic of this region, rather than tropical rain forests. Tropical rain forests are famous for their high biodiversity and consequently they have attracted most attention. However, recent evidence suggests that seasonally dry tropical forests might be just as diverse as tropical rain forests (ELLIOTT *ET AL.,* 1989) and they may be more endangered than tropical rain forests (JANZEN, 1988). Furthermore, seasonally dry tropical forests present unique challenges for restoration, of which annual drought and frequent fires are the most serious.

By concentrating on the technical and scientific aspects of forest restoration for wildlife conservation in Southeast Asia's seasonally dry tropical forests, the workshop avoided repeating what other workshops and symposia had already covered and promoted a new area of scientific discovery for many of the countries in the region.

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Bischofia javanica Bl. (Euphorbiaceae) – its dense canopy shades out weeds; it provides timber for construction and furniture, as well as fruits for birds and mammals.

TRENDS OF WILDLIFE CONSERVATION IN CHANGING FOREST RESOURCE SITUATIONS IN THE ASIA-PACIFIC REGION

Masakazu Kashio[1]

INTRODUCTION

As a result of rapid social and economic growth in the Asia-Pacific Region, many developing countries are increasingly confronted with serious environmental crises, resulting from the degradation and depletion of the basic natural resources required for human life, such as agricultural land and water, forestland and marine resources. Among these natural resources, the depletion of once rich natural forests is increasingly recognised as a threat to maintaining the sustainability of productive soils, a clean and regulated water supply, fishery stocks and biological diversity. In most cases, however, due to the indirect and invisible functions of forests in the long-term, their roles have been neglected under the pressure to fulfil short-term, immediate needs for food production.

Wildlife conservation is one of the needs for sustaining healthy human life, providing rural communities with food and income and urban citizens with recreational opportunities. Also, there are some fundamental philosophical questions behind this subject. “Wildlife deserves an equal right to live as human beings” is one. “Skewed economic development may result in the corruption of human morals and hence human communities” is another.

This paper reviews trends in human community development and wildlife conservation, with regard to depletion and restoration of forest resources.

LAND

The total land area, excluding inland water bodies, covered by FAO’s members in the Asia-Pacific Region (30 countries) in 1994, was 3,005 million ha, accounting for 23.0% of the world’s land area (13,048 million ha). This also accounted for 33.7% of the world’s arable and permanently cropped land; 30.1% of the world’s permanent pastureland and 18.8% of the world’s forests and woodland. The proportions of 1) arable and permanently cropped land; 2) permanent pasture; and 3) forests and woodland to the total land area of the Region, were 17%, 34% and 26% respectively (FAO, 1999).

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The total land area of the 27 developing countries of the Region in 1994 was 2,173 million ha, amounting to 16.7% of the world's land area.

POPULATION

As shown in Table 1, the total population of the Region during the years 1977, 1987 and 1997 increased from 2,353 million, to 2,820 million and then to 3,137 million, or 55.7%, 56.1% and 53.9% of the world's total population respectively. The total agricultural population of the Region during the same period increased from 1,540 million to 1,692 million, and then 1,862 million or 71.9%, 72.6% and 72.9% of the world's agricultural population respectively. Therefore, the net increase of the population in the Region during 1977-97 was 784 million as a whole, and 322 million in the agriculture sector. The percentages of the agricultural population of the Region are much higher than those of the rest of the world.

The Region is, therefore, heavily populated with 53.9% of the global population living on 23.0% of the world's total land area. This is particularly true in the agricultural sector of developing countries. For example, the ratio of arable and permanently cropped land to agricultural population in the Region declined from 0.34 ha/capita in 1961 to 0.26 ha/capita in 1990, and dropped further to 0.25 ha/capita in 1997. This is a direct indication of land scarcity. It contrasts sharply with land/capita ratios in the rest of the world, which were 1.61 ha/capita in 1961, 1.52 ha/capita in 1990, and 1.44 ha/capita in 1997. Farmers in the Region cultivate smaller land areas to support larger populations per unit farmland than elswhere.

Table 1. Population changes in the Asia-Pacific Region during 1977-1997 (millions)

	Total Population (T)			Agricultural population (A)			Percentage of A to T		
	1977	1987	1997	1977	1987	1997	1977	1987	1997
Developing countries (27)	2,222	2,678	2,989	1,524	1,682	1,855	68.6%	62.8%	62.0%
Developed countries (3)	131	142	148	16.2	10.1	7.2	12.4%	7.1%	4.9%
Asia-Pacific Total (30)	2,353	2,820	3,137	1,540	1,692	1,862	65.4%	60.0%	59.3%
Rest of World	1,873	2,207	2,686	602	637	692	32.1%	28.9%	25.8%
World Total	4,227	5,026	5,823	2,141	2,329	2,554	50.7%	46.3%	43.9%

Sources: Selected Indicators of Food and Agriculture Development in Asia-Pacific Region, 1978-88. RAPA Publication: 1989/7
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TRENDS IN FOREST LAND AND RESOURCES

Deforestation

Deforestation continues in developing countries in the tropics of the Region. According to estimates made by two FAO global projects, "FAO/UNEP Tropical Forest Resources Assessment" (FAO, 1982), and "Forest Resources Assessment 1990 (FRA 1990)" (FAO, 1993), the annual rate of deforestation in these countries of the Region increased from 2.0 million ha during 1976-80 to 3.9 million ha during 1981-90. Whether this trend accelerated, was constant or declined the 1990s is of great concern to everyone.

In 1997, FAO released the estimated deforestation figures of the world with the reference year 1995 (FAO, 1997). Since these figures were mostly derived from calculations based on the deforestation rates estimated in the FRA 1990 assessment, these figures did not necessarily reflect the real situation. In order to update global information on forest resources, FAO has been carrying out the "Forest Resources Assessment 2000 Programme (FRA 2000)" since 1997, including estimating the deforestation rate during the 1990s in the Region. The results of FRA 2000 will be published in late 2000. From preliminary observations, the deforestation rate of the Region seems to be slower than that of 10 years ago.

Shrinking natural forests and malfunctioning forest ecosystems in the tropics have resulted in many problems. They range from an increased occurrence of natural disasters to changing climatic patterns. Every year and every season, the media reports tragic stories of victims of floods, drought, landslides, etc. Irrigation departments and electricity authorities warn that irrigation channels and dams are deteriorating due to accelerated siltation. Forest industries are hastening the depletion of wood resources. Scientists warn of the danger of losing wildlife habitats and the extinction of plant and animal species that will cause irreversible damage to biodiversity and so forth. In many cases, they quote mistreatment of forests. In-depth analyses of the consequences of deforestation are rare, especially those that dig deeper to reveal our ill-fated way of life and how we interact with nature.

Degradation

In addition to deforestation there is gradual, often hidden, degradation of forests. If deforestation is analogous to the tip of an iceberg, degradation is the massive body in the deep sea. It is not obvious like deforestation. Since most degradation processes are not so easily detectable and there are no effective monitoring and assessment systems, its reality and consequences are not well understood by the general public. Many experts strongly believe that degradation is much more serious and widespread than deforestation in terms of areas covered. It is like a chronic disease that deteriorates one's health in the long run. A certain level of degradation can be cured by the regenerating capacity of nature. Beyond this limit, however, a natural ecosystem is pressed into a secondary condition, which sometimes results in absolute deforestation — leaving unproductive wastelands. We can see a few hundred million hectares of wastelands that were once rich and productive in ancient times, in countries such as China and India in the Asia-Pacific Region. Most degradation was caused by man's abuse of natural resources (ANON., 1999b).

The dilemma has been deepened between our agricultural production systems (the spine of human life support systems) and the depletion of natural resources. Forests have always acted as a buffer to absorb increased human pressures, providing additional land to human communities for food production, and regenerating themselves when the pressure was eased. This tacit understanding between man and nature appears to have been broken by our greed and stupidity.

Experiences in developed countries offer some possible solutions, such as: 1) increased yield of agricultural products per unit area; 2) intensive management of natural resources; 3) rehabilitation of degraded lands; 4) population control; 5) improved land use planning and management; 6) increased job opportunities outside the agriculture sector and 7) enhanced education and training. Every effort has been made and there have been some successes like the *Green Revolution* in high potential agricultural land, mostly located on alluvial soils, to increase crop yield. In marginal lands, on slopes or in dry areas in the tropics with prevailing poverty, however, nobody knows how much of this advice will be applicable. In the tropics, most nutrients are deposited in biomass, not in the soils and nutrients in the soils are easily washed away. Intensified population pressure has reduced almost to zero the area of forestland suitable for conversion to agriculture. Landless people have no 'new world' to migrate to, as millions of people did in the 19th century.

RESTORATION OF DEGRADED FORESTS

New Recognition

In developing countries, it is now widely recognised that forests play an important role in long-term national security, as shown by the effects of the declining trend of forest resources. People have realised that there can be no agricultural development without water, the supply of which is guaranteed by forests. This directly affects rural farmers who have been living in and with natural ecosystems.

Urban citizens, living a stressful modern life, instinctively desire the mental relief provided by nature, as represented by forests, even though they rarely get opportunities to visit them. Forests are attaining a more symbolic meaning to these people. Thus, the "Conserve nature (this mostly means 'forests')" slogan voiced by environmental NGO's or journalists has been winning the sympathy of citizens. Both rural and urban people have started to feel that there is little sense in environmental protection, biodiversity conservation and public welfare without protecting forests.

Such a changing atmosphere in the last 10-15 years has driven government authorities in two policy directions: 1) protection of remaining natural forests, and 2) rehabilitation of degraded forest land by promotion of reforestation programmes. Now, almost every country has launched nation-wide programmes for nature conservation (in most cases this means "forest conservation") and reforestation, which are often referred to as "regreening programmes".

Table 2. Protected Areas in Thailand, 1979-1998 (ha)

Year	National Parks		Forest Parks		Wildlife Sanctuaries		Non-hunting Areas		Wildlife Parks		Botanical Gardens		Arboreta		Whole Country	
	No	Area	No	Area	No	Area	No	Area	No	Area	No	Area	No	Area	No	Area
1979	16	932,915	32	35,429	21	1,866,538	15	227,987	2	2,455	3	616	21	1,207	110	3,067,147
1981	40	2,152,196	47	72,868	24	1,992,268	22	234,408	2	2,455	4	658	28	2,195	167	4,457,048
1983	47	2,449,342	55	126,360	25	1,991,968	28	236,835	2	2,455	5	1,272	29	2,483	191	4,810,715
1985	50	2,605,380	57	150,112	27	2,036,248	37	299,847	2	2,455	5	1,000	42	3,127	220	5,098,169
1987	54	2,815,625	56	76,191	29	2,173,660	42	314,847	2	2,455	5	1,000	42	3,127	230	5,386,905
1989	60	3,181,618	50	50,221	31	2,468,397	47	414,550	2	2,455	5	1,000	42	3,127	237	6,121,368
1990	63	3,386,718	36	31,999	33	2,531,397	48	417,090	2	2,455	5	1,392	40	3,187	227	6,374,238
1991	74	3,869,550	44	61,024	34	2,606,145	48	417,090	2	2,455	5	1,400	42	2,870	249	6,960,534
1992	77	3,928,350	44	61,024	35	2,786,724	49	418,791	2	2,455	5	1,538	44	3,188	256	7,202,070
1993	77	3,928,350	47	82,377	36	2,828,520	43	295,889	0	0	13	2,051	42	2,619	258	7,139,806
1994	79	4,021,615	42	52,746	37	2,888,639	43	295,889	0	0	13	2,051	44	2,719	258	7,263,659
1995	81	4,173,825	42	62,673	38	2,938,839	42	295,889	0	0	15	5,649	47	2,836	265	7,479,711
1996	82	4,233,226	57	76,173	42	3,098,696	44	321,739	0	0	15	5,649	47	2,836	287	7,738,319
1997	82	4,233,226	66	86,061	44	3,201,189	43	297,239	0	0	15	5,649	49	3,081	299	7,826,445
1998	87	4,418,212	65	86,771	46	3,267,184	44	310,183	0	0	15	5,649	53	3,432	310	8,091,431

Source: Forestry Statistics of Thailand, 1985, 1992 and 1998, Royal Forest Department (RFD).

In many countries, upgrading of conventional forest reserves into permanent protection forests has been intensified. They are categorised as special protected areas, such as national parks, wildlife sanctuaries, forest parks, etc., and their total areas are constantly increasing. Table 2 clearly indicates this movement in Thailand. The number of national parks and wildlife sanctuaries has increased from 16 and 21 in 1979, to 87 and 46 in 1998 respectively, with a significant increase in total protected areas.

TRENDS IN THE REGION

One option to restore degraded natural ecosystems (most of them are found in forests) is through protected areas. Table 3 shows the current regional situation of protected areas classified according to the IUCN's six categories of protected area.

The definition of a protected area used here follows that adopted by IUCN, i.e.: "An area of land and/or sea especially dedicated to the protection and maintenance of biological diversity, and of natural and associated cultural resources, and managed through legal or other effective means." IUCN (1994) noted that although all protected areas meet the general purposes contained in this definition, in practice the precise purposes for which protected areas are managed differ greatly.

The following are the main purposes of management:

- Scientific research (Category Ia);
- Wilderness protection (Category Ib);
- Preservation of species and genetic diversity (Category II and IV);
- Maintenance of environmental services (Category II and V);
- Protection of specific natural and cultural features (Category III);
- Tourism and recreation (Category II and V);
- Education (All Categories but particularly II);
- Sustainable use of resources from natural ecosystems (Category VI); and
- Maintenance of cultural and traditional attributes (Category III, V and VI).

The IUCN's six protected area categories and definitions are given in the Annex. This list, based on the UN List of Protected Areas 1997, indicates that 280 million ha of land, inland waters and coastal zones (including sea surface) were covered by various types of protected areas in the Region (it is assumed that those figures were at the end of 1996). They account for approximately 9.3% of the total land area of the Region, although this figure is not absolutely accurate due to the inclusion of inland water bodies and seas. The total number of protected areas is 3,796, with an average size of 73,896 ha. It is remarkable to know that Australia alone has 1,148 protected areas (30.2% of the whole), covering 103 million ha (36.8% of the whole). Among developing countries, the shares of China (608 with 68 million ha), Indonesia (709 with 34 million ha) and India (379 with 14 million ha) are quite large. It is, of course, proportional to their large landmass, but both China and India are countries that have been suffering from environmental and socio-economic problems over a few hundred million hectares of wastelands, resulting from the long historical process of degradation of forests and woodlands. Protected area systems are very important to conserve remaining natural forests, wildlife habitat, biodiversity, historical sites and scenic beauty in these countries, as well as to restore degraded forest lands.

In terms of coverage rate, New Zealand is ranked in the first position with 23.63% of the total land area, followed by Bhutan (21.23%), Brunei (19.97%), Indonesia (18.99%), and Cambodia (18.51%). Australia's figure, 13.52%, reflects extensive protective coverage as already mentioned above. Sri Lanka (13.29%), New Zealand and Australia were the first three countries in the Region to establish protected areas in the latter part of the 19th century. Indonesia took the lead in establishing protected areas after its first one in 1910 up to 1949. China, after declaring its first protected area in 1956, rushed to establish more protected areas during the 1980s (456 were established during this period).

The countries that have very few protected areas include Myanmar (2 protected areas with 0.26% of coverage), Vanuatu (1 with 0.28%), Solomon Islands (1 with 0.30%), and Bangladesh (9 with 0.75%). Six out of 10 countries in this group belong to the island nations in the South Pacific Ocean.

The FOREST DEPARTMENT OF MYANMAR (1999a) reported that they established a Protected Areas Network in the early 1980's through an FAO-assisted conservation project. Since then, a total of 28 protected areas, including wildlife sanctuaries and national parks, have been established in representative bio-units of the country.

Individual reserves vary in size from 125 to 2,100 km^2; today the total area under protection is 13,684 km^2 or about 2.02% of the total land area. In the short-term, Myanmar hopes to bring at least 5% of its total land area under protection, with a long-term objective of increasing this to 10%. However, management of currently gazetted protected areas is minimal due to serious financial and human resource constraints.

This statement contrasts with the UN List of Protected Areas 1997 because it has listed only two protected areas for Myanmar against 28 reported by the Forest Department. This indicates three possible scenarios: 1) Myanmar established 26 protected areas during 1997 and 1999; 2) Myanmar had not reported all of their protected areas to the UN; or 3) the UN recognised that most protected areas in Myanmar do not fulfil the required standard, due to poor management. The reality is not known, but most likely, the Forest Department was so ashamed of the poor management of the protected areas that they hesitated to report these to the UN.

A similar discrepancy in the number of protected areas in Thailand can be seen. The UN List says that Thailand had 140 protected areas, including 75 national parks and 37 wildlife sanctuaries (assumed in 1996). They contrast with the figures in 1996 shown in Table 2 — 82 national parks and 42 wildlife sanctuaries. Another case is seen in India. The UN List shows that the numbers of national parks and wildlife sanctuaries are 65 and 314 respectively, while the same categories reported in the National Forestry Action Programme report (ANON., 1999b) shows 80 and 441 respectively. In this case, of course, the reference years are different. There is a possibility of an increase in numbers during 1996 and 1998 (or 1999). These cases suggest that it is safer to refer to the information in the UN List as indicative figures to see the general trend of protected areas in the Region.

The UNESCO's World Heritage programme covers some national parks and wildlife sanctuaries, such as the Manas Wildlife Sactuary in India, the Royal Chitwan National Park in Nepal and the Thungyai – Huai Kha Khaeng Wildlife Sanctuaries in Thailand. Those covered can get special funds to enhance their nature conservation programmes. As a result, wildlife conservation activities can be much more extensive and effective.

The Ramsar Convention also helps to conserve wildlife in various kinds of wetlands, by rivers, coastal lines, inland lakes and swamps, including natural vegetation.

BENEFITS IN THE PROTECTED AREA SYSTEMS

There is no doubt that protected area systems have greatly contributed to conservation of nature, scenic beauty, historical monuments, and cultural heritage. Many endangered species and biodiversity in original ecosystems could not have been conserved without protected area systems.

Modern tourism depends on attractive sites in these protected areas. All earnings from tourism cannot be attributable to protected areas, but a large portion comes from natural and cultural attractions visited in protected areas. The tourism industry also provides various job and income opportunities to all levels of people, particularly those who are living in local communities.

Table 3. Protected Areas in Asia and the Pacific Region by the IUCN's Protected Area Category I to VI

Country	I				II				III			
	No.	Ave. size (ha)	Total Area (ha)	%	No.	Ave. size (ha)	Total Area (ha)	%	No.	Ave. size (ha)	Total Area (ha)	%
Australia	471	57,214	26,947,636	25.9	432	54,704	23,631,96	22.8	64	5,256	336,372	0.3
Bangladesh	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Bhutan	1	64,400	64,400	6.5	4	173,075	692,300	69.4	0	-	0	0.0
Brunei Darussalam	9	7,364	66,274	57.6	1	48,859	48,859	42.4	0	-	0	0.0
Cambodia	0	-	0	0.0	7	105,179	736,250	22.5	0	-	0	0.0
China	37	1,314,277	48,628,247	71.3	20	40,784	815,673	1.2	9	13,302	119,715	0.2
Fiji	5	3,784	18,922	100.0	0	-	0	0.0	0	-	0	0.0
India	2	98,022	196,043	1.4	63	51,599	3,250,755	22.8	0	-	0	0.0
Indonesia	70	36,785	2,574,950	7.5	35	362,533	12,688,65	36.9	1	5,000	5,000	0.0
Iran	0	-	0	0.0	7	153,614	1,075,300	13.0	2	3,075	6,150	0.1
Japan	8	3,056	24,446	1.0	15	86,399	1,295,988	50.8	0	-	0	0.0
Kiribati	0	-	0	0.0	0	-	0	0.0	3	8,877	26,630	100.0
Korea, DPR	0	-	0	0.0	9	16,683	150,143	47.7	4	2,625	10,500	3.3
Korea, Rep.	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Lao PDR	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Malaysia	26	3,403	88,487	5.9	17	47,964	815,388	54.2	0	-	0	0.0
Mongolia	11	929,256	10,221,814	63.4	6	809,944	4,859,665	30.1	17	58,699	997,881	6.2
Myanmar	0	-	0	0.0	1	160,580	160,580	92.7	0	-	0	0.0
Nepal	0	-	0	0.0	8	127,175	1,017,400	80.1	0	-	0	0.0
New Zealand	52	30,289	1,575,052	24.9	13	220,228	2,862,966	45.2	77	3,879	298,669	4.7
Pakistan	0	-	0	0.0	6	147,033	882,195	23.6	0	-	0	0.0
Palau	0	-	0	0.0	0	-	0	0.0	1	1,200	1,200	30.0
Papua New Guinea	0	-	0	0.0	3	2,441	7,323	0.7	0	-	0	0,0
Philippines	2	7,492	14,983	1.0	5	89,637	448,185	30.8	0	-	0	0.0
Samoa, W.	0	-	0	0.0	1	2,857	2,857	24.9	0	-	0	0.0
Singapore	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Solomon Islands	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Sri Lanka	15	4,910	73,644	8.6	22	20,725	455,946	53.1	0	-	0	0.0
Thailand	0	-	0	0.0	74	53,343	3,947,398	55.8	28	13,739	384,687	5.4
Tonga	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Tuvalu	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Vanuatu	0	-	0	0.0	0	-	0	0.0	0	-	0	0.0
Vietnam	0	-	0	0.0	9	22,500	202,496	20.4	0	-	0	0.0
Total	709	127,637	90,494,89	32.3	75	79,219	60,048,28	21.4	206	10,616	2,186,804	0.8

Source: The UN List of Protected Areas 1997 (downloaded from the website of the World Conservation Monitoring Centre, WCMC).

Remarks: 1) No protected areas are listed in the above UN List for the following countries: Cook Islands, Maldives, Marshall Islands, Nauru, Niue, and Tokerau.
2) Average sizes and shares in percentage in each category are calculated by the author.

IV				V				VI						
No.	Ave. size (ha)	Total Area (ha)	%	No.	Ave. size (ha)	Total Area (ha)	%	No.	Ave. size (ha)	Total Area (ha)	%	No.	Ave. size (ha)	Total Area (ha)
77	10,632	818,657	0.8	15	307,417	4,611,259	4.4	89	533,947	47,521,272	45.8	114	90,477	103,867,157
6	13,889	83,332	85.0	3	4,903	14,708	15.0	0	-	0	0.0	9	10,893	98,040
4	60,275	241,100	24.2	0	-	0	0.0	0	-	0	0.0	9	110,867	997,800
0	-	0	0.0	0	-	0	0.0	0	-	0	0.0	10	11,513	115,133
8	173,125	1,385,000	42.4	5	148,400	742,000	22.7	3	134,650	403,950	12.4	23	142,052	3,267,200
149	37,725	5,621,095	8.2	63	73,978	4,660,642	6.8	330	25,371	8,372,485	12.3	608	112,200	68,217,857
0	-	0	0.0	0	-	0	0.0	0	-	0	0.0	5	3,784	18,922
313	34,574	10,821,691	75.7	1	18,600	18,600	0.1	0	-	0	0.0	379	37,697	14,287,089
42	85,563	3,593,648	10.4	30	12,188	365,651	1.1	531	28,587	15,179,821	44.1	709	48,530	34,407,729
22	138,610	3,049,421	36.7	37	112,667	4,168,695	50.2	0	-	0	0.0	68	122,052	8,299,566
29	16,469	477,610	18.7	13	57,865	752,239	29.5	0	-	0	0.0	65	39,235	2,550,283
0	-	0	0.0	0	-	0	0.0	0	-	0	0.0	3	8,877	26,630
6	25,673	154,039	49.0	0	-	0	0.0	0	-	0	0.0	19	16,562	314,682
6	5,848	35,089	5.14	20	32,365	647,304	94.9	0	-	0	0.0	26	26,246	682,393
17	162,135	2,756,300	100.0	0	-	0	0.0	0	-	0	0.0	17	162,135	2,756,300
9	64,416	579,745	38.5	1	1,011	1,011	0.1	1	20,682	20,682	1.4	54	27,876	1,505,313
1	49,940	49,940	0.3	0	-	0	0.0	0	-	0	0.0	35	460,837	16,129,300
0	-	0	0.0	1	12,691	12,691	7.3	0	-	0	0.0	2	86,636	173,271
4	23,525	94,100	7.4	0	-	0	0.0	2	79,500	159,000	12.5	14	90,750	1,270,500
66	3,361	221,850	3.5	17	80,584	1,369,930	21.6	1	5,400	5,400	0.1	226	28,026	6,333,867
45	60,371	2,716,693	72.7	4	30,513	122,051	3.3	2	9,069	18,137	0.5	57	65,598	3,739,076
0	-	0	0.0	0	-	0	0.0	1	2,800	2,800	70.0	2	2,000	4,000
0	-	0	0.0	0	-	0	0.0	17	60,517	1,028,786	99.3	20	51,805	1,036,109
1	89,359	89,359	6.1	10	90,111	901,109	62.0	0	-	0	0.0	18	80,758	1,453,636
2	3,608	7,215	62.9	0	-	0	0.0	1	1,400	1,400	12.2	4	2,868	11,472
1	2,796	2,796	100.0	0	-	0	0.0	0	-	0	0.0	1	2,796	2,796
0	-	0	0.0	0	-	0	0.0	1	8,270	8,270	100.0	1	8,270	8,270
32	10,285	329,106	38.3	0	-	0	0.0	0	-	0	0.0	69	12,445	858,696
37	73,717	2,727,545	38.6	1	13,100	13,100	0.2	0	-	0	0.0	140	50,520	7,072,730
0	-	0	0.0	0	-	0	0.0	1	2,835	2,835	100.0	1	2,835	2,835
0	-	0	0.0	0	-	0	0.0	1	3,300	3,300	100.0	1	3,300	3,300
0	-	0	0.0	0	-	0	0.0	1	3,470	3,470	100.0	1	3,470	3,470
43	18,417	791,948	79.6	0	-	0	0.0	0	-	0	0.0	52	19,124	994,444
920	39,834	36,647,279	13.1	221	83,262	18,400,990	6.6	982	74,065	72,731,608	25.9	379	73,896	280,509,866

The total contribution of tourism to social and economic development is well demonstrated in some countries like Thailand, India and Nepal[2].

It is impossible to assess the educational values and mental satisfaction that protected areas offer to visitors, but it should be an invaluable contribution for healthy human communities.

The chances to restore and rehabilitate damaged sites are greater within protected area systems because of stricter legal status and protection programmes.

CONSTRAINTS IN PROTECTED AREA SYSTEMS

It should be noted, however, that the current protected area systems practised in each country have some constraints, which prevail in developing countries in particular.

The case of Myanmar mentioned above represents the commonly observed constraints in economically weak and heavily populated countries. These include serious shortages of 1) financial support and 2) well-trained and experienced human resources in the management of protected areas. In other words, it implies a gap between the reality of the protected area management in these countries and the expected international standards.

The UN List of Protected Areas displays a wide range of terminology used by countries in their protected area classifications and management. For example, 'National Park' is the most commonly used terminology in the Category II, but there are many others, such as 'Conservation Area', 'Nature Reserve', 'Nature Park', 'State Reserve', 'Historical Reserve', 'Park', 'National Conservation Park', 'National Reserve', etc. Australia uses both 'National Park' and other terms for the Category II. On the other hand, China does not use the 'National Park' terminology, but 'Nature Reserve' in use has the same meaning. This confusing situation makes a comparison between countries difficult, unless their management concepts and objectives are known.

It is also a well-known fact that so-called protected areas are not always well protected. Unless local communities and individuals observe the law, illegal logging, hunting or encroachment cannot be stopped. Unclear boundaries, poor enforcement of laws, lack of incentives to local communities and lack of strong partnerships among all concerned can create major problems. Complex land ownership and lack of legal provisions often make the effective management of protected areas impossible.

Lack of land to establish protected areas extensive enough to conserve viable populations of large vertebrates, such as tiger, elephant and rhinoceros, is another constraint. This is especially true in smaller countries. Even in India, a large country, with 3.3 million ha of 'tiger reserves' within the protected areas system, "many sanctuaries are too small to maintain viable wildlife populations particularly of larger mammals" (ANON., 1999b). Lack of scientific knowledge on how large protected areas must be to conserve viable populations, without genetic degradation, has made it more

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2 Bhatt (1996) reported that the Sagarmatha (Everest) National Park and the Annapurna Conservation Area in Nepal have faced serious environmental problems caused by too many visitors. Over consumption of fuel-wood and local food products, pullution of drinking water and accumulation of garbage left by trekkers are major problems.

difficult to negotiate and convince land-related departments or ministries of the need for large protected areas.

One effective strategy to establish large protected areas is to do so jointly with neighbouring countries, across international borders. There are very few examples, however, like the "Royal Manas National Park" (97,500 ha) in Bhutan, which was designated in 1988 adjoining the "Manas Wildlife Sactuary" (39,100 ha) in India.

It is wise that the IUCN Categories have been defined according to management criteria instead of using nominal terms such as 'National Park' or 'Wildlife Sanctuaries'. As already mentioned, such nominal terms differ from one country to another and this situation will probably continue. Although the IUCN Categories provide principles of protected area management, the real control and management of protected areas are in the hands of national or local governments and people. They are the driving forces for setting the management objectives of protected areas and achieving them.

OTHER OPTIONS

It is recognised that conservation of wildlife by protected area systems alone is not enough. Setting a buffer zone around a protected area reduces pressure on wildlife and also helps reduce conflicts between wildlife and people, arising from crop damage or deaths or injuries caused by wild animals. These buffer zones should not necessarily be a part of the protected areas. If buffer zones become degraded, they should be restored.

Individual protected areas tend to exist in isolation like islands in the ocean. This situation prevents genetic exchange amongst wildlife species, especially amongst the large mammals, and consequently degrades their genetic viability. Many experts strongly recommend connecting protected areas by corridors with remaining natural forests or even with man-made plantations. Appropriate use of riparian forests, roadside tree belts, mountain ridges or even narrow hedgerows in farmlands can help the migration of wildlife. If those forests or vegetation belts are degraded, they should be restored, either by natural regeneration or artificial tree planting with certain conservation measures such as prohibiting hunting. Artificial transmigration should sometimes be considered.

Local people often regard woodlots inside or around temples, shrines, graveyards and historical sites as sacred areas. They also offer a good refuge for wildlife. Restoration and maintenance of these woodlots are, therefore, important, even if their sizes are relatively small.

Although not well known, some countries in the Region have a long history of establishing protected areas. Many of them were established under strong religious influences and some of them are still in practice. IUCN (1991), for example, quoted the statements of Singh (1985): "protection of wildlife has a long tradition in the Indian subcontinent. The concept of protected areas dates back at least to the 4th century BC in India, with the establishment of *Abhayaranyas*, or forest reserves, advocated in the *Arthasashtra*, the well-known manual of state-craft." Similarly, in Sri Lanka, IUCN (1991) quoted the statements of (DIKSHIT, 1986): "... one of the world's first wildlife sanctuaries was created in the 3rd century BC by King Davenampiya Tissa at the same time that Buddhism was being introduced to the island." In Japan, *Kasugataisya*, a shrine in Nara, has been sheltering deer in forests behind the shrine, for at least a few hundred years. Also, the shrine has prohibited hunting on their premises. This has resulted in the co-existence of wild deer and citizens in the middle of Nara City (although the deer sometimes suffer from traffic accidents). In Bhutan, it is strictly prohibited to kill wildlife, including fish, within a 500-m radius of any monastery. Such traditions should be encouraged.

SOME BASIC PREREQUISITES FOR EFFECTIVE WILDLIFE CONSERVATION

When we consider restoration of degraded forests for wildlife conservation, either inside or outside protected areas, there are some prerequisites. First of all, the co-operation of local communities is essential. By encouraging participation, there is a chance to raise awareness of wildlife conservation. Also, we can understand their require ments and wishes better. Through this process, the programme staff and local people can develop incentives.

Secondly, people's participation becomes reliable by various institutional and legal support mechanisms. The level of official commitment confirms the rights and duties of people living in or around protected areas. Technical assistance, land ownership or entitlement, financial supports, credit schemes, etc. from forestry departments, research institutes and other public or private sectors cannot act well without such commitment.

Thirdly, a good understanding as to why we need the conservation of nature or biodiversity is essential in the whole society of a nation. In this regard, efforts to enhance environmental education for children in schools and for the general public through the media are essential. Both tangible benefits, like economic returns from tourism and intangible or long-term benefits, such as flood prevention, water supply, and also philosophical aspects to broaden human morals are required.

CONCLUSIONS

In human history, we can find many examples of nations or communities losing vitality and territory and being replaced by other tribes. Historians attribute this decline to incapable kings or leaders, or strong invaders. However, an interesting observation by one historian was that as human communities expanded their society, culture flourished in one place for one period. This was often followed by decline, leaving behind a vast wasteland. This observation implies that the real cause of decline might be due to forest destruction and land degradation: no more water either from the sky or mountains; no more soil fertility and consequently no more food production. Faced with this grave constraint, the self-sustainable and self-defence capacities of nations were weakened. Such nations became vulnerable to invading forces or, the people dispersed to more promising land. This mechanism is probably one of the fundamental forces driving human history.

It seems to me that, in most tropical countries, such a process has been taking place over the last few decades. The agricultural policies of these countries have tended to put an emphasis and priority on the expansion of arable land, whilst neglecting the overall functions of forest ecosystems - the mechanisms of which were not known until recent years. When forest resources were abundant and policy makers could concentrate on how to feed increasing populations, conversion of forests into agricultural lands was justifiable. By human nature, it is unbearable to see people suffer from starvation. There was also a wide social consensus to support this decision. However, the whole situation seems to have changed. Forest resources have been continuously lost and their ecological functions to regulate water, soils and climate have also been reduced to a critical point, beyond which short-term recovery is impossible (KASHIO, 1995).

It is time to shift the development paradigm towards conservation and better management of natural resources to co-exist with all species on Earth. We are often trapped in a phantom dream of materialistic fulfilment or short-sighted comfort, striving for freedom from endless desires. By restoring degraded nature, we will find that saving wildlife is not only for other species but also for us, to open our eyes to a balanced way of life — based on self-control of our greed and co-existence with other species. That is our duty to ensure our own survival.

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Annex

IUCN Categories and Definitions for Protected Areas

CATEGORY IA: STRICT NATURE RESERVE: PROTECTED AREA MANAGED MAINLY FOR SCIENCE

An area of land and/or sea possessing some outstanding or representative ecosystems, geological or physiological features and/or species, available primarily for scientific research and/or environmental monitoring.

CATEGORY IB: WILDERNESS AREA: PROTECTED AREA MANAGED MAINLY FOR WILDERNESS PROTECTION

A large area of unmodified or slightly modified land, and/or sea, retaining its natural character and influence, without permanent or significant habitation, which is protected and managed so as to preserve its natural condition.

CATEGORY II: NATIONAL PARK: PROTECTED AREA MANAGED MAINLY FOR ECOSYSTEM PROTECTION AND RECREATION

A natural area of land and/or sea, designated to (a) protect the ecological integrity of one or more ecosystems for present and future generations, (b) exclude exploitation or occupation inimical to the purposes of designation of the area and (c) provide a foundation for spiritual, scientific, educational, recreational and visitor opportunities, all of which must be environmentally and culturally compatible.

CATEGORY III: NATURAL MONUMENT: PROTECTED AREA MANAGED MAINLY FOR CONSERVATION OF SPECIFIC NATURAL FEATURES

An area containing one, or more, specific natural or natural/cultural feature of outstanding or unique value because of inherent rarity, representativeness, aesthetic qualities or cultural significance.

CATEGORY IV: HABITAT/SPECIES MANAGEMENT AREA: PROTECTED AREA MANAGED MAINLY FOR CONSERVATION THROUGH MANAGEMENT INTERVENTION

An area of land and/or sea subject to active intervention for management purposes so as to ensure the maintenance of habitats and/or to meet the requirements of specific species.

CATEGORY V: PROTECTED LANDSCAPE/SEASCAPE: PROTECTED AREA MANAGED MAINLY FOR LANDSCAPE/ SEASCAPE CONSERVATION AND RECREATION

An area of land, with coast and sea as appropriate, where the interaction of people and nature over time has produced an area of distinct character with significant aesthetic, ecological and/or cultural values, and often with high biological diversity. Safeguarding the integrity of this traditional interaction is vital to the protection, maintenance and evolution of such an area.

CATEGORY VI: MANAGED RESOURCE PROTECTED AREA: PROTECTED AREA MANAGED MAINLY FOR THE SUSTAINABLE USE OF NATURAL ECOSYSTEMS

An area containing predominantly unmodified natural systems, managed to ensure long term protection and maintenance of biological diversity, while providing a sustainable flow of natural products and services to meet community needs.

SOME ECOLOGICAL PRINCIPLES FOR RE-ASSEMBLING FOREST ECOSYSTEMS AT DEGRADED TROPICAL SITES

David Lamb[1]

INTRODUCTION

I have been asked to discuss some ecological principles that might be relevant to restoration ecology in the seasonal tropics. I will attempt this, although practice has advanced far more rapidly than theory. That is, in many parts of the world people have:

- Identified plant species that once grew in landscapes that are now degraded.
- Studied the timing and the extent of seed production of these species.
- Developed methods of raising these species in nurseries.
- Planted these species out in the field in mixed communities with the objective of eventually re-establishing the original ecosystem or, at least, something resembling that ecosystem.

The results of these efforts have ranged from "very promising" to "poor". At "very promising" sites, the planted trees have all survived and are growing rapidly. With time their canopies have merged and closed and additional species have begun to be introduced by seed dispersers such as birds. Poorer results have been experienced:

- where species have been planted at sites outside their original range;
- where sites are no longer suitable for the original species because they have been too severely degraded;
- where insufficient weed control has been carried out and the planted trees have become swamped by grasses or vines and/or
- where (exotic) animals have grazed or disrupted the new successions.

Through a process of trial and error, these common problems have become well known and there is now every chance that the success rate of restoration projects will improve in the future. What, then, is a listing of ecological principles likely to add to this process? Isn't the task now one of simply extending these operations to a larger scale?

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That is, haven't the major problems become socio-economic in nature rather than ecological problems?

In response I pose two questions. Firstly, are these approaches really working? We are now in the position of being able to predict the likely future height, cover and biomass of many of these new communities. However, we are still not able to clearly say just what the total species richness of the new community will be in, say, 10 or 20 years time. Nor can we usually say just which plant species (including those planted) will be present at that time. Will the new community have been colonised by the most common species in nearby intact forests or by those species that fruit most prolifically? We can usually only speculate about the range of life forms or functional groups that might be present and can rarely say much at all about the wildlife component of these new ecosystems.

Secondly, are these new communities sustainable? Although the new communities appear to be growing well, are all the species they contain reproducing and replacing themselves? Or is only a sub-set of those planted doing so? Might the newly established community quickly degrade once the populations of the various planted species senesce? Might the site eventually become dominated by a relatively small number of dominant species, rather than develop a diverse mix of species.

In a situation where detailed local ecological information is limited, trial and error is a necessary and a valuable approach. But we also need to:

- learn lessons from these trials. That is, develop generalisations that might be applied elsewhere ("theory") and
- test existing theory learned in other situations when designing new trials and while waiting for results from our own field work.

SOME RELEVANT ECOLOGICAL THEORY?

Some theory relevant to restoration:

Niches: every species occupies a multi-dimensional ecological space, referred to as the niche of that species. This is the habitat of that species and that area of the landscape in which it is normally found. It is necessary, however, to distinguish between the potential niche a species might theoretically occupy and the actual niche it does occupy. Part of the theoretical space may be unoccupied because not enough time has elapsed to allow a particular species to disperse and colonise all parts of a landscape potentially open to it. Part may also be excluded because of competition or predation.

Consequence for restoration: knowledge of the resource requirements and tolerances of species is necessary before attempting to re-introduce these to degraded landscapes.

Successions: the ways in which ecosystems change over time, as new species enter and some existing species are replaced, has been a topic of ecological research for more than 100 years. Despite this, we are still unable to predict the outcome of successional change over time in any particular ecosystem, because successional theory is still poorly developed. What does seem clear, however, is that several processes may occur during successions. These include facilitation (in which one species facilitates the entry of another into the successional community), inhibition (in which a species inhibits the entry of one or more species to the successional community) and tolerance (where a particular species is able to enter a successional community despite the presence of other species already present).

Consequence for restoration: the benefits of facilitators e.g. nitrogen-fixing trees such as *Acacia*, or bird-attracting species, such as figs, are well-known. Sometimes, however, the same species can act as a facilitator to some species, whilst simultaneously inhibiting others. For example, a dense stand of *Acacia* may slow forest succession for many years, despite enriching the soil with nitrogen. Conversely, species such as grasses, normally regarded as inhibitors of forest succession, may sometimes benefit seedlings of tree species, normally found only in mature successional stages, by providing shade. This means that ecological theory is still poorly developed in areas most relevant to restoration. It is unable to provide much more than broad generalisations to guide practice and is unable to offer much predictive capacity.

Disturbance and change: the environments in which plant communities are found are always changing and, as a consequence, all ecosystems are invariably in a state of flux. Ecosystems are subject to a disturbance regime defined by differences in disturbance frequency, intensity and scale. Species in any particular ecosystem are adapted to these disturbance regimes and many are dependent upon them for reproduction and survival.

Consequence for restoration: a prime need in any restoration work is to exclude disturbances (especially those that may have led to degradation in the first place) to allow restoration to proceed. But, at some time, disturbances must be allowed again if the restored ecosystem is to function as before. The question is when might this be desirable and what sort of disturbances (e.g. fire?) might be allowed or even fostered?

Species interactions: ecosystems are made up of food webs spread over 3-4 trophic levels. A variety of interactions occur between species in these webs. These include herbivory or predation as well as competition and mutualistic relationships (e.g. pollination, seed dispersal) or commensal relationships (e.g. epiphytes on trees).

Consequence for restoration: species forming obligatory mutualistic relationships will need both partners to survive and reproduce in the newly restored ecosystem. This may mean both must be re-established at the site or that they can access the site from intact forest remnants nearby. Herbivory, predation and competition have the capacity to exclude certain species from a community and may need to be managed to prevent this.

Predicting successional outcomes from theory

If we knew the niche requirements and attributes of various species, as well as how these species interact with one another and with the abiotic environment, we might be able to predict long-term consequences of various approaches to restoration. Managers could then fine-tune their management inputs to achieve desired outcomes and we could predict these outcomes with some degree of success. Unfortunately ecological theory is nowhere near developed enough to do this.

Three possible outcomes of initiating a restoration project in a particular environment are shown in Fig 1. The first alternative (A) indicates that a large number of future states are possible and the identity or nature of these depends entirely on the species used to initiate the community. In this situation the environment itself exerts little influence. By contrast, alternative C indicates that in that particular environment only one outcome is likely over the longer term irrespective of what species are used to initiate the succession. The third alternative (B) falls between these two and shows that the initial species composition is influential but that environmental conditions and chance still play a role and that it is difficult to predict the outcome over time.

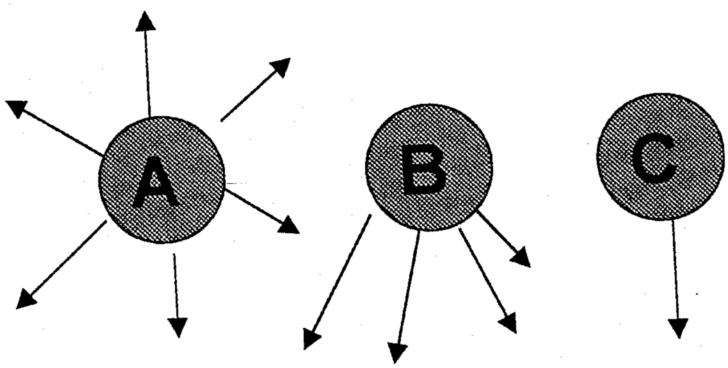

Figure 1. Possible successional trajectories

Present evidence suggests alternative A is most likely in complex, species-rich systems not subject to stress. In these situations, chance historical events such as the sequence in which various species arrive influence the assembly trajectory. Alternative C is more likely in simple systems subject to predictable stresses such as a severe annual dry or cold season that limits the number of potential community members. Alternative B is probably more common than A or C in the seasonal tropics. It these areas, environmental constraints apply but the species themselves and their manner of entry into the new community are also important.

SOME DRAFT "PROPOSITIONS" GUIDING COMMUNITY ASSEMBLY

In 1975, Diamond coined the expression "rules of assembly" to describe how bird communities developed in a series of New Guinea offshore islands. There has been considerable interest since then in widening the idea to describe how other and more complex ecosystems might be assembled. So far the work has mostly been undertaken by theoreticians and no one has attempted anything as complex as developing assembly rules for tropical forests. Our understanding of these ecosystems is still far too rudimentary to attempt formulating rules of the type envisaged by Diamond. However, I outline below a series of "propositions" and some corollaries as a first step in this process on the assumption that these can be tested, modified and expanded in the light of further field experience.

Proposition 1.

The future state of any restored forest heavily depends on the current state (i.e. the species initially sown or planted at the site).

Corollary: small differences in initial conditions (e.g. rainfall, soil fertility) can cause successional trajectories to diverge rapidly, making it difficult to predict outcomes.

Corollary: disturbances are capable of changing successional trajectories (e.g. fires or grazing animals can remove particular plant species from a site).

Corollary: feedback loops can be very significant (e.g. canopy closure occurs enabling seed-dispersing birds to enter the succession, thereby accelerating the rate at which new plant species enter the community).

Proposition 2.

The more plant species that can initially be re-introduced, the faster the subsequent succession.

Corollary: the more species the greater the structural complexity at a site and hence the more likely it is to be attractive to a wider range of wildlife species.

Proposition 3.

Some plant species combinations are unlikely to be successful. Fast growing species with dense crowns may exclude some slower growing species unless these latter are especially shade tolerant or canopy gaps are present or are frequently created.

Proposition 4.

An initial (planted) community of pioneer and early secondary species will be short-lived and is unlikely to be self-sustaining. It is not necessary or desirable to attempt to simulate natural successional patterns by only initiating restoration projects using pioneer species. In many (though not all) cases, species from the functional groups usually found in later stages of successions can also be grown in the open in early stages of community development. In many natural successions their delayed colonisation may be as much a consequence of their limited dispersal as their physiological tolerances. This means many species from mature successional phases can often be planted in relatively open, old-field situations.

Corollary: plantings of species from functional groups represented by fast-growing pioneer and early secondary species may be useful as a means of quickly eradicating weeds. Ideally there should be forest remnants nearby from which species from more mature successional stages and other functional groups will colonise. If not, such species can be subsequently sown or under-planted beneath this initial canopy.

Proposition 5.

The sequence in which species are re-introduced to a site are important in determining the assembly trajectory. At a trivial level this is obvious. For example trees are necessary before epiphytes can colonise a site. But at a more fundamental level, we may need some important "structuring" species early in a successional sequence rather than at a later stage. If these species are not present then some introduced species may fail and disappear. This is not to argue that all primary forest species must only be planted beneath a canopy of early secondary forest species. Rather, this principle re-affirms that facilitation and inhibition can occur during succession and can influence successional trajectories.

Corollary: the most influential species able to "structure" a succession are likely to be those that rapidly modify the physical environment or those with large numbers of mutualistic relationships with other plant or animal species.

Proposition 6.

The rates at which restoration occurs depends on the extent of the environmental stresses present. Sites with strongly seasonal climates or with low soil fertility are likely to be more difficult to restore than those with more benign climates or with more fertile soils. Frequent but unpredictable stress (e.g. fires, droughts) make it particularly difficult to re-assemble new communities. Once restored however, such communities may buffer some of the stresses (e.g. the more humid microclimate within a new forest may limit the rate of spread of fires)

Corollary: it may be necessary to use some non-native species on highly degraded sites that are no longer suitable for some of the original species. Non-native species can ameliorate site conditions (e.g. nitrogen fixers that improve soil fertility) and facilitate the subsequent re-entry of native species.

Proposition 7.

Most new tree species reaching a restored site will be carried there by animal dispersers.

Corollary: the diaspores of these species will have attributes that make them attractive to animals (e.g. fleshy fruit, arils, mostly small to medium fruit size).

Corollary: certain plant species will be unlikely to colonise restored sites and will always need to be introduced. These include poorly dispersed species (e.g. with diaspores lacking animal-attracting features, those with large fruit or those that fruit infrequently) as well as rare species usually present in small numbers.

Corollary: few wind-dispersed species will reach and colonise a site once canopy closure occurs.

Proposition 8.

The rate at which additional plant species enter a site, once restoration has been initiated, depends on the distance to sizeable intact forest remnants. The rate also depends on the extent to which populations of animals capable of dispersing seed from these remnants remain in the landscape.

Corollary: little colonisation is likely at isolated sites or in landscapes where only small forest fragments remain and so restoration of tropical forests is rarely feasible at such sites (although it may still be possible to re-establish species-rich forest communities).

Corollary: the nature of the vegetation matrix separating the restored site and intact forest will influence the rate at which seed dispersal and colonisation occur. A matrix, containing shrubs and scattered trees, is likely to foster faster seed dispersal than a grassland.

Proposition 9.

The attractiveness of a site to animal seed-dispersers affects the rate at which they bring in seeds of new species. Structurally complex sites are likely to be more attractive than simple ones and animals are likely to begin to enter the new community in significant numbers after canopy closure. Sites with tall trees are likely to be more attractive than those with only short trees or shrubs; large restored areas are likely to be more attractive than small areas.

Proposition 10.

Species colonising a restored site, after canopy closure has occurred, must have some degree of shade tolerance, enabling them to persist as understorey species (or to eventually grow up and join the canopy layer). It is difficult for secondary species to enter a restored site once canopy closure has occurred. Even primary forest species that colonise after canopy closure may take many years to grow up and join the canopy layer. This means the rate of successional change and progress towards a fully restored state will be slow after canopy closure.

Corollary: Rapid canopy closure reduces the likelihood (but will not necessarily prevent) weed colonisation. Some weed species may still be able to persist under moderate levels of canopy cover, particularly when that canopy cover is uneven. Alternatively weeds may arrive at a site and persist in a soil seedbank.

CONCLUSIONS

The task of restoring the most complex ecosystems on Earth will be difficult. Ecological theory is still in a comparatively early stage of development and has not yet reached the stage at which prediction of successional trajectories is possible or assembly rules can be declared. On the other hand, enough experience has now accumulated in various tropical forest ecosystems to establish a set of propositions or generalisations defining how newly established forest communities are likely to develop. What needs to be done now is to test these. Are they useful generalisations or are they restricted in their applicability? Have they any predictive value for restorationists? More particularly, can they be improved?

Any improvement is only likely to come if those engaged in restoration learn much more from their trials than has been the case so far. Some suggested details that should be recorded are listed in Table 1. Forest restoration is a long-term task and those doing the evaluation will not necessarily be those establishing the trials. Meticulous documentation is needed, to allow restoration trajectories to be monitored and evaluated. In addition, more varied approaches to restoration should be tested. For example, perhaps sets of adjacent trials might be established in which different species introduction sequences are used. Do these lead to different outcomes? Might these sets of trials collectively hold more species than would be the case if the same area were reforested using just one approach?

Table 1: Objective setting and monitoring tasks for restoration trials.

Task	Details
Define objective	Set quantifiable objectives such that the degree of success can be evaluated in the future (e.g. the objective is to increase site species richness to a particular level by a certain time).
Specify methods used	What species were planted or sown? What proportions of each were used? What functional groups were represented? What was the sequence of species introduction? What form of management has been applied? When did this cease?
Specify the prevailing environmental conditions	What levels of soil fertility? What weather conditions at the time of establishment and subsequently?
Monitor community development	Have all introduced species survived? Have these reproduced and have seedlings become established? What new colonists have regenerated? What wildlife species are now using (for reproduction?) these new ecosystems? Under what circumstances did plant and animal colonisation occur (e.g. timing)? What are the attributes and habitat requirements of these plant and animal colonists?

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QUESTIONS AND COMMENTS

Ulfah Siregar

I think that ecological theory alone is not enough to predict the likely success of various approaches to forest restoration. We must include consideration of genetics as well as environmental factors.

David Lamb

I agree

David Young

Formal ecological research has been going on for over 100 years, but it is still unable to provide us with definitive answers. Is it better to be 70% correct and carry out forest restoration now or wait another 100 years to be 100% correct? I refer specifically to the use of indigenous knowledge for forest restoration.

David Lamb

I think we need to implement forest restoration projects now on the basis of the best knowledge currently available, including both ecological research and current traditional practices.

John Parrotta (right) poses for a post-workshop photo with colleagues (left to right) David Blakesley, David Lamb and Nigel Tucker.

CATALYSING NATURAL FOREST RESTORATION ON DEGRADED TROPICAL LANDSCAPES

John A. Parrotta[1]

ABSTRACT

Tropical forest loss and degradation are proceeding at unprecedented rates, eroding biological diversity and prospects for sustainable economic development of agricultural and forest resources. There is increasing evidence that forest plantations can play a key role in harmonising long-term forest ecosystem rehabilitation or restoration goals with near-term socio-economic development objectives. Recent studies have shown that plantations can facilitate or "catalyse," forest succession and biodiversity enrichment in their understories on sites where persistent ecological barriers to succession would otherwise preclude recolonisation by native forest species. These studies suggest that the catalytic effect of plantations is due to changes in understorey microclimatic conditions, increased vegetation structural complexity, and development of litter and humus layers that occur during the early years of plantation growth. These changes lead to increased seed inputs from neighbouring native forests by seed dispersing wildlife attracted to the plantations, suppression of grasses or other light-demanding species that normally prevent tree seed germination or seedling survival, and improved light, temperature and moisture conditions for seedling growth. Wildlife, particularly birds and bats, are critical "allies" in the restoration process, responsible for seed dispersal for the overwhelming majority of tree, shrub and liana species present in moist tropical forests. Understanding the habitat preferences and behaviour of these restoration facilitators, including their relationship to vegetation structure and composition, can help us to better design restoration treatments (including tree species selection) that will lead to rapid increases in floristic diversity and overall improvements in the value of these forests as wildlife habitat. In this paper, the results of recent studies conducted since 1995 in several countries in Latin America, Africa and the Asia-Pacific region on the phenomenon of plantation-catalysed native forest restoration will be summarised and their potential application in wildlife conservation programmes discussed.

Keywords: biodiversity, forest restoration, plantations, rehabilitation, silviculture, succession

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INTRODUCTION

Tropical forest loss and degradation, as well as degradation of lands that formerly supported forest, are proceeding at unprecedented rates, eroding biological diversity and prospects for sustainable economic development of agricultural and forest resources. Each year, an estimated 15.4 million ha of tropical forests and woodlands are destroyed or seriously degraded, principally through agricultural expansion, uncontrolled livestock grazing, logging, and fuel-wood collection (WORLD RESOURCES INSTITUTE/IIED, 1988; FAO 1993). Estimated annual losses of forest cover range from 0.6 to 1.1% among tropical forest zones (FAO 1993), with the greatest losses occurring in moist deciduous forests (6.1 m ha y^{-1}) and in tropical rain forests (4.6 m ha y^{-1}). Significant losses are also occurring in upland forest formations (2.5 m ha y^{-1}) as well as in dry and very dry forest zones (2.2 m ha y^{-1}).

Historically the most common response to land degradation has been abandonment, or reliance on natural forest succession to restore lost soil fertility, species richness, and biomass productivity. Periodic land abandonment has been the basis of apparently sustainable traditional shifting cultivation and livestock herding systems. In many tropical regions, however, fallow periods are often shortened or eliminated due to increased population pressures and agricultural intensification. Without adequate inputs (such as plant nutrients), productivity and land utility commonly decline, often precipitously, as in the CASE of pasture development in the Amazon Basin (UHL *ET AL.* 1988a, 1988b; NEPSTAD *ET AL.* 1991). As a result, extensive areas of former forestlands are in varying stages of degradation. Such areas need management to improve their productive capacity, to meet human needs, to improve local and regional watershed management and to contribute to biodiversity conservation, by providing improved habitats for wildlife, both inside and outside protected areas.

Strategies and techniques for rehabilitating degraded areas should be based on the priorities and objectives of stakeholders, as well as the costs and benefits associated with available rehabilitation techniques. A large proportion of marginal lands, currently classified as degraded, can and should be rehabilitated primarily for food production. New cropping practices (such as agro-forestry technologies) and more efficient agricultural resource management systems can assist this process and ensure that agriculture remains sustainable and thereby minimise local pressures on natural forest ecosystems. There remain, however, significant formerly forested areas in many countries that cannot be economically rehabilitated for either agricultural or intensive commercial forestry production in the near term, and degraded lands of high potential value for conservation and watershed protection.

An unknown proportion of these lands would naturally revert fairly quickly to secondary forest, if the pressures on them (i.e., biomass harvesting, grazing, fire) are lifted. This has occurred in parts of Latin America where substantial areas of secondary forest have established following the collapse of cattle raising activities (BROWN & LUGO, 1990; SIPS 1993). In many areas of South and Southeast Asia, Joint Forest Management programmes have resulted in dramatic rates of forest recovery, following implementation of effective community-based forest protection measures (POFFENBERGER & MCGEAN, 1996). Other, more severely degraded, landscapes require some form of human intervention, or management, to facilitate their recovery. On such sites, persistent physical, chemical and biological barriers, or stresses, preclude or severely limit the rate of natural forest succession. These barriers typically include some combination of the following "symptoms": recurrent fires; soil compaction, waterlogging, salinisation or other soil physical and chemical limitations; erosion and soil nutrient limitations; absence of obligate fungal or bacterial root symbionts; seasonal drought; low seed or rootstock availability; lack of suitable microhabitats for seed germination and seedling establishment; seed and seedling predation; and severe competition with grasses or ferns.

At present most tropical reforestation efforts focus on the development of forestry and agro-forestry systems aimed at maximising production of a very limited number of tree species of economic importance. Alternatively, forest restoration projects usually involve planting of a diversity of forest species and aim to recreate the forest ecosystem believed to have formerly occupied the landscape. Intensively managed commercial forestry and agro-forestry systems have limited potential for biodiversity conservation. Although ecosystem restoration can yield extremely good results in terms of biodiversity recovery, their high costs make them economically unattractive for large-scale application in most tropical countries except under very specialised circumstances, such as in the restoration of mine sites (KNOWLES & PARROTTA 1995; PARROTTA & KNOWLES 1999) or degraded habitats in conservation units and on private land (GOOSEM & TUCKER, 1995; TUCKER & MURPHY 1997). What is needed for large-scale application in many regions are forest rehabilitation and management systems that simultaneously accelerate regeneration of species-rich native forest ecosystems and provide economically and socially valued forest products.

PLANTATIONS AS A TOOL FOR CATALYSING NATIVE FOREST SUCCESSION

There is increasing evidence to support the assertion that forest plantations can play a key role in harmonising long-term forest ecosystem rehabilitation or restoration goals with near-term socio-economic development objectives (*cf.* PARHAM *ET AL.*, 1993; BROWN & LUGO, 1994; LAMB & TOMLINSON 1994, PARROTTA & TURNBULL, 1997; KIKKAWA *ET AL.*, 1998; LAMB 1998). Several studies conducted between 1985 and 1995 demonstrated that plantations accelerate or catalyse forest succession in their understories (particularly where intensive silvicultural management is neglected) on sites where persistent ecological barriers to succession would otherwise prelude recolonisation by native forest species. See, for example, YU *ET AL.* (1994) for China; BHASKAR & DASAPPA (1986), KUSHALAPPA (1986), SONI *ET AL.* (1989), GEORGE *ET AL.* (1993) and SRIVASTAVA (1994) for India; MITRA & SHELDON (1993) for Malaysia; and KUUSIPALO *ET AL.* (1995) for Indonesia; KNIGHT *ET AL.* (1987), LÜBBE & GELDENHUYS (1991), GELDENHUYS (1993, 1996) and VAN WYK *ET AL.* (1995) for South Africa; FIMBEL & FIMBEL (1996) for Uganda; LUGO (1992), PARROTTA (1992, 1993, 1995), and LUGO *ET AL.* (1993) for Puerto Rico; GUARIGUATA *ET AL.* (1995) for Costa Rica; VIEIRA *ET AL.* (1994) and SILVA JUNIOR *ET AL.* (1995) for Brazil.

These studies have shown that under certain conditions (particularly where forest remnants and forest seed-dispersing wildlife are present on the landscape), forest plantations significantly accelerate natural succession by overcoming barriers to natural regeneration. This is due to their influence on understorey microclimatic conditions, vegetation structural complexity, and development of litter and humus layers during the early years of plantation growth. These changes lead to increased seed inputs from neighbouring native forests by seed dispersing wildlife attracted to the plantations, suppression of grasses or other light-demanding species that normally prevent tree seed germination or seedling survival, and improved light, temperature and moisture conditions for seedling growth. In the absence of silvicultural management aimed at eliminating woody understorey regeneration, the monospecific plantation system is replaced by a mixed forest comprised of the planted species and an increasing number of early and late successional tree species and other floristic elements drawn from surrounding forest areas. This process can be observed in many tropical countries where plantations established decades ago are no longer being managed for timber production due to changing economic conditions within the forestry sector and, in some cases, environmental legislation banning forestry activities in ecologically sensitive zones such as montane and riparian areas. Eventually, if the planted species are short-lived and light demanding (as are most of the commonly planted commercial species), they may disappear entirely from the system following their harvest of natural mortality, leaving a floristically rich secondary forest.

Plantations as successional catalysts: results of a recent international research programme

Based on these earlier findings, an international collaborative research project on tropical tree plantations and biodiversity rehabilitation was initiated in 1994 by the USDA Forest Service (International Institute of Tropical Forestry) with financial support from the World Bank, the Center for International Forestry Research (CIFOR) and the Overseas Development Authority/UK (ODA). Its purpose was to critically evaluate the effects of forest plantings on native forest succession on severely degraded or deforested tropical landscapes. Specifically the research addressed a series of hypotheses concerning the relative importance of environmental conditions, plantation species selection and other design criteria and silvicultural management practices on the process of native forest regeneration in established plantations. A common set of study protocols was used to quantify floristic composition and other ecological parameters in a variety of plantation systems of different ages and in unplanted "control" areas across a range of site conditions (Table 1). These studies were carried out in 1995-96, and an international symposium/workshop convened in Washington DC in June 1996 to present and discuss the findings of these studies and those of related research by investigators working in a number of other tropical and subtropical locations. The results of this project and associated studies presented at this symposium, were published in a special issue of *Forest Ecology & Management* (PARROTTA & TURNBULL, 1997).

The 1996 symposium/workshop provided an opportunity for participants to evaluate the hypotheses that guided the international research project, to identify areas for further research and to discuss the potential applications of project results under a variety of management conditions. Workshop participants considered the following questions:

- Do plantations accelerate natural forest succession on degraded tropical sites?

- If so, what site conditions, plantation designs (species selection, spacing, etc.), and silvicultural management practices (site preparation, understorey management, thinning regimes) favour the adoption of this technique for native forest rehabilitation/restoration over alternative methods?
- What is the role of wildlife in the process and how can plantations be designed to increase their effectiveness as seed-dispersers?
- To what extent does the regeneration of a diverse understorey flora affect the productivity of the planted crop in plantations established primarily for timber production, and how can the regeneration process be managed to optimise yields of a diverse product mix to meet economic, social and environmental conservation objectives?
- What are the potential uses of the "catalytic effect" of plantations to harmonise forest production goals and forest rehabilitation and/or restoration objectives?

The following conclusions and suggestions for future research emerged from the 1996 workshop:

- Relative to initially similar, unplanted sites, plantations generally have a marked positive effect on native forest redevelopment (succession) on severely degraded sites (such as mined lands and severely eroded areas) and on sites dominated by grasses and ferns which otherwise preclude colonisation by forest species;
- The degree to which plantations accelerate colonisation and establishment by native forest species increases with increased site degradation and from drier to wetter sites, and generally decreases with increasing distance from remnant native forest stands (i.e., seed sources). Further research was recommended to develop techniques for accelerating natural forest succession on drier sites;
- Choice of plantation species can significantly affect the process of understorey regeneration, several studies having shown that plantations of different species of the same or similar age grown on very similar or identical sites showed marked differences in the density and species composition of their woody understorey communities. These differences are due to a combination of factors, including the effect of the overstorey species on understorey light environments and seasonal regimes, soil chemical and biological characteristics, nutrient cycling processes and their relative value to seed-dispersing wildlife;
- Structural complexity of the planted forest is an important determinant of subsequent biodiversity enrichment due to the importance of habitat heterogeneity for attracting seed-dispersing wildlife and microclimatic heterogeneity required for seed germination for a variety of species. This suggests that broadleaf species yield generally better results than conifers, and that mixed-species plantings are preferable to monocultures, due in part to their increased structural complexity. Future studies were suggested to assess the influence of overstorey (planted) species architecture and phenology on understorey microclimate heterogeneity (spatial and temporal patterns), and aspects of forest floor and soil development that influence recruitment of native forest species, under a variety of site and landscape conditions;
- Wildlife, especially bats and birds, are of fundamental importance as seed dispersers

in tropical regions. Their effectiveness in facilitating plantation-catalysed biodiversity development on degraded sites depends on the distances they must travel between seed sources (remnant forests) and plantations, the attractiveness of the plantations to wildlife (ability of plantations to provide habitat and food) and the condition of the forests from which they are transporting seeds (WUNDERLE, 1997). Additional research is needed under a variety of ecological conditions to better understand the dynamics of animal seed dispersal in degraded landscapes, to develop appropriate plantation designs to encourage seed transport from remnant forest stands, and to determine the range of distances between seed sources and rehabilitation sites over which seed dispersal by animals is likely to be effective;

- Larger-seeded forest species are far less likely to colonise degraded sites than smaller-seeded species due to seed dispersal limitations, and therefore require management interventions (e.g., enrichment planting) to facilitate their establishment, particularly where forest restoration is a major objective. Further studies are recommended to develop low-cost techniques for establishing large-seeded species either at the time of plantation establishment, or as enrichment plantings at appropriate stand ages;
- Regarding silvicultural management options, the workshop examined the effects of site preparation alternatives (mechanical, fire, chemical), understorey management practices and plantation thinning regimes on both the planted trees and the species-rich native forest understorey they foster. Due to the complexity of interactions among the many factors involved, however, specific recommendations are dependent on initial site conditions, the goals of plantation management, and the relative importance of the planted trees for timber or biomass, the regenerating understory and other socio-economic and environmental goods and services provided by the rehabilitating forest system. The issue of "trade-offs" between overstorey productivity and understorey development was identified as an important topic for further study, requiring experimental studies to determine the effect of plantation understorey regeneration on overstorey growth and nutrient cycling processes during the course of stand development;
- There was a broad consensus that the "catalytic plantation" approach is a promising tool for degraded land rehabilitation in a variety of contexts. Given the growing recognition in the scientific and development communities, among policy-makers, and in the private sector of the need to incorporate biodiversity rehabilitation and conservation in land-use planning and forest management, this approach is attracting broad interest as a means for integrating social, economic and environmental land management goals. Potential applications of this approach included restoration plantations in riparian areas and on other critical sites (such as steep eroded slopes); plantings designed to foster development of mixed native forests for a variety of locally used and valued species; and alternative management strategies for long-rotation timber plantations, short-rotation fuel-wood or fibre plantations and agro-forestry systems.
- Management issues and potential applications discussed during the workshop clearly indicate the need for additional research in a number of areas related to plantation design and management. Specifically, experimental research is required

to systematically evaluate the effects of site preparation, plantation species selection (both single- and mixed-species alternatives), understorey management practices, and stand manipulation techniques (e.g., pre-commercial thinnings, liberation thinnings, enrichment plantings) on the productivity of both the planted crop and its regenerating understory, the associated economic and social costs and benefits, and the environmental impacts of alternative design and management systems related to biodiversity conservation, soil fertility rehabilitation and carbon sequestration. These questions need to be addressed in the context of local ecological conditions. There must also be recognition of the current and future priorities of local communities, individual landholders and land managers to ensure that forest rehabilitation and management options evaluated are consistent with socio-economic realities, development priorities and conservation goals.

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Table 1. Characteristics of study sites included in international research programme on the effects of forest plantations on natural forest regeneration (1995-1996)

Site	Local Vegetation Type	Elevation (m) & Annual Rainfall (mm)	Plantation Species	Plantation Purpose	Plantation Age (years)	References
Upper Waiakea and Ola'a Forest Reserves, Hawaii, USA	Native rainforest, dominated by *Metrosideros polymorpha* and *Acacia koa*	850-950 m; 4800 mm	*Eucalyptus saligna*, *Flindersia brayleyana*, *Fraxinus uhdei*	Large-scale experimental plantations	26-32	HARRINGTON & EWEL 1997
Trombetas, Pará State, Brazil	Bauxite-mined lands surrounded by old-growth upland Amazonian forest	180 m; 2200 mm	Mixed-species plantings of 70+ native forest species	Native forest restoration	10	PARROTTA *et al.* 1997; PARROTTA & KNOWLES 1999
La Selva Biological Station, Atlantic Lowlands, Costa Rica	Abandoned pastures	65 m; 3900 mm	Single-species blocks of 7 native and exotic tree species	Experimental; evaluation of tree plantation effects on soils	7	POWERS *et al.* 1997; HAGGAR *et al.* 1997
Sarapiqui, Atlantic Lowlands, Costa Rica	Abandoned pastures	40-100 m; 3900 mm	*Hyeronima alchorneoides*, *Vochysia ferruginea*, *V. guatamalensis* (all native)	Small-scale timber production on private lands	6	HAGGAR *et al.* 1997
Pointe Noire & Loudima, Congo	Grassland and shrub savanna	40-180 m; 1070-1250 mm	*Eucalyptus* hybrid, *Pinus caribaea*, *Acacia auriculiformis*	Industrial wood production (*Eucalyptus*); Experimental (all species)	6-26	LOUMETO & HUTTEL 1997; MBOUKOU-KimbatSa *et al.* 1998

Site	Local Vegetation Type	Elevation (m) & Annual Rainfall (mm)	Plantation Species	Plantation Purpose	Plantation Age (years)	References
Ulumba Mountain, southern Malawi	Degraded miombo woodland	1075 m; 780 mm	*Eucalyptus camaldulensis*	Community woodlot (fuelwood)	1-8	BONE *et al.* 1997
Eastern Escarpment & Soutpansberg mountains, Northern Province, South Africa	Fire-maintained grasslands with patches of mixed evergreen forest in riparian and other protected sites	1200-1760 m; 1200-1900 mm	*Pinus patula*, *P. elliotii*, *P. taeda*, *Eucalyptus saligna*	Commercial plantations	7-90	GELDENHUYS 1997
Atherton Tablelands, north Queensland, Australia	Deforested lands adjacent to intact rainforest	1425-3625 m	*Araucaria cunninghamii*, *Flindersia brayleyana*, *Toona ciliata* (native); *Pinus caribaea* (exotic)	Commercial timber plantations	5-64	KEENAN *et al.* 1997
Eubenangee Swamp N.P., Lake Barrine N.P., Wooroonooran N.P, Malanda township, north Queensland	Degraded riparian mesophyl vine forest and upland rainforest	0-760 m; 1450-3650 mm	Numerous fleshy-fruited native tree species	Native forest restoration	5-7	TUCKER & MURPHY 1997

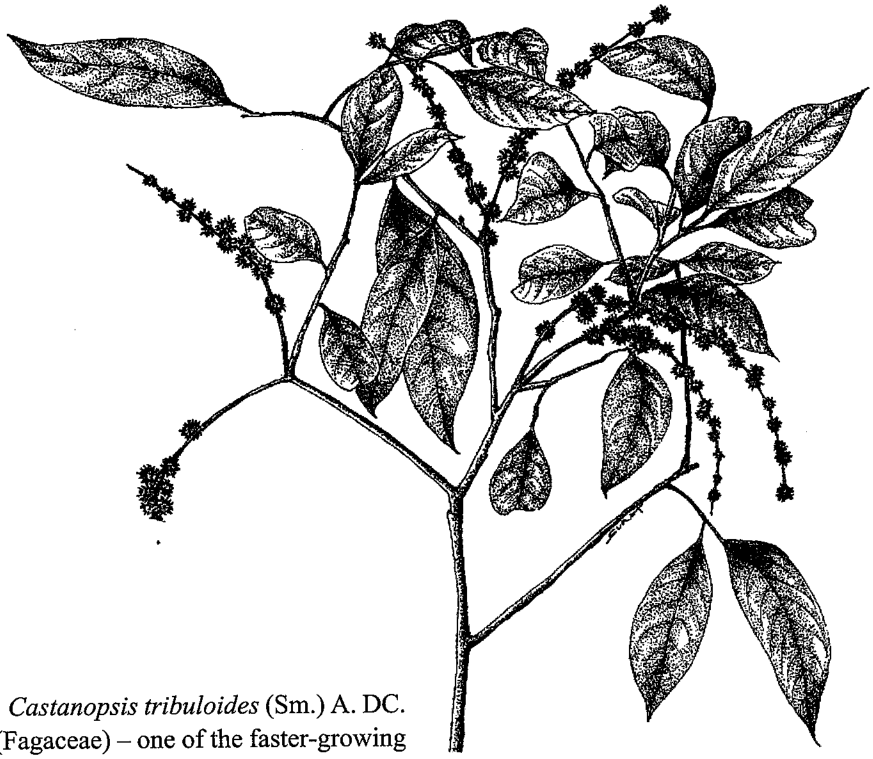
PART TWO

COUNTRY AND PROJECT REVIEWS

Editor

Janice Kerby

M. R. Smansnid Svasti teaches international students the importance of conserving and restoring northern Thailand's watershed forests at the Mae Soi catchment, 1992.



Castanopsis tribuloides (Sm.) A. DC. (Fagaceae) – one of the faster-growing members of the Fagaceae; this family is a major component of northern Thailand's upper watershed forests.

INTRODUCTION

Janice Kerby[1]

This session provided a broad overview of the various forest restoration techniques being practised in the region. Speakers presented historical perspectives of their countries or projects, including their most relevant findings and their requirements for further research to improve forest restoration for wildlife conservation.

The countries represented encompassed substantial variation in biogeography and economic development, which inevitably led to differing priorities for forest restoration. For example, in Bangladesh there is high pressure on forest resources to sustain the livelihoods of the very poor, whereas in Hong Kong the mainly urbanised population no longer relies on their immediate environment to provide their daily needs. All countries had a history of large-scale deforestation for both timber and to provide agricultural land but had now reduced logging and increased reforestation. The problem of growing populations and increased demand for fuel-wood, timber and NTFP's was a common theme. For example, the volume of wood used annually as fuel in Myanmar is tenfold the volume harvested for timber. Serious soil erosion, watershed degradation and loss of wildlife due to unsustainable forest exploitation were all identified as serious problems by most speakers.

All presented papers revealed a history of state-lead commercial afforestation predominantly by establishing mono-specific plantations of exotic tree species. Notably, most countries are now starting to move towards more community-based forestry programmes with increased emphasis on planting native species to meet local needs. However, the familiarity of state forest departments with a limited number of exotics inevitably leads to their continued use in many plantations, even though suitable native alternatives may be available. Most speakers considered that detailed knowledge of how to produce native seedlings in their countries was limited to only a handful of species. There was general agreement amongst participants that forest restoration could help wildlife, not only directly through replenishing habitat, but also indirectly through reducing pressure on remaining natural forests.

The speakers suggested many ways of tackling the issues described above. Several techniques were commonly mentioned, such as the inclusion of species which bear edible fruits or which can be coppiced for firewood, so that local people will have an incentive to support the forest restoration. The use of a mixture of pioneer and climax species in forest restoration planting schemes is being practised in Thailand, Vietnam, China and Myanmar. Adaptation of traditional silvicultural techniques is also widespread, such as the use of native species as nurse crops, inter-planting and thinning to improve plantation diversity and structure. Such techniques can substantially increase the value of restored sites for wildlife at an early stage. The majority of current forest restoration projects are carried out

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by planting pot-grown seedlings raised in nurseries. In contrast, in Hong Kong, both direct seeding and bare-root planting have been planted with varying degrees of success, whilst in Vietnam, direct seeding has been very effective.

A key theme was the need to protect young plantations from fire and the substantial problems posed by the scale of fires started by people. Various methods were identified. Cutting of firebreaks seemed to be common in most countries, whilst education of local people about fire prevention was highlighted as an area needing further work.

Workshop participants generally agreed that the old paradigm of forestry being undertaken only by the state and commercial companies is changing and there is considerable potential for new partnerships. In the Philippines, Thailand, Burma and Hong Kong, involvement of NGO's in facilitating planting schemes is increasing. In addition, the role of academic institutions in developing techniques that can then be adopted by other sectors is growing.

The speakers identified a wide range of research requirements, covering all aspects of forest restoration from tree species choice to silviculture of developing plantations. There is a need to identify suitable native species for planting that have high wildlife value, can grow in degraded sites and also have characteristics that will engender community support. Considerably more research is necessary on storage, treatment and germination of seeds. Methods of reducing nursery costs were also targeted, as currently native seedlings can be more expensive to produce than commercial exotics, because of the economies of scale associated with production of the latter. Direct seeding was also identified as an area in need of further development, particularly concerning techniques to expand the scale of planting, such as aerial seeding. In discussion sessions, ideas on direct seeding were developed into an outline research proposal (see Part 7, 4.3).

Improved techniques for fire control and greater understanding of the ecology of forest fire were highlighted (see Part 7, 3.1 & 3.2). It was also suggested that there is a need for augmenting knowledge of the behaviour of fragmented forest ecosystems, with regard to their provision of seed and seed dispersers. In addition, there is a clear gap in available knowledge as to what degree wildlife actually utilises restored sites and thus it is hard to evaluate how effective restoration has been.

All speakers presented a wealth of data, ideas and experience, many of which can be adapted and applied throughout the region. Several of the techniques presented generated substantive discussion later in the workshop and lead to identification of priority research areas. At present, most forest restoration plots are small and experimental. It is essential to expand the scale of forest restoration, if it is going to be effective at reducing losses of wildlife species. Thus it is timely to investigate restoration methods that will be suitable for large-scale implementation.

A BRIEF REVIEW OF FOREST RESTORATION PROGRAMMES IN MYANMAR

Sein Maung Wint[1]

ABSTRACT

Evolution of the Myanmar strategy of forest restoration is reviewed and five types of forest plantations, with different sets of objectives, under different ecological conditions are described. Socio-economic and environmental issues of reforestation through plantation forestry are discussed and technical aspects of site selection, species choice, nursery practice, planting methods and follow-up silvicultural treatments are briefly presented. Use of well-adapted genetic resources; correct site/species matching, good silviculture and sustained protection at all stages from seed collection to harvesting is stressed. Priority areas of further research needs are also indicated.

***Key words*:** Myanmar, strategies of forest restoration, forest plantations, socio-economic and environmental issues, site-selection, planting methods, silvicultural treatments, sustained protection, research

INTRODUCTION

Many international and national studies have identified that the forests of most developing countries in the tropical region are gradually being depleted due to a mix of socio-economic factors such as:

1. over-exploitation of forest products, especially firewood, timber, posts and poles by an ever-increasing population;
2. uncontrolled forms of shifting cultivation with shorter fallow periods by hill people;
3. clearing forest for more attractive forms of land use like cultivation of diverse agricultural crops to increase livelihood security of landless farmers;
4. illicit logging, coupled with weakness in monitoring and
5. inadequacy of extension activities, seeking involvement of rural communities in resource management.

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Forest degradation leads to loss of wildlife habitat and disturbance of ecosystem functioning. These changing scenarios call for a concerted effort towards restoration of tropical forests by all possible means.

HISTORICAL ASPECTS OF FOREST RESTORATION IN MYANMAR

The Union of Myanmar is endowed with a diversity of flora and fauna. There are 2,088 species of trees, 1,696 shrub species, 96 bamboo species, 36 rattan species, 841 orchid species, approximately 300 mammal species, more than 1,000 species of birds and more than 400 species of reptiles and amphibians (FOREST DEPARTMENT, 1996). However, being a developing country, it has suffered forest degradation and depletion. Out of 34 million ha of forest area, 29 million ha is classified as closed forest and 5 million ha as degraded forest (MINISTRY OF FORESTRY, 1999). The forests of Myanmar have been subject to shifting cultivation for more than a century. Shifting cultivation has supported rural communities for many years, especially hill people, living in the vicinity of forests.

Historically, in order to create teak plantations, in conjunction with cultivation of agricultural crops on hill slopes, the so-called *taungya* system was adopted in Myanmar in 1869. The term *taung* in Myanmar language actually means hill and *ya* means a plot of agricultural land on a slope.

In those days, *taungya* cutters or slash-and-burn cultivators were allowed to practice *taungya* cultivation wherever they pleased, on condition that they planted teak seedlings provided by the Forest Department (FD) when they raised their crops.

The *taungya* system has the advantages that it provides land to grow agricultural crops, while teak trees are planted at a regular spacing of 1.8 x 1.8 m (or approximately 3,000 trees per ha), among the crops, almost free of charge. A nominal amount, depending on the survival percentage was paid to the farmers in the form of a bonus. FD field staff normally count the surviving trees in December of the first year of planting.

Some other tropical countries facing population increase, encroachment into forests for agriculture and subsequent degradation of forests, have also adopted the Myanmar experience of reforestation with teak and other high value species by means of the *taungya* method.

On the other hand, experience in Myanmar reveals that some of the teak plantations established by *taungya* cutters were located on unsuitable sites or were scattered over wide areas in small patches. They were consequently difficult to effectively tend, manage and protect. For example, lack of regular thinning of teak plantations led to stunted growth and soil erosion due to lack of undergrowth vegetation.

The lesson is that the *taungya* system of planting teak can be successful only if it is undertaken on suitable sites with proper tending and supervision.

EVOLUTION OF THE MYANMAR STRATEGY OF FOREST RESTORATION

Professional foresters in Myanmar, both past and present, generally agreed that the original *taungya* system was successful in raising teak trees in the form of compensatory plantations on a small scale. In fact, the average area planted per year was only about 1,000 ha (2,620 acres) during the period of 45 years (1896-1941) before the Second World War. The extent of plantations reached 47,167 ha up to 1941 (FOREST DEPARTMENT, 1999).

However, under changing scenarios of the political, social and economic situations in the country, there is a need to meet the increased demand for timber and firewood due to population growth, the rise in the standard of living and the establishment of more wood-based industries. Watersheds of newly constructed dams and reservoirs have to be properly maintained to reduce soil erosion and siltation. The scale of the annual plantation area has therefore gradually increased, reaching a peak of 42,891 ha (105,984 acres) in 1998 (MINISTRY OF FORESTRY, 1998). The Forest Administration has also adopted a new strategy of forest restoration through the creation of five types of forest plantations, four types having been undertaken by the State and one by rural communities as follows:

1. Commercial Plantations (established by the State sector) (FOREST DEPARTMENT 1999)
2. Village Supply Plantations (established by the State sector) (FOREST DEPARTMENT 1999)
3. Industrial Plantations (established by the State sector) (FOREST DEPARTMENT 1999)
4. Watershed Plantations (established by the State sector) (FOREST DEPARTMENT 1999)
5. Community Plantations (established by rural communities)

Commercial Plantations

In order to supplement timber production from natural forests and to assure a sustainable supply of teak and other hardwoods for the export and domestic markets, commercial plantations with high-value species like teak (*Tectona grandis*), *pyinkado* (*Xylia dolabriformis*) and *padauk* (*Pterocarpus macrocarpus*) are established by the State sector every year.

This strategy also aims to transform low-value, degraded natural forests into high-value forest plantations. Landsat images and aerial photographs are extensively used to formulate reforestation plans and to stratify different forest types and growth conditions. Degraded forest with a very sparse density of growing stock, low stem height and scrubby condition in the moist deciduous forest zones are initially delineated on maps and final selection of the site is made after a ground check for reforestation with commercial species (WINT, 1993)

In other words, ecological conditions are identified carefully in advance. This helps to avoid clear felling of good natural forest and it also assists in the selection of species for proper site-species matching. Teak grows well on well-drained slopes with deep sandy loams in moist deciduous forest, while *padauk* can be planted in the same blocks, but on higher ridges where teak is less suitable.

As teak is site-sensitive, one of the main issues in the formation of large-scale teak plantations is to select the most suitable sites for good growth and production of quality timber without "bee-holes", knots and twisty grain. Other major issues include collection of seed from well-adapted genetic resources and weeding regularly in the first, second and third year until the height of the tree is well above aggressive weeds. These include *thetke* (*Imperata cylindrica*), *bizat* (*Eupatorium odoratum*) and also bamboos shooting from old stumps burnt over during site preparation.

Research is therefore needed to study and recommend the most economical and practical methods of weeding, including considerations such as the advantages and disadvantages of chemical weeding, mechanical weeding, manual weeding and ploughing. In Myanmar, manual weeding at the rate of 3:2:1 time per year in the first, second and third year of planting is generally practised, depending on growth conditions and budget allotment.

The comparative benefits of fertiliser application and planting of nitrogen-fixing plants in the form of a second story to stimulate faster growth may also be investigated. Cost-efficient planting and tending techniques are needed where labour is scarce and/or expensive. The financial return and indirect benefits of complex plantations against simple plantations may also be studied to achieve best economic gain from a piece of reforested land and also to conserve the soil and the natural environment as far as possible.

In Myanmar, most commercial plantations are established under the departmental *taungya* system, evolved from the original *taungya* system adopted by the Forest Administration before the Second World War.

Under the departmental *taungya* system, *taungya* cultivators are paid to clear sites for planting by the Forest Department in the form of minimum daily wage or on a piecework basis. Similarly, fixed rates for each stage of plantation establishment are paid to the villagers. On the social side, temporary forest villages including a primary school and water supply system are established for villagers who agree to participate in the work on a full time basis. These villagers therefore enjoy the benefit of a good income for their labour as well as income from the agricultural crops they grow in the plantation areas. The more facilities are provided, the more attractive it is for villagers to participate in departmental plantation work.

Again, the more income they can make from their crops, which are sometimes sold at the nearby markets of the towns and cities, the more they carry on with the plantation work under the departmental *taungya* system. The District Forest Officers normally oversee the situation and manage the programme as a measure to solve the socio-economic problems of landless villagers dwelling near the forests. This system works well in large-scale commercial plantation programmes.

The technique of raising commercial plantations normally includes selection of a suitable site, as noted above, extraction of remaining trees useful for commercial purposes, clear felling of useless trees and shrubs and planting of either stumps or seedlings raised in tree nurseries. This is followed by weeding, patching, counting of surviving plants, fire protection up to the age of 5 years and thinning in the later years, as required (KERMODE, 1964).

In other words, good silviculture at all stages from nursery to final felling is considered vital in the establishment of commercial plantations. Issues like budget constraints under public ownership, fostering of a favourable climate for private investment, stewardship of the environment and uplift of community values need to be addressed for successful restoration of forests on degraded areas, as identified vividly in high resolution satellite images.

Village Supply Plantations

Traditionally, rural people collect firewood mostly from neighbouring natural forests and trees growing in their farmland and homestead. In Myanmar, the Forest Law permits villagers to fell any unreserved trees growing in unclassified public forestland within a 40-km (25-mile) radius from their village. It also allows villagers to fell trees growing in Local Supply Reserved Forests, managed under the coppice-with-standards system. Normally, a 20-year felling cycle is fixed and the villagers are allowed to extract firewood, posts and poles.

In conjunction with gradual population growth, the demand for firewood and charcoal has increased many times. The old management system was therefore re-inforced with a new strategy of forming firewood plantations in degraded reserved forests and protected public forests with multi-purpose tree species like *mezali* (*Cassia siamea*), *sha* (*Acacia catechu*), *auri-sha* (*Acacia auriculiformis*), and *bawzagaing* (*Leucaena leucocephela*). In addition, *Eucalyptus camaldulensis* and *gandasein* (*Prosopis juliflora*) are also planted in the central dry zone where average annual rainfall is approximately 500 mm.

Prosopis juliflora was introduced into Myanmar about 3 decades ago, because it grows well in arid zones. It is also well known as a 3-dimensional tree, because it provides firewood for cooking, pods for fodder and shade for man and cattle in the dry season. A few years after its introduction, however, some villagers rejected its use due to thorns on the stem. Consequently, its popularity declined. However, seeing and believing that it grows so well under adverse conditions and coppices so well after cutting for firewood, villagers developed a technique for handling *Prosopis* branches and stems without any harm. Currently, the species is planted on the poor gravelly slopes of the hills in the Dry Zone where other species cannot grow well. There is a research need on how to propagate and study the growth of the thornless variety of *Prosopis* in the Dry Zone of Myanmar and other arid areas of the Asia-Pacific region. Under mangrove reforestation programmes, *thamegyi* (*Avicenia officinalis*), *kanbala* (*Sonneratia apetala*) and *madama* (*Bruguiera caryophylloides*) are being planted with the aim of supplying firewood, charcoal and poles on short rotation.

Different planting methods are used, depending on ecological conditions including altitude, topography, soil, climate, natural vegetation and the silvicultural characteristics of the species selected for planting. Generally speaking, contour trenching in staggered arrangements and planting seedlings in containers is recommended for dry zone reforestation. Direct sowing or planting with seedlings in containers is recommended for other reforestation programmes.

The main issue is the creation of village supply plantations in the dry zone under adverse conditions of low rainfall, poor soil and high population density of humans and livestock. Recently, a Dry Zone Greening Department was formed as a major Institution under the Ministry of Forestry to address this issue. The main tasks include restoration of forest cover by planting, as well as effective protection of remaining natural forests, a drive for fuel-wood substitution and search for water resources.

Industrial Plantations

Industrial plantations are established near each specific industry as required. The main objective is to assure a supply of raw material to industry without depending on natural forests and to reduce the cost of transportation of raw materials. In this way, natural forest resources are rationally utilised, whilst domestic wood-based industries continue to grow.

Experiences in Myanmar, for example, have proven that good quality writing paper can be produced by the paper mill at Sittaung with the use of *Eucalyptus camaldulensis* wood from nearby plantations and bamboo from natural forest, mixed at a specific ratio. It is considered that further research to replace bamboo with a suitable long fibre hardwood or softwood species may be undertaken in order to reduce felling of natural forests and to conserve the environment. It may also assist in the production of strong kraft paper for many industrial uses. Currently, many entrepreneurs are showing great interest in the production long fibre industrial wood, namely *tha-le* (paper mulberry) (*Broussonetia papyrifera*) in the highlands of Myanmar.

Watershed Plantations

In view of the construction of more than 100 dams and reservoirs, big and small, in the last decade by the State sector, watershed management has become vital to extend the life span of reservoirs through mitigation of siltation and sedimentation. The current strategy is to adopt the principle of multiple land-use systems whereby pure reforestation as well as agro-forestry practices are encouraged in the interest of local level farmers who traditionally cultivate various agricultural crops on the slopes of the watersheds.

Personnel from the Irrigation Department, Myanmar Agriculture Service and Forest Department collaborate to promote use of the latest technology for proper land-use with co-operation from local communities and NGO's like FREDA.

The main issue in watershed management is to solve the socio-economic problems of rural people who practice slash-and-burn cultivation on the slopes of the watersheds. The people are simple, honest and struggling for their livelihood. Most of the grass-roots-level farmers have no access to modern agro-forestry practices. Research in land management is highly needed for maximum production, soil conservation and restoration of the forests on the steep slopes.

Community Plantations

It may be stressed again that in Myanmar, the population is growing at an annual rate of 1.8-2.0% and the demand for firewood, including charcoal, is ever increasing. In fact, the volume of wood felled annually for firewood is estimated to be around ten-fold the volume of timber harvested for export and local use.

Under such a scenario, it is considered that the scale of village supply plantations established by the State is not adequate to meet the demand. In order to restore denuded forest land, provide basic requirements for the rural poor and maintain environmental stability, the Forest Administration has recently given high priority to establishing community forests. These are to be planted, operated and utilised by rural communities in the form of User Groups.

This new concept of participatory forestry encourages the growing of suitable multipurpose tree species, in accordance with the ecological conditions of the locality and ensures management of community plantations as well as nearby natural forests by the communities themselves. The land is to be made available by the State through 30-year long leases. Leases may be extended, depending on the performance and desire of the community. This form of forestry aims to produce firewood, posts, poles and small logs for use by the rural community concerned. The programme also aims to help generate extra-income, by allowing User Groups to sell surplus produce. The objective is to reduce pressure on the natural forests, some of which are managed for commercial and other production and some for biodiversity conservation.

In order to promote participation of rural people, the Forest Department of Myanmar issued Community Forestry Instructions (CFI) in 1995 (FOREST DEPARTMENT, 1995). It is hoped that local communities, at large, will respond to the objectives and incentives of the programme sooner rather than later. The contents of CFI are rather simple and yet it is mandatory to prepare a management plan before the area earmarked is handed over or leased by FD. This is a kind of bottom-up approach, since the community has the right to express their views concerning selection of sites and species for planting, as well as selection of a 5-member committee for each User Group.

Success of the program will depend on increasing awareness of the concept amongst rural communities. Adequate numbers of well-trained and dedicated extension workers are needed to gain the confidence and trust of communities and to assist in planning and execution of the programme. This calls for concerted and co-ordinated efforts of both the personnel of Government Institutions and NGO's. These personnel have understand the socio-cultural background of the local community and seek co-operation from leading farmers, village elders, Buddhist monks, teachers and health workers in the target area, through personal contact at the grass-roots level.

So far, approximately 4,000 ha (10,000 acres) has been handed over to communities under 30-year leases for community forests. The achievement so far is rather encouraging. The programme is receiving technical assistance from UNDP and FAO of the United Nations and the Forest Resource Environment Development and Conservation Association (FREDA) - a local NGO in the forestry sector of Myanmar, as well as co-operation and collaboration from the FD and local communities.

Creating community plantations includes meetings with the community, socio-economic surveys, landuse surveys, selection of sites, survey and mapping of sites selected, formation of a Users Group, application for permission from the Forest Administration, preparation of management plan, issue of a 30-year leases, planting of tree species selected by the community under the guidance of the FD, UNDP, FAO, FREDA and follow-up activities, like weeding, patching, protection, and harvesting. The essence of the programme is the participatory approach; community forests created by the community for the community!

It is believed that, as news of the success story spreads through all kinds of information media, rural people will show more interest and volunteer to participate in the restoration of the forests.

The main constraint limiting community forestry is lack of access to the latest developments in concepts and directions of the Community Forestry Instructions and reforestation techniques by rural communities. Ironically, hill people who practise slash-and-burn cultivation and destroy the forests have less access to the latest technology and assistance due to the remoteness of their villages. Adequate funding, support and technical assistance is needed to deploy necessary numbers of qualified and dedicated extension workers to implement appropriate community forestry programmes on a wider scale.

On the other hand, there is also a need for research to identify the most suitable tree species, including fruit trees for correct site-species matching and also to study financial yields of those species recommended for planting by the community. In real life, those rural poor struggling for existence will have much interest in the value of tree planting, provided it can be expressed in terms of cents and dollars or income generation in the shortest possible time. This area of research may therefore cover not only species selection and financial yield of each species, but also techniques for maximum production and soil improvement. It is believed that the research findings would also help in restoring forests on denuded lands, as well as indicate measures for soil improvement.

RESTORATION OF HABITAT FOR WILDLIFE

Within the framework of the forest plantation and conservation programmes, the Nature and Wildlife Division of the Forest Department are undertaking restoration of habitat for wildlife. Statistically, there is a network of 23 wildlife sanctuaries and 5 parks, covering a total area of around 1.4 million ha. It constitutes about 2.02 percent of the total land area of the country. The ultimate goal is to extend it up to 10 percent.

Since part of these areas are degraded due to human disturbance in the past, the Forest Administration has adopted a two-pronged strategy of complete protection of natural forests and reforestation of the depleted areas by forming man-made plantations.

The Forest Department established a total of approximately 4,000 ha of forest plantations in the degraded areas and buffer zones of the Shwesettaw and Chatthin Wildlife Sanctuaries and Hlawga and Mt. Popa Parks during the period 1993 to 1999. The main purpose was to restore forest cover with suitable tree species like *Leucaena leucocephala, Eucalyptus camaldulensis, Cassia siamea, Acacia auriculiformis, Tectona grandis, Xylia* *dolabriformis* and *Pterocarpus macrocarpus.* These species were chosen to restore vegetation cover for wildlife in core zones and to supply posts, poles and firewood for communities living in buffer zones.

In addition, under a collaborative programme entitled "Shin Than Yee" (Surviving Together) of the David Shepherd Conservation Foundation (DSCF) of the U.K., Global Survival Network (GSN) of U.S.A and Forest Resource Environment Development and Conservation Association of Myanmar, FREDA has established a tree nursery at Yinmarbin near Alaungdaw Kathapa National Park to produce seedlings of fodder and fruit tree species to planting inside the Park and in the buffer zone. The aim is enrichment of the habitat as well as distribution of trees to rural people around the Park for income generation. Protection of the Park, covering around 160,000 ha, is also in place with the support of the authorities concerned and DSCF/GSN/FREDA.

It is transparent that establishing any form of forest plantations in depleted forest is beneficial for wildlife conservation, directly or indirectly. The more the man-made forests are created in depleted areas, the more forest produce will be available to the local community, with the result of less disturbance to remaining natural forests, which serve as habitat for wildlife. Unless and until the demand for forest produce by an ever-increasing population can be adequately met, the logical trend will be to cut existing natural forests without consideration for the survival of wildlife.

It is also believed that populations of certain mammals and birds could be increased through by manipulation and planting of selected framework species in harmony with prevailing ecological conditions and the specific requirements of each wildlife species.

In other words, the concept of " Surviving Together " should form an integral part of wildlife conservation programmes, since the long- term survival of wildlife depends heavily on the attitudes of people of all strata in the communities concerned.

CONCLUSION AND RECOMMENDATION

It may be concluded that numerous types of plantation programmes would certainly help in the restoration of seasonally dry tropical forests and wildlife habitats in one way or another.

Experience in Myanmar has proven that pressure on natural forests has been reduced to some extent through establishment of forest plantations. The condition of the forest in certain parts of the central dry zone has improved. Where the environment has been transformed from denuded barren land to forest-covered areas, by intensive planting and protection activities, the graceful Eld´s deer (*Cervus eldi thamin*) and Barking deer (*Muntiacus muntjak*) have re-appeared.

In order to achieve forest restoration for man, wildlife and the environment, it is strongly recommended that appropriate forest plantation programmes should be formulated in the context of the individual socio-economic and environment needs of each region. Such programmes should be implemented properly, with the joint efforts of the government agencies concerned, international and national NGO's and rural communities for sustainable development.

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A REVIEW OF THE FOREST STATUS IN BANGLADESH AND THE POTENTIAL FOR FOREST RESTORATION FOR WILDLIFE CONSERVATION

Md. Abdur Rashid[1]

ABSTRACT

Forestry plays a significant role in Bangladesh, contributing to the livelihood and subsistence needs of the predominantly rural population. It provides a source of energy, supplies forest products such as fuel-wood, fodder, timber, poles, thatching grass, medicinal herbs, construction materials and contributes to the conservation and improvement of the country's environment. About 2.6 million ha or 18% of Bangladesh's total land area of 14.8 million ha is categorised as forestland which includes state forestland (2.2 million ha) and private homestead forest (0.27 million ha). The six pan-European criteria have been taken as terms for sustainable forest management of Bangladesh in this paper. This paper aims to provide qualitative and quantitative information on the factors that characterise the state of sustainability of forestry in Bangladesh.

BACKGROUND

Bangladesh is a Unitary and sovereign Republic, known as the People's Republic of Bangladesh; it gained its independence on March 26, 1971. Bangladesh occupies a unique geographic location (20°34'N – 26°38'N latitude to 88°1'E – 92°41'E longitude) – spanning a relatively short stretch of land between the mighty Himalayan mountain chain and open ocean. The broad physiographic regions are classified as – flood plains occupying about 80%, terrace about 8% and hills about 12% of the land area. The 1998-99 national census recorded a population of 129.1 million, a density of 755 persons per sq km. Bangladesh enjoys generally a sub-tropical monsoon climate. Winter begins in November and ends in February. In winter, temperatures fluctuate from minima of 7.22°C-12.77°C to maxima of 23.88°C-31.11°C. The monsoon starts in July and continues until October. The monsoon accounts for 80% of the total rainfall. Average annual rainfall varies from 1,429 mm to 4,338 mm (BBS, 1996).

Bangladesh, being a tropical country, enjoys a wide range of bio-diversity covering both wild and cultivated land. Of the total area of Bangladesh (147,570 sq. km.), agricultural land makes up 64%, forest lands account for almost 18%, whilst urban areas are 8% of the area. Water and other land uses account for the remaining 10%.

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GENERAL DESCRIPTION OF THE FORESTS

Of a total area of 2.46 million ha under forest, about 1.46 million ha are under the management of the Forest Department. Approximately 0.73 million ha are depleted and denuded state-owned forests, known as *unclassified state forests,* under the control of the civil administration and subject to various disturbances, particularly through shifting cultivation by tribal people, since time immemorial. The remaining 0.27 million ha are homestead forests (see Table 1).

Table 1. Forest Classification

Organisation-wise distribution	Area of Forests (million ha)	Percentage of forest land against total area of the country
Forest managed by Forest Department (National Forests)	1.46	10.15
Unclassified state forests (managed by civil department)	0.73	5.06
Village homestead	0.27	1.88
Total		17.09

Source: LASKAR, 1998

National production forest is located in the hilly region of Chittagong, Cox's Bazar & the Chittagong hill tracts and also in the tidal plain to the Southwest and to a small extent in the Modhupur and Barind tracts. These are not only inadequate and unevenly distributed throughout the country, but also yield is very low. Due to heavy population pressure, national forest is not only shrinking but is being depleted through theft of forest produce, encroachment and uncontrolled grazing. About 0.27 million ha of homesteads are located in 68,000 villages. Such areas provide a fragmented forest resource base. Due to the population explosion and high prices of forest produce, these village woodlots are also being rapidly depleted. Consumption rates of timber, 0.01076 m^3/per head and firewood, 0.0654 m^3 per head, are very low compared with those of other developing countries; yet the annual felling rate greatly exceeds the annual increment, leading to profound adverse effects on the environment. If the rate of depletion is allowed to continue, particularly in the northern part of the country, all unclassified state forests will be converted into barren savannah-land. In that condition, it would be extremely difficult to rehabilitate the land suitable for human use.

Forest area by type

A forest type is the unit of vegetation, which possesses (broad) characteristics in physiognomy and structure sufficiently pronounced to permit of its differentiation from other such units. This is irrespective of physiographic, edaphic or biotic factors.

1. *Tropical evergreen forests:* characterised by high tree species richness; lofty and dense evergreen forests 60-65 m tall; leaves tend to be of medium size, rather thick, entire and rarely hairy or much divided.

Mean annual temperature	22.22°-25.55° C
Mean annual rainfall	254 cm
Mean annual humidity	83%

Source: CHAMPION *ET AL.*, 1965

2. *Tropical semi-evergreen forests:* contains an appreciable proportion of deciduous trees (60-65 m tall). The larger trees are possibly more commonly buttressed than in evergreen forest. The soil is more freely drained in drier sites.

Mean annual temperature	24.4° C
Mean annual rainfall	241.3 cm
Mean annual humidity	75%

Source: CHAMPION *ET AL.*, 1965

3. *Tropical moist deciduous forests:* characterised by closed, tall forest (around 30 m tall). All dominant species are deciduous, Bamboos are very rare and only restricted to wet sites.

Mean annual temperature	22° C-24° C
Mean annual rainfall	203.2 cm
Mean annual humidity	80%

Source: CHAMPION *ET AL.*, 1965

4. *Tropical littoral and swamp forests:* all tropical mangrove forest situated in the south-west corner of Bangladesh, which comprises 41% of the total forest of the country and which is the main abode of the national heritage of Bangladesh, the home of the carnivore, the Royal Bengal Tiger (*Panthera tigris tigris*). This forest contains species of *sundari* (*Heritiera fomes*), *passur* (*Carapa melucensis*), *baen* (*Avicennia officinalis*), *kankra* (*Bruguiera gymnorhiza*), *goran* (*Ceriops roxburghiana*), *keora* (*Sonneriatia apetala*), *golpatta* (*Nipa fruticans*) etc.

Mean annual temperature	23.88° C-35° C
Mean annual rainfall	165-177 cm
Mean annual humidity	75-80%

Source: CHAMPION *ET AL.*, 1965

DESCRIPTION OF THE WILDLIFE OF BANGLADESH

The wildlife of Bangladesh includes amphibians, reptiles, birds, animals and plants, including 300 endemic species. Approximately 5,700 species of vascular plant include 300 tree species. In the case of birds and mammals, wildlife refers only to undomesticated species. There are approximately 840 wildlife species in Bangladesh. These include 19 amphibian species, 124 reptile species, 578 bird species and 119 mammal species. Among the birds, 199 species are migratory (AKHOND, 1999).

Amphibians

Amphibian species include 2 species of toad and 17 species of frog. The most common or very common and widely distributed species of amphibians are I) Common Toad/*Kuno Beng* (*Bufo melanostictus*), II) Skipper Frog/*Kotkoti Beng* (*Rana cyanophlictis*), III) Bull Frog/*Kola Beng* (*Rana tigerina*), IV) Cricket Frog/*Jhejhe Beng* (*Rana limnocharis*).

Reptiles

These species have a rich and quite diverse composition in Bangladesh. They include freshwater turtles and tortoises, land tortoises and sea turtles in the Order Chelonia; lizards and monitor lizards under Suborder Lecertilia (Order Squamata); snakes in the Suborder 'Ophidia' (Order Squamata) and crocodiles and gavials in the Order 'Crocodylia'.

Birds

The birds that are commonly found in Bangladesh are predominantly dependent on large trees. Most birds live on the trees and build nests in the branches of the canopy and in holes.

Fowls and Pheasants

In the very recent past Red Junglefowl (*Gallus gallus*) was present in all kinds of forests (except mangrove plantations), but now it is reported absent in the Bhawal-Madhupur Sal (*Shorea robusta*) forests. Kalij *Pheasant (Lophura leucomelana)* and Peacock-pheasant (*Polyplectron bicalcaratum*) were common in the forests of Chittagong, Cox's Bazar and Chittagong hill tracts. These species are now rare, due to habitat degradation. Two Peafowl species (*Pavo cristatus* and *P. muticus*) formerly inhabited forest areas, but are now extinct.

Aquatic birds and waterfowl

The total number of species in the Orders Podicipediformes, Pelicaniformes, Ciconiformes and Anseriformes (grebes, pelicans, cormorants, darters, herons, storks, ibises, sponbills, ducks and geese etc.) are 66, of which 24 are migrants. The commonest species in the above groups are Little Grebe (*Podiceps ruficollis*), Little Cormorant (*Phalacrocorax niger*), Darter (*Anhinga rufa*) and Large Egret (*Ardea alba*). Seventy shorebird species have been recorded in Bangladesh, of which 50 are migratory and mainly visiting Bangladesh in the winter. The commonest three species are Mongolian Plover (*Charadrius mongolus*), Curlew Sandpiper (*Calidris ferruginea*) and Black-tailed Godwit (*Limosa limosa*). Some globally threatened species, recorded in the estuaries of Bangladesh, include Spoon-billed Sandpiper (*Eurynorhynchus pygmeus*), Eastern Knot (*Calidris temurostris*), 3. Nordmann's Green-shank (*Tringa guttider*), Asian Dowitcher (*Limnodormus semipat*), Red Knot (*Calidris canutus*) and Bar-tailed Godwit (*Limosa tapporica*).

Diurnal birds of prey

Forty-eight species of diurnal birds of prey in the families Accipitridae and Falconideae have been recorded in Bangladesh. Common species include Black-winged Kite (*Elanus caeruleus*), Black-crested Baza (*Aviceda leuphotes*), Brahminy Kite (*Haliastur indus*) and Shikra (*Accipiter badius*).

Mammals

Insectivores

There are four species of insectivores in Bangladesh: the Common Tree Shrew (*Tupia glis*), Grey Musk Shrew (*Suncus murinus*), Sevi's Pygmy Shrew (*Suncas etrucus*) and Eastern Mole (*Talpa micrura*). Of these, the Grey Musk Shrew (Chika) is widely distributed and the other species are found only in the forest in the north-east and south-east of the country.

Bats

Thirty-one bat species live in the country. However, only seven are either common such as the Leaf-nosed Bat (*Hipposideros galeritus*) or very common, such as the Flying Fox (*Ptropus giganteus).*

Primates

There are records of 11 species of (non-human) primates in Bangladesh.

Pangolins

There are records of three Pangolin species in the country, but only the Indian Pangolin (*Manis crassicaudata*) occurs in forests of south-east, especially in the forests of Chittagong hill tracts.

Carnivores

Twenty-six carnivore species occur in the country, including three species of fox and dog, three bear species, six species of civet, three mongoose species and eight cat species.

Asian Elephant

At present, the population status of elephant (*Elephus maximus*) is around 100 in Chittagong and Cox's Bazar.

Aquatic Mammals

Aquatic mammals include the Dugong (*Dugong dugong*), 3 whale species of and eight species of dolphins and porpoises.

MANAGEMENT PROCESSES

Forestry practices have remained almost the same for a long period. The only objective of management in the past was the production of wood. Revenue was the major consideration in the formulation of management practices. Little attention was given either to other components of forest ecosystems or to the socio-economic impact of management. Interactions between people and the forest were not taken into account, while formulating management plans in the past. The concept of forest management has changed drastically over the last couple of decades and it is now universally accepted that trees cannot be managed in isolation. An increasing demand for wood has also made it impossible to manage forests in a casual manner.

The situation of natural forests and man-made forests

Because of uncontrolled "*Jhuming*" (growing of agricultural crops through clearing the forests by tribal people) in the hill tracts, topsoil is being eroded and the production capacity of the land is decreasing day by day. However, the demands of people in the uplands for food and shelter are increasing, because of their increasing population. Consequently people are encroaching on more forestlands and cultivating agricultural crops in these areas and cutting valuable trees. As a result, the abode of wildlife is also decreasing proportionately. The situation has now become alarming and the Government is finding difficulties in solving this problem.

Forestland use situation

As per Government policy, forestry land should be used only for forestry purposes and none other. But in Bangladesh, reality does not allow this and at present the Forest Department controls about 1.46 million ha (10.15% of the land) which is in fact, under scientific management. An additional 0.73 million ha of land, known as unclassified state forest, is under the control of the civil administration. Shifting cultivation and unscientific management in these areas at present has lead to their becoming almost barren and in need of immediate rehabilitation. Encroachment is a serious problem in our country, the main reasons being because of scarcity of agricultural land to meet the demand for food, urbanisation and industrialisation.

Forest restoration in a wildlife context

Wildlife, comprising both plants and animals, is the critical component of an eco-system and food chain. Ecological succession of plants and animals is a sequential process. For forest restoration purposes, animals can be categorised into two functional groups: a) herbivorous and b) carnivorous. Knowledge of how these groups interact can help in designing forest restoration schemes. For example, carnivorous animals are dependant on herbivorous i.e. the Royal Bengal tiger is mainly dependent on Spotted Deer (*Axis axis*).

Herbivorous animals are dependent on grasslands in the Sundarbans. The Spotted Deer & Common Barking Deer are specially attracted to *Keora* (*Sonneriatia apetala)* leaves and grasslands. Unfortunately, these are a scarce resource. For the management of small cats, big trees are required. Undisturbed breeding grounds and suitable habitats for feeding are key aspects in the management of wildlife.

Bangladesh possesses diverse forest ecosystems viz. tropical evergreen, tropical semi-evergreen, deciduous, tidal/mangrove and fresh water swamps. Consequently, wildlife species are highly diverse. It is evident that in well managed forests the presence of wildlife species, in terms of both abundance and the diversity of species, are much greater than in degraded ones. For instance, the Forest Department has raised successful plantations in the newly accreted coastal areas and once the plantations became established various wildlife species have naturally recolonised those areas. It is accepted that protecting existing natural forest is the best way to conserve wildlife but that forest restoration is an important second. The Forest Department is primarily responsible for this sort of habitat creation, habitat improvement and management both through establishing plantations and by creating other facilities. In addition, the Forest Department has undertaken programmes for captive breeding of some wildlife species.

Priorities for wildlife conservation:

The enactment of wildlife conservation and bio-diversity programmes in Bangladesh is the result of recent changes in thought. In addition to the Rio Declaration and Agenda 21, Bangladesh has, so far signed, ratified and acceded to 22 international Conventions, Treaties and Protocols related to the Environment and has taken several initiatives to protect fragile ecosystems and to conserve biological diversity in the country. At this moment, the Forest Department has prioritised the following actions:

- large-scale afforestation in the country's hilly, marginal & fallow land; newly accreted char-land and coastal areas;
- reforestation in denuded and degraded forest areas;
- propagation of various wildlife species;
- habitat improvement;
- capacity building;
- personnel development;
- legal measures;
- medical facilities for wildlife;
- documentation and training and
- motivation and public awareness campaigns.

Adverse factors affecting the process

The major challenge facing Bangladesh is to meet basic human needs while sustaining the very limited resource base upon which these needs depend. Bangladesh faces serious problems of over-population, extreme poverty, illiteracy and environmental degradation with natural resource depletion. These factors combine to exacerbate the scale of constant socio-economic setbacks imposed by recurring natural hazards, often of exceptional magnitude. Over the years, the country has undergone a process of environmental degradation, which is a cause of considerable concern. This is illustrated by deforestation, destruction of wetlands and inland fisheries, soil depletion, inland salinity intrusion, water pollution etc. The major roots of man-made problems are lack of understanding of ecological principles of EIA (Environmental Impact Assessment), poverty and a lack of adequate alternatives. (REAJUDDIN, 1999). Main causes of deforestation are:

- increasing population;
- increasing demand for cultivable land;
- transfer of land for industrialisation, urbanisation and communication infrastructure;
- pilferage, the unlawful taking of forest products from the forest area;
- encroachment and
- shifting cultivation, particularly in the hill-tracts region.

Restoration measures

Under the tremendous pressure of the human population explosion, to achieve the goals of the Convention on Biological Diversity, the implementation strategies with respect to the Forest Department are to be:

1. combat desertification;
2. reduce felling and
3. create public awareness through:
   a) motivation and training supported by research and education;
   b) public participation in sharing the inputs and outputs in afforestation and
   c) involvement of non-government organisations (NGO's) in the implementation of social forestry projects.

Any conservation strategy affects people and therefore conservation of biological diversity and protection of the natural resource base should be ecologically and socially sustainable. This concept is now well recognised among conservationists in addition to the narrower concept of conservation of a particular species. We should however, try to preserve the complexity and the integrity of the entire ecosystem in relation to the human context. Such initiatives can serve local populations who depend on the exploitation of natural resources and encourage them to regard an ecosystem as a sustainable resource base for the future. As it serves the interest of the local stakeholders who depend on this sustainable use of their resources, they should be involved in such initiatives.

Restoration measures by the Forest Department (FD)

Afforestation activities (Man-made forest establishment, present & past)

The Forest Department of Bangladesh has been given due importance in five-year plans for forestry development. The broad objectives are as follows:

1. increase state and homestead production of both timber, firewood and non-timber crops through afforestation, reforestation and social forestry programmes;
2. accelerate programmes for the development of short-cycle plantations for fuel-wood etc. in order to protect more valuable trees for wildlife, timber and ecosystem function in rural areas and
3. optimally exploit forest resources, without disturbing the ecological balance, to meet the demand of timber, fuel-wood, fodder and raw materials for wood based industries.

To meet the above national objectives, the Forest Department of Bangladesh has undertaken a large number of plantation projects in different zones to increase the supply of firewood and industrial wood. Plantation programmes are mostly concentrated in the newly accreted land along the coast of the Bay of Bengal, Unclassified state forests, Hill forests and inland Sal-forests. At present, the Forest Department is undertaking a very ambitious project known as the *Forestry Sector Project*. The main objectives of this are to develop tree resources and fruit-bearing tree resources in order to provide habitat for native birds, involving people directly, following benefit-sharing mechanisms. Target people from rural areas are selected through NGO's and become involved in strip plantations along roads, railways and embankments. Benefits (of agro-forestry) to the people involved are: (1) full 1st thinning (after 5 years); (2) full 2nd thinning (after 10 years) and (3) 55% of the sale value after final harvesting.

The Forest Department of Bangladesh (FD) has afforested 24,994 ha of denuded upland areas and 21,785 ha of shore front coastal areas and mud flats since 1992 (see table 2. below), the year of signing the Earth Summit 1992.

Table 2. Afforestation by FD in different eco-type since 1992 (hectares).

	Eco-type	*1992-93*	*1992-93*	*1992-93*	*1992-93*	*1992-93*	*1992-93*	*Total*
1.	Mangrove	4632	5032	3881	2730	2905	2875	21785
2.	Sal forest (Wood Lot)	3833	4664	2804	1340	1550	1280	15471
3.	Sal forest (Agroforestry)	756	807	2146	100	100	100	4009
4.	Denuded hill forest	4271	4276	4274	4438	4330	3405	24994
5.	Unclassified state forest	1359	4169	5216	1154	4208	2124	43229
6.	Strip plantation along roads (in km)	3577	5476	3913	944	1300	1450	16660

Source: FOREST DEPARTMENT OF BANGLADESH, 2000

Habitat building

Because of recent world-wide fears about the greenhouse effect, which is now at an alarming stage, the Government has taken it seriously and formed an independent Ministry, namely the Ministry of Environment and Forestry with two departments i.e. Department of Forestry and Directorate of Environmental protection. This Ministry has undertaken several plantation programmes both in forest areas and in marginal land and village homestead areas. It is understood that, whilst restoration is a powerful tool, protection of the remaining natural forest is the main priority for wildlife conservation. In an attempt to strengthen the conservation of flora and fauna under the biodiversity convention, two new forest divisions have been created since 1995 to manage, monitor and look after the protected areas. Besides these, more than 142,000 ha of forestland has been added to the existing protection areas (see Table 3. below).

Table 3: Protected and Park areas of Bangladesh

	Name	*Area (ha)*	*Declared protected during*	*Nos. of flora*	*Nos. of fauna*
1.	Ramsagar national park	52	1947	N.A	N.A.
2.	Himchari national park	1729	1980	157	65
3.	Madhupur national park	8434	1982	108	62
4.	Bhawal national park	5022	1982	225	65
5.	Lawachara national park	1250	1996	30	64
6.	Tekhnaf game reserve (Elephant)	11615	1983	29	136
7.	Sundarbans east wildlife sanctuary	31227	1996	29	136
8.	Sundarbans south wildlife sanctuary	36970	1996	22	110
9.	Sundarbans west wildlife sanctuary	71502	1996	21	116
10.	Rema Kalenga wildlife sanctuary	1795	1996	107	63
11.	Char Kukri Mukri wildlife sanctuary	40	1981	82	61
12.	Pablakhali wildlife sanctuary	42087	1983	N.A.	N.A.
13.	Rampahar sitapahar wildlife sanctuary	3026	1986	N.A.	N.A.

For scientific management of the environment and wildlife, the post of Deputy Chief Conservator of Forest (Environment) in Dhaka and two posts of Divisional Forest Officer (Environment) at the Headquarters in Khulna and Chittagong have been created, under the Forest Resource Management Project. For habitat restoration, the botanical garden at Mirpur, Dhaka and a national zoological garden in Dhaka and Chittagong have been established. The Bangladesh Rifles Peelkhana, Dhaka and the University of Dhaka are conserving wetlands, as a result there has been an increases in several species of migratory birds visiting Bangladesh every year.

Undertaking wildlife conservation programmes needs substantial financial support and the Forest Department is trying its best to manage these programmes with international assistance. We hope to provide a good environment for wildlife in the country's available habitats and thereby save them from extinction.

Bangladesh as a member of CITES

Bangladesh became a party to CITES in 1982 and, as a signatory to CITES, the provisions are strictly implemented. No wildlife or trophies or their derivatives have ever been allowed to be exported for commercial purposes. Bangladesh is also a party to the Ramsar Convention. The Bangladesh Sundarbans (a wildlife sanctuary) was declared as a

World Heritage Site under the World Heritage Convention in 1993. Bangladesh is a member of the Global Tiger Forum (GTF) and hosted the First General Assembly of the GTF during the 18th – 20th January, 2000. At this meeting, Bangladesh was elected as the chairman of GTF.

RESEARCH NEEDS

1. It is necessary to study the effects of massive uncontrolled exploitation of wildlife in relation to human populations and ecological linkages between these factors.
2. A study should be performed on the importance of mixed communities of native tree species for animals in Kaptai National Park, in order to establish better techniques for encouraging colonisation by wildlife.
3. Bangladesh has good prospects for crocodile farming; a study on crocodile farming in the Sundarbans mangrove forest should be undertaken.

CONCLUSION

Forest restoration and wildlife conservation can contribute to sustainable rural and national development. If the carrying capacity of forest ecosystems is continuously exceeded, however, they will ultimately disintegrate. The major constraints for sustainable forest management in Bangladesh are the dense human population and the high rate of population growth. But, despite many constraints, Bangladesh is trying to manage her forests sustainably and to conserve and enhance biodiversity and forest ecosystems. The concept of forest restoration for wildlife conservation may lead to new scientific interventions when practical experience of the applicability of techniques becomes available. Such interventions will broaden the scope of afforestation programmes in Bangladesh and contribute further to sustainable management of the State forests.

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DECLINE OF THE PHILIPPINE FOREST

Presented on behalf of ESSC by

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ABSTRACT

This paper describes how the Philippine forests have declined in terms of how they are used, managed and administered. We present two scenarios: one assumes commitment in words only, with no budgetary support for people-oriented programmes but budget support for mining and plantation development. The second, a hopeful one, assumes sincere committed action to implement realistic programmes. We recognise that there is a struggle to strike a balance in terms of the interest of all stakeholders in forest management. We do not propose a concrete alternative but we call for understanding of important concepts that influence actions. Instead, we propose some questions on the premise that we have our own initiatives and that the government has the mandate to provide services and must be capable of change.

In pursuing participation of local communities in forest management, we need to define "community-based" as a strategy. How do communities become organised? Who benefits from community-based undertakings? In whom are the access and control of resources vested? Who has the power? How are conflicts addressed? Do we have real co-operation, genuine partnership or mere collaboration in producing output or fund-driven activities?

Key words: deforestation, change in attitude, participation of local communities and indigenous peoples

THE FOREST SCENARIOS

In the Philippines, our forests comprised 70% of our total area in 1901; the figure was 21Mha out of 30 Mha. Now, this resource is almost entirely gone and only 5.5 Mha remains, resulting in a low forest cover of 18.3% (see Maps 1 and 2).

The mangroves were downsized from 500,000 hectares to only 140,000 hectares whilst all the rest of the forest types, particularly the dipterocarps, have been constantly reduced. Records show that this rapid deforestation took place within the last 40 years. As a result, the Philippines is now considered to be one of the most deforested countries in the tropics.

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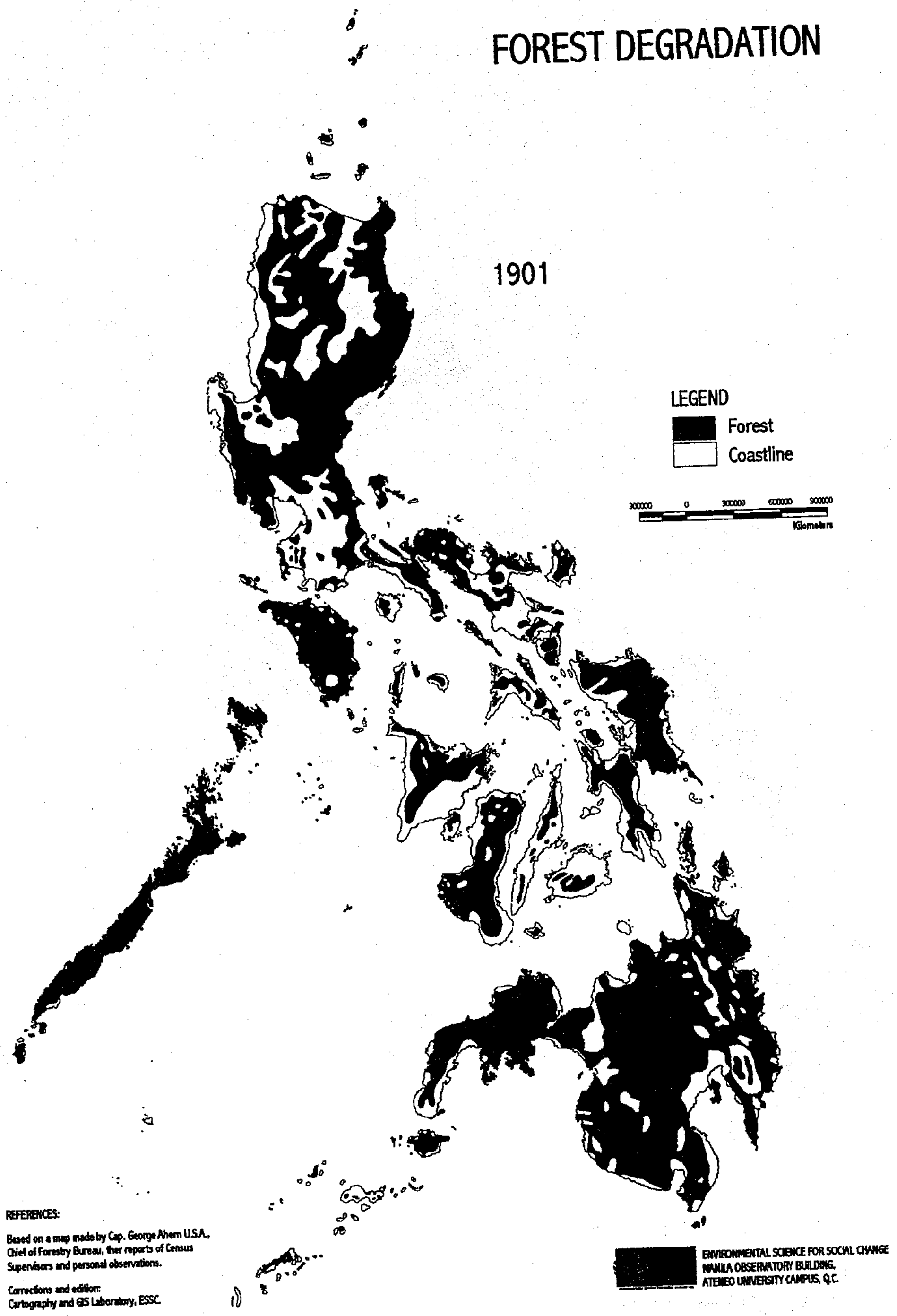
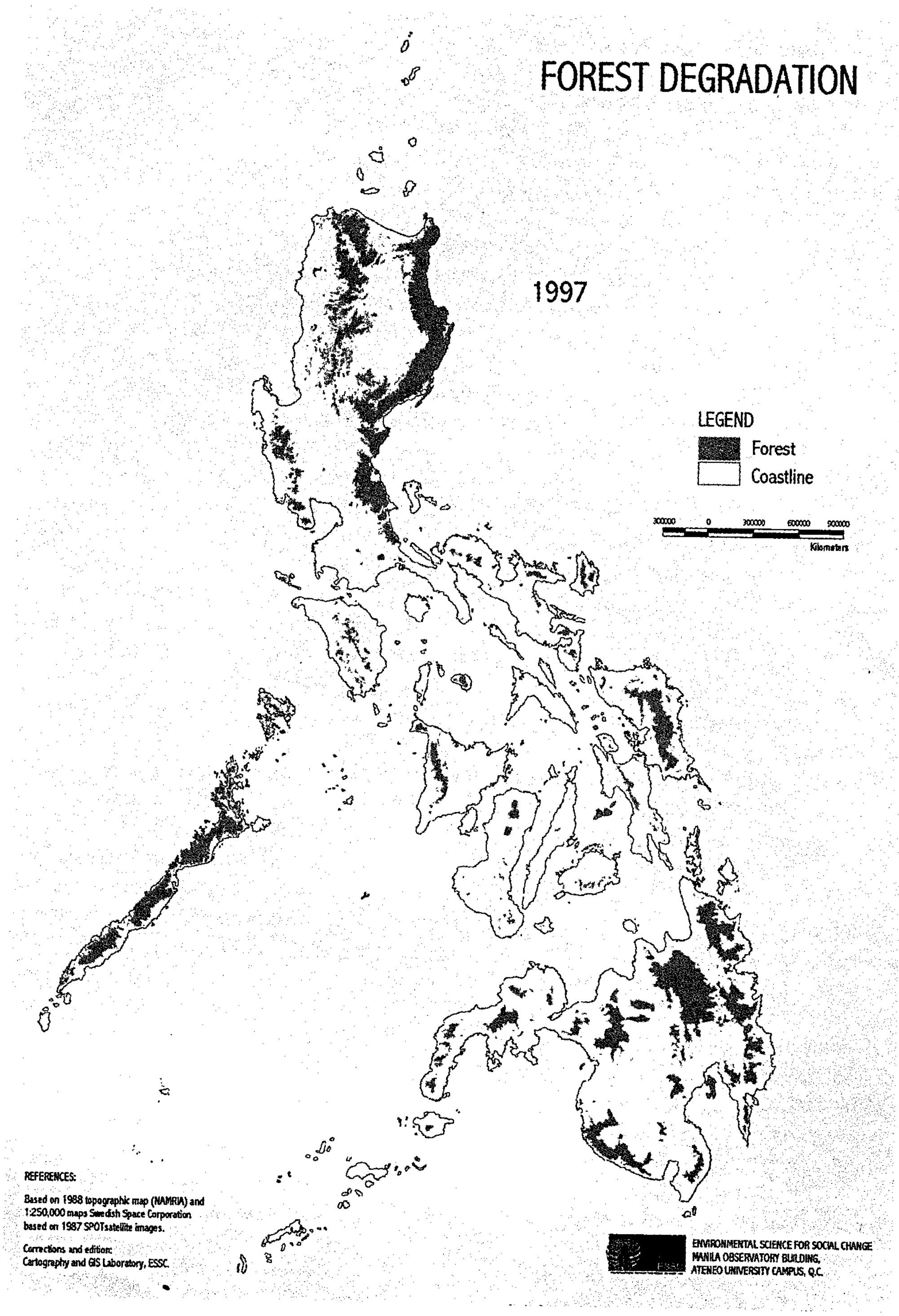
Map 1. Forest cover in the Philippines, 1901



Map 2. Forest cover in the Philippines 1997.



This tragedy, the decline of our forests, can be described in terms of how they are used, managed and administered and their impact on the people.

In the 1900's the Americans introduced logging. Export of wood became a profitable business, since there was great demand for tropical woods in the international market. To sustain logging, silviculture was also instituted as an intervention in forest management. However, deforestation has continued to outpace rehabilitation through silviculture.

Dictated by the interests of the few who belong to the traditional elite, the military and the realm of politics, the 1960s to mid-1970s were a logging boom in the Philippines. The government saw it was necessary to export natural resources in an attempt to have an industrialised economy. In addition, mining has also found its niche in forestlands. Mining was one of the income-generating businesses that the government depended on for its foreign currency transactions. Prior to these years, the government made a move to clear tracts of forests to accommodate agriculture and settlements projects. Thus, by the end of 1970, the forested area was reduced to 10.2 Mha.

During the 1980's some local officials supported open access to forestlands, whilst the government was trying to implement control measures against rapid depletion of forest areas. The government also imposed a logging ban in some parts of the country. The forces behind illegal logging, however, proved to be much stronger than the government. By the 1990's, therefore, deforestation in the Philippines was 100,000 hectares a year. At this point, the government pushed for the preservation of the primary forests, and legal logging was no longer allowed in those areas. Still, those involved in logging, legal or illegal, managed to circumvent this policy. Even now, many loggers have been taking advantage of the absence of on-the-ground delineation between the secondary and the primary forests. Logging, therefore, may still be ongoing in some primary forests. Much as the multi-sectoral forest protection committees, which have been organised in some areas, would like to negate deforestation, they could not match the degree of influence of those involved in illegal logging.

It was also in the 1980's that the concerns of the upland communities were regarded as major issues in forestland management. The government instituted a number of programmes wherein communities have become one of the major interest groups.

In addition, it is important to point out that, with the depletion of forest resources, local economies dependent on forests were forced to shift to other sources of livelihood. Most people left the uplands and became part of the labour force in the cities and other emerging businesses downstream. Those who could not survive in this new field had no other choice but to suffer in poverty. Thus, upland communities regarded government interventions in forest protection, species conservation and reforestation in terms of economic impact rather than as environmental considerations.

We therefore associate these dynamics of forests and people with more serious problems of food insecurity, water insecurity and wood shortage. Why do we relate the forest cover to these problems? This is because these consequences will become extreme if we do not make the right choice regarding our forest cover.

On food insecurity, we are primarily concerned with production, which in turn is very much dependent on the fertility of the soil. If there is disturbance of the soil, its capacity to support production is subsequently affected. One disturbance critical to this issue is soil erosion that results in depletion of nutrients and a low crop yield.

In the Philippines, 100,000 hectares of land, to a depth of one meter, have been lost to erosion. Most provinces have already lost at least 50% of their topsoil to erosion and 70% of croplands in the country are vulnerable to erosion. This situation will be exacerbated when more forests are cut and thus pave the way for higher surface run-off.

Concerning water insecurity, the direct relationship between forests and water is embodied in watersheds. These catchments are critical when they support major service areas such as irrigation for food production, electricity for residential and commercial establishments, and potable water. In relation to these major roles of water, it is important to know that more than half of the 57 major watersheds is critically denuded. While there is constant use of water, there is a loss of water that penetrates the ground but fails to recharge water tables nation-wide. Cities like Manila, Cebu, Davao and Baguio are now facing water shortages and new major health risks are arising because of deteriorating water quality.

When the sources of water for these services are on the verge of being lost, then there is no other way but to try to regain it, thus there is reason to adopt sound forestland management to protect watersheds.

Wood shortage is a direct result of losing forest cover. As discussed earlier, the Philippines was a major international wood exporter. Its wood built galleons plying the trade routes during the 1500's up to late 1800's. Now, the Philippines is a net wood importer. This shortage may also lead to increased pressure on remaining forests. Deforestation means increased fires and a loss of carbon to the atmosphere. To address this in a myopic way would also potentially lead to misguided and socially unacceptable siting of plantations that do not respond to local needs.

Therefore, the Philippines is left with two scenarios; Scenario A for disaster and Scenario B for hope (Maps 3 & 4). If the Philippines decides to take option A, then we are completing the tragedy that started in the 1900's. We are not being overly pessimistic here; taking our experiences and with all things constant, only a miracle can save this country from disaster. It would take the other option, Scenario B, with all its radical moves to ease the burden.

Scenario A

Scenario A would result in forest cover of **6.6%** of the total land area. This will happen **if:**

Lack of knowledge and non-involvement of local government units (LGU's) in forest management continues. National policies and specific laws converge at local levels that are under the jurisdiction of LGU's. One area of concern, that has both national and local relevance, is forest management. However, LGU's have no substantial experience in this field, since this task was given to a national department. The involvement of LGU's was limited and did not require their full attention. This lack of meaningful involvement of LGU's in forest management makes them incompetent in the eyes of other agencies, particularly the national agencies. Therefore, how do we expect them to fully internalise the cause for sound forest management? Without the active participation LGU's in forest management, scenario A will happen.

Social forestry becomes a basis for land speculation. Instead of social forestry as a vehicle for collaboration between the government and the local communities towards people-oriented forest management, it would become an opportunity to exacerbate the land distribution problem. With people already granted tenure in forestlands and the livelihood insecurity brought about by deforestation, many would sell their lands to land speculators; thus such land may end up as titled forest lands.

Community forestry management is not institutionalised as an accepted strategy and the Community-Based Forest Management Programme (CBFMP) is not given a central place. The programme is presently peripheral and has no budgetary support for expansion. Although the government has recognised community forestry management as an approach, there is still a need to actualise its principles, not only in terms of programmes and projects, but also in systems and procedures that regulate forest management activities. If we continue to use the regulations based on our experience with corporations, then there is no institutional translation of community forestry management. Everything will stop when a certain programme or project terminates and there will be no windows for sustaining its efforts. Thus, communities will never be partners in forest management. When this happens, they will again be considered violators of forest laws and regulations for having been residents in public forestlands. The conflict of interests between the government and this sector will inevitably spark anew and the following will occur:

a) The estimated 100,000 hectares a year of deforestation will increase, due to lack of serious government commitment and the insecurity of people.
b) Communities are not given a key role in the rehabilitation management and protection of forests and watersheds.
c) Communities continue to open up new forest and to degrade secondary forest areas.
d) Forest fires are not controlled, erosion worsens and clean water continues to be scarce.

Consequently, deforestation would not be arrested and people will be discontented. Those in large industries would continue to enrich themselves at the expense of local communities who are caught in a trap of trying to survive whilst losing their means for survival. The logging elite would begin to rule in the guise of large plantation developments. Local communities would serve as labourers and the means of production. The government would continue to receive revenues from loggers but would be unable to reinvest these sums of money in forest rehabilitation. Therefore, deforestation would certainly accelerate.

The present 350,000 to 400,000 indigenous families in the uplands are not given tenure security and have no input to decisions that affect their livelihood. The National Commission on Indigenous Peoples (NCIP) is not given adequate budgetary support and the DENR-ADMP (Department of Environment and Natural Resources-Ancestral Domain Management Programme) is not supported for delineation of new areas of CADC/CADT (Certificate of Ancestral Domain Claim/ Certificate of Ancestral Domain Title) with channels of accountability to communities.

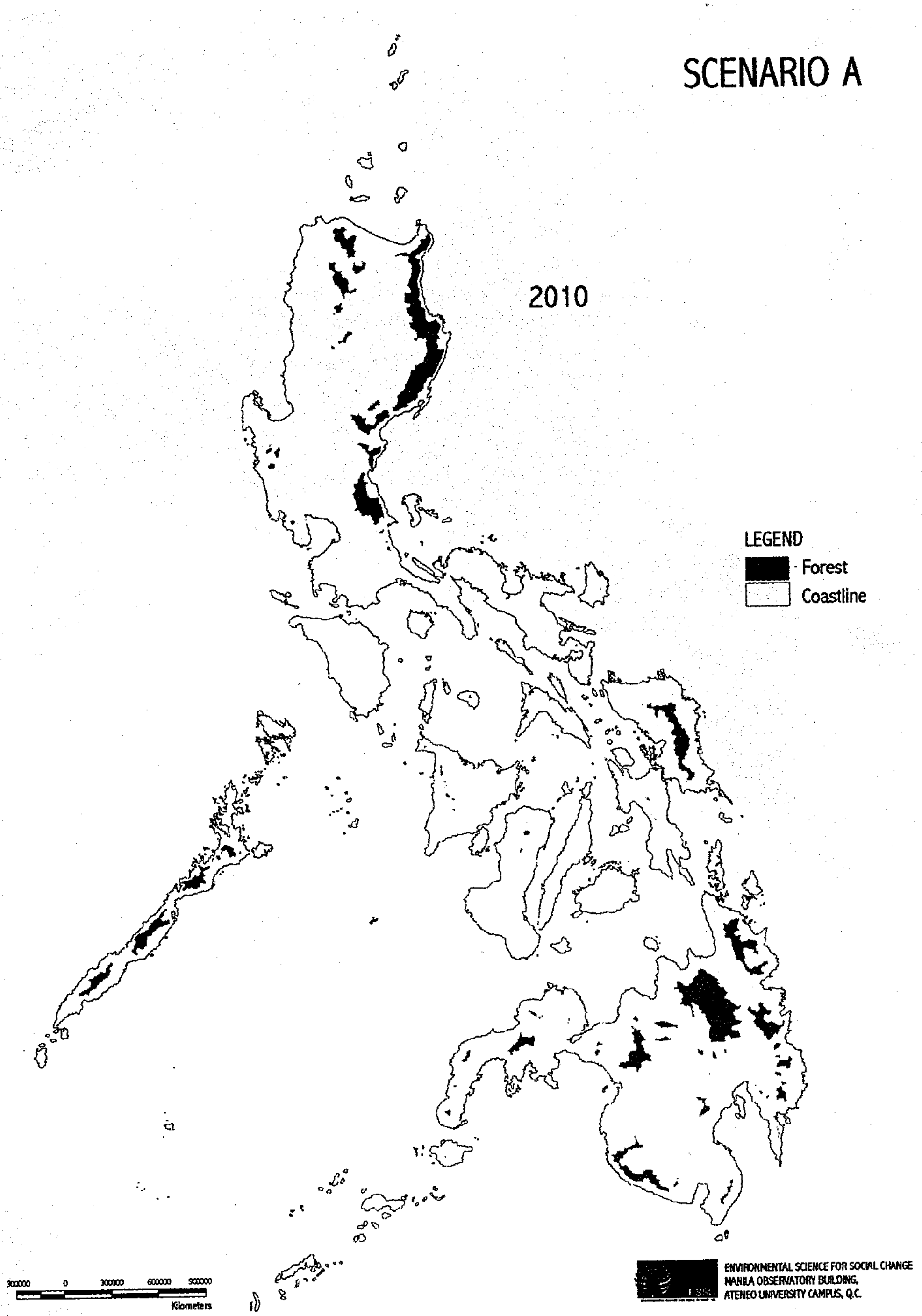
Under the present scenario, the concerns of indigenous peoples' (IP's) would not be considered a significant part of forest management; they would be regarded as another sector without giving due importance to their culture. In effect, the operational problems of the NCIP and the DENR-ADMP would never be an issue as IP's would be left on their own, thus opening the gates for manipulators and capitalists to take advantage of the situation.

Changes in the environment in the uplands that have effects downstream, impact on aquatic resources and increase the cost of basic commodities, are not dealt with or are wilfully ignored. The role of forest as both source and sink of carbon would be set aside. Thus, instead of developing forest management strategies that are relevant to climate change, the forest would only be regarded as a source of timber. Therefore, indiscriminate harvesting of the forest would create an economic imbalance, since the food sector would be adversely affected as earlier discussed. Reduced supply of basic commodities such as rice would mean a higher demand and increased costs. With Scenario A, the government would refuse to see the relationship and would continue to favour revenues from timber.

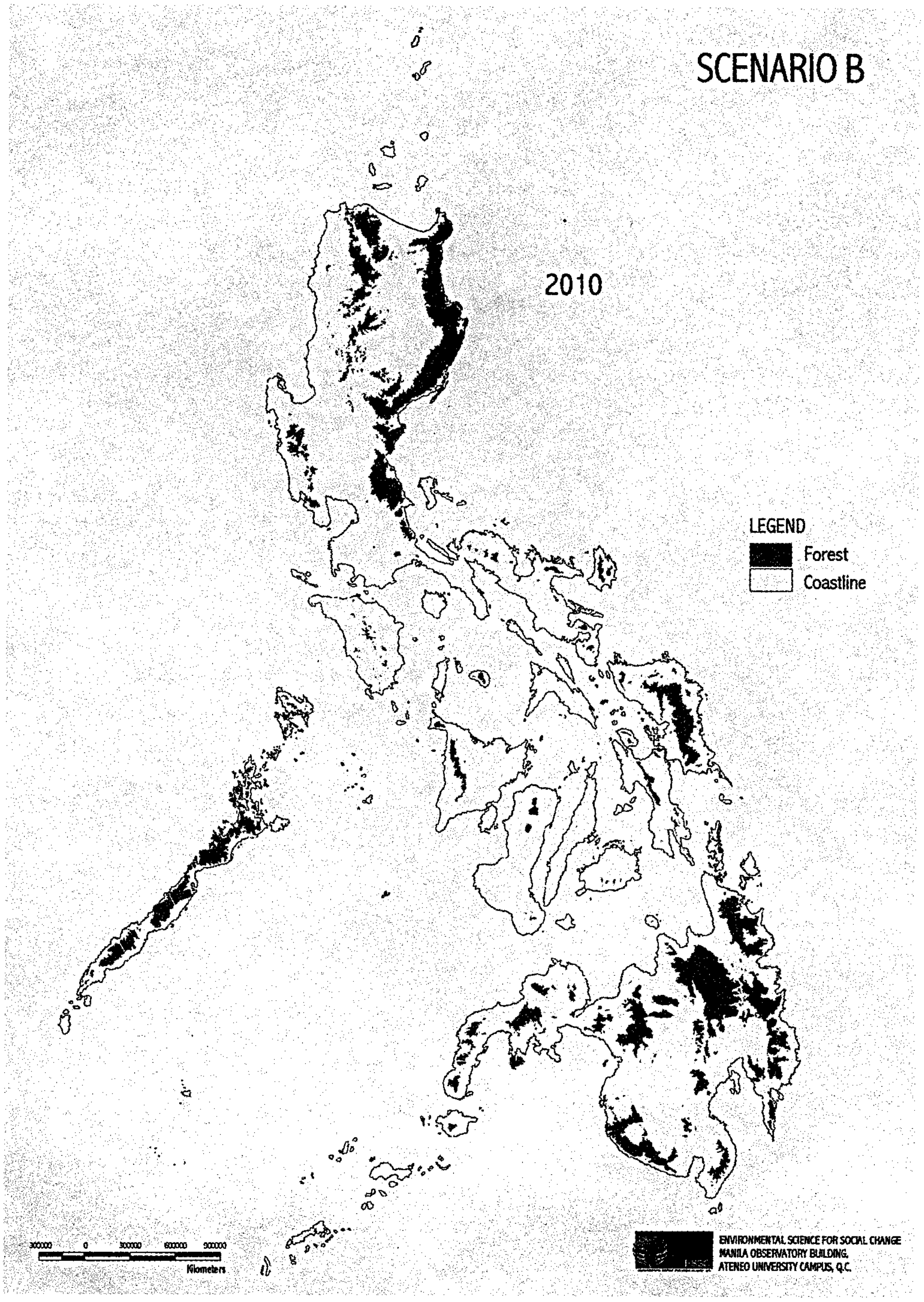
Loss of biodiversity is not given importance. The fifteen biogeographic zones in the Philippines, in which distinctive assemblages of flora and fauna are found, would not be considered in forestland use plans. This may lead to lack of proactive actions toward the protection and conservation of habitats such as rainforests, coral reefs, pine forests, grasslands, mangroves, volcanic craters and lakes. Destruction of these habitats endangers biodiversity.

The components of biodiversity that must be given importance are as follows. In the Philippine, wildlife is represented by over 15,000 known plant species, including 8,120 flowering plants, 1,030 species of ferns and world famous hardwoods such as *apitong, tangile, yakal, bagtikan, palosapis* and *manggachapui.* In addition, the coral reefs have 2,000 known fish species and 488 coral species in 78 genera. As earlier mentioned, there are at least five habitats in the Philippines that serve as life support systems for both wildlife and people. Biogeographic zones represent various types of habitats and life forms therefore vary to a certain extent from one habitat to another.

Map 3. Forest cover in the Philippines 2010.



Map 4. Forest cover in the Philippines 2010.



Concerning human activities, extensive agriculture, urbanisation and pollution, road building, selective species collection and hunting also disrupt biodiversity at varying intensities. At the extreme, we can say our interventions have led not only to the extinction of other living things but also to degradation of our quality of life.

A habitat once destroyed will drive away the existing wildlife community and will create a new community that may no longer support human beings. Each organism has its own niche. In a layperson's concept, once we discover some insects, for example, in an unexpected place, then we become aware that their habitat has been disturbed. With due respect to all life forms, we should be aware that we co-exist because there is a balance of nature. Biodiversity is the wealth that goes with that equilibrium and gives value to the role of each organism. We do not want to see wild snakes staying with us in our homes, nor large spiders in our offices. Their value in the cycle of life is best appreciated if they are in their respective habitats such as forests. If we lose such species through deforestation, then we cause a break in the food cycle and will probably end up with unpredictable results. We may also be unable to find some medical answers that require certain species to constitute a certain mix of solutions.

Scenario B

Scenario B offers a better option; it would work provided that i) the deforestation rate is reduced to 50,000 hectares a year and ii) the key role of communities in forest management is recognised and supported. With this scenario, forest cover will increase **slightly to 19% if:**

Primary forest is preserved for propagation purposes, as most seeds cannot be found in secondary forests. This would require banning logging and other commercial extraction activities in primary forests. The government has already promulgated a policy on this. However, serious implementation is needed.

Effective mechanisms are sought to address the different concerns of indigenous peoples and the issues of migration and land speculation in protected areas and Protected Areas Management Boards or PAMB's are given organisational assistance in managing NIPAS (National Integrated Protected Areas System) areas. With the NIPAS, IPRA (Indigenous Peoples Rights Act) and CBFM, the government should be able to organise an integrated approach to such mechanisms. This would require inter-agency collaboration since a sectoral approach would no longer work in an area where all these issues occur at the same time but with different intensities. To achieve this, we need a very strong political will from the government and vigilance from civil society.

The key role of the community in forest management is affirmed, operationalised and supported:

a) Forest management systems involve communities in the rehabilitation of secondary forests and degraded areas, and clear cutting in these areas is prohibited.

b) Community programmes such CBFMP are supported by local communities.

c) TLAs (Timber Licence Agreements) are phased out and community support systems are put in place.
d) Appropriate infrastructure projects contribute to the welfare of upland communities and help stabilise the environment.
e) Forest fires are controlled and incentives are created to ensure this in the long term.
f) Deforestation is reduced to 50,000 hectares a year or much less.

As discussed earlier, the role of local communities should be seriously considered; they are the *de facto* forestland managers. Lessons from within and outside the country reveal that communities can be our assets and we can take their potent force in terms of their organisations in order to move in the same direction in forest management. If indigenous peoples can be victims of degeneration of the forest, they can also be partners in forest regeneration. All we need to do is to provide them with the basic services due to them as people who are as equally important as those in the lowland areas. This requires however, that the services in the lowlands will similarly be improved so that we prevent further migration to the uplands. When the livelihood of people are secured, pressure on the forest will be reduced.

In this scenario, 350,000 to 400,000 indigenous families in the uplands are given tenure security through CBFMA (Community Based Forest Management Agreement) and CADC/CADT. Indigenous communities in upland areas would actively participate in forest management so that they have food security and can assure a sustained supply of clean water for the lowlands.

The domain that supports the indigenous families would be recognised as such and, therefore, their land and food security would be assured. The people would also realise their critical role in supporting life in the lowlands. Hence, the essence of communities both in the uplands and the lowlands would be given meaning in terms of supporting each other, instead of posing threats to one another.

Old reforestation areas are devolved to local governments with a proven track record of good community management. Mining company operations are to have minimal impact, substantive mitigation and are properly accountable to LGU's so that forest resources and water are not degraded in the area under their operational control.

Some form of devolution would have to be undertaken, as the national agency could never be in all necessary places. LGU's could be more effective in some areas; therefore, the national government should let go of these areas and allow LGU's to manage them. The basic assumption here is that there would be provision of capacity building for LGU's to handle the technical aspects of forestry and mining. The line agencies, together with academia and some donors, could craft institutional strengthening for LGU's to prepare them for these new concerns.

A reliable forest management system operates to provide proven plantation managers with the opportunity to reforest degraded grasslands, pasture leases are minimised and agro-forestry is prioritised. Similarly, the private sector could contribute in terms of viable plantations that encompass both forestry and social aspects. Appropriate areas should be made available for these ventures.

With the conversion of natural forests to grazing lands, we effectively limit the areas suitable for rehabilitation aimed at striking the balance between forest cover and lands that can be titled. Pasture leases should be evaluated as to whether they should remain or not. No further areas should be allocated solely for pasture; instead, agro-forestry should be encouraged. In this way we could help to meet concerns relating to both forest cover and economic development.

CULTURE (IN RELATION TO FOREST AND FOREST RESOURCES) AND GOVERNMENT ATTITUDE

Deforestation and population pressures have encouraged governments in Southeast Asia to shift their strategies in relation to forest management. Populations of local communities have been increasing, both in the lowlands and in the uplands, hence, demand for resources, such as wood products and water, has become a core issue in forest management.

Governments will also have to realise that there are still indigenous peoples who are directly dependent on natural resources within their respective domains. The indigenous peoples' own way of treating their natural resources differ from that of upland migrants; they have an intense respect for these resources. They believe that their gods provided them with these resources and that they have to be judicious in utilising them. A wealth of experience and knowledge of forest ecology and sustainable-use practices among the indigenous communities have already been documented.

Many of the indigenous pastoral, swidden farming and agro-forestry systems in Southeast Asia are based on the efficient use of land and labour and cause little damage to the larger forest ecosystem. Some case studies compiled by the Working Group on Community Involvement in Forest Management depict that there are communities that have succeeded in attaining self-sufficient systems of natural resources over time. Indigenous forest management systems show that local populations retain 50 to 80 percent of the biodiversity found in neighbouring natural forest ecosystems (WORKING GROUP-COMMUNITY INVOLVEMENT IN FOREST MANAGEMENT, pers.com.)

Inspired by various experiences in the uplands and with the limitations that are imposed by government rule over forest lands, small groups of foresters, scientists, and community development specialists in Southeast Asia were prompted to develop methods to empower forest communities with the rights to manage public lands. Consequently, there has been a growing recognition that local communities are part of the solution to deforestation rather than part of the problem. They can be partners in forest management in addition to the fact that they have rights to share in forest resources. Local communities are usually willing to take on management responsibilities if given the chance.

In the Philippines, we have approximately 150 cultural communities that can be broadly divided into those that are mainstream, sea-based, or upland cultures. We have over 7 million indigenous people and migrant settlers living inside state forestlands and at least 10 million upland migrants and people living in adjacent areas.

Our indigenous peoples whose cultures co-evolved with the land possess a profound land ethic. However, their natural environment has changed and has become degraded to such a degree that it can no longer recover easily from the formerly gentle activities of their ancestors. This is exacerbated by the increasing rate of lowland landless families migrating into forested areas.

Deforestation therefore affects not only the supply aspect of resources but also the habitat of the people who consider the forests as their home.

An important issue to reflect on is cultural erosion, which precedes environmental erosion. A manifestation of this is when the forests are cleared by means of indiscriminate logging in contrast to traditional non-mechanised cutting of trees used by Filipinos. When logging was introduced as an advanced technology in the Philippines, the way of life of the people changed, and hence, our forest environment suffered.

The Philippines belongs to a region that now acknowledges that local communities should be active participants in the management of natural resources. We have a long history in terms of finding the right formula in community-based natural resources management. At this point, we would like to focus on forest management, as it is a very significant subject of the present local governance.

We value how our people-oriented forestry evolved through time as shown in Annex A. However, the present government does not fully support the implementation of CBFM as a Strategy, thereby adversely affecting all programmes and projects anchored to it.

The present government is not supportive of and has no real intention to pursue CBFM. The Secretary of the DENR suspended the processing of cutting permits applied for by the CBFM Agreement holders. After receiving complaints from CBFMA holders and clarification that all application permits were based on respective Community Resources Management Frameworks (CRMF) and anchored on sustainable development, the Secretary lifted the suspension. But, because of lack of understanding of the communities' concern for survival and resources management, he confined tree cutting to plantations. The plantations being offered by the Secretary are mostly located outside the CBFMA holders' areas and are not yet due for harvesting.

DENR has turned its back on their covenant with communities; politically and operationally, CBFM has been put back in the corner. Field personnel have been demoralised due to lack of moral support from top management and therefore, CBFM in the hands of the DENR has lost its momentum.

The government, through DENR, is inclined to promote timber production sharing, industrial forest plantations and similar approaches that are destructive. Records would show that with these approaches, the secondary forest is often cut and monocultures of exotics are planted. In short, the government is going back to the old school of thought that the forest is mainly an economic resource.

The pressures of increasing demand for forest products from the international community have caused the present government to react in the above manner. Coupled with the lack of competence in resource management of the DENR's top management, there is great uncertainty about its reaction to the future strength of market forces towards forest products.

Studies show that the world is biologically capable of supplying the quantity and type of wood that will be needed in the future (WORLD FORESTRY CONGRESS- XI, 1997). However, production is not the only factor that counts. Management of this resource must ensure long-term availability of such forest-based products and services. Therefore, those who have the means and the capacity will most likely put pressure on those who have low purchasing power. Prime products may be given to those who can afford them, whilst the poor are confined to substitutes. So, remaining forest resources in developing countries like ours, could not easily escape from this economic cycle, unless there is a change in attitude on the part of the government and its partners in forest management. Everything will start from the key issue of how we view and treat our forests.

Unless that radical change in attitude and behaviour happens, long-term strategic considerations will be overlooked and taking into account the scenarios presented on forest management, we will be adopting the Scenario A- Disaster.

Another critical concern that may not be attractive to the present government, due its indirect relationship to the economy, is carbon in the context of forest management. There have been agreements on carbon emissions and carbon sequestration. However, more has to be done on their implications for primary and secondary forests, as well as plantations wherein local communities are present.

Local communities can participate in the management of biodiversity and watersheds, since they are most closely involved in these areas. The government may enter into international contracts on these areas but may not be sensitive to the communities within those areas.

Various conferences have shown equitable sharing of benefits by local communities must be considered in addition to (i) provisions for sustainable biodiversity conservation; and (ii) duration, exclusiveness and limits of rights. Similarly, watersheds are hinged on the hydrological functions of forests where there are tenured communities. Governments in Southeast Asia need to prepare for cross-country watershed management although this concern is not yet critical.

CHALLENGES

What needs to be done? A concrete alternative may not be offered at this time. But, important concepts that guide strategies need to be understood.

Reviews of donor agencies on their respective interventions show that collaboration with local communities can be an advantage in forest management. When they are organised and empowered, they can be the best managers of natural resources. Empowerment here also includes legal assistance apart from economic, technical and financial assistance.

In general, governments have the mandate to provide services but they need to strengthen their capacities to provide assistance to local communities. In short, the government must also be capable of change.

In pursuing the involvement of local communities in forest management, we also need to define "community-based" as a strategy. Is it mere inclusion of communities in government-initiated activities? Or is it the recognition of the community as the core source of power that defines its existence and future?

Apart from the experiences of governments in Southeast Asia in community-based undertakings, other initiatives are also worthy of review where there were no projects introduced and yet people became organised. How are communities organised? In relation to this, we can raise the question of who are benefiting from community-based undertakings by various groups including that of governments. In whom are the access and control of resources vested? Who has the power? How are conflicts addressed? Do we have real co-operation and genuine partnership or mere collaboration in producing output or fund-driven activities?

POSSIBLE RESEARCH UNDERTAKINGS

By participating in this workshop, we hope to enhance our intention of pursuing *"Community-Based Development of Assisted Biodiversity Regeneration Methodologies"*. To contribute to the achievement of scenario B and considering forest restoration efforts in the Philippines, we hope to:

1. assess the rate of natural regeneration of floral communities through:
   a) plant community mapping with local human communities and
   b) scientific surveys combining training with incentives;
2. know the value of biodiversity to local communities through:
   a) regular dialogues and understanding of relationships between local communities' practices and natural regeneration of the floral community and
   b) photo and process documentation;
3. allow local communities to understand their own knowledge in the scientific society's plane and at the same time impart to partners (extension workers, assisting organisations, professionals, LGUs) the capability to understand communities' methods;
4. produce an evolving handbook (on the premise that users will enhance it) from the experiences of partners and communities and
5. conduct process training for users of the handbook.

The above concerns will better equip those involved in forest restoration in understanding natural regeneration in the light of communities who are directly or indirectly dependent on forests. Therefore, policies and programmes will be sensitive not only to the condition of the forests but also to the communities who are most closely involved in forests.

ACRONYMS

ADMP	Ancestral Domain Management Programme
BFD	Bureau of Forest Development
CADC	Certificate of Ancestral Domain Claim
CADT	Certificate of Ancestral Domain Title
CBFM	Community-Based Forest Management
CBFMA	Community-Based Forest Management Agreement
CBFMP	Community-Based Forest Management Programme
CRMF	Community Resources Management Framework
CTF	Communal Tree Farming
DENR	Department of Environment and Natural Resources
FAO	Forestry Administrative Order
FAR	Family Approach to Reforestation
FOM	Forest Occupancy Management
IP	Indigenous People
IPRA	Indigenous Peoples Rights Act
LGU	Local Government Unit
NCIP	National Commission on Indigenous Peoples
NIPAS	National Integrated Protected Areas System
PAMB	Protected Areas Management Board
PD	Presidential Decree
POFAP	People-Oriented Forestry Action Programme
TLA	Timber Licence Agreement

ANNEX A. Description of Major Legislation, Policies, and Events Leading to the People-Oriented Forestry Action Programmes (POFAPs)

YEAR	POLICY/EVENT	BRIEF DESCRIPTION
1874	Banning of Kaingin-making or shifting slash and burn agriculture	Banned Kaingin Making
1889	Royal Decree of the King of Spain, "Definitive Forest Laws and Regulations"	Imposed heavy penalties on offenders- " kaingineros"
1901	Kaingin Law (Act 274)	Focused on prosecuting, imprisonment and ejection of kaingineros and other forest occupants from forest lands
1904	Forest Act (Act 1148)	Qualified the nature of kaingin making as an offense. Kaingin was no longer absolutely prohibited. It was punishable if done without authority
1939	Commonwealth Act (Act 447)	Allowed kaingin as may be authorized by the Director of Forestry. Lawful and unlawful status of the "kaingineros" remained unclear
1963	Revised Kaingin Law (RA 3701)	Defined actual occupants or occupants as residents, cultivators, those who introduced improvements and profit from the forest land
1964	Kaingin Council Meeting	Gathered representatives from government, private, and academic sectors to discuss the kaingin problem, which was recognised as not only technical or legal but also a socio-economic one
1965	National Conference on the Kaingin Problem	Recommended resettlement of "kaingineros" and increase of jobs in agricultural industries
1971	Kaingin Management and Land Settlement Regulations (FAO 62) Guidelines in the implementation of the Forest Occupancy Management Programme (BFD Circular 11)	Embodied the basic policies on kaingin management and signalled the government's formal adoption of Forest Occupancy (Kaingin) Management as a forest

YEAR	POLICY/EVENT	BRIEF DESCRIPTION
		development and conservation strategy. FAO 62 emphasised the resettlement or relocation of forest occupants while BFD circular focussed on the management -in - place of forest occupants
1974	Forestry Revised Code of the Philippines	Reiterated the implementation of forest occupancy management and relocation plans, agroforestry, census of forest occupants, and employment Created the Kaingin Management Section under the Forest Protection and Utilisation in the BFD
1975	Revised Forestry Code of the Philippines (PD 705)	Prescribed the census, management of forest occupants, and agrof-orestry development Provisional amnesty was granted to kaingineros who entered into forestlands prior to May 19, 1975, provided they do not increase their clearings and they undertake activities prescribed by BFD
1976	Forest Protection and Forest Occupancy (Kaingin) Management Plans for Timber Licenses and Permittees (BFD Circular 12)	Embodied the basic guidelines for the preparation, submission, and implementation of forest occupancy management plans by timber licencees and permittees
1977	Philippine Environmental Code (PD 1152)	Included in its provisions the implementation of kaingin management and agro-forestry
1978	Amending PD 705, Revised Forestry Code of the Philippines	Emphasized the relocation of kaingineros and other forest occupants, whenever the best land use of the areas so demands, to the nearest and most accessible government resettlement areas
	Complete Census of Forest Occupants (BFD Circular 2)	Prescribed the instructions, guidelines, and procedures for complete census of forest occupants

YEAR	POLICY/EVENT	BRIEF DESCRIPTION
1979	Regulations on Communal Tree Farming (Ministry Administrative Order 11)	Embodied the basic guidelines for implementing the Communal Tree Farming Programme and signalled the government's adoption of CTF as a strategy in reforestation and forest development
	Creation of the CTF Development Staff in the Bureau of Forest Development (Ministry Administrative Order 2)	Included the composition, organisational set-up, and functions of the CTF Development Staff in the BFD
	Implementing Guidelines for Family Approach to Reforestation (BFD Circular 45)	Embodied the basic guidelines for Family Approach to Reforestation Programme and signed the government's formal adoption of FAR as a strategy in reforestation and forest development
	Revised Forest Protection and Forest Occupancy Management Plans for Timber Licencees and Permittees (BFD Circular 46)	Prescribed the preparation of four-year (1980-84) Forest Occupancy Management plans by timber licensees and permitees to be integrated in the District's Occupancy Management Plan
	Delegation of authority for approving Forest Occupancy Permits to Regional Directors (BFD Order 117)	Contained the delegated authority to BFD Regional Directors to approve/sign FOM permits
	Additional Guidelines in the Implementation of Forest Occupancy Management Program (BFD Circular 14)	Mandated the preparation of district-wide Forest Occupancy Management Plans
1980	Issuance of two-year term Forest Occupancy Permit under the Forest Occupancy Management Program (BFD Circular 9)	Provided for the extension of the term of Forest Occupancy Agreement Permits from one to two years, renewable for similar periods
1981	BFD Policy Directions for the 80s (Memorandum of the BFD Director)	Embodied the three major policy directions of BFD: Forestry for Environmental Development,

YEAR	POLICY/EVENT	BRIEF DESCRIPTION
		Forestry for Industrial Development, and Forestry for Rural Development
1982	Presidential Letter of Instruction 1260	Launched the Integrated Social Forestry Programme and signalled the government's formal adoption of social forestry as a forest management and development strategy
1995	Executive Order 263	Declared the Community-Based Forest as the National Strategy for Forest land Management

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QUESTIONS AND COMMENTS

Masakazu Kashio

You said that logging was responsible for most of the deforestation in the Philippines, I think that there are other causes that are as significant, can you explain in more detail?

Marlea P. Munez

Logging is a major cause, not the only one. The Philippines had a logging boom when logging-technology was introduced in the 1900's. They exported logs for construction of ships, all over the world. This was followed by expansion of the industry in the 1960's and 70's for construction and for export, including wood-chips. Whenever forest resources were extracted, this was usually followed by migration of communities into the uplands to use them for farming. So there are many factors.

Masakazu Kashio

Logging causes degradation not deforestation?

Marlea P. Munez

Deforestation means clearing the forest and a loss of biomass, soils etc. Therefore, it is degradation of forests too. It is all semantics. For sure the forest is gone and there is a dire need to integrate the views of government and forest communities in forest management. I cannot say what the most appropriate prescription is, but we need to understand and establish a dialogue between government and communities and bring them together with scientists to put together methodologies for restoring forests.

Abdur Rashid

What is the proportion of benefit-sharing for communities from forest harvesting?

Marlea P. Munez

Officially there is no more forest cutting, but if you have a plantation under an agreement to harvest, 30% of your proceeds goes to a trust fund, and 70% is reinvested in public forest lands for the community. If you are harvesting secondary forest, you have to pay environmental fees to the government. At the current time a new secretary of DENR has suspended harvesting in community forestry projects.

Cinnamomum iners Reinw. Ex Bl. (Lauraceae) – its dense canopy rapidly shades out weeds; its fruit attracts animals and its wood is used for carving and furniture.

USE OF NATIVE SPECIES IN FOREST REHABILITATION AND CONSERVATION IN VIETNAM

Nguyen Hoang Nghia[1]

ABSTRACT

In 1993, forest covered 9,650,000 ha in Vietnam, including: conservation areas, such as National Parks and nature reserves; protection forests, such as watersheds; coastal forests and plantations. This short communication considers the proportion of forested land in each of these categories, future plans for reforestation in Vietnam and describes species and combinations of species, which have been planted.

INTRODUCTION

In 1993, in Vietnam, forest covered 9,650,000 ha, divided into 3 categories: special-use forest, 924,000ha (National Parks, nature reserves); protection forest, 2,798,500 ha (watershed forests, coastal forests) and production forest, 5,926,400 ha (materials for industry). Of this, plantations amounted to more than 1 million ha. Programme 327 supports plantation establishment and natural forest protection in special-use and protection forests. From 1993 to 1998, about 640,000 ha of plantations were established, averaging 110,000 ha per year. The Government of Vietnam has also launched a major programme of afforestation, with a target of five million hectares by the year 2010. In 1999, the first year of this program, about 200,000 ha of plantations were established. A list of almost 100 native tree species has been suggested for plantation establishment and forest enrichment on different scales in various ecological regions for rehabilitation and conservation.

Use of native species in planting

Pure plantations

Tree species planted in single species plantations include *Styrax tonkinensis* (Styracaceae) and *Manglietia glauca* (Magnoliaceae) to supply pulp and timber. Other timber trees include *Erythrophloeum fordii* (Leguminosae), *Chukrasia tabularis*, *Toona surenii* (Meliaceae), *Canarium album* (Burseraceae), *Paulownia fortunei* (Scrophulariaceae), *Dipterocarpus alatus, Hopea odorata* (Dipterocarpaceae), *Afzelia xylocarpa* and *Dalbergia* spp. Preliminary data on growth of some of these species are presented in Table 1.

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Table 1. Growth and age measurements of some native species used in single species plantations.

Species	Age	Diameter (cm)	Height (m)	Location
Erythrophloeum fordii	35	38.1	12.22	Tam Dao-Vinh Phuc
Erythrophloeum fordii	35	39.48	14.98	Cau Hai-Phu Tho
Erythrophloeum fordii	5	7.28	5.38	Cau Hai-Phu Tho
Peltophorum tonkinensis	5	8.66	6.48	Cau Hai-Phu Tho
Ormosia balansae	5	6.03	6.27	Cau Hai-Phu Tho
Endospermum chinense	5	10.81	7.94	Cau Hai-Phu Tho
Castanopsis cerebrina	5	12.71	7.57	Cau Hai-Phu Tho
Cinnamomum ilicioides	5	9.28	6.36	Cau Hai-Phu Tho
Chukrasia tabularis	12	12.5	11.5	Nghia Dan-Nghe An
Xylia xylocarpa	10	8.0	12.0	Daklak
Dalbergia cochinchinensis	38	29.0	21.8	Dong Nai
Dalbergia bariaensis	41	15.3	14.9	Dong Nai
Canarium album	27	5.2	14.0	Huu Lung-Lang Son
Annamocarya sinensis	7	8.7	5.5	Cuc Phuong-Ninh Binh

In South Vietnam, pure plantations of *Dipterocarpus alatus* and *Hopea odorata* have been established on different scales since the early 1930s, initially by Paul Maurand, a French scientist, with the help of shade trees such as *Cassia siamea* and *Indigofera teysmanii*. The method employed was very successful, leading to the establishment of new plantations with *Acacia auriculiformis* and *Leucaena* spp. as shade trees. *Dipterocarpus alatus* and *Hopea odorata* have also been planted successfully in pure plantations without shade trees in some provinces in South Vietnam such as Tay Ninh, Ba Ria and Dong Nai. In some cases, *H. odorata* has been planted at high densities (>3000 trees/ha) to promote mutual shading, competition and early, rapid growth.

Mixed planting

It was recognised that pure plantations of *Manglietia glauca* and *Styrax tonkinensis* depleted soil nutrients, causing reduced productivity in subsequent rotations. Pests and diseases also became a problem. Therefore, mixed plantings were tried. In the early 1970s in North Vietnam, *Styrax tonkinensis* was planted with *Manglietia glauca*, *Erythrophloeum fordii*, *Ormosia balansae*, *Peltophorum tonkinensis*, *Tephrosia candida* and *Prunus arborea*. The productivity of *Styrax* in mixed plantations increased by 15-20%, compared with pure stands. At the same time, *Manglietia glauca* was planted in mixtures with *Erythrophloeum fordii*, *Khaya senegalensis* and *Tectona grandis*. Two species, namely *Khaya senegalensis* and *Tectona grandis*, could not adapt well to the site, so mixed plantations became pure plantations. Only mixed plantings with *Erythrophloeum fordii* were successful, because *Erythrophloeum fordii* grew slowly in the first few years, so *Manglietia glauca* trees could develop an over-storey. However by age 10-12 years, both species reached the same height. More research is required to determine the optimum ratio of the two species. In the early 1980's, in the northern part of Central Vietnam, *Chukrasia tabularis* was planted with *Peltophorum tonkinensis*, *Ormosia balansae*, *Michelia* sp. (*Magnoliaceae*) and *Gmelina arborea* (*Verbenaceae*), whilst in South Vietnam, *Dipterocarpus alatus* was planted with *Hopea odorata* and *Afzelia xylocarpa*. During 1976-1995, La Nga Forest Enterprise (Dong Nai) established 810 ha of mixed plantations of *Dipterocarpus alatus*, *Hopea odorata* and *Afzelia xylocarpa* and a small area of *Pterocarpus macrocarpus*, *Dalbergia* sp. and *Lagerstroemia* sp. with different density combinations.

Conservation of native tree species

For conservation, national surveys of threatened tree species have been carried out to categorise them, according to IUCN categories (1994) (Table 2). Rare or endangered species have been propagated and planted in arboreta. However, we would like to follow the idea that "conservation is for development and development is to serve conservation". Consequently these valuable threatened tree species must be involved into forest planting and enrichment programs so that we can protect rare species from extinction.

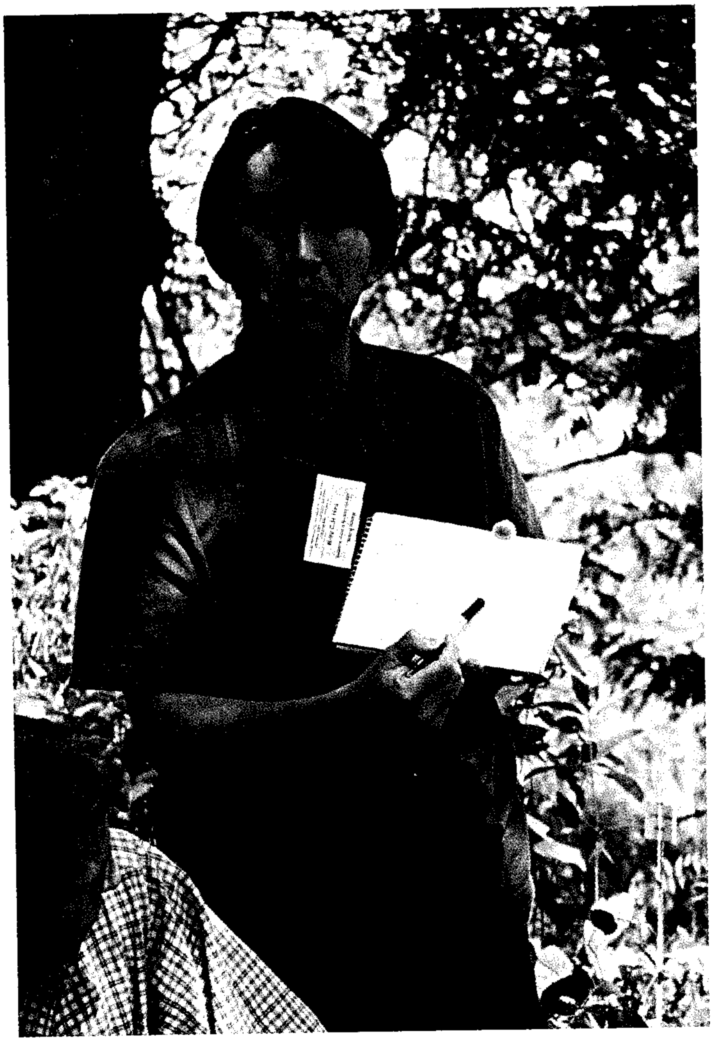
Table 2. Threatened tree species according to IUCN categories (1994).

Species	Family	IUCN category [1]	Propagation method
Afzelia xylocarpa	Leguminosae	EN A1cd	Seed
Anisoptera costata	Dipterocarpaceae	EN A1cd	Seed
Annamocarya sinensis	Juglandaceae	CR D	Seed
Aquilaria crassna	Thymeleaceae	CR A1cd	Seed
Calocedrus macrolepis	Cupressaceae	EN D	Seed/Cutting
Dalbergia annamensis	Leguminosae	EN A1cd	Seed
Dalbergia bariaensis	Leguminosae	EN A1cd	Seed
Dalbergia mammosa	Leguminosae	EN A1cd	Seed
Diospyros mun	Ebenaceae	CR A1cd	Seed
Dipterocarpus tonkinensis	Dipterocarpaceae	EN A1cd	Seed
Erythrophloeum fordii	Leguminosae	EN A1cd	Seed
Fokienia hodginsii	Cupressaceae	VU A1cd	Seed/Cutting
Keteleeria evelyniana	Pinaceae	VU A1	Seed
Madhuca pasquieri	Sapotaceae	VU A1cd	Seed
Pinus krempfii	Pinaceae	VU A1cd	Seed
Hopea cordata	Dipterocarpaceae	CR D	Seed
Pterocarpus macrocarpus	Leguminosae	VU A1cd	Seed
Shorea falcata	Dipterocarpaceae	CR D	Seed
Taxus chinensis	Taxaceae	CR D	Cutting

[1] Critically Endangered (CR); Endangered (EN); Vulnerable (VU); Low Risk (LR)

REFERENCE

IUCN, 1994. IUCN Red List Categories. Gland, Switzerland, 21pp.



Billy Hau makes a point during a discussion session on tree planting methods during the workshop's field trip to Ban Mae Sa Mai.

PROMOTING NATIVE TREE SPECIES IN LAND REHABILITATION IN HONG KONG, CHINA

Billy C. H. Hau[1]

ABSTRACT

Hong Kong has over 100 years of environmental forestry history. The government has planted more than one million trees annually for land rehabilitation since the early 1990's. Exotic tree species are dominant although more native tree species have been tried in the last ten years. Currently, only a few native tree species have proven successful in many sites and are planted in significant numbers. The failure of many native species in previous planting trials is one of the reasons hindering the wider use of native trees in land rehabilitation in Hong Kong. The other reason is the lack of information on the phenology and silvicultural techniques of most of the 390 native tree species, making large-scale production of many native species not yet possible. Despite these difficulties, the government has been promoting the use of native tree species in land rehabilitation in the Country Parks since the mid-1990's. The Kadoorie Farm and Botanic Garden (KFBG), a locally based conservation charity, also set up a native tree nursery in 1997 to conduct research on native tree species with respect to seedling production and reforestation. Due to the shortage of land, urban development has been expanding into the countryside. There are thus increasing numbers of landscaping projects in urban fringe/countryside edge areas where planting native species would be preferable. However, exotic species are still dominant in the landscaping field and commercial supply of native tree species is insufficient. As such, another aim of the KFBG nursery project is to promote the use of native species amongst landscape architects and transfer the information on native tree seedling production to commercial nurseries. This paper describes the nature of the different types of reforestation work in Hong Kong and the problems hindering the use of native tree species are discussed. The research needs for planting native species are identified.

INTRODUCTION

Between 1842 and 1997, Hong Kong was a self-administered British Dependent Territory. Since 1 July 1997, Hong Kong has been a Special Administrative Region of the People's Republic of China but maintains a high degree of autonomy. The legal, political and economic systems remained more or less the same before and after the change of sovereignty. Since the mid 19th century, the population has grown from approximately 3000

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people on Hong Kong Island to about 6.8 million in the whole Territory today, making Hong Kong one of the most densely-populated cities in the world.

Hong Kong lies between 22°09' - 22°37'N and 113°52' - 114°30'E. The Region consists of a large, irregularly shaped peninsula extending from the southeastern coast of Guangdong Province into the South China Sea and has approximately 230 offshore islands. The total land area of Hong Kong is about 1053 km^2, excluding over 37 km^2 of land reclaimed from the sea (STYLES AND HANSEN, 1989). The topography of Hong Kong is rugged; over 800 km^2 of the land area is considered hilly (CHIU & SO, 1986). The highest peak is Tai Mo Shan (957 m) in the central new Territories. The majority of the population resides on the coastal flat land and land reclaimed from the sea.

Hong Kong is more than 100 km south of the Tropic of Cancer but does not have a typical tropical climate. The absolute minimum and maximum air temperatures at the Hong Kong Observatory in Kowloon since records began were 0 and 36.1°C. The mean annual temperature is 23°C (1961-1990). January has the lowest mean temperature (15.8°C) and July has the highest (28.8 °C). At least a few days every winter have temperatures below 10°C, which is in the range known to cause chilling damage to sensitive plant species (DUDGEON & CORLETT, 1994). Due to the low temperatures in the winter, local ecologists regard Hong Kong's climate as subtropical monsoon (CORLETT, 1999; DUDGEON AND CORLETT, 1994). The mean annual precipitation at the Hong Kong Observatory is 2,214 mm (1961-90) and it is highly seasonal; monthly precipitation from November through February averages < 50 mm and the total sum in these months accounts for only 6% of the annual total. Over 77% of the annual total rainfall falls between May and September with the highest in August (18%). The difference in rainfall across Hong Kong is great, with mean annual rainfall ranging from less than 1600 mm in the periphery to over 2,400 mm on Tai Mo Shan. Typhoons regularly affect Hong Kong in the summer months, bringing strong winds and heavy rains.

HONG KONG VEGETATION

The potential climax vegetation in Hong Kong has been suggested to be tropical semi-evergreen or evergreen broad-leaved monsoon forest, or subtropical evergreen broad-leaved monsoon forest (THROWER, 1975; ZHUANG, 1993). None of the original forest exists today except tiny forest remnants on some remote and steep ravines that may have escaped or recovered from a long history of human destruction. Today, the most common vegetation types are secondary shrub-lands (396 km^2 or 37 % of the total land area), grasslands (177 km^2 or 16.5 %) and spontaneous secondary forests (86 km^2 or 8%; ASHWORTH *ET AL.*, 1993). Though the date at which major deforestation occurred is uncertain, CORLETT (1997) suggests that it was most likely in the period from 1300 to 1600 AD.

Clearance for cultivation, cutting for firewood and charcoal, and hill fires are believed to be the main cause of deforestation in Hong Kong (DALEY, 1975; JIM, 1986; DUDGEON & CORLETT, 1994; THROWER, 1975). With the rapid economic advancement and the gradual decline in agriculture in the last two decades, only hill fire remains an important threat. In the last eight years, there were 1,083 hill fires in Country Parks. In recent years, urban development in the rural areas has become an additional threat in the lowlands (CHONG, 1996; TERRITORY DEVELOPMENT DEPARTMENT, 1995; WEBB, 1993).

FOREST SUCCESSION IN HONG KONG

Until the mid 1970s, the harvesting of biomass (mostly grasses, ferns and small shrubs) for domestic fuel was a major factor preventing forest succession on uncultivated hillsides in Hong Kong (CHEN, 1993; CHEN, CORLETT & HILL, 1996). This has now stopped in Hong Kong but still produces "shaven", treeless hillsides over large areas of rural Guangdong. The cessation of biomass harvesting has probably increased the impact of hill fires, both by increasing the fuel load and by reducing the incentive for rural people to prevent fires. A study of the relationship between fire and vegetation in Hong Kong found that grassland persists largely in areas which have been burned in the last 10 years, and is replaced by shrub-land in the absence of fire (CHAU, 1994). Grasslands occupy the most frequently burnt areas and grasslands are the most frequently burnt. On favourable sites, *Machilus*-dominated secondary forest, 10-15 m in height, can develop in a further 30-50 years (ZHUANG, 1993; ZHUANG & CORLETT, 1997), but forest succession is apparently much slower on sites which are remote from tree seed sources or where the soil has been highly degraded (WONG, 1999; ZHUANG, 1997). The only older forests in Hong Kong, apart from some tiny patches in topographically protected montane sites, are Fung Shui Woods (Woodland behind active or abandoned villages that have long been protected by villagers. ZHUANG & CORLETT, 1997; CHU & XING, 1997). However, these are not simply the product of forest succession, and include a variable proportion of planted species. *Machilus*-dominated secondary forest supports both a much higher bird density and a higher diversity of forest-dependent bird species than monoculture plantations of *Lophostemon confertus*, the most widely planted tree species (KWOK & CORLETT, 2000). *Machilus*-dominated forest also typically contains 16-45 tree species in a 400-m^2 plot (ZHUANG & CORLETT, 1997). However, the majority of the 390 native tree species in Hong Kong are confined to upland sites which were, apparently, never completely cleared, but have not succeeded in invading secondary forests (ZHUANG & CORLETT, 1996).

FILTER-BARRIERS TO FOREST SUCCESSION IN HONG KONG

Low seed dispersal, poor seed germination and seed predation together significantly reduce woody species seed availability on degraded grasslands in Hong Kong. This is particularly the case on open grassland without woody species cover, and therefore delays the rate of forest succession (HAU, 1999). Once a seed disperses and germinates, seasonal drought, grass competition and low soil nutrients do not affect its survival. A study in open grassland at Tai Mo Shan showed that seed dispersal into the grassland was approximately one woody species seed per 5 m^2 per year, that is 2000 seeds per hectare (HAU, 1999). The mean percentage seed removal by seed predators over 60 days at this site was 74% (s.d. = 23%, 12 seed species) in 1996 (HAU, 1997). Seed germination rate at this site varied from 0 to 53% depending on species (HAU, 1999). Thus, for the 520 seeds per hectare that survived seed predation, between zero and 244 seeds may germinate. Seedling survival in the first two years was generally high at this site varying from 70 - 100% (except one out of ten species). Therefore, between zero and 244 woody plants per hectare per year will be able to establish at this grassland in this model. Weed competition and low soil nutrients, however, tend to slow seedling growth. All these together explain the low rate of early succession at this site. The longer the succession period continues before a closed canopy is formed, the higher is the risk of wild fire arresting succession. The current fire frequency at this grassland site is once every ten years, which is considered low by Hong Kong standards (CHAU, 1994). However, forest succession is unlikely to be fast enough to escape the impact of fire at this site.

REFORESTATION IN HONG KONG

Hong Kong has over 130 years of afforestation history and may have been the first territory to start afforestation for purely protective reasons in the tropics. The major justification for afforestation has shifted from health and aesthetic reasons in the 19th century, to soil erosion control and improving water supplies in most of the 20th century, to the current interest in ecological restoration. Forestry in Hong Kong has never been commercially viable. Despite such a long history, afforestation in Hong Kong does not appear to be a great success (CORLETT, 1999). Tens of millions of trees have been planted, but most of the existing forest cover consists of spontaneous secondary forests (about 8% of the land area). These mostly developed after 1945 (most of the Hong Kong vegetation was cut for fuel during the Japanese Occupation between 1942 and 1945; ZHUANG & CORLETT, 1997). Such secondary forests are dominated by *Machilus* spp., which have not been planted in significant numbers until very recently (CORLETT, 1999). Today, only about 62 km^2 or 5.8% of the land area is plantation woodlands (ASHWORTH *ET AL.*, 1993). However, most plantations in Hong Kong are monocultures and the invasion of native woody species, especially in young plantations, is significantly impaired by silvicultural management practices such as weeding (ZHUANG, 1997).

Various methods had been tried in the reforestation history of Hong Kong. Between 1871 and 1880, afforestation was accomplished by planting bare-rooted seedlings of both native and exotic species raised in nurseries (FORD, 1880). Seeds were sown in prepared ground in two nurseries. Seedlings were allowed to grow for a year after germination. They were then lifted from the nursery ground, taken to the planting sites and planted in prepared pits. FORD (1880) wrote that afforestation in these 10 years was not very successful. Seventy five percent of the trees planted died. Most of the surviving trees appeared very sick and had little promise of surviving. The failure was attributed to poor nursery practices, post-nursery care and planting skills. Seedlings were not carefully lifted from the nursery ground so that the roots were severely injured. The roots were not properly protected during transportation and transplanting, so that most seedlings died soon after being planted. Some planting holes were not filled-in with enough soil and some seedlings were planted too deep.

Direct seeding experiments were initiated in the late 1870s involving mainly the native pine *Pinus massoniana*, although a few other native and exotic species were also tried (FORD, 1883). The results were satisfactory for pine on sites with good soil and the scale of direct seeding was gradually enlarged. All the suitable sites on the northern side of Hong Kong Island were earmarked for direct seeding in 1883. However, FORD (1883) noted that on south-facing slopes, direct seeding appeared less promising due to the stronger drying influence of the sun. In addition, on steep slopes heavy rains tended to wash away the loose soil together with the seeds. Direct-seeding was first undertaken by spot sowing in prepared pits but in 1883 and 1885, experiments were conducted on broadcast sowing pine seeds on hillside grasslands that had no ground preparation (FORD, 1887). The results were successful and the scale of this method was gradually enlarged in subsequent years (FORD 1889). From 1881 to 1940, direct seeding of *P. massoniana* seeds was the main afforestation method. FLIPPANCE (1939; 1940) noted that although germination was a little variable, much better results were obtained from broadcasting than from spot sowing. Pit planting of bare-rooted seedlings of both native and exotic tree species was used on poorer sites where direct seeding was not appropriate (FORD, 1883). However, FLIPPANCE (1939) noted that direct seeding of *P. massoniana* was gradually found more effective than planting bare-rooted pine seedlings raised in the nursery. Thus, the latter method was discarded for pine trees but retained for broad-leaved tree species, which, in contrast, was generally unsuccessful by direct seeding.

In 1907, an experiment was conducted with a small number of *Castanopsis fissa* seedlings that had been raised from seeds sown in pots, i.e. planting container-grown seedlings. The seedlings were planted out in the spring similarly to bare-rooted *P. massoniana* seedlings on open ground in Pokfulam Road. The results were negative and the method was said to be unsuitable (DUNN, 1908). Except in 1908, this planting method was no longer mentioned in subsequent forestry reports in this period. On the contrary, it appeared in various forestry reports throughout this period that only bare-rooted seedlings were used in afforestation. Daley (1975) also indicated that until the 1950's, planting bare-rooted seedlings was the usual afforestation method.

Afforestation restarted immediately after the end of the Japanese occupation in Hong Kong (1940-1945). It was done mainly by broadcast sowing as nursery stock for planting was not yet available (DALEY, 1975). Planting container-grown seedlings were soon introduced and quickly became standard practice due to higher survival rates and lower dependence on weather conditions (CORLETT, 1999; DALEY, 1975). The decline in reliance on *Pinus massoniana*, due to its susceptibility to fire damage and the occurrence of two serious new pests (CORLETT, 1999) contributed to the disappearance of direct seeding as an afforestation method in Hong Kong.

Experiments with chemical fertilisers were started soon after the war and their use, along with chemical pesticides became routine (CORLETT, 1999). However, weeding has been increasingly undertaken by mechanical rather than chemical means in recent years due to rising environmental concerns (personal observation). Ever since afforestation started, light pruning, adding fertilisers and replacement planting were provided in the first few years after seedlings were planted. Since the 1960's, the annual number of trees planted has increased from around 300,000 to over a million in the 1990's (CORLETT, 1999).

During the pre-war period, the provision of tree nurseries near the major afforestation areas was normal practice. This had the advantage of reducing the cost of transportation and the stress to seedlings during transplantation. However, with the increasing reliance on planting container-grown seedlings after the war, a centralised nursery was formed. Today, most afforestation projects in Hong Kong rely on supplies from the nursery managed by the Agriculture, Fisheries and Conservation Department, which is able to produce approximately one million seedlings per year. Commercial nurseries also serve as a major source of exotic tree seedlings but have, so far, played a minor role in supplying native tree species in local afforestation.

Up to 1882, afforestation was organised by less than 10 forestry staff. "Coolies" (i.e. casual labourers) undertook seed collection and transplanting on a daily basis. With the increase in the scale of afforestation, the government started contracting out seedling supply and planting work in the early 1880's (FORD, 1883). In 1886, the planting operations were carried out through five different contracts: seed supply, nursery production, making tree pits, planting tree seedlings and direct seeding (FORD, 1887). The frequent failures of contractors to fulfil the planting contracts forced the Botanical and Forestry Department to take over the large forestry operations previously carried out by contractors in 1907 (DUNN, 1908). In the transition forestry year 1906-1907, the part of the forestry programme carried out by contractors largely failed while that undertaken by the department was most satisfactory. None of the forestry reports between 1908 and 1940 mentioned forestry contracts. Apparently, the Botanical and Forestry Department employed large numbers of temporary workers to accomplish afforestation after 1908. For example, the average number of daily temporary employees was 58 in 1938 and 116 in 1939 (FLIPPANCE 1939; 1940).

Contractor involvement in afforestation resumed after the war. Since the 1980's, contractors have carried out the majority of the afforestation projects, especially those managed by the Territory Development Department. Normally, an afforestation contract will include the supply of seedlings (if seedlings are not to be supplied by the Government nursery), the delivery of seedlings to the planting site, site preparation, seedling transplanting, and post-planting maintenance, which lasts for 1-3 years (WEBB, 1993; personal observation). The performance of contractors nowadays should also be questioned. All government contracts, including afforestation contracts, in Hong Kong are required to be open for tender, and the lowest tender is usually picked. Despite the fact that afforestation contracts normally have very detailed clauses with respect to seedling specification, post nursery care, the planting method and post-planting maintenance, they are usually ignored so as to maximise profits from very low contract payments. In seedling delivery, in order to maximise the number of seedlings in each truckload so as to reduce the number of trips between the nursery and the planting site, seedlings are put in baskets in several layers and lots of seedlings are damaged or killed during transportation.

Despite the fact that the most commonly planted tree species in the early afforestation history of Hong Kong (1871-1965) was a native pine, *Pinus massoniana* (it lost its importance due to pest problems and susceptibility to fire), Hong Kong relied heavily on a limited number of exotic species in the 1970's and 1980's. Between 1871 and 1990, a total of 150 tree species were named in Hong Kong forestry reports, of which only 33 were native species (CORLETT, 1999). In recent years, with an increasing concern for ecology, there is greater social pressure to use native tree species in reforestation. Thus, an increasing number of native species has been tried in recent years but a higher percentage of exotic species are still used in reclamation projects on barren lands (CHONG, 1996; WEBB, 1993). To date, with a few exceptions, the survival of all native species has been reported to be very low (e.g. LAY *ET AL.*, 1999). It has been suggested that the dominant use of exotic species in afforestation programmes in Hong Kong can be attributed to the ease of nursery production and the ability of exotic tree species to survive better and grow faster than natives on degraded lands (CORLETT, 1999; CHONG, 1996; WEBB, 1993). However, HAU (1999) shows that good post-nursery care and transplanting precautions as suggested by Forest Restoration Research Unit (1998), can greatly enhance the survival of native tree species in the first two years. In addition to being a confounding factor in scientific experiments, poor post-nursery care and transplanting precautions could lead to very high seedling mortality. This is a possible explanation for the failure of many planting trials using native tree species in Hong Kong and the suggestion that exotic species are better than native species in forest restoration is thus doubtful. Finally, the lack of seed supply and reliable knowledge in silviculture are part of the reasons leading to very few native tree species supply in the commercial market.

DISCUSSION

Despite the fact that various reforestation methods have been tried in Hong Kong, including direct seeding, planting bare-rooted seedlings and container-grown seedlings. No single method seems to be highly successful in reforesting Hong Kong with species-rich secondary forests. In addition, none of the methods are very cost-effective under the present economic conditions, i.e. in a developed, high-wage economy. Creating foster ecosystems to accelerate natural forest regeneration has been proposed as a cost-effective method in the tropics as well as in Mainland China but this is yet not been considered in Hong Kong. A comprehensive forest restoration strategy, combining fire prevention, active reforestation by various means and practices to accelerate natural forest regeneration, is currently lacking. This may be partly attributed to the fact that reforestation in Hong Kong involves several different Government Departments (Agriculture, Fisheries and Conservation Department, Territory Development Department and to a lesser extent, Highways Department and Civil Engineering Department) under different Bureaux.

A forest restoration strategy for Hong Kong

Considering the rugged terrain and very high labour costs in Hong Kong, it is reasonable to assume that reforestation by promoting natural forest regeneration will also be cost-effective. It is possible that the various filter-barriers to forest regeneration on degraded hillsides in Hong Kong can be overcome, making forest regeneration possible. Here, I proposed a low input and efficient planting strategy for Hong Kong, which may also be used in South China in the future.

Fire is the major threat to the terrestrial ecology of Hong Kong (CHAU, 1994). No forest restoration strategy can be successful without effective fire-control measures. Therefore, for any given reforestation site, the first step is to conduct a fire hazard assessment, which should include a fire history review and the identification of fire sources at or near the planting site. A properly designed firebreak network should then be established. The firebreak should consist of a planted tree belt no less than 15 m wide and a no-vegetation belt 10 - 20 m wide outside the tree belt. Tree species in the firebreak should be fast growing. Apart from exotic species such as *Acacia confusa*, native species may also be considered, although as yet, no native species have been tested as firebreak trees in Hong Kong. However, densely planted native *Schima superba* (<1 m spacing) has been widely used in South China forests as a firebreak. In addition, a number of native species are commonly used in South China in green belts for fire prevention. They include *Castanopsis fissa, Liquidambar formosana, Quercus myrsinaefolia, Syzygium cumini, Viburnum odoratissimum, Homalium cochinchinensis, Machilus thunbergii, Schefflera octophylla, Eurya japonica, Camellia oleifera* and *Psychotria rubra* (CHAU, 1994). A complementary publicity campaign on fire prevention should be launched in the rural villages near the planting site. Fire hazard warning signs should be erected along the paths in the planting site to alert countryside visitors.

The second step is to accelerate forest succession by increasing the input of tree propagules to the site. The lack of seed dispersal can be overcome by promoting natural seed dispersal and by direct seeding. The natural seed rain could be increased by the provision of bird perches to reinforce any island vegetation on site. This could be accomplished by planting tree seedlings in patches across the site and using artificial perches (HOLL, 1998). Since only a small area (c. 5%) relative to the total area of the site needs to be planted for this purpose, a higher planting standard can be achieved. Native species should be used and higher planting requirements should be set to ensure high survival and growth. All seedling transportation and planting precautions should be strictly enforced and post-planting irrigation in extremely dry weather should be provided to minimise seedling mortality. To promote faster seedling growth, bigger planting holes should be prepared and fertilisers should be provided. Root-zone competition can be removed by herbicide or by manual weeding if herbicide use is considered too controversial.

The overall diversity of the site can be increased by direct seeding, especially by species that are not well-dispersed either naturally (e.g. the wind-dispersed species) or due to the local extinction of seed dispersers, e.g. the Fagaceae, the *Camellia*, *Styrax suberifolius* and *Tutcheria championii*. To do this, a seed predation experiment and rodent trapping study should be conducted in advance to assess the seriousness of seed predation. Should seed predation be important, seeds for direct seeding should be chemically treated with rodent repellent. Since seed germination in the field could be very low, most seeds used for direct seeding should consists of seed species that at least are known to have high germination rates in the nursery. For example, *Schefflera octophylla, Castanopsis fissa, Cyclobalanopsis myrsinifolia, C. neglecta, C. edithiae, Machilus berviflora, Reevesia thyrsoidea, Sterculia lanceolata, Pygeum topengii* and *Cordia dichotoma* (unpublished data). The last three species are worthy of special consideration. They fruit either at the beginning or in the middle of the summer wet season, and in addition to high germination rates, they germinate immediately after dispersal and have a high initial growth rate (they could reach 30 cm in two months). In theory, these attributes would allow them to establish better on degraded hillside sites. However, field trials are needed to verify this.

Ideally, the fire prevention plan should be in force until a closed shrub-land or secondary forest is formed, which will then be relatively immune to fire (CHAU, 1994), which would probably take 15 to 20 years. However, the fire prevention plans may be suspended after the firebreak is fully functional (5 - 10 years). Management of the island vegetation will only be needed for three to five years. Apart from this, the site should require no further management. Additional direct seeding could be done as a booster if resources are available.

Research needs

An obvious hole in the reforestation history in Hong Kong is the lack of scientific research. Very few studies are available in the literature concerning forest restoration ecology in Hong Kong. Most planting trials in the past were not adequately documented (CORLETT, 1999). Basic information on the more than 390 native tree species in Hong Kong is insufficient. The seed germination rates of many species and the nursery techniques required to produce most native species are unknown. However, there has been gradually more and more research interest in this area in recent years. In addition to government departments and universities, the Kadoorie Farm and Botanic Garden, a local-based voluntary environmental conservation and education centre, set up a native tree nursery in late 1997 to promote research in reforestation and the use of native species.

It has been shown that bird perches could significantly enhance the seed rain on degraded hillsides in Hong Kong, however, whether fruit-bearing perches could further increase the seed rain or increase the diversity of the seed rain is unknown (HAU, 1999). A further field study on this should be conducted, as this would affect the species choice for the island vegetation to be established on the reforestation site in order to accelerate natural succession. A large-scale field experiment to demonstrate the effectiveness of island vegetation in accelerating natural forest succession is also needed to convince the administrators and the public that this is a suitable and cost-effective reforestation strategy in Hong Kong. Further seed predation experiments using chemical rodent repellents should be conducted so as to find out if it is possible to minimise seed predation. Currently, direct seeding has only been successful with one species (*Pinus massoniana*) in the reforestation history of Hong Kong. Similarly in South China, only this species was found to be successful in aerial seeding although another native species, *Schima superba*, was also found to be successful when mixed with the pine species (HUANG & SHEN, 1993). However, in view of the far lower cost of direct seeding and the advantages of this method at remote and steep sites, direct seeding experiments using different native species at different times of the year are needed to find out the best species and timing for successful seed germination and seedling establishment. Properly designed planting trials on native species with adequate planting precautions and documentation are needed. One of the aims of these planting trials should be to identify framework species that could facilitate forest formation (FOREST RESTORATION RESEARCH UNIT, 1998; GOOSEM & TUCKER, 1995). Finally, the effects of using native species in forest restoration on wildlife should also be monitored.

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QUESTIONS AND COMMENTS

Steve Elliott

Your schools project is very encouraging. Is the quality of planting with the children better than the contractors? What is the scale of the planting?

Billy Hau

There is a problem of scale – in Hong Kong over 1 million trees/year are being planted but only about 50,000 per year by schools. A lot of the native tree planting has failed because of contractor's problems, but we need to resolve the planting problems in order to tell which species are suitable. The contractors have confounded the results of using native species, so it is hard to work out if the problems are with the seedlings or not. It is hard to convince the Government of this, when they let most of the contracts.

Abdur Rashid

Do you have any projects to rehabilitate the indigenous people into caring for the trees and stopping the deforestation?

Billy Hau

The history of Hong Kong is very strange, we have indigenous hill-people, but they are less agricultural now; they have a very city-based mentality although they live in rural areas. The environment is not their concern, they are not interested as they have all the water, fuel etc that they want; they are very developed. I have a warning – if you continue your deforestation, other countries could end up like Hong Kong if you are not careful.

Nigel Tucker

As people's income increases, does the level of education increase, and thus their interest in the environment and the importance of trees?

Billy Hau

That is an argument, but in Hong Kong it is very weak. Everyone works 14-15 hours per day, including holidays, they are very eager to earn money – not interested in the environment around. I blame the UK government – they did not want Hong Kong to have a culture so it was lost. There is some interest in trees and the environment – a few growing, green groups driven by middle-class people who have received a good education, but the public at large is not concerned about the environment.

Pat Dugan

Have any attempts been made to ameliorate the sites with cover crops or succulents, as a precursor to planting, especially fire resistant species e.g. *Desmodia* ?

Billy Hau

No, we are weak in that area of forestry research, we have only just started forest research for wildlife restoration, so have not gone that far yet. So far, we have been using fast-growing exotics to make firebreaks, or we cut 30 m wide firebreaks. However, this is not adopted in every single project in Hong Kong, e.g. if a power company wants to plant a site, they will invest a lot of money in planting, but it would be better to make firebreaks first, or they will waste a lot of money. But planting generates a lot of publicity for the company and improves their green image, which is more important for them than actual results. Other countries too will need to think about involving private enterprises, as an alternative to government money.

Nguyen Van So

Land in Hong Kong is very expensive. Do you have any issues with land availability?

Billy Hau

Land availability is very simple, the Government owns all hilly slopes and farmers own the fertile land in the valleys. Therefore, the Government can make the hills available for planting. However, if we rely on farmers for the other land – it will not be very successful.

M. R. Smansnid Svasti (centre) discusses forest restoration techniques with Hmong village leader Naeng Zedong (left) and Patrick Dugan (right).

RIVERS IN JEOPARDY: A VILLAGE COMMUNITY'S RESPONSE TO THE DESTRUCTION OF THEIR UPPER WATERSHED FORESTS IN THE MAE SOI VALLEY CATCHMENT, NORTHERN THAILAND

M. R. Smansnid Svasti[1]

ABSTRACT

Forest clearance in the upper watershed of the Mae Soi catchment led to severe soil erosion and the subsequent drying up of streams to the valley. In a self-help community effort, the lowland villages are restoring their forests, using native species and encouraging natural regeneration by laying tanks and water pipes on the vertical ridges of the catchment and establishing strict measures against fire.

Seeds are collected locally so trees grown are genetically suited to local conditions and germinated in local soil to retain mycorrhizal associations. The survival of planted seedlings proved poor on slopes subjected to repeated cultivation and lack of research prevented the adoption of more successful methods. Reforestation here was best carried out by allowing natural regeneration to take place with judicious planting of proven hardy species. Later seed collection has concentrated on species formerly dispersed by animals now extirpated from the area.

After 8 years, forest cover has been sufficiently restored to establish perennial flow of the Mae Soi River, together with the return of much wildlife. However, because of a long-standing conflict involving rights of settlement in forestlands, fires are deliberately lit to destroy reforestation efforts every year. The ultimate success of the project lies in the resolution of the current conflicts on watershed management.

INTRODUCTION

Destruction of upper watershed forests in northern Thailand is being caused by unsuitable land practices. The result is not only loss of forest resources but also soil erosion, siltation of reservoirs and the drying up of streams and rivers. Local people who depend on forest and water resources for their livelihoods are experiencing increasing hardship.

The Mae Soi valley catchment lies 74 km southwest of Chiangmai in the rain-shadow of Doi Inthanon, Thailand's highest mountain. Elevations range from 270 – 1,600 m above sea level. The upland area gives rise to three rivers, the Mae Soi and its two tributaries, the Mae Pok and the Mae Tim which are used to irrigate cultivation in the valley. The rivers flow into the Mae Ping, one of the four tributaries of the Chao Phraya, which together form Thailand's major river system.

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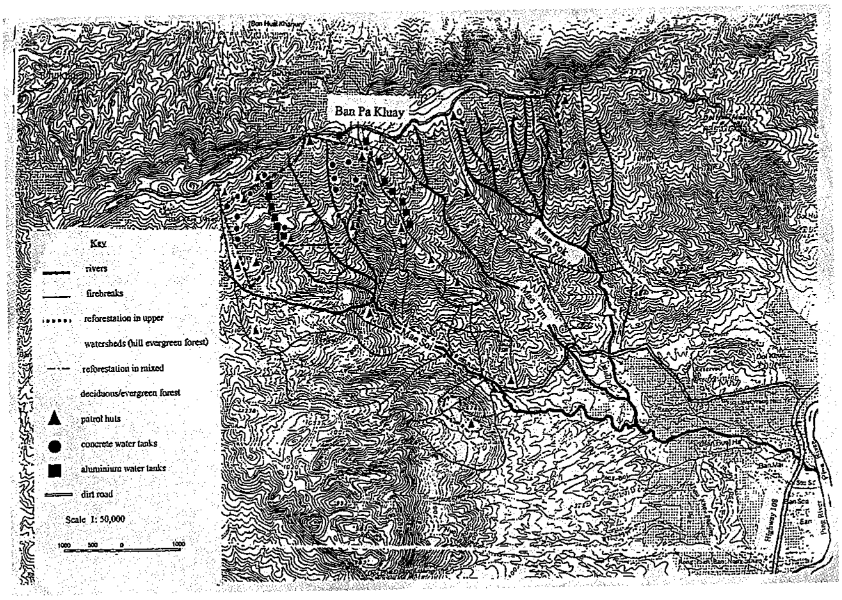
Destruction of the lowland forests of the Mae Soi catchment began in the 1940's with logging, followed by cattle-grazing and felling for charcoal-burning. However, while the headwater (upper watershed) forests remained intact, the rivers still flowed and were able to sustain the traditional cultivation of three annual crops in the valley. In the 1970's, migrant opium-growing peoples moved into the headwater forests, setting up the village of Ban Pa Kluay. With the help of foreign development aid aimed at opium eradication, the forests were soon being cleared for large-scale commercial production of cabbages. With the loss of the headwater forests, the streams to the valley began to dry up and the lowlanders could no longer grow enough food to feed their families.

Appeals to local authorities failed and the desperate villagers turned to their traditional centre of recourse, the monks. Phra Ajahn Pongsak, in the course of his 36 years as a forest monk, had come to understand how all life depends upon forest health and, together with the villagers, set up the Mae Soi Valley Project in response to their problems.



Map 1 The Mae Soi Catchment

The project works on two levels: first by arousing awareness of the importance of forest conservation through demonstration of their functions, and second, by launching rural development and forest conservation programmes. The first of these programmes is aimed at providing a living that does not depend on forest-degrading activities by the construction of an irrigation system of small reservoirs and feeder canals to create some 20 sq km of viable land for cultivation in the valley. The second programme is aimed at restoring the original forest ecosystems and so re-establishing the streams to the valley.

FOREST RESTORATION: METHODS AND ACTIVITIES

1. Upper Watershed Sites

Investigation by Ajahn Pongsak and village leaders proved that 21 km^2 of the headwater forests had been cleared at varying times, mostly between 1977 and 1984, noting history and vegetation cover. Priority sites for reforestation were identified, i.e. those where forest regeneration was not taking place due to competition from invasive weeds, notably *Imperata cylindrica,* lack of seed trees and poor soils due to repeated cultivation and irreversible changes in soil structure after annual fires.

Activities undertaken following the survey

1.1 Construction of nurseries

Four nurseries were constructed, 2 in the lowlands and 2 in the uplands, water being piped in from nearby streams or head-waters.

1.2 Seed Collection

It was observed that the pioneer species appearing on the poorest soils colonised by *Imperata* were legumes, small herbs and then shrubs such as *Pueraria thomsonii.* In more level, moister places, a number of species were regenerating naturally, many of them oaks and false chestnuts. As these had been an important component of the former climax forest, the first seed collections concentrated on the Fagaceae, together with legumes. Fagaceae collected included *Quercus semiserrata, Castanopsis tribuloides, C.acuminatissima, C.diversifolia,* an unidentified *Lithocarpus* species, whilst legumes collected were *Archidendron clypearia* and *Dalbergia fusca.* Several species of Magnoliaceae were present in the remnants of the original forest and an abundant source of *Michelia champaca* was found, which was added to the initial seedlings raised in the upland nurseries.

Seed collection in later years concentrated on those trees providing food for wildlife – flowers or fruits – in order to attract back former animal species now extirpated from the area. Besides the oaks and false chestnuts, *Helicia nilagirica* is proving particularly useful in attracting small rodents (Muridae), squirrels (Sciuridae) and porcupines (Hystricidae). This tree species is able to withstand drought and full exposure to sunlight, unlike species with large fleshy fruits, which seem to require greater shade and moisture. Other food tree seeds collected were *Artocarpus lakoocha, Melia toosendan, Turpinia pomifera, Phoebe cathia, Garcinia cowa, G.xanthochymus,* 3 *Ficus* species, *Eugenia albiflora* and *Choerospondias axillaris.*

In addition, more than 300 seedlings of *Prunus cerasoides* were provided by the Royal Forest Department.

1.3 Germination

Fagaceae: It was found that only fruits very recently fallen to the ground or actually picked ripe off the trees germinated. Approximate germination success rates of viable seeds were as follows:

Quercus semiserrata	over 90 %
Castanopsis tribuloides	70-80 %
C.acuminatissima	70-80 %
C. diversifolia	60–70 %
Unidentifed *Lithocarpus sp.*	over 95 %

Leguminosae: Seeds were soaked for 24 hours before sowing. Approximate germination success rates were 50-60% for *Dalbergia fusca* and 70-80% for *Archidendron clypearia*.

***Michelia champaca*:** Ants attacked arils surrounding the seeds, so the arils were removed before sowing the seeds. Subsequently a success rate of 80 % germination was achieved.

***Helicia nilagirica*:** No treatment was required before sowing. The germination success rate achieved was nearly 100%, since most seeds collected were already sprouting.

With the exception of *Eugenia albiflora*, where 70 – 80 % of seeds collected germinated, germination of food tree seeds was very poor. Notable amongst them have been all *Ficus* species and those having fleshy fruits with hard stones, all important components of the forests we hope to restore. Using methods suggested by FORRU and research by Dr Kate Hardwick, we hope to be more successful next year.

After the treatment specified, all seeds were sown straight into plastic bags 18 x 6 cm filled with forest soil so as to retain the mycorrhizal associations. Upland and lowland nurseries have 2-3 workers each (depending on number of seedlings to be cared for), one supervisor on the ridges and one overall supervisor.

1.4 Planting

1.4.1 Site preparation: Weeds are removed in metre-wide strips, 2 metres apart, the strips running across (rather than vertically) the slopes to minimise erosion. Where *Imperata* is present, care is taken to dig out the full rhizome mass and any tree saplings already established naturally are left to grow. Tree seedlings have been planted at 2 m x 2m spacings in all the experiments at Mae Soi to date. However, 3 trial plots of 1.6 ha (10 rai) each are being prepared for this year's planting where holes will be dug 1.5 metres apart, using 30,000 Fagaceae seedlings presently being raised in the nurseries.

1.4.2. Planting methods: After weed removal, holes are dug to about 20 cm deep. When planting, the most humus-rich top soil is used to fill the hole first and the seedling placed in a small depression in order to conserve moisture as Mae Soi being in a rain-shadow, has less rainfall than the neighbouring catchments. The cut weeds are then piled around the seedlings as mulch. Many planting methods have been tried.

With or without bag removal: we were advised that seedlings would suffer root damage when removed from their plastic bag containers and the first plantings were a mixture of those planted wholly in bags, some in bags which were split along the sides and the bottoms cut off and some removed completely from the bags. Survival and growth rates were measured for comparison over 3 years and proved decisively that unless rainfall was heavy enough to promote rapid growth, root development was too slow to break through the bags to allow the seedlings to survive the long dry season (Table 1).

Table 1

Seedlings planted in May 1990 and 1991. Figures below show survival rate by October 1994 in 3 plots			
	Plot A	Plot B	Plot C
Planted entirely in bag	12 %	none planted in this way	
Planted with bag cut open	none planted	56 %	27 %
Planted without bag	none planted	64 %	40 %

Direct seeding: An abundant masting of *Quercus semiserrata* in 1991 encouraged us to try direct seeding of this species. Their survival rate generally proved greater than those raised in the nurseries where tap roots tended to break through the bags and become damaged.

With fertiliser: Fertiliser NPK 16/20/0 was used for the first time in May 1999 and was placed at the bottom of holes before planting the seedlings. Monitoring of any improved performance has not yet taken place.

1.5 Maintenance

Weeding trials have been undertaken and the optimum timing appears to be once at planting time at the beginning of the rainy season and again about a month before the end of it so that vegetation cover over the young trees can help to conserve soil moisture during the dry season.

1.6 Survival of planted seedlings

Besides the bag trials mentioned above, we found that survival rate (apart from those destroyed by fire) depends on soil moisture and correct shading for the species grown. The plots shown in the table above were all on slopes of soils that could hold little water, being largely lateritic. The highest rate of survival was 64%. On the other hand, a fairly level plot at the base of the slopes planted with 4 species of Fagaceae, *Helicia nilagirica, Eugenia albiflora* and a *Cinnamomum* species performed much better. Heavy rain had followed a day after the planting and of the 150 trees monitored, only 5 died, showing a survival rate of 96% after 2 years.

1.7 Encouragement of natural regeneration

On exposed slopes of poor soils, monitoring of random areas showed that the trees that established naturally were far hardier than those planted. Careful planting of proven hardy species - *Parkia leiophylla, Helicia nilagirica* and *Quercus semiserrata* – in between naturally regenerating trees promises better results, although the introduction of further drought-tolerant species attractive to wildlife would enrich and hasten the process.

Mixed deciduous/evergreen forest in the lowlands

When Ajahn Pongsak first visited this area in 1970, the forest was thick and largely undisturbed. Since then, however, illegal logging removed most of the economic hardwoods such as *Tectona grandis, Xylia xylocarpa* var.*kerrii, Afzelia xylocarpa, Hopea odorata* and *Pterocarpus macrocarpus*. Patchy burning, but no cultivation, followed logging. The present forest consists mostly of bamboo – *Thyrsostachys siamensis, Dendrocalamus strictus* – and a few large trees of non-economic value remaining along the streams.

2.1 Seed collection

Initially, a collection was made of all tree species mentioned above except *Hopea odorata* as there were no suitable riparian planting sites. An abundant fruiting of *Mangifera caloneura* allowed us to include it in the first plantings. Later collections concentrated on food trees for wildlife: *Mangifera caloneura, Irvingia malayana, Terminalia chebula.*

2.2 Germination

With all seeds soaked for 24 hours germination success rates were as follows:

Tectona grandis	70 – 80 %
Xylia xylocarpa var. kerrii	70 – 80 %
Afzelia xylocarpa	over 90 %
Pterocarpus macrocarpus	none
Irvingia malayana	70 – 80 %
Terminalia chebula	70 – 80 %
Mangifera caloneura	80 – 90 %

Germination failure of *Pterocarpus macrocarpus* may lie, like the Fagaceae, with the timing of seed collection. More research needs to be undertaken in this area.

2.3 Planting

After disturbance such as logging in this forest type, bamboos are generally the first to establish themselves, followed very gradually by the former tree species should seed sources be still available. Our plan in these lower forests is to speed up succession and at the same time introduce food trees to attract wildlife and so try to re-create an approximation of the original ecosystem.

To this end, seedlings have been planted in gaps between bamboo clumps, starting by the sides of the streams where the soil is most moist. As the trees grow, the moisture spreads with their roots, which at the same time help to control bank erosion. The bamboo at first provides essential shade for the growing trees but as these become larger, the outer culms of the bamboo clumps are cut away to allow more sunlight to reach the ground. We find this to be particularly necessary for teak; *Xylia* and *Afzelia* are more able to withstand considerable shading.

2.4 Weeding

None is needed as there is very little groundcover

2.5 Growth and survival

Performance has been high in these moist soils of fair humus content.

2.6 Return of Wildlife

The return of wildlife to these forests in the last 2 years has been marked. A rough bird census in April 1999 listed over 30 species including a Wreathed Hornbill (*Rhyticeros undulatus*) at 600 m and 3 flocks of Jungle Fowl (*Gallus gallus*). Populations of porcupines Common Wild Pig and Common Barking Deer (*Muntiacus muntjac*) have all increased though sadly 14 of the latter were killed this year by hunters. Jackals (*Canis aureus*) have been seen as well as the tracks of Leopard Cat (*Felis bengalensis*). A troop of macaques (*Macaca nemestrima*) was seen fighting off a python (*Python reticulatus*). Other animals reported by villagers include squirrels, Slow Loris (*Nyticebus coucang*), hares (*Lepus peguensis*), pangolin (*Manis javanica*) and many snakes including *Chrysopelea paradisi* and *Ancistrodon rhodostoma*.

3. Fire

The greatest danger, however, to successful reforestation in Thailand is fire. Villagers set fire to the forest to clear the floor of slippery leaves and to drive animals out while hunting, to expose ground mushrooms especially *Astreus hygrometricus* and to force new leaf flush of *Sauropus androgynus*, a popular wild vegetable.

At Mae Soi, though, while fires are lit for the above reasons, the main cause arises from a socio-political conflict. In the last 40 years, opium-growing peoples have been migrating into Thailand fleeing war and unrest in neighbouring countries, some of them acting as Communist infiltrators. The Royal Projects were set up to win over their loyalty by first giving economic aid and later by introducing them to alternative cash crops in response to increasing drug problems in the West. Many international agencies set up similar projects and hill tribe development programmes followed, set up by NGO's.

Since Sukothai times, 700 years ago, upper watershed forests where the headwaters of rivers are formed in Thailand, have never been cleared for cultivation. They have been left undisturbed. The indigenous forest-dwelling tribal peoples, understanding the functions of different forests, rarely settled higher than mid-catchments. However, opium in the tropics cannot grow at altitudes lower than 1,000 m and the recent tribal migrants were forced to settle illegally in the upper watershed forests, and clear them for cultivation.

For the last 15 years, the development NGO's – presently numbering over 420 – citing human rights, are directing a movement to secure land rights for all settlers in forest lands regardless of site, whether in National Parks, Wildlife Sanctuaries or 1A classified watersheds. In the Mae Soi catchment, this movement and world sympathy with tribal rights has created misunderstanding and hostility between highlanders and lowlanders. Problems have remained unsolved through the intervention of third parties. At the beginning of the project, the Hmong of Ban Pa Kluay agreed to settle in the valley in a site that the lowlanders found for them, and of which they approved. A foreign aid agency working with the Hmong at the time, however, not understanding the threats that the

Hmong presence posed to water resources and wildlife, persuaded them to stay in the highlands, accusing the lowlanders of probable duplicity against them. Since then, human rights campaigners have reinforced this misunderstanding with accusations of racism against tribal people. Feelings have run high and have led to annual deliberate firing of the Mae Soi forest restoration, the most serious being in 1998, when over 1600 ha of the forests were burned.

3.1 Protective measures against fire

Protective measures against fire have had to be very rigorous and comprise the following:

Firebreaks: over 30 km of firebreaks 5 m wide are constructed every year and maintained from January to the first rains, which sometimes do not fall until June.

Patrols: each year 12 temporary huts are built to shelter 3 villagers each to watch for fires and maintain the firebreaks on a 5-day rota. The rota operates from January – June. Two fire-fighting teams of 45 village volunteers each, acting in turn, are alerted by radio of any fires that cannot be dealt with by the patrols. These are backed up an emergency team of 30 men when needed.

Equipment used (assembled over time as needs dictated):

a) Pipes and storage tanks: pipes have been laid along vertical ridges from the nearest headwaters leading to storage tanks placed at intervals along the pipelines.
b) 3 radios, 2 with the patrols on the ridges, 1 in the valley - for fire watchers in the highlands to alert fire fighting teams below.
c) Bamboo alerts for each patrol – bamboo sections which when struck produce a resonance loud enough to alert neighbouring patrols, who then assemble at the site of the fire.
d) 3 vehicles: a motorbike to contact fire-fighting teams in the villages; a 6-wheel truck for transport of fire fighting teams from the valley to ridges of the catchment and a 4WD pick-up truck to carry portable pumps and hoses to fire sites
e) Lace-up shoes, rather than rubber-thonged sandals, for walking through hot ashes.

Fires have been repeatedly lit throughout the dry season in the 13-year course of the project. The above measures, gradually implemented over the years, have effectively protected the growing forests so that by 1996, nine years after the start of the project, the Mae Soi ran as a perennial stream, the only one out of nine in the District of Chomthong to do so. The fires of 1998 put a temporary arrest to the flow, but as there was little change in the soils, stream flow resumed after the first rains. Lowlanders are now able to make a living from lamyai (*Dimocarpus longan*), mango and tamarind orchards and cash crops such as chilli and *krachiep (Hibiscus sabdariffa*).

Two-thirds of project funds are spent on fire protection. If fires were eliminated from the catchment, the forests might be able to regenerate naturally, with the succession being speeded up with judicious planting. Costs would be comparatively low. But the issue of land rights and forest management in the highlands is still far from settled and fires will continue to destroy efforts at reforestation either to gain more land for cultivation or in protest for land rights.

RESEARCH NEEDS

The most pressing research needed, is clearly fire control, particularly the use of controlled burning techniques[2]. These would include besides experimentation into different methods, the seasonal timing of such burns as well as their frequency. Other information which the project presently lacks, such as more reliable methods of wildlife monitoring[3] and the germination of important species e.g. *Ficus* and *Pterocarpus macrocarpus* is available and will be sought. However, a further study of drought- tolerant species suitable for high altitude slopes of poor soils would be most useful.

POSSIBLE APPLICATIONS OF THE MAE SOI PROJECT

The project's activities have encouraged the other 8 subdistricts of Chomthong and neighbouring catchments as far as Mae Chaem and Lampang to form associations for the protection of their upper watershed forests. Ajahn Pongsak, by promoting awareness of the environment, has motivated village communities to help themselves and this promises to produce a model of environmentally sound development at very modest cost. However, more widespread education about the functions of Thailand's high-altitude forests is needed before general sustainable management of forest and water resources is assured. Until this is effected and the understanding acted upon, the success of attempts to restore the crucial upper watershed forests of northern Thailand and the river sources to which they give birth, will continue to be uncertain.

ACKNOWLEDGEMENTS

The project has been most fortunate to have had the advice and expertise of the following people:

J. F. Maxwell, who made a botanical survey of the catchment and identified species collected; Dr Kate Hardwick, who initiated and set up the monitoring system; Dr Oy Kanjanvanit, who has given much helpful information and comment; and most particularly of all, Dr Steve Elliott, who has given his time so generously as consultant on activities,

[2] Discussion groups subsequently responded to this need see Part 7 proposal 3.2.

[3] See Part 7 proposal 1.4

editor of written work and initiator of research work on many aspects of our reforestation programme.

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QUESTIONS AND COMMENTS

Rick Burnette

Given the present tension between lowland and upland communities, how can hill-tribe people participate in forest restoration activities?

M. R. Smansnid Svasti

The Hmong villagers were invited to become involved as part of the Tambon (District) Council. They agreed that destruction of the forests was drying up rivers and that they would resettle voluntarily, if provided with suitable land to settle on. They also agreed to help with reforestation, but each time they have agreed to move to the valley, a 3rd party has intervened to discourage them from doing so.

THE POTENTIAL OF LOCAL TREE SPECIES TO ACCELERATE NATURAL FOREST SUCCESSION ON MARGINAL GRASSLANDS IN SOUTHERN VIETNAM

Nguyen Van So[1]

ABSTRACT

In Vietnam, to rehabilitate the marginal grasslands resulting from over-logging and shifting cultivation, reforestation has been applied as the most promising strategy to increase soil productivity and restore ecological balance. If protected from forest fire and over-grazing, such marginal, fallow lands will become colonised by fast growing, pioneer and later climax tree species. However, natural forest succession often takes a long time to accumulate enough nutrients, accelerate nutrient cycles and enhance the activity of soil micro-organisms and earth-worms. This can be solved by human intervention in selecting appropriate local fast growing pioneer species and planting them on marginal grassland to accelerate the natural pioneer-climax species succession.

This paper discusses the applicability of the Accelerated Pioneer-Climax Series (APCS) Method for restoring forests to degraded areas in Southern Vietnam, particularly for lowland and hilly Dipterocarp plantations, using many local species of both pioneer and climax trees. These include the pioneers *Indigofera teysmanii, Trema orientalis, Anthocephalus chinensis, Wrightia tomentosa* etc.; intermediate species e.g. *Dalbergia cochinchinesis, Xylia dolabriformis, Cassia siamea* and *Lagerstroemia angustifolia* and climax species e.g. *Dipterocarpus alatus, D. dyerii, Hopea odorata, Anisoptera cochinchinensis* etc.

Initial results from this method have shown that not only is the natural succession shortened and the biodiversity enhanced, but also local community and foresters can benefit from short and mid-term products such as fuel-wood, poles, small timber etc through thinning activities.

Key words: natural forest succession; natural pioneer-climax species succession; closed nutrient cycling process

INTRODUCTION

The forest area in Vietnam has been greatly decreased by the effects of war, heavy exploitation by logging, shifting cultivation and expansion of agricultural land. This decrease also adversely affects the upland environment, particularly the climatic and soil conditions of watershed catchment areas, causing several problems for agricultural production and directly to

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people's life in the uplands. More importantly, as a wave of colonisation and development clears new areas, it creates in its wake a land often thoroughly wasted for any meaningful human use: marginal grasslands. In some areas, forest clearing is followed by large tracts of monoculture for agricultural exports such as coffee, rubber, bananas etc, in a bleak agro-industrialised landscape.

Tropical forestland is difficult to exploit for several ecological reasons. One of the most important constraints is that tropical soils have low concentrations of nutrients, since high temperatures and rainfall throughout the year leach chemical nutrients from the soil. With few exceptions, the nutrients in a tropical forest ecosystem are mostly in the plants themselves. When plants die and are attacked by organisms, the nutrients that are slowly released are trapped by fungi, the main agents of decay, and delivered to the roots of the succeeding trees and shrubs through complex symbiotic interactions. If the forest is felled and burned for agriculture, nutrients are rapidly flushed into the soil, where they are only available for crops over a few rotations. Without the slow and complex mechanisms of nutrient recycling, these free ions are literally washed out of the soil. Vegetative cover is reduced and grasses and scrub invade the cleared areas. If the soil is compacted through mechanical clearing or subsequent grazing, the exposed soil will be eroded by large raindrops pounding its surface - a particularly acute problem on hillsides.

BARRIERS TO TROPICAL FOREST REGROWTH

Tropical forests seem distinctly unable to reclaim land once it has been cleared and used for agriculture. There are a number of reasons for this:

- Clearing and burning is likely to release most of the nutrients into poor tropical soils, which are then leached out by warm tropical rains.
- The process of forest regeneration is complex and the seedlings of hardwoods found in forest often tolerate only a narrow range of humidity and light conditions and cannot, therefore, grow in open areas. Under natural conditions a succession of different species, starting with pioneers, provides this environment.
- Tropical forest fruits and seeds are most often spread by animals, sometimes by relatively few species. That is why a seed source has to be near the clearing and disperser populations must be able to withstand drastic habitat changes.
- Forest species are often pollinated by means of animals through cross-pollination between individuals, so close proximity of individuals of the species and readily available suitable pollinators are essential.
- Both pollination and dispersal are made more difficult by the relative rarity of any tropical forest species. This rarity is a natural consequence of diversity since tropical forests are not usually dominated by a small number of species.
- Trees may require specific symbiotic relationships with fungi known as mycorrhizae.
- There is a collection of ungerminated seeds in the soil known as a seed bank, but it is unclear how long seeds remain viable under the of effects insect, fungal and human activities. This is part of the "gap ecology" in tropical forests.

- Tough, browsing and fire-resistant grasses, such as *Imperata* and shrubs take hold after long periods of burning and grazing.

Given these constraints, it can be seen that belief in the ability of forests to regenerate quickly towards their original state is unfounded. Therefore, positive human interventions, enrichment planting and afforestation seem necessary to rehabilitate tropical forests from degraded secondary forests and marginal grasslands.

CONCEPT AND EVIDENCE FOR "ACCELERATED PIONEER-CLIMAX SERIES" (APCS) APPLICABILITY

APCS is based on the ecological principle of natural succession wherein pioneer species, which have the ability to adapt to adverse site conditions, improve the microclimate and soil conditions, rendering them favourable for the establishment of climax species. However, since natural succession is a slow process, this can be accelerated through the planting of pioneer species first and later inter-planting with climax species. To rehabilitate degraded upland soils, reforestation by APCS has been proposed as a promising strategy to improve the soil productivity and to restore ecological balance.

Advantages of APCS Strategy

APCS is an environmentally sound strategy, particularly in upland areas because of the following:

1. It follows the principle of natural succession.
2. It promotes biodiversity, since at least two types of species (pioneer and climax) are planted.
3. It can restore some grassland areas, which were formerly dipterocarp forests, into dipterocarp plantations,
4. It improves the microclimate and provides immediate cover, even if the inter-planted climax species fail.
5. It protects upland soils from erosion.

APCS is socio-economically sound because:

1. Thinnings from the pioneers and intermediates provide fuel-wood, pole-wood, fodder, mulch, organic fertiliser and small timber for local consumption.
2. Local people easily accept it, since the practice allows participating farmers to gain different products from the plantations shortly after establishment to the end of the climax species rotation.
3. It is cost-effective, especially on open grasslands, since the pioneers and intermediates quickly suppress light-demanding grasses. Their high survival guarantees suitable conditions for planting climax species in the long term.

Examples of Applying APCS to Rehabilitate Barren Land in Vietnam

Several versions of APCS have been applied in Vietnam using different tree species and various planting densities. Initially, the objectives were both to i) rapidly rehabilitate waste, marginal, hilly grassland; ii) produce fuel-wood and small timber to meet local demand and iii) improve and make site conditions favourable for the climax species development. These practices can be classified into 2 main ones as follows:

1. ***Plantations of fast-growing species*** to rehabilitate *Imperata* grassland to provide better cover for wildlife and later to provide fuel-wood and small wood for local requirements.

Plantation characteristics:

- high densities (2,000-3,300 trees/ha);
- trees quickly suppress light demanding grasses after 2 years;
- plantation design: trees are spaced 1.5-2.0 m apart within rows, with 2.0 m between rows;
- potential species: *Indigofera teysmanii, Gliricidia sepium, Sesbania grandiflora, Lagerstroemia angustifolia, L. calyculata, Trema orientalis, Anthocephalus chinensis, Acacia auriculiformis, A. mangium*;
- thinning: after 4 years of establishment, line-thinning operations are carried out to harvest one row in every three for fuel-wood and small pole production. This is flexible depending on the owner's objectives;
- agricultural crops and Dipterocarp species are then grown in the alleys between two bands of fast growing forest at its early stage and
- at years 8 and 12, pioneer species will be gradually cut and removed to provide more light and space for the climax species.

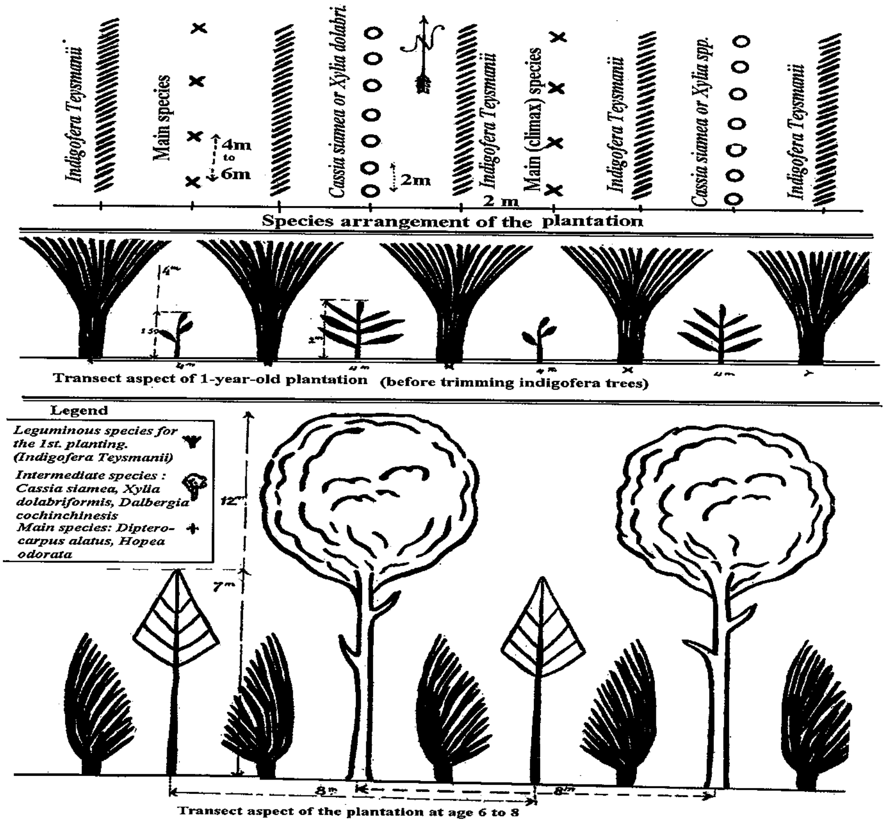
2. ***Mixed plantations*** with three pioneer, intermediate and climax tree species as illustrated in Fig. 1.

Plantation characteristics:

- species planted: *Indigofera teysmanii*, *Gliricidia sepium* (pioneer species), *Acacia auriculiformis*, or *Cassia siamea, Xylia dolabriformis, Dalbergia cochinchinensis* (intermediate species) and *Dipterocarp* species such as *Dipterocarpus alatus, D. dyerii, Anisoptera cochinchinensis, Shorea roxburgii* and *Hopea odorata*. Most of these species are chosen based on their establishment at several stages during natural forest succession, following forest clearance. Almost all selected species are indigenous species except for *Acacia auriculiformis*, a site-matching exotic species, which grows fast under all conditions.
- planting densities: 1666 trees/ha (4 m x 1.5 m) for pioneer species, 833 trees/ha (8 m x 1.5 m) for intermediate species and 278 trees/ha for climax species.
- cutting regime: the pioneer species *Indigofera teysmanii* is cut to ground level every two years for fuel-wood production, since this species grows fast and coppices well. Intermediate species (*Acacia auriculiformis, Xylia*

dolabriformis,etc.) are gradually thinned out over six years providing fuel-wood, poles, small timber and more light for the main species. Climax species (*Dipterocarpus alatus* or *Hopea odorata*) have a 60-year rotation producing timber for construction. (See Appendix A for species descriptions)

Fig.1. Model of Mixed Plantation by Mr. Paul Maurand



From some initial results in the southern part of Vietnam, this practice has proven to be technically sound because:

1. The pioneers have good potential to improve soil conditions particularly the soil biological and physical properties.
2. The growth performances of the intermediates and climax species are improved and much better than those in pure stands.
3. It enhances the nutrient cycling process. Therefore, it restores the productivity of the tropical forest ecosystem in uplands.
4. It provides short-term products such as firewood, fodder, poles and small timber from the cutting and thinning operations of the pioneers and intermediates.

FURTHER RESEARCH NEEDS

Although this afforestation scheme seems more complicated than pure plantations, it is consistent with natural ecological balance and supports wildlife development. Huge amounts of litterfall from the pioneers concentrated on the soil surface encourage micro-organisms and earth-worms. In addition, several tree species such as *Trema orientalis* and *Anthocephalus chinensis,* bear fruits which are particularly attractive to birds and bats.

However, in order to gain further knowledge more studies must be carried out to better understand the links between this scheme and wildlife conservation. On the other hand, the technology needs to be simplified and made economical, within the reach of rural poor farmers who are still working traditionally with slash and burn cultivation. One area, which deserves further attention, is the potential of using direct seeding to rehabilitate fallowed areas[2].

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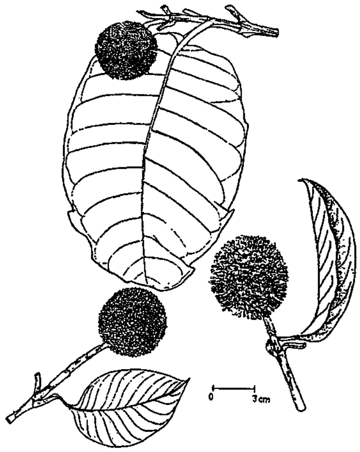
[2] Editor's note: this topic was subsequently taken up by discussion groups and a research proposal formulated. See Part 7, proposal 4.3.

Appendix A: Description of Local Species used in APCS

Anthocephalus chinensis (Lamk.) Rich. Ex Walp.
Family: Rubiaceae



NAMES:

Synonyms: *A. cadamba* (Roxb.) Mig., *A. indicus* A. Rich., *Cephalanthus orientalis* Linn.

Vietnamese name: *gao trang, gao nhot.*

DESCRIPTION: *gao trang* reaches 25 to 38 metres in height and 60 cm in diameter, deciduous, open crowned; slightly buttressed trunk with good form. The leaves are simple, opposite, coriaceous, 20 to 25 cm long and 12 to 15 cm wide (see above Figure, source: HENSLEIGH & HOLAWAY, 1988). They are ovate to oblong, with an acute apex and an obtuse or rounded base, and overall are heart shaped. The margin is entire to slightly expand; the veins are distinct underneath. The leaves are dark green above and pale yellowish green underneath. The flowers are small, yellowish white, sessile, and set in stalked, round, burr like heads about 3 cm across. The corolla is a long, slender, narrowly lobed tube from which a style projects. The fruit is globose, 5 cm in diameter, orange mass of fleshy capsules each containing many minute seeds. The sapwood is white with a light yellow tinge and is not differentiated from the heartwood. The bark is slightly rough and grey or light brown.

DISTRIBUTION: The current range of this tree is in humid tropical areas from Nepal to New Guinea. In dry sites it is difficult to establish in a plantation, however it is more successful in hot and wet weather. *Gao trang* is very common in the midlands of the southern part of Vietnam.

ECOLOGY:

Soils: The species prefers deep, moist, well drained, alluvial soils, it grows poorly in heavy textured or very infertile soils.

Temperature: Mean annual temperature range in its native range is 20° to 32°C. It is frost sensitive.

Altitude: *gao trang* does best at altitudes below 1,000 meters.

Rainfall: It is found growing in areas with 1,500 to 5,000 mm of rain annually. It tolerates dry periods of less than 4 months in duration. Uniformly distributed rainfall is ideal.

Competitive ability: On good sites growth is vigorous and fast, it is a pioneer species common to old logging sites.

Limitations: *gao trang* needs full sunlight.

USES AND YIELDS: Under good conditions plantations can yield 50 m^3/ha/yr (MAI). Usual production is 10 to 40 m^3/ha/yr. The wood has a specific gravity of 0.35 to 0.40 and poor durability but is easy to work. Uses include light construction, short fibre pulp, veneer, plywood, carving, and wooden shoes.

CULTURE:

Seed collection and storage: ants readily eat fruits, so collect immediately after fruit fall. Seed maintains its viability for 2 years under refrigeration or for 3 to 6 months if stored in dry, airtight containers in a shaded area. There are approximately 2,600,000 to 6,000,000 seeds/kg or 150,000 seeds/litres. Extract seeds from the fleshy fruit and dry. No germination treatment is needed.

Sowing and producing seedlings: broadcast the seeds in a seedbed or box composed of 50% sand. Provide heavy shade. Germination is in 7 to 14 days. Potted seedlings 3 to 4 months of age are recommended for out-planting.

Care and harvest: after germination, water regularly (in the morning only to avoid problems with damping off) for 3 to 4 months or until seedlings are 30 to 45 cm tall. Outplant with 3 x 3 or 4 x 4-metre spacings.

Pests and diseases: seedlings are susceptible to damping off. The trees may be attacked by root knot nematodes (Meloidogyne) resulting in root knots and galls, *Arthoeshista hilarallis* may defoliate it.

***Dalbergia cochinchinensis* Pierre**
Family: Leguminosae; Sub family: Papilinoideae

Vietnamese name: *Trac*

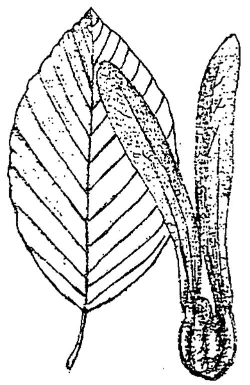
DESCRIPTION: A large evergreen tree, 25-30 m tall, diameter 60-120 cm. Bark brownish-yellow, longitudinally fissured, sometimes peeling. Profusely branched. Crown spherical. Leaves pinately compound, alternate or subopposite, apex obtuse, or shortly acuminate, base cuneate, 3-5 cm long and 1.8 - 2.5 cm wide, leathery (see above Figure, source: HO, 1990). Veins slightly prominent. Inflorescence paniculate, axillary, bracteate and braeteolate. Flowers white. Sepals connate, glabrous. Petals with straight claws, standard rectangular. Stamens 9. Pod flat, narrow, 5-6 cm by 1cm. Seeds 1-2, brown.

DISTRIBUTION AND ECOLOGY: Distributed in Vietnam, Laos and Cambodia. In Vietnam found from Quang Nam - Da Nang southwards, in Gia Lai and Kom Tum (Dacto, An Khe, Sa Thay). Scarce in other provinces. Llight-demanding and drought-tolerant but not demanding with regard to soil conditions. Shade-tolerant when young, growing in open and semi-deciduous forests, occasionally in pure stands, mostly at altitudes of 400-500 m above sea level. Prefers deep sandy clay soil and calcareous soil. Growth rate is rather slow, but it coppices strongly. Flowering in May to July, seed matures in September-November.

CULTURE: Pods are collected in September-November and sun dried to extract seeds manually. Approximately 30,000-40,000 seeds/ kg. Store seeds ventilated containers until sowing. Seeds are sown in nursery beds immediately after extraction. Seedlings are transferred into plastic bags. To hasten germination, seeds are dipped in hot and then cold water to 24 hours. Seedlings are raised in the nursery for 6-7 months before planting in the field when the rains are due. Young seedlings need shade, which is gradually reduced when older. *Trac* can be planted bare-rooted or as a potted seedlings as well as by stumps.

USES: Timber large-sized, sapwood and heartwood distinctive: sapwood greyish, heartwood brown-red or black, texture fine, very hard and heavy with a density of 1.09, easy to work and resistant to insects and termites, durable, and not splitting when dry. This wood has beautiful patterns when sawn, being classified as a first class prime timber, and is used for furniture, wood turnery, fine-art articles, musical instruments and sewing machines. Vulnerable species.

***Dipterocarpus alatus* Roxb.**
Family: Dipterocarpaceae
Vietnamese names: *Dau rai, dau con rai, dau nuoc.*



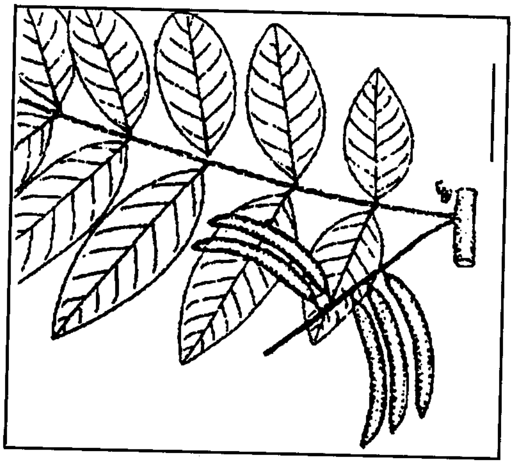
DESCRIPTION: A big tree, 35-45m tall, diameter 60-100cm. Trunk cylindrical, straight. Crown umbellate, late branched. Branches big. Twigs coarse. Bark white-grey. Inner bark yellowish-brown, resinous. Leaves simple, alternate, ovate or oblong-ovate, elliptic, 20-25cm long, 10-15cm wide, slightly acute, dark green above, pale green beneath, tomentose (see above Fig., source: HO, 1990). Lateral veins 15-20 pairs, parallel, evident beneath. Bud-stipule large, red, covered with tomentum. Inflorescence, a white-pink raceme. Flowers pentamerous (sepals 5, petals 5). Stamens about 30, arranged in two rings. Fruit, 1.5-2cm in diameter with 2 big wings, developed from sepals, 11-14cm long and 1.5-2cm wide, red when young and yellowish-brown when mature. One seed.

DISTRIBUTION AND ECOLOGY: Common in India, Myanmar, Thailand, Laos, Cambodia, Vietnam, Indonesia and the Philippines. In Vietnam, found from Quang Nam Da Nang province and southwards, in Dong Nai, Binhduong, Binhphuoc and Ba Ria Vung Tau provinces, growing gregariously in small pure stands along streams and river banks. The species always occurs at the highest storey of tropical evergreen forests, below 800m asl. (mainly from 200-500m asl.), usually mixed with *Dipterocarpus turbinatus, Sindora siamensis, Dalbergia cochinchinensis and Pterocarpus macrocarpus*. A light-demanding tree, but shade-tolerant when young, after 4-5 years, it demands full light for development. Natural regeneration is good, especially along rivers or on moist, flat lands. Flowering in November-December, fruiting in April- May.

CULTURE: Fruits are collected from the ground in May after the rains. Fruits have a reduced germination capacity after 1 month of storage, therefore they need to be sown as soon as possible after collecting. Fruits are sown directly in pots or in nursery beds and then transplanted to pots later. Shading and watering are needed to raise the seedlings for at least 1 year in the nursery. Dau rai can be established as seedlings in enrichment planting or by planting on barren land with pioneer species.

LIMITATION: It can not tolerate after being burnt and coppices poorly.

Indigofera teysmanii **Miq (*I. Zollingerana* Miq)**
Family: Leguminosae; Subfamily:*Papilionoideae*



NAMES: Vietnamese: Dau cham, cham canh ranh.

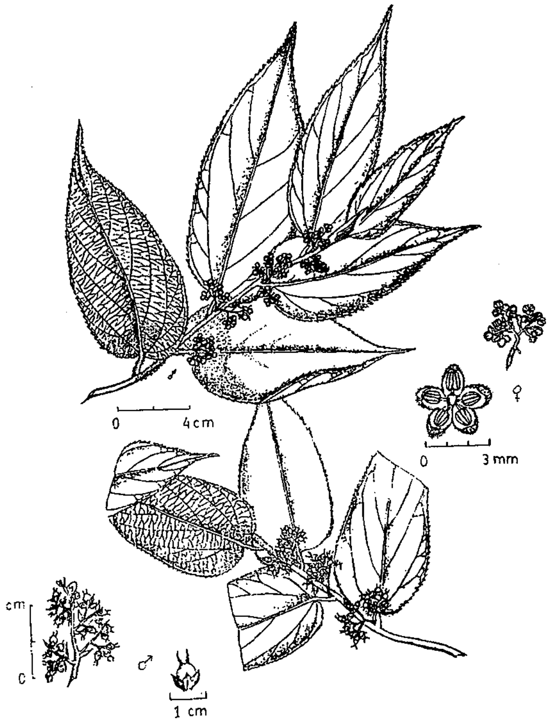
DESCRIPTION: Small to medium tree up to 12 m in height; branches and leaves have white hairs. Leaf is 20 cm long and composed of 11-17 leaflets, sized 4-7 x 2-3 cm (see above Fig., source: Ho, 1990). Flower is a corolla, 10-20 cm long, brownish hairs, pink flowers, 2 mm high. Fruit is a legume, pods 35-45 mm long, indehiscent, each contains 10 round seeds.

DISTRIBUTION: Naturally grown along fences, savannah, open forest, on abandoned slash and burn fields. It can be found throughout Vietnam from Hoang Lien Son mountain in northern to the southern parts. This is a pioneer species, which often invades open areas or degraded land after burning. *Indigofera* can tolerate living on poor soils and enriches them due to nitrogen fixation and high litterfall that reverts organic matter back to soil.

CULTURE: Dau cham bears flowers in October-November and fruits in January-March. Seed is harvested in February by collecting the pods and drying them in open areas to gather seeds. Dried seeds can be well stored in normal conditions for 2 years. To hasten seed germination, dip seeds into hot and cold water successively. Planting can be done by direct seeding or by seedlings. Seedlings develop quickly and can reach 2 m high after 1 year old, this species coppices very well and is vigorous. It is a full light-demanding species and can suppress *Imperata* grass easily after 1-year of establishment. 1 kg of seeds consists of more than 100,000 seeds.

USES: Dau cham is a pioneer species for degraded and *Imperata* grass lands, it provides a good firewood source since it coppices easily, and can also be used as a shade tree for tea and coffee plantations, or a hedgerow species to control soil and water erosion. The leaf provides good folder for livestock and poultry and can be fed to some grass fish. This is a good species to rehabilitate barren lands before planting climax species.

Trema orientalis (Linn.) Blume
Family: Ulmaceae



NAMES: Synonyms:
Vietnamese local name: Trung ca rung
Other common names: Charcoal tree, gunpowder tree

DESCRIPTION: Trung ca rung is a small tree with a spreading crown reaching heights of 18 m and diameters of 60 cm. Branches have a monopodial growth habit. Leaves are alternate in 2 ranks, ovate to lanceolate, 6 to 15 cm long, 2 to 7 cm wide, acuminate, usually pubescent and rough, and finely toothed (see above Fig., source: HENSLEIGH & HOLAWAY, 1988). The leaves are unequal sided, have 3 main veins extending from a slightly notched base, and are thin. The upper surface is dull, rough, and light green with sunken veins; the lower surface is pale, slightly hairy, with prominent light yellow veins. The petiole is grooved above and 6 to 10 cm long. Flower clusters are shot cymes in leaf axils, 1 to 2 cm long and 1 to 2 cm broad. The many flowers are nearly stalkless, 3mm wide, and light green. The purple or black fruits are round, 3 to 5 mm in diameter, and juicy with a stone 1.5 mm long inside.

The bark is light gray brown, smooth, finely fissured, and thin. The inner bark is pink, soft, fibrous, and bitter tasting.

DISTRIBUTION: Trung ca rung is native species in Vietnam and other South East Asian, South Asian countries, and China where it is widespread and abundant.

ECOLOGY: Trung ca rung is a pioneer species of newly cleared lands, eroded soils, and volcanic ash, it is common in secondary forests.

Soil: The tree grows in poor soils and barren environments.

Altitude: It is found growing to 2000m in the Himalayas. However, it is rare above 1000m in Vietnam.

Rainfall: It prefers a humid, moist climate with high rainfall but it is also found in areas which have a 6 month dry season.

Competitive ability: This is a fast growing, pioneer species which can outgrow other species in recently cleared areas, it dominates abandoned, fallowed land in some parts of Vietnam.

Limitations: This trees serve as a reservoir for populations of defoliating insect pests and thus may put at risk nearby plants of economic value. The tree grows rapidly but is short lived .

CULTURE:

Seed collection and storage: Trung ca rung is reported to flower from January to April. Lopez , in the Philippines, reports flowering from June through July with fruit maturing in September.

Establishment: *Trema orientalis* regenerates easily from seed if kept moist or stump cuttings may be used. Heating the seeds in water at 38° C to 58° C for 5 to 10 minutes encourages even germination and improves germination percentage (LOPEZ, 1953). Maceration and washing the fruits to remove the seeds may improve germination also.

Pests and diseases: This tree coppices vigorously but mortality of new shoots may be high. Causes of sprout mortality are not well understood. Trung ca rung harbors defoliating insects (of the *Lepidoptera* genus) but these seem to serve as natural pruning agents since they generally do not kill the tree.

USES AND YIELDS: Suitable for afforestation programmes in denuded and disturbed areas, it is also planted for shade in coffee, cacao, and other plantation crops.

Mainstem and branches: Due to its fast, growth, coppicing ability, and availability, it is widely used as a fuelwood although light. Specific gravity is 0.28 to 0.40 and the calorific value is 4500 kcal/kg. On good sites in Vietnam this has yielded from 28 to 40 m^3/ha/yr with a 6 year rotation. In a study of this species growing in abandoned fallowed land in the midlands of the southern part of Vietnam (100-200m) 2-year-old trees were 10 to 13 cm in diameter, from 2 to 3-year-old trees were 14 to 20 cm in diameter and 3-4 year old were 20 to 40 cm. The wood is used to make gunpowder charcoal and is comparable to that of *Anthocephalus chinensis*. In the past it has been mixed with bamboo pulp to make paper. In some areas of Vietnam the tree is used for construction poles and in the manufacture of wall board, it rots easily and is destroyed by termites.

Leaves: The leaves may serve as a substitute source of folder, forage or browse. The leaf analysis reports 18% crude protein in dried leaf meal of trung ca rung.

Fruits: The small sweet fruits are edible.

Others: The bark is a source of tannin. Rope made from the bark is weak but when wet its resistance is doubled. Tensile strength of dry rope is 134 kilos/cm^2.

QUESTIONS AND COMMENTS

Kate Hardwick

Where *Imperata* is dominant, you said that the grass is shaded out after 2 years. How did you control it at the beginning when the trees were too small to shade it out?

Nguyen Van So

We use fast-growing species such as *Indigofera*. We have to use easily grown species. If they need lots of nursery care, farmers won't grow them, so we are trying direct seeding. We weed twice: 1 month after planting and at the end of the rainy season.

Salamat Ali

Do you use line sowing or broadcasting?

Nguyen Van So

We sow the seeds in lines. We prepare a line and use as many seeds as possible, but the distance between the lines stays the same.

Nigel Tucker

How do you treat the seed? What was the *Imperata* grassland structure when you sowed the seeds?

Nguyen Van So

We treat the seeds with hot water, using a formula to determine the amount of hot water for the weight of seeds. *Indigofera* seeds are very small. Along the planting lines, we put in sticks and weed. We maintain the line for at least 6 months, checking germination and weeding. Especially in harsh conditions, you should not suppress *Imperata* by burning in the dry season. We suppress the grass by cutting in the rainy season and the rhizome decays. We don't dig out the rhizomes. If you cut during the dry season it will come again.

Laura Johnson

What is the effect of fire on your plantations? Does the plantation act as a barrier?

Nguyen Van So

After 6 months as the canopy has already closes there is no risk of fired. *Indigofera* suppresses fire in the plantation.

Yadi Setiadi

I'm very surprised that direct-seeding works in the grassland, this is very hard in Indonesia because of competition. Do you put on any fertiliser?

Nguyen Van So

On acidic soils we use lime to enhance the performance of legumes.

ACCELERATING REHABILITATION OF NATIVE FOREST BY ESTABLISHING A SEEDLING PRODUCTION SITE IN SOUTH CHINA

Zhuang Xueying[1], Wang Tong[1], Huang Jiuxiang[1], Zeng Rongre[2] and Huang Jiancheng[2]

ABSTRACT

Due to long term and frequent human disturbances, the original forest of South China has been almost cleared. Natural forest succession and rehabilitation have been retarded. In the past decade, efforts have been made to rehabilitate forest on degraded hills in South China, which has notably increased regional forest coverage. However, most of the current plantations consist of a few exotic, fast growing trees. They support low biodiversity and weak ecological function. Rehabilitation of native forest, or plantations consisting of native trees can enhance restoration and development of local flora and fauna. This paper reports the floristic diversity in four major forest types, e.g. *Pinus massoniana* plantation, *Pinus elliottii* plantation, *Paraserianthes falcataria* plantation and secondary forest, of Zengcheng City, South China. A project to produce seedlings of native species is described. This project aims to provide seedlings of native trees to accelerate the reintroduction of native species in plantations in South China.

Key words: South China, seedling production, restoration of native forest

INTRODUCTION

Guangdong is a fast growing area in South China. With dramatic progress in industrial, urban and suburban development in the past two decades, have come serious environmental problems. The Guangdong Provincial Government has paid great attention to replanting trees on degraded hills to improve the local environment in the past decade. Provincial forest cover increased from 26.7% in 1985 to 48.9% in 1990. However, most of the plantations consist of few species of conifers or fast-growing exotics, which produce dry fruits that are not eaten by local wildlife. In 1997, the Government proposed that 30% of the total forest area would be used or planted for conservation purposes. The importance of native forest for wildlife conservation is gradually becoming understood. However, utilisation of native tree species in plantations is limited by local shortages of planting stock and by a lack of knowledge of appropriate techniques to use to replant native species.

Floristic diversity plays an important role in biological conservation and soil nutrient cycling. Understanding the development of the plantation understories is necessary to guide plantation management (YU *ET AL.*, 1999). Zengcheng is one of the national demonstration

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cities in China. Major forest types are secondary forest and plantations. Secondary forests are mainly distributed in the north and have been protected since 1983. Main plantation species include *Pinus massoniana*, *P. elliottii*, *Paraserianthes falcataria*, *Eucalyptus urophylla*, and *Acacia mangium*. This study investigated the floristic diversity of native forest and various plantations in Zengcheng. A project to produce seedlings of native species will be implemented to accelerate forest restoration in South China.

METHODS

Study site

Zengcheng (23° 5'- 23°37' N, 113°29'- 114°E) is a suburb of Guangzhou City in Guangdong Province. It has a south sub-tropical monsoonal climate. The mean annual temperature is 21.6°C and the mean annual rainfall is 1921.6mm. The hottest month is July with a mean temperature of 29°C, whilst the coolest month is January with a mean temperature of 13°C. The rainy season lasts from April to September. The wettest months are May and June when mean monthly rainfall exceeds 300 mm. The dry season, when mean monthly rainfall falls below 100 mm, lasts from October to March. The vegetation zone is south sub-tropical evergreen monsoon forest.

Field survey

Fifteen plots (each 4×100m^2) were set up in four forest communities: *Pinus massoniana* (Pm) plantations, *P. elliottii* (Pe) plantations, *Paraserianthes falcataria* (Pf) plantations and native forest, from November 1998 to April 1999 (Table 1). In each plot, trees with diameters at breast height (*dbh*) >2cm were measured and identified.

Table 1 Brief description of the study sites

Plot No.	Forest Type	Age (year)	Location	Altitude (m)	Slope (°)	Aspect
1	Secondary forest	<20	Site 1	670	20°	S
2	Secondary forest	<20	Site 1	570	42°	SE
3	Secondary forest	<20	Site 1	560	36°	N
4	Secondary forest	<20	Site 1	390	35°	N
5	Secondary forest	<20	Site 1	440	50°	NW
6	Secondary forest	>50	Site 1	620	35°	SE
7	Secondary forest	>50	Site 1	740	26°	NW
8	Pf Plantation	8	Site 2	100	25°	NE
9	Pf Plantation	8	Site 2	100	25°	NE
10	Pm Plantation	24	Site 2	90	10°	N
11	Pm Plantation	24	Site 2	90	10°	N
12	Pm Plantation	20	Site 1	310	31°	S
13	Pm Plantation	20	Site 1	310	22°	N
14	Pe Plantation	9	Site 2	50	30°	NE
15	Pe Plantation	9	Site 2	50	30°	NE

Ordination of the plots

The density data matrix of species and plots was analysed by Detrended Correspondence Analysis (DCA) (HILL & GAUCH, 1980) and Single Linkage Clustering (LAMBERT & WILLIAMS, 1962).

Calculation of the indices of Diversity and Evenness

The Shannon function: H = SUM Pi ln Pi, where Pi is the relative proportional abundance of species i and evenness index E = H / ln S (where S is the number of species with dbh greater than 2 cm) were used to describe the communities.

RESULTS

Ordination of the stands and species

A total of 164 tree species (>2 cm dbh), belonging to 50 families and 97 genera, were recorded in the 15 plots, including two nationally protected species, *Artocarpus hypargyrea* and *Amentotaxus argotaenia.* The result of the DCA ordination showed that native forests were separated from those of plantation plots in the first DCA axis due to a negative relationship with altitude ($r^2 = 0.633$, $p<0.001$). In general, native forests are distributed at higher altitude and have low values between 0 and 2.33, while the plantation plots are usually at low altitude and had relatively high values between 2.44 and 5.07. Two plots of *Pinus elliottii* plantations (Nos. 14 & 15) were grouped together, but no clear isolation was found between *Pinus massoniana* plantations and *Paraserianthes falcataria* plantations. Plot 4 of the native forest was close to plots 14 and 15 of *Pinus elliottii* plantations in the first DCA axis.

Classification of the 15 plots

A clustering dendrogram showed that the study plots could be roughly clustered into 4 groups: *Pinus elliottii* (Pe) plantations, *Pinus massoniana* (Pm) plantations, *Paraserianthes falcataria* (Pf) plantations and native forest. However, one of the plantations of *Pinus massoniana* (Plot 13) is clustered with the group of native forest plots.

The two-way table (Appendix 1) showed that the abundance of the major components in different types of forest communities was different. Many of the species were only confined to native forests, including two nationally protected species and several species in the families Fagaceae, Magnoliaceae, and Theaceae which have large seeds.

By comparison, species present in plantations were usually light-demanding or widespread shrubs and small trees, e.g. *Rhodomyrtus tomentosa, Sapium discolor, Litsea cubeba, Ficus variolosa, Glochidion puberum, Rhaphiolepis indica*, and *Itea chinensis.* Many of these species are usually easily dispersed by birds or by wind. Of these, *Schefflera* *octophylla* and *Sapium discolor* are the favourite food of frugivorous birds in winter (CORLETT, 1992). The seeds of *Itea chinensis* are small and well dispersed by wind

Major characteristics of the four forest communities

In general, the native forests had higher species richness, higher species diversity and evenness than the plantations (Table 2). Of the plantations, *Paraserianthes falcataria* plantations were the youngest. They not only had the highest basal areas but also had relatively high floristic diversities. *Pinus elliottii* plantations had the lowest diversity (Table 2).

Table 2 Floristic characteristics of the four forest communities. The value in brackets is standard deviation. Pf=*Paraserianthes falcataria*; Pm=*Pinus massoniana*; Pe=*Pinus elliottii*.

Forest type	Species richness	Density (per ha)	Basal area (cm^2/ha)	Diversity H	Evenness E
Native forest	35 (7)	3 182 (1244)	23.25 (3.88)	3.07 (0.27)	0.86 (0.04)
Pf plantation	19 (4)	3 763 (1220)	24.21 (0.10)	2.17 (0.30)	0.74 (0.04)
Pm plantation	18 (2)	2 857 (571)	17.25 (11.42)	2.16 (0.12)	0.74 (0.05)
Pe plantation	19 (1)	3 300 (813)	11.38 (2.76)	1.76 (0.06)	0.60 (0.04)

DISCUSSION

Biodiversity of native forest and plantations

Many studies elsewhere have demonstrated that plantations can catalyse the rehabilitation of native flora on degraded tropical lands, but that the effect varies with the species selected for planting, management practice and site conditions (PARROTTA *ET AL.*, 1997; LUGO, 1997; ZHUANG, 1997). Our study showed that *Paraserianthes falcataria* plantations have a greater beneficial effect, both on production and biodiversity, than the coniferous plantations of *Pinus massoniana* and *Pinus elliottii*. The floristic diversities of the plantations are also influenced by seed source availability. It was observed that two plots (nos. 12 & 13) in *Pinus massoniana* plantations were closer to native forest and had more regenerating native trees than those plots (nos. 10 & 11) in site 2, where there was no well- developed native forest. Therefore, the low diversity of the plots in site 2 was possibly due to restricted seed sources. Our study also showed that the floristic composition of the forest communities varied with altitude. One of the reasons for this was because the temperature and moisture of the microhabitats varies with the altitude. The second and more important reason in the present study was because most native forest is confined to higher altitudes, while most secondary forests in the lowlands have been cleared or frequently disturbed by human activities. Therefore, replanting of native species is necessary to facilitate rehabilitation of native forests in the lowland area.

The diversity of native forest is obviously higher than that of plantations. They are precious natural resources and biological heritage and we should protect them. However, the native forests in Zengcheng are mainly dominated by light-demanding species. Many dominant trees in intact forest, such as species in the families Fagaceae and Magnoliaceae, are rare. These species are usually vulnerable to change in habitats because they are poorly dispersed and grow slowly. The seeds of several *Castanopsis* spp. (Fagaceae), such as *C. lamontii*, *C. eyrei*, *C. carlessii* and *C. fabri* are collected from the trees before falling or from the forest floor by local residents. These human activities will decrease the seed population of these species *in situ* and thus affect their regeneration. Planting of these species in ecological plantations can both propagate their population and also provide food for human beings.

Potential utilisation and limitations of native flora in plantations

The importance of native forest to wildlife conservation is gradually becoming understood. Native tree and shrub species have been increasingly required in garden planting and ecological plantations, but they are not able to be widely applied because planting stock of most native species is not available in the local market and information about native plants are generally lacking. It was found in some local nurseries that the seeds and seedlings of many native species could germinate and grow well. However, it is difficult to obtain seed because there are only a few seed and seedling markets of native woody species. In addition, the prices of native species are generally much higher than those of common plantation species like *Eucalyptus* and *Acacia*. Another major limitation is that the growth of many native species is not as fast as that of exotic species. Therefore, screening species for fast growth and high economic and ecological values and decreasing costs of production are key issues for the utilisation of native species in plantations.

Research on seedling production of native species of South China

The project for production of suitable tree species was initially supported by the Forestry Department of Guangdong Province from 1998 and will be supported by Kadoorie Farm and Botanic Garden between 2000-2002.

The main purpose of this project is to establish a production nursery for native tree seedlings that are suitable for reforestation and urban planting in South China including Hong Kong. The second purpose is to set up an arboretum with native tree species that have high utilisation potential in South China. Both the nursery and arboretum will also serve as research sites for the study of native plants. The long-term objective is to accelerate the natural process of forest succession on degraded lands in South China. In 2002, the Nursery aims to produce 200,000 seedlings of 60 native species.

The project started last year when seeds of 54 native tree and shrub species in 30 families and 44 genera (Appendix 2) from local secondary forest were collected and sown in the nursery. More than 70% of species produce fresh fruits/seeds which can provide food for birds or mammals. Some species such as *Acer cinnamomifolium*, *Rhodoleia championii*, and *Tutcheria championii* can also potentially be used for ornamental or urban planting. For each species, mean size and weight of the fruit/seed were measured and recorded. Seeds were sterilised with a 0.5% $KMnO_4$ solution for 30 minutes and soaked in water for 1 day before sowing in seedling beds containing sandy soil. No special treatments were conducted to stimulate seed germination except for a few species with a hard and thick seed/fruit coat, which were soaked in hot water before sowing. To date, approximately 20 species have germinated successfully in the greenhouse (Appendix 2).

The use of stem cuttings is also an important approach for seedling production and is especially necessary for species with low seed production or low seed germination rates. An experiment on stem cuttings was done on a few shrub species such as *Ficus hirta, Melastoma sanguinea, M. candidum, Rhodomyrtus tomentosa, Ilex asprella* last year. The preliminary results show that many of these species could produce new roots and shoots from cuttings, but the survival rates vary with the season and are usually low in summer. Cutting trials will be continued on other species this year.

The first batch of 10 native species, including species of the families Magnolicaeae and Fagaceae will be planted in the demonstration site in March this year. At least 30 native species will be planted for demonstration before 2003. Monitoring of survival and growth of planted seedlings will be conducted soon after planting.

CONCLUSION

Native forests have richer diversity than plantations, but most of the existing secondary forests in Zengcheng are dominated by light-demanding pioneer species. Plantations can catalyse the rehabilitation of native flora, but the effects vary with the species chosen for planting, altitude and distances from intact forests that produce seed. *Paraserianthes* plantations are better than coniferous plantations for both growth and floristic diversity.

Planting native species can accelerate recolonisation of degraded forest sites by native flora and fauna. Major limitations for the use of native species are lack of planting material of most native species in local markets and shortage of information about propagating native trees. Our project to produce seedlings of native species aims to accelerate rehabilitation of native forests in South China by providing suitable seedlings for both plantations and urban planting.

ACKNOWLEDGEMENTS

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QUESTIONS AND COMMENTS

Yadi Setiadi.

What measures have been taken to prevent attack by pest insects, which we have had in Indonesia?

Zhuang Xueying

I know that there have been such problems in our urban plantings, but not in these plots which are less than 30 years old. However, I would be concerned about pest problems with all exotic species.

John Parrotta

The forest fragments – how well protected are they? Do you have the support of the forestry bureau and local people in the province? This would be good for you to promote larger scale production in the future.

Zhuang Xueying

The forest fragments are currently protected – cutting is forbidden by a policy introduced last year. Plantations are separate. They can be cut, but only for conservation purposes. Usually in private plantations, they are harvested after about 5-6 years, which can cause problems to have such short rotations, but now they are starting to protect the understorey and to encourage other vegetation to grow. This project is supported by the local government and also by the farmers.

Appendix 1 Two-way table of clustering analysis for the 15 plots on density data.

Forest Type	Plot No Species	14	15	8	9	10	11	12	13	4	1	2	3	5	6	7
Pm	*Adina pilulifera*	1	4		2	8	7			1						
	Rhodomyrtus tomentosa					10	4	4	2	2						
	Pinus massoniana					40	47	37	9	1						
	Zanthoxylum avicennae		1			1	3			4						
	Melastoma candidum						1	1	1							
	Camptotheca acuminata							6	4							
Pe	*Sapium discolor*	1	1	8	8	1	2	1	4	1						
	Litsea rotundifolia	2	1		1			1	3		2	1				
	Rhus chinensis	30	17	2												
	Ilex asprella	8	2			1										
	Phyllanthus emblica	4	3													
	Pinus elliottii	82	58													
	Eurya ciliata	2		1												
	Liquidambar formosana	4	1													
Pf	*Glochidion puberum*	9	5	1	20	13	2		1							
	Aporosa dioica	1	1		3	3	1									
	Litsea cubeba			3	18	4	7									
	Rhus succedanea	1			8	1	2									
	Cratoxylon cochinchinense	1	4		2											
	Microcos paniculata		3		1	1										
	Evodia lepta				38	6	7		1							
	Paraserianthes falcataria			15	45											
Native forest	*Ficus variolosa*		2		1	3	14	1	1		20	13	3	9	3	8
	Diospyros morrisiana				11			5	5	1	6	5	4	4		
	Syzygium buxifolium									6	6	7	2	6	7	2
	Castanopsis fissa		2					1			1	1		1		1
	Schefflera octophylla	1		1	3	7	5			20				3		
	Randia cochinchinensis			1							5	10	2	6		6
	Rhaphiolepis indica		1			5					1	7	4			7
	Cinnamomum parthenoxylon	1			2									3	2	1
	Helicia reticulata							1		2	2			2	4	
	Rapanea neriifolia								3	2	22	33		11	2	5
	Lithocarpus harlandii										10	9	5	2	12	
	Engelhardtia fengelii											2	3	2		1
	Symplocos lancifolia										2	3			1	1
	Itea chinensis				7	5	1	1	57	1	14	2		1		
	Machilus chekiangensis									4	1				2	1
	Machilus velutina									1		1	4	2		
	Machilus breviflora										11	1	1	8		2
	Altingia chinensis											8	4		2	1
	Illicium dunnianum											1		1	1	
	Euyra nitida											14	2	11		2
	Ormosia semicastrata								12		7	1				2
	Elaeocarpus chinensis										2			1	1	
	Litsea verticillata										2		1	1		
	Pentaphylax euryoides							1						2	1	
	Lithocarpus glaber													3	1	3
	Homalium cochinchinense											1	3		3	
	Artocarpus hypargyrea											1		3	1	

Forest Type	Plot No Species	14	15	8	9	10	11	12	13	4	1	2	3	5	6	7
Native	*Ilex virdidis*							2	2		11			1		
Forest	*Eurya trichocarpa*									14			1	1	12	
cont.	*Euyra macartneyi*										17	21		2		1
	Reevesia pubescens							1			4		1			
	Beilschmiedia intermedia										5	1			1	
	Beilschmiedia percoriacea													1	1	
	Symplocos lancilimba													1	1	
	Tricalysia dubia											3		4		
	Diospyros kaki									2					3	
	Cinnamomum wilsonii											1			2	
	Ilex formosana												5		13	
	Cryptocarya chinensis													1		20

Note: Only 61 major species are shown. Planted species shown in bold.

Appendix 2 The life form, fruit type, potential dispersal agency, current germination status of the species being studied in the project.

Family	Species	Life form	Fruit type	Dipersal[1]	Treat-ment[2]	Germination[3]
Aceraceae	Acer cinnamomifolium	tree	samara	W		+
Anacardinaceae	Choerospondias axillaris	tree	drupe	M	*	++
Aquifoliaceae	Ilex asprella	shrub	berry	B		-
	Ilex pubescens	shrub	berry	B		++
	Ilex rotunda	tree	berry	B		-
Araliaceae	Aralia chinensis	shrub	berry	B		++
	Schefflera octophylla	tree	drupe	B		++
Caprifoliaceae	Viburnum sempervirens	shrub	berry	B		-
Chloranthaceae	Sarcandra glabra	shrub	berry	B		++
Ebenaceae	Diospyros chunii	tree	berry	B & M		+
	Diospyros morrisiana	tree	berry	B & M		-
	Diospyros tsangii	tree	berry	B & M		++
Euphorbiaceae	Antidesma japonica	shrub	drupe	B		++
	Mallotus apeltus	tree	capsule	B		+
	Sapium discolor	tree	capsule	B		+
Fagaceae	Castanopsis eyrei	tree	nut	unknown	*	-
	Castanopsis fabri	tree	nut	unknown	*	-
	Castanopsis fissa	tree	nut	unknown	*	++
	Cyclobalanopsis flueryi	tree	nut	unknown	*	+
	Cyclobalanopsis hui	tree	nut	unknown	*	-
	Lithocarpus glaber	tree	nut	unknown	*	-
Hamamelidaceae	Altingia chinensis	tree	capsule	W		++
	Liquidambar formosana	tree	capsule	W		++
	Rhodoleia championii	tree	capsule	W		+
Hyperiaceae	Cratoxylum cochinchinense	tree	capsule	W		+
Lauraceae	Litsea rotundifolia	shrub	drupe	B		+
	Phoebe shearei	tree	drupe	B		++
Magnoliaceae	Tsoongiodendron odorum	tree	follicle	B		+
Melastomataceae	Melastoma candidum	shrub	capsule	B		++
	Melastoma sanguineum	shrub	capsule	B		+
Moraceae	Ficus hirta	shrub	fig	B & M		++
Myrsinaceae	Ardisia crenata	shrub	berry	B		++
Myrtaceae	Rhodmyrtus tomentosa	shrub	berry	B		++
	Syzygium buxifolium	shrub	drupe	B		++

Family	Species	Life form	Fruit type	Dipersal[1]	Treat-ment[2]	Germination[3]
Papilionaceae	Ormosia semicastrata	tree	legume	B	*	+
Pittosporaceae	Pittosporum glabratum	shrub	capsule	B		-
Podocarpaceae	Podocarpus flueryi	tree	drupe-like	M	*	+
Rhamnaceae	Hovenia dulcis	tree	drupe	B & M		-
Rosaceae	Pyrus calleyriana	tree	pome	B		++
	Rhaphiolepis indica	shrub	pome	B		++
Rubiaceae	Gardenia jasminoides	shrub	berry	B & M		+
	Psychotria rubra	shrub	berry	B		++
	Tricalysia dubia	tree	berry	B		-
Rutaceae	Evodia lepta	shrub	capsule	B		-
	Evodia meliaefolia	tree	capsule	B		-
Staphyleaceae	Euscaphis japonica	tree	capsule	B		-
	Turpinia arguta	shrub	drupe	B		-
Styraceae	Rehderodendron kwangungensis	tree	dry fruit	unknown		-
Theaceae	Eurya chinensis	shrub	berry	B		++
	Tutcheria championii	tree	capsule	unknown		++
	Tutcheria microcarpa	tree	capsule	unknown		++
Tiliaceae	Microcos paniculata	tree	drupe	B		-
Ulmaceae	Trema cannabina	shrub	drupe	B		-
Verbenaceae	Callicarpa pedunculata	shrub	drupe	B		-

Notes: [1]Agency of dispersal: B=bird, M=mammal, W=wind;
[2]Treatment: *=soaked in hot water before sown;
[3]Germination status: ++ = well germinated, + = poor germinated, - = not germinated.

Erythrina subumbrans (Hassk.) Merr. (Leguminosae, Papilionoideae) – this very fast-growing thorny tree has spectacular scarlet flowers that produce copious amounts of nectar relished by birds.

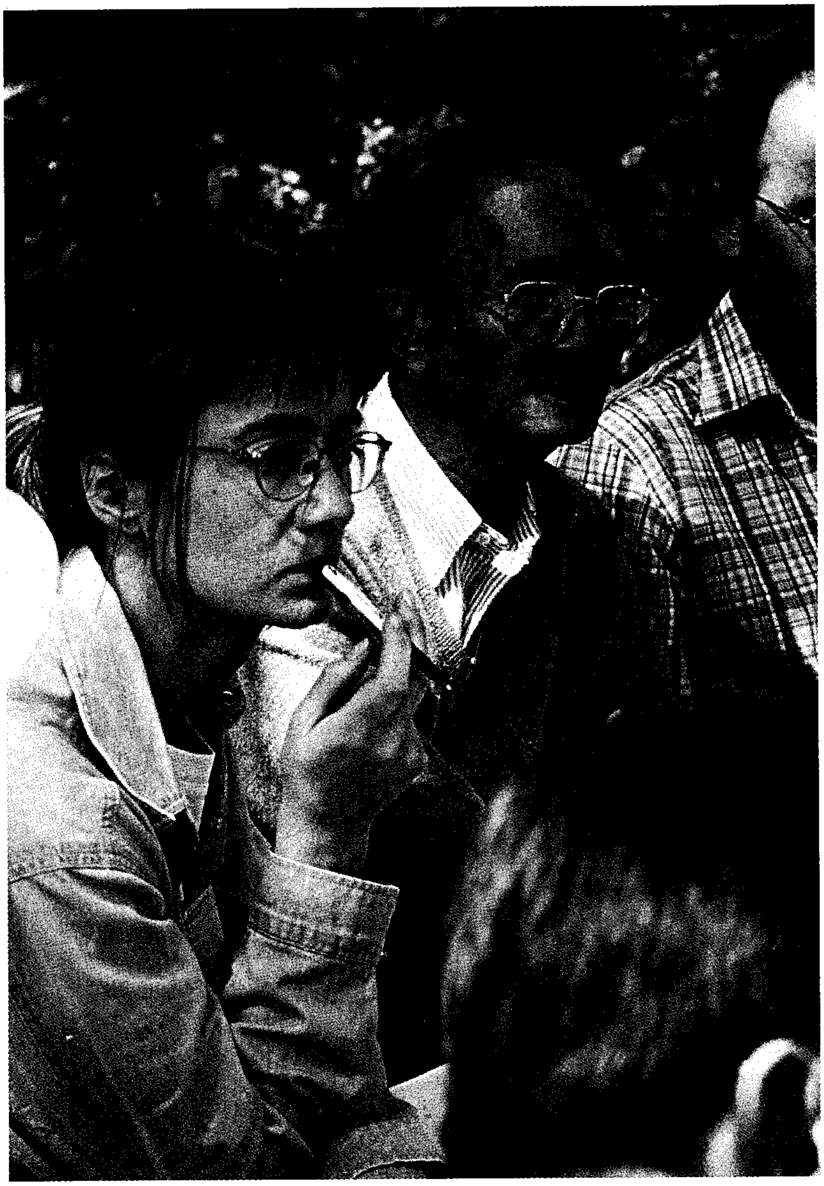
PART THREE

ACCELERATED NATURAL REGENERATION

Editor

Kate Hardwick

Tree stumps – an often-neglected component of natural regeneration.



Kate Hardwick (left) ponders a question on accelerated natural regeneration with Sein Maung Wint (right) at one of the field discussions during the workshop.

INTRODUCTION

Kate Hardwick

Throughout history, vast forests have regenerated naturally after large-scale natural and man-made disturbances. There is evidence of extensive forest regeneration after widespread fire and agriculture in the tropics (see review in LAMB *ET AL.*, 1997). Pollen records show that forests spread across North America and Europe at rates of up to 1 kilometre per year, following glacial retreat at the end of the Pleistocene (CLARK, 1998).

Humans have long used this natural phenomenon to their advantage. For thousands of years, shifting agriculture has been practised in small clearings and, on a larger scale, foresters have manipulated forest regeneration after logging to maximise the re-growth of desirable timber species (e.g. the Malayan Uniform System). However, the concept of actively promoting natural regeneration to reforest extensive degraded lands is relatively recent, first emerging in the Philippines in the 1970s (JENSEN & PFEIFER, 1989). The Filipinos coined the term "assisted natural regeneration" or "ANR" to describe this approach, although the term "accelerated natural regeneration" is preferred in some circles (DRILLING, 1989). ANR has been implemented and developed in the Philippines for over 20 years, but until now there has been very little published information to enable other nationalities to learn from their experience.

ANR is a flexible reforestation approach, which depends on identifying factors limiting regeneration of woody plants, then implementing management techniques to overcome those factors. In the Philippines, the key limiting factors were fire and growth of weeds, so the methods used included protection from fire and weed control around naturally established woody seedlings or coppice sprouts (DALMACIO, 1987). One innovative technique was to control grass by flattening it using wooden planks suspended by rope handles, rather than cutting it, which tends to stimulate tillering (SAJISE, 1972). Where other factors are found to be limiting, different techniques may be more appropriate.

Even recently abandoned sites, dominated by grass and forbs, may harbour a surprisingly high number of species of tree seedlings, growth of which can be encouraged by ANR techniques. VAN SON explores this idea in Vietnam in the second paper in this part of the proceedings. However, where there is a low density of woody regeneration, or where desired species are missing, tree species may need to be artificially introduced through enrichment planting of seeds or seedlings. This will usually take place after initial ANR treatment has been implemented for at least one year to promote natural establishment of woody plants and decrease weed competition. Whether the ultimate objective is wildlife conservation or economic plantations, ANR is an effective first step. As the vegetation develops, it serves as a nurse crop for late secondary and primary species, which are planted or establish naturally later on. In some cases, it may be possible to increase natural dispersal of seeds into sites undergoing restoration by providing perches or roosting sites for birds and bats or by planting groups of fruit-bearing trees and shrubs to attract them.

ANR offers an efficient, technologically simple and cost-effective approach to forest restoration. Comparisons carried out in Indonesia showed it to be 26 - 72% cheaper than traditional methods of intensive tree planting (DRILLING, 1989). It is particularly appropriate for remote and inaccessible areas where tree planting would present practical difficulties. Furthermore, by allowing tree communities to re-establish naturally, it ensures that they are ecologically appropriate to the site. Despite these advantages, there has been some resistance to ANR among foresters. One practical drawback of ANR is that both the final species composition of the restored forest and the amounts of time needed to achieve forest cover are uncertain. Also, it is possible that ANR may not be effective in areas far from tree seed sources, although it is not known exactly how close source areas should be.

The first paper in this part shows how ANR fits into the broad range of forest restoration approaches now under development and provides an ecological background to natural regeneration in the seasonal tropics. HARDWICK *ET AL.* review information relevant to developing protocols for site assessment and new methods of ANR and identify areas in need of further research. This general review is followed by two case studies from Southeast Asia. VAN SON concentrates on the botanical side of forest regeneration; his study of agricultural fallows in Vietnam clearly demonstrates the natural process of succession that ANR seeks to accelerate. In the final paper, DUGAN provides a social context for ANR. After presenting an example of its application, he discusses the general uptake of ANR in the Philippines, highlights the importance of community participation and suggests ways of making ANR more socially attractive.

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RESEARCH NEEDS FOR THE ECOLOGY OF NATURAL REGENERATION OF SEASONALLY DRY TROPICAL FORESTS IN SOUTHEAST ASIA

K. A. Hardwick[1], J. R. Healey[1] and D. Blakesley[2]

ABSTRACT

Widespread forest restoration on degraded lands is needed to meet local and national targets for natural forest cover. Accelerated natural regeneration (ANR) is a relatively cheap method of reforestation, which encourages natural establishment of trees and shrubs. It requires a low input of labour but a high input of ecological information. In this paper, the knowledge required to predict and manipulate natural regeneration of seasonal tropical forest is reviewed and areas in need of further research are identified.

Forest regeneration is influenced by four groups of potentially limiting factors. (1) Disturbance: how can we minimise the negative and maximise the positive effects of fire and grazing? (2) Site resources: how do spatial and seasonal variations in moisture availability affect regeneration and how do they interact with other limiting factors? Under what circumstances are low levels of mycorrhizal inoculum limiting and how can they be increased? (3) Weed competition: how do competition and facilitation vary with season, weed species and the size and species of tree seedling? (4) Plant and propagule availability: how can stumps, seedlings and the seed rain be quantified and plant establishment from them predicted? How can the seed rain be increased?

We should collate all available information to create tools that will enable managers to judge the regeneration potential of sites and to select the most appropriate ANR techniques.

Key words: accelerated natural regeneration; succession; forest restoration; monsoon forest

INTRODUCTION

Destruction of Southeast Asia's seasonally dry tropical forests is widely acknowledged to be a serious problem, causing degradation of water catchments, losses of biodiversity and exacerbating rural poverty. Most countries are now attempting to solve the problem by protecting remaining forest. However such forest is often too degraded to meet the need for

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healthy, natural forest. For example, in Thailand government policy is for 25% of the total land area to be covered with conservation forests (LEUNGARAMSRI & RAJESH, 1992), but at present less than 23% is forested (FAO, 1997) and much of the forested area is made up of commercial plantations and severely degraded natural forest. There is a need to restore original forest ecosystems, where they have been partially or totally destroyed, to meet local and national objectives, including countries' international obligations following the United Nations Conference on Environment and Development.

Large-scale restoration of complex tropical forests is a comparatively modern dilemma, which has been approached in a variety of ways in recent years (Table 1). Each approach involves either introducing plant material to the site or encouraging natural regeneration of woody plants or a combination of the two. Planting seedlings is the most labour- and capital-intensive option, as it involves human input at all stages of the regeneration process: collecting seed, raising seedlings in a nursery, planting and maintaining the seedlings until they can survive and grow without further attention. Encouraging natural regeneration requires less human input and is thus a cheaper alternative, but it demands a higher input of ecological information about each site. Furthermore, it can only be used on sites where there exists, or there is the potential for, sufficient woody regeneration to be accelerated (Fig. 1).

Table 1. Various approaches to forest restoration.

Restoration approach	Stage 1 (site capture)	Stage 2 (species enrichment)	Examples
Staggered planting of primary forest spp.	Plant a mixture of exposure-tolerant spp.	Plant a mixture of "shade-demanding" spp.	KNOWLES & PARROTTA, 1995
Framework spp. method	Plant a mixture of "framework" spp.	Encourage subsequent natural regeneration	GOOSEM & TUCKER, 1995
Catalytic monoculture	Plant a catalytic monoculture	Encourage subsequent natural regeneration	PARROTTA, 1993 LUGO, 1997
ANR[a] with enrichment planting	Encourage natural regeneration	Plant missing primary spp.	DALMACIO, 1987 (unpublished)
ANR without enrichment planting	Encourage natural regeneration	Encourage natural regeneration	

[a]ANR = accelerated natural regeneration

This paper focuses on research needs for accelerated natural regeneration (ANR). In ANR, natural establishment of tree and shrub species is promoted and any missing, but desired, species are subsequently introduced by enrichment planting. Enrichment planting will not be included here, since the methods involved are covered in other parts of this volume. Some successful ANR techniques include fire prevention, weeding around naturally established trees and shrubs by cutting or pressing (DUGAN, 2000) and using domestic cattle to trample and eat weeds, while dispersing seeds through their faeces (JANZEN, 1988). Techniques that have been tested but not implemented on a large scale include erecting perches to encourage seed dispersal by birds (McCLANAHAN & WOLFE, 1993; HOLL, 1998) and scattering tree seeds (SUN & DICKINSON, 1995).

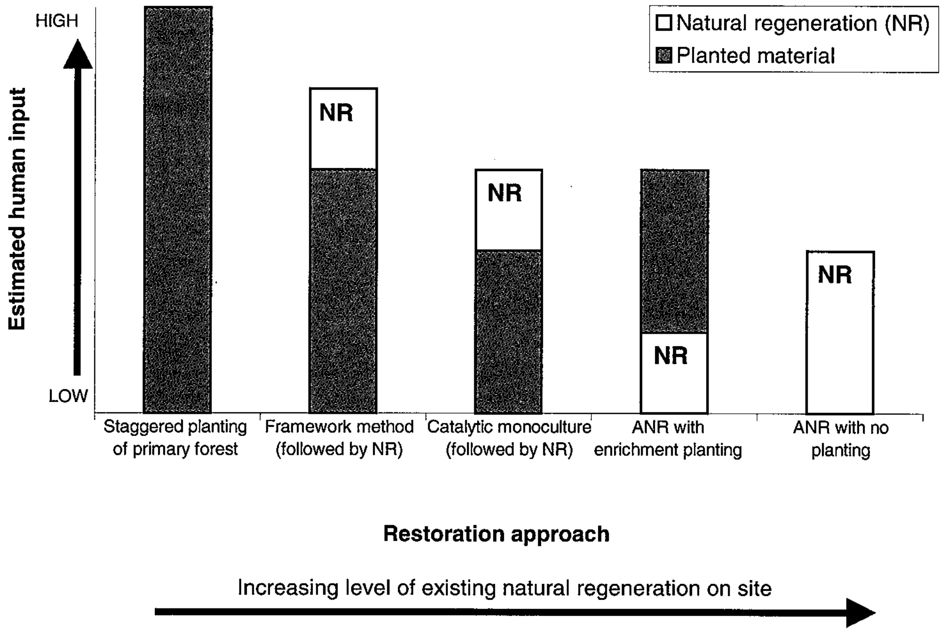

Figure 1. A summary of the range of approaches to forest restoration, showing relative levels of human input involved and the role of planted material and natural regeneration in each. The level of human input declines with decreasing emphasis on planting, although the columns are not to scale or based directly on actual economic data. From left to right, the use of natural regeneration increases with the level of natural regeneration already present on site.

Research priorities are identified from the perspective of managers or landowners faced with restoring degraded land for conservation. Managers will have to make certain decisions and will need ecological information to do so. The decision-making process will be briefly outlined and relevant ecological knowledge reviewed. Gaps in the present knowledge base will be highlighted and suggestions made for further research and for collation and distribution of research results.

MANAGEMENT DECISIONS

To select an appropriate approach to forest restoration, a manager must first assess actual and potential levels of natural regeneration. It is important that the whole area for restoration is carefully observed, since the level of regeneration may be highly heterogeneous, depending on distances from nearest seed sources, aspect, topography, soil type, duration and intensity of past use and time since last disturbance. The most appropriate restoration approach may vary considerably within a heterogeneous site. For example, it may be best to confine ANR to certain actively regenerating parts of the site, such as edges or isolated islands around fruiting trees, while planting framework species in central areas, further from seed sources. If ANR is considered appropriate for a site, the next decision will be what site management techniques to use to accelerate regeneration most effectively. The aim of the techniques will be to overcome factors limiting succession. These factors can be divided into four groups:

1) disturbance,
2) resources (too high or too low),
3) weed competition and
4) lack of established plants or propagules.

Any single technique may overcome one or several limiting factors (Table 2). Managers must not only choose the most appropriate techniques for each site, but also plan the timing of application of each technique. The latter is an important consideration in a seasonal climate and requires an understanding of the changing nature of limiting factors with the seasons. The choice of restoration approach and specific management techniques will be dictated by the particular limiting factors operating at each site and the levels of these should be assessed.

It is important to consider the limiting factors operating at all stages of the regeneration process, namely seed production and dispersal, and seedling recruitment, establishment and growth (HARDWICK *ET AL.*, 1997). A technique to overcome a factor limiting an early stage in the process would be useless if another factor limiting a later stage were ignored. It is notable that those techniques that affect the existing vegetation influence all limiting factors, in either a positive or negative way (Table 2).

EXISTING KNOWLEDGE BASE AND RESEARCH NEEDS

Qualitative indices of both existing regeneration and of the severity of limitations should be developed to help the manager interpret the results from the site assessment. The ecological information needed to establish data-collection protocols and to develop indices to help interpret the site data will be explored in this section[3]. Each group of limiting factors will be considered in turn.

[3] See Part 7, research proposal 1.1.

Table. 2. Factors limiting forest regeneration and the techniques to overcome them. An "x" indicates which limiting factors are affected by each technique.

Techniques	Limiting factor				
	Disturbance	Site resources		Weed competition	Plant/propagule Availability
		Soil	Micro-climate		
Guarding	x				
Fire-breaks	x				
Fencing	x				
Cultivation	x (↓ fuel)	x (↓ compaction)	x (↓ plant cover so ↑ light)	x	x (↑ germination?)
Weed control	x (trash ↑ fuel)	x (trash = mulch)	x (↑ light, ↓ humidity, but trash shades soil)	x	x (↑ germination?)
Thinning woody growth	x (trash ↑ fuel)	x (trash = mulch)	x (↑ light, but trash shades soil)	x	x (↑ germination & coppicing?)
Controlled burning	x (↓ fuel)	x	x (↑ light, ↓ humidity)	x	x (↑ germination & coppicing?)
Grazing	x (↓ fuel)	x (manure ↑ nutrients)	x (↑ light, ↓ humidity)	x (weeds eaten & trampled)	x (seeds eaten & dispersed by animals)
Bird perches		x (bird droppings ↑ nutrients)			x
Tree seed scattering					x
Tree seed planting[a]					x (protects from predation)

[a] Seedling planting techniques have been omitted as they are covered in other papers.

1. Site disturbance regime

Fire is the predominant form of disturbance in seasonal tropical forests. Although rare fires are arguably a natural part of the ecosystem in deciduous forests (STOTT, 1986), fire in the montane evergreen forests are invariably started by man and lead to forest degradation.

Controlled burning at the start of the restoration process has been used as an ANR tool in Amazonia (NEPSTAD *ET AL.*, 1990) to reduce weeds and leaf-cutter ants, which are severe limiting factors there. However, its suitability for Southeast Asia is questionable: uncontrolled annual burning is one of the key causes of forest restoration failure in northern Thailand (pers. obs.). Fire could potentially be useful for opening up poorly regenerated sites dominated by colonisation-resistant weeds, such as ferns. In addition, it stimulates root suckering in *Rhus chinensis* (pers. obs.) and may have a similar effect on other tree species. However, the risk of fire spreading to surrounding areas may outweigh any potential benefits. The risk of accidental fire is highest in highly degraded, grass-dominated sites and decreases as regeneration proceeds and the grass is shaded out. When the trees reach a certain height they may be able to withstand occasional low intensity fires.

Like fire, grazing has both positive and negative effects and needs to be strictly controlled. In Costa Rica, grazing severely reduces woody regeneration in plantations (HAGGAR *ET AL.*, 1997), but cattle have been used to promote regeneration by suppressing grass and dispersing heavy seeds through their faeces (JANZEN, 1988).

Research needs

The potential for controlled burning in ANR should be further investigated[4], if it is judged to be socially and politically acceptable. The timing of fire susceptibility in relation to successional stage is loosely understood but needs to be more clearly defined so that managers can plan long-term maintenance and protection. For how long should sites be protected from fire? Should controlled burns be used when the trees reach a certain height to reduce fuel loads and thus lower the risk of accidental fire and uncontrolled spread of intentional fires? Is it practical and economic to plant tall, more fire- and grazing-resistant saplings or cuttings in areas where disturbance is unavoidable? In fire-prone grasslands, it is particularly important to identify fast growing species that can regenerate after burning - they may be the only species able to establish.

The effectiveness and practicality of using domestic animals as an ANR tool in seasonal Southeast Asia warrants further attention. In heavily grazed areas, where grazing clearly limits natural regeneration, the priority should be to identify unpalatable species to be planted or encouraged in the initial site capture stage.

2. Site resources

In moist areas, light is the critical limiting factor for the regeneration of most tree species (i.e. the more the better). In dry areas, water is most limiting and too much sunlight can be detrimental, causing damagingly high leaf temperatures that cannot be ameliorated by the cooling caused by transpiration. Thus in seasonal climates, the key limiting factors

[4] See Part 7, research proposal 3.2.

are likely to fluctuate from light to water according to season. It also follows that the effect of "nurse trees" (whether naturally established or planted) on woody regeneration may be related to site moisture availability (PARROTTA *ET AL.*, 1997). On drier sites, established trees would compete for water with the regenerating seedlings, while simultaneously providing beneficial shade and higher air humidity. The net effect is likely to vary between positive and negative in different situations, but most of the evidence is still anecdotal.

Direct measurement of site resources, such as soil nutrients, soil moisture, temperature, light and humidity are time consuming, costly and require the use of equipment which may be unavailable to the manager. It is thus more practical to infer the level of resources from widely available climatic data and from easily observable on-site factors that regulate and/or indicate the level of resources, e.g. the structure and composition of the soil and dominant vegetation.

Nutrient availability is a key factor in the restoration of post-industrial and primary successional land, but its importance in secondary succession, where there is an intact soil, is much less clear. It is believed that the ability of trees to take up available soil nutrients is improved by symbiotic mycorrhizal associations (HARLEY & SMITH, 1983; READ *ET AL.*, 1992), which are often specific to particular tree species. However, again there is a severe lack of knowledge concerning the importance of mycorrhizal fungi availability as a limiting factor in tree regeneration. This is partly due to the difficulty of identifying the different species. Abandoned agricultural sites are unlikely to lack mycorrhizal fungi, although the number of species of fungi that form symbioses with forest trees may be greatly depleted (MUSOKO *ET AL.*, 1994). Primary successional sites, such as abandoned mine sites, are often severely deficient in mycorrhizal fungi, and fungal inoculation has been found to be an effective intervention to promote tree establishment in a dry tropical environment (WILSON *ET AL.*, 1991).

Research needs

More research is needed to compare the efficacy of different ANR techniques in relation to season and site moisture availability, with particular emphasis on the "catalytic" effect of nurse trees. Also, the depletion of mycorrhizal fungi populations, after different intensities of disturbance, warrants further attention. Research into inoculation methods for mycorrhiza-deficient soils would be of particular value.

3. Weed competition

Although in temperate climates any vegetative cover is seen as a barrier to tree colonisation (HILL *ET AL.*, 1995), in the seasonal tropics the effect varies according to season, due to the seasonal fluctuations in site resources mentioned above. For example, in northern Thailand, during the rainy season, weeds compete with young tree seedlings for light and retard growth, but in the hot dry season they can protect seedlings from damagingly high levels of solar radiation (HARDWICK 1999).

Different weed communities have different levels of resistance to colonisation by tree species. In a study in temperate North America, HILL *ET AL.* (1995) found that weed canopy height was the crucial factor. Different weed communities equally inhibited the growth rate of newly established seedlings, but growth increased dramatically once seedlings emerged above the weed canopy. Thus the higher the weed canopy, the slower the rate of tree colonisation: shrub communities with a high canopy were more resistant to colonisation by trees than low growing grass communities. By contrast, in tropical Amazonia, the shrub *Cordia multispicata* was more favourable for tree seedling growth than the grass *Panicum maximum*, as it increased soil nutrient availability, litter nutrient concentrations and light availability (VIEIRA *ET AL.*, 1994).

HILL *ET AL.* (1995) devised two measurements for comparing the invasibility of different weed communities: the Establishment/Emergence Ratio (the ratio of the number of seedlings established in a given year to the number of those seedlings that survive to reach 2 m in height) and the Time to First Emergence (the time taken for the fastest growing seedling in a cohort to emerge above the weed canopy). This approach could usefully be adapted to tropical environments

Research needs

Research is needed to grade the common weed communities in seasonal Southeast Asia according to their "resistance" to tree colonisation, possibly using the indices of HILL *ET AL.* (1995). Also more research is needed to clarify the protective or competitive roles of different weed species according to season, so that weed removal can be timed for optimum benefit.

4. Established plant / propagule availability

Regeneration of forest tree species may arise either from existing on-site sources (tree stumps, seedlings or a soil seed bank) or from incoming seed rain. The soil seed bank will not be considered here as after long-term disturbance it is likely that any seeds deposited during the time of forest cover will have died or germinated (NEPSTAD *ET AL.*, 1996) and the soil seed bank is likely to be dominated by weed seeds.

a) Stumps

Researchers agree that the most rapid establishment of forest cover is from sprouting tree stumps (coppicing), (DE ROUW, 1993). Primary forest species are as likely as secondary species to regenerate from stumps (DE ROUW, 1993 ; KAMMESHEIDT, 1998) and when they exist in disturbed areas they should be the focus of initial ANR efforts. Coppicing stumps have greater resistance to fire and browsing than young seedlings and their faster initial growth rate enables them to grow above the weed canopy more quickly.

The manager will need to know which stumps are likely to produce sprouts. There is much variation between species in their ability to resprout after repeated cutting and in particular after burning (DE ROUW, 1993 ; MILLER & KAUFFMAN, 1998) but as yet, no satisfactory functional grouping has been developed to explain and predict differences in coppicing ability. Physical characteristics of stumps may help to predict sprout production. Many studies have found that stump height is a key factor influencing the occurrence and vigour of sprouting (e.g. KHAN & TRIPATHI, 1989; JOHANSSON, 1992; MISRA *ET AL.*, 1995). NEGREROS-CASTILLO & HALL (2000) found that the number and height of sprouts was related to the parent tree diameter and RIJKS *ET AL.* (1998) found that sprout production from *Chlorocardium rodiei* (Lauraceae) stumps in Guyana was less likely for hollow stumps than for intact ones. Sprout number may not be the best indicator of establishment success from stumps; in many circumstances the growth rate of the largest sprout is more significant and in some cases this is negatively correlated with sprout number. However, sprout number becomes more important if sprouts suffer significant mortality (e.g. due to fire or herbivory) and the maintenance of a large "sprout bank" may then be important. Tall stumps have a better chance of surviving fire, browsing and weed competition as the vulnerable sprouts are produced above the height of disturbance.

Where possible, there is enormous value in influencing the nature of the initial disturbance to maximise the density and height of live stumps. This may be feasible when the forest is being cut for timber or short-term, shifting-cultivation agriculture.

Research needs

Much of our knowledge of coppicing comes from dry, naturally fire-prone areas of the world (such as African miombo, Australian savannah and American chaparral), where resprouting is an important natural regeneration mechanism. The information presented above needs to be tested in moister areas of the seasonal tropics (such as montane northern Thailand and Indo-China), where fire has become more prevalent due to the impact of human beings and where the native species may be less able to coppice, or may suffer higher rates of mortality following coppicing, e.g. due to fungal infection. An assessment of the ability of evergreen forest species to coppice after fire is particularly important. Also, we need to know what can be done to stimulate sprout production from stumps, for example weeding, recutting or application of hormones. Is there such a thing as stump dormancy or is a non-sprouting stump a lost cause? Identification of stumps is a valuable management activity, which will be examined further in the final section.

b) Seedlings

A protocol is needed for the survey of seedling regeneration, so managers may gather relevant data that will enable them to predict the regeneration potential of the site. Seedling density alone is not a good indicator of regeneration potential because the probability of establishment of an individual seedling is closely related to its size (HARCOMBE, 1987): the probability of success of a seedling 1.2 m tall is much greater than one that is 20 cm tall. Although the nature of the size-survivorship relationship varies between species (CONDIT *ET AL.*, 1998), it would be practical to identify a minimum size for inclusion in the seedling survey, which can be applied to all species. SAJISE *ET AL.* (1989) have recommended a minimum height of 15 cm in the Philippines, but this limit needs further testing in other locations and across a range of species. Rather than measure the size of each individual seedling it may be more efficient to count seedlings in a number of rough and ready size classes, e.g. knee to waist, waist to chest, and above (for a standard-sized forester!). As the probability of a seedling successfully developing into an adult tree may be much greater once it has grown above the weed canopy, it may be more useful to record the seedlings' height relative to the top of the weed canopy, i.e. the distance above or below it, or simply whether they are taller or shorter.

An alternative indicator of site regeneration potential is seedling frequency, which here refers to the percentage of sample plots of a given size in which seedlings of woody species are present. In the Philippines, a unit area of 1 m^2 has been used (SAJISE *ET AL.*, 1989). Seedling frequency may be more important than the average density across a whole site, as seedling distribution can be very clumped. A site is more likely to be successfully colonised when seedlings are widely dispersed because mortality is usually high in dense seedling clumps and "safe sites" for seedling establishment are often few and far between.

Research needs

There is a need for long-term monitoring studies, to assess the initial condition of tree and shrub seedlings using several variables (e.g. density, frequency, species, absolute height, diameter, relative height below or above the top of the weed canopy) and the subsequent course of regeneration. After a few years, information on successfully established seedlings should be compared with the initial site data to see which index (single variable or combination of variables) best predicted the outcome (NDAM, 1998). A long-term study is needed. Tools for seedling identification are also seriously lacking and this need is explored further in the final section.

c) Seed rain

After severe and prolonged disturbance, remnant stumps, seedlings and the soil seed bank will be sparse or absent, so the potential for natural regeneration will depend entirely on incoming seed rain. An understanding of seed shadows (i.e. patterns of seed dispersal) is crucial for predicting which potential parent trees will contribute seed to a clearing - an important step in assessing the regeneration potential of sites. A two-curve model has been proposed to describe an individual tree's seed shadow (CLARK, 1998). According to this model, most seeds produced by a tree are locally dispersed and their density declines exponentially with distance from the tree, i.e. density falls off steeply with distance. Approximately 10% of the seeds are dispersed over long distances. Their seed shadow is described with a "fat-tailed" curve. Seed density gradually diminishes and extends over great distances of 1 to 10 km. Little is know about the long-distance component of the seed rain, as it is difficult to measure due to the very low density of seeds. However, this component is essential for the regeneration of isolated sites.

Tall, fruiting trees located in and adjacent to a site make the biggest contribution to the seed rain irrespective of the overall species composition of surrounding forest (HARDWICK, 1999), so managers may be able to predict the species composition of the seed rain by surveying these potential parent trees. Caution is needed in interpreting seed rain data, because species differ in the number of seeds expected to produce a single seedling (HARDWICK, 1999). However, it has already been shown that the spatial distribution of seedling recruitment in the forest understorey can be predicted from adult tree distributions (RIBBENS *ET AL.*, 1994) and there is scope for further research along these lines to predict recruitment in clearings.

Bird species have been found to be highly effective in seed dispersal of tropical forest trees, in some cases over long distances from the seed parent tree (SUN *ET AL.*, 1997; WHITNEY *ET AL.*, 1998). Structural diversity of vegetation encourages bird diversity

(MACARTHUR & MACARTHUR, 1961). The presence of "bird perches" generally increases bird-dispersed seed rain compared to open areas, although natural branches (alive or dead) are more effective than straight bars (HOLL, 1998). The presence of fruit on bushes or bait on artificial perches in clearings does not necessarily improve seed dispersal at that spot (WILSON & CROME, 1989; HOLL, 1998), possibly because birds do not always eat and defecate in the same place. Thus, providing that fruiting trees and shrubs are present to attract birds into the general area, species bearing wind-dispersed seeds may also improve seed dispersal by providing perches, even though they do not provide the birds with food.

Perches increase seed rain and seedling establishment in denuded ex-mine sites in North America, (MCCLANAHAN & WOLFE, 1993). However, the effectiveness of perches may depend on the severity of limiting factors operating at later stages of regeneration. For example, in weedy clearings in Costa Rica, seed rain was increased by perches, but seed predation and weed competition severely limited recruitment and establishment, so the established seedling population was not greatly increased (HOLL, 1998). In such cases where weed competition limits seedling establishment, the nurse trees planted in the "framework" or "catalytic monoculture" approaches to ANR would have the double advantage of attracting seed dispersers and shading out weed competition (PARROTTA, 1993), although their shade may also limit tree seedling establishment. Most studies agree that seed predation in cleared areas is a significantly limits seed availability, with mortality levels ranging from c. 20% (OSUNKOYA, 1994) to at least 80% (UHL, 1987; HAMMOND, 1995) of all seeds. Burying seeds may reduce the risk of predation (SHAW, 1968).

Research needs

We need to be able to predict more precisely the seed-shadow dimensions of the locally dispersed component of the seed rain. In particular we need to know how this is related to tree size and seed dispersal mode and how it is affected by whether dispersal is through forest or across degraded areas. Innovative research methods are required to quantify the long-distance dispersal component of the seed rain. Long-distance dispersal curves should be characterised for species representing a range of dispersal mechanisms (i.e. wind, bird, bat and mammal) under a range of local conditions representing variations in forest cover and the presence of animal dispersers.

Confirmation of the above results on the effect of perches would be valuable and we also need to know how distance from a forest seed source affects the efficacy of perches[5]. More research is needed on methods of avoiding predation of direct-sown seeds[6].

INFORMATION INTERPRETATION AND OUTPUT

It is clear that there is a pressing need for more and better identification manuals for seedlings and stumps to enable the manager to carry out accurate site surveys. In most of Southeast Asia tools for seedling identification, in particular, are severely lacking and this is a major obstacle to regeneration surveys. If it is not possible to identify to species level,

[5] See Part 7, research proposal 2.2.
[6] See Part 7, research proposal 4.3.

the most useful identifiable group should be determined. This may be genus or family, or it may be sufficient to classify seedlings according to a morphological trait, such as size or dispersal mechanism of seeds, or gross shoot architecture or leaf-form. Whilst the bark of stumps will correspond to that of intact trees, the morphology of epicormic shoots may differ from that of adults. Such characteristics might usefully be included in new identification manuals.

A broad research project is needed in the region, to determine whether the rate and path of succession is predictable from an assessment of the limiting site factors described above and, if so, to develop a model to predict the pattern of succession under given site conditions[7]. The research should establish which site variables (e.g. rainfall, frequency of disturbance, type and intensity of disturbance, weed cover, distance from nearest seed source) were most relevant to the rate of recovery. The results could be used to develop indices for rapid site assessments to determine the potential for ANR and the most appropriate ANR techniques to employ.

In developing countries, a large amount of ecological knowledge is held by local people and has not yet been adequately integrated with formal scientific knowledge (SINCLAIR & WALKER, 1999). Many farmers carrying out slash-and-burn agriculture manage regenerating forest as fallows before another cycle of cultivation. It is therefore likely, in some environments, that local people's knowledge could make a major contribution to the information needed for improved methods of forest restoration. Therefore one priority should be the recording of relevant local knowledge of forest regeneration and its integration with scientific knowledge. This may well lead to an adjustment in the priorities identified for new scientific research (e.g. PAUDEL *ET AL.*, 1997).

Ultimately, all relevant information should be collated to create a decision support system for managers. This may take the form of a handbook, interactive software or other methods appropriate for particular user groups. A computer programme has already been created in the UK for the restoration of ecosystems such as wetlands and grasslands (PYWELL & COX, 1998) and it demonstrates the exciting possibilities for the use and interpretation of ecological information for the restoration of tropical forests.

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[7] See Part 7, research proposal 1.1.

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QUESTIONS AND COMMENTS

M.R. Smansnid Svasti

Regarding fire-tolerant species, we have indeed been monitoring species to see which can coppice and sucker after fire. Gymnosperms had the best survival, because their leaf buds are tightly enclosed and do not burn, so after the fires they can still produce new growth. However, after the last fire, everything except the Gymnosperms burnt to the ground and died. Every year we get fire and we do not think that selecting fire-tolerant species is enough to combat the problem, so this year we have undertaken a very intensive fire-protection programme.

Kate Hardwick

It is very interesting and useful to look at which species can survive fire and why. However, I agree that, when a site is burnt every year, just planting fire-tolerant species cannot solve the problem. We also need to explore other techniques such as controlled burning to reduce the fuel load on the site.

David Lamb

Not all fires are the same and variations in intensity, time of year etc. may well give us opportunities to manipulate fires through controlled burning. Also there are great differences between species in how they respond to different intensities of fire. Coppicing is probably much more common than we think and we do see it in a lot of species in moist areas. Instead of asking which species coppice, we should be asking questions such as: what is the upper limit to stump size? Will regrowth be unstable and snap off in high winds?

Kate Hardwick

I would agree with that, but would add that the answers to these valuable questions will vary between species and that should be taken into consideration in any further research.

Ulfah Siregar

With so many species in native forest, how do you choose which species should be assisted in their regeneration? Secondly, regarding long distance seed dispersal, one method would be to use genetic markers to see where seeds are coming from.

Kate Hardwick

It is an interesting idea to use genetic markers. The choice of species to assist is an important consideration which would be governed by many of the same factors which determine the choice of species to plant, and these will be covered in the next session.

THE PROCESS OF NATURAL FOREST REGENERATION AFTER SHIFTING CULTIVATION IN KY SON DISTRICT, NGHE AN PROVINCE, VIETNAM

Hoang Van Son[1]

ABSTRACT

Plant succession was studied in agricultural fallow fields at two sites in Ky Son district (a mountainous area of Nghe An province, Vietnam) and wildlife in these areas was recorded.

There was clear evidence of forest regeneration at both sites. At the upper site (1,020-1,120 m elevation), 133 species belonging to 52 families were recorded in fallow fields aged one to six years. The dominant vegetation changed from light-demanding herbs and shrubs in the first year of fallow to large shrubs and small pioneer trees in the second and third years. By the sixth year, a multi-layered, secondary forest formation had developed, with a canopy of timber trees (11 species) and large shrubs, an understorey of small shrubs and climbers and a ground layer of shade-tolerant ferns, herbs and moss.

In the lower site (650-750 m elevation), 98 species belonging to 47 families were recorded in fields aged one to six years, rising only to 106 species and 52 families when ten-year-old fields were included. *Eupatorium odoratum* dominated the fallow fields for the first three years, with a frequency of 90%. In the second and third years, several species of small tree began to regenerate, including *Trema orientalis* and *Mallotus philippensis*. In the fourth year, *E. odoratum* declined to 60%, while shrubs and trees began to form an open canopy, interspersed with bamboo (*Bambusa schizostachyoides*). After ten years, the coverage of *E. odoratum* was greatly decreased (10%) and a closed tree canopy had started to emerge.

Of the 37 rare and endangered animal species present in Nghe An province, 16 species (43%) were found in the research areas, of which four were endangered.

INTRODUCTION

In mountainous areas, the restoration of forest cover after cultivation of fields has a fundamental effect on other natural processes, such as the restoration of soil nutrition, the system of water regulation and the creation of habitats for wild animals. Forest restoration is thus essential for management of resources for agriculture and conservation. Natural regeneration can play a key role in resource management policies at both the community and national levels.

Ky Son district of Nghe An province is situated in the north central region of Vietnam. Ky Son is in the highlands, located at $18^0 10$ to $18^0 41$ N and from $103^0 52$ to $104^0 29$ E, about

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600 m to 1400 m above sea level. The total area is 1,891.7 km^2, of which forest and forestland (i.e. previously forested land, now bare) account for 163,468 ha. Exploited timber forest (i.e. areas with logging concessions) covers 3,186 ha and the unexploited areas total 2,982 ha. Forest for "special use" covers 347 ha, forest for national defence, 4,260 ha and protected forest, 15,450 ha.

Ky Son has a tropical monsoon climate, with two seasons: the dry and cold season is from November to March, under the influence of north east winds and the hot and humid season is from April to October, under the influence of south east winds. Muong Xen is the main town in Ky Son. It is one of the driest regions of Vietnam with an average annual rainfall of 1,200 mm to 1,400 mm and a dry season of seven to nine months. The dominant plant families in the area are *Poaceae, Euphorbiaceae, Annacardiaceae, Cycadaceae* and *Dilleniaceae.* The forest is predominantly deciduous (VAN TRUNG, 1976). There are many fallow fields dominated by early successional communities including species such as *Saccharum spontaneum, Ageratum conyzoides, Erigeron crispus* and *Eupatorium odoratum*. These fields eventually develop into secondary shrub and bamboo forests.

Compared with the 1970's, the forest of Ky Son is now under threat due to cultivation in mountainous areas (TAT CHUNG & CONG HOAN, 1995). As a result of increasing population pressure and loss of forestland, the fallow period in shifting farming is steadily declining. In the 1930's to 1960's, the land was cultivated for three to four years and then allowed to lie fallow for 15 to 20 years to fully restore productivity. Now, in many places, fields are cultivated for three to four years, then allowed to lie fallow for the same period. This shortened fallow period results in decreased soil fertility and increased weed competition (JAMIESON *ET AL.*, 1998). Also, the abundance of tree seeds in the soil seed bank is severely reduced, which consequently reduces the potential for natural forest regeneration. Due to continued destruction of vegetation cover, many hills and mountains in Vietnam are unable to regenerate naturally. Tree planting in such areas is one measure to restore vegetation cover.

OBJECTIVES

The objectives of this research were to describe the natural regeneration of vegetation in fallow areas in Ky Son district and assess the species richness of wildlife in the regenerating areas. This information will be of practical use in developing agro-forestry ecosystems and in devising methods to promote natural forest regeneration.

METHODS

Pioneer vegetation differs between areas at 900 – 1,200 m and 600 – 800 m elevation. At upper elevations, recently abandoned agricultural fallows are dominated by *Saccharum spontaneum*, *Miscanthus japonicus* and *M. nepalensis*, while at lower elevations the dominant species are *Eupatorium odoratum* and *Imperata cylindrica*. For this reason, vegetation surveys were carried out in two areas: one at 1,020-1,120 m elevation and the other at 650-750 m. At 1,020-1,120 m elevation, forestland covering approximately 700 ha at Nam Can village was chosen and at 650-750 m elevation forestland at Ta Ca village was selected, covering about 1000 ha. After interviewing local people, land in both research areas was chosen for study on the basis that it had been used for slash-and-burn agriculture for at least 40 years.

Because of the short time available for fieldwork, it was not possible to return to the same newly created site and repeat the measurements year after year, so regeneration was assessed in fallow fields of different ages. At the upper site, fields in the first, second, third and sixth year of fallow were surveyed, while at the lower site the survey was repeated in fields in the first, second, third, fourth and tenth year of fallow. Three 30 m x 30 m permanent plots were randomly established in fallow fields of each age. All plants, at least 5 cm tall, were included in the survey. Identification followed HOANG HO (1991, 1992 and 1993). The frequency of each species was determined for each site in each year by calculating the percentage of all plots in which each species was recorded. Data on the presence of mammals and reptiles at both sites was obtained by interviewing local hunters, farmers and foresters.

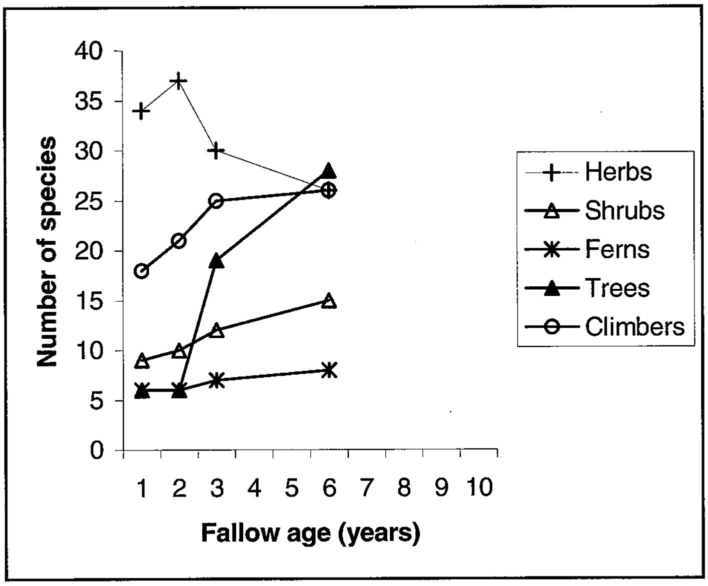
RESULTS

Upper site at 1,020-1,120m elevation

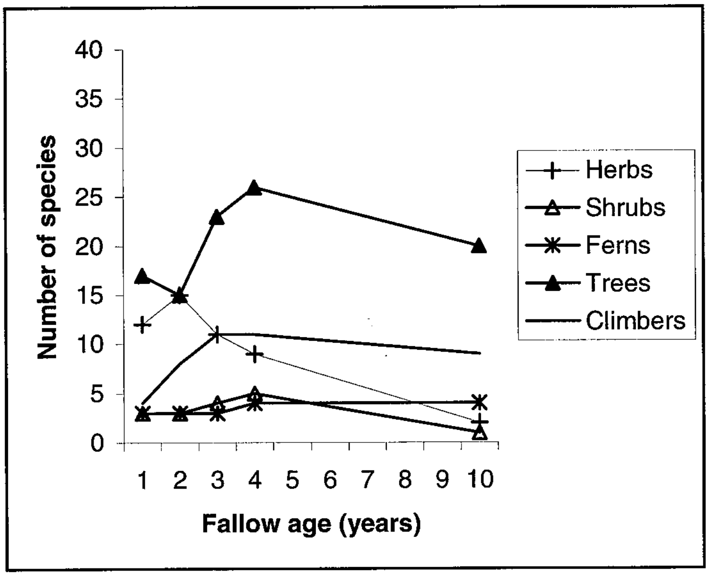
During the first six years of the fallow period, 133 species belonging to 52 families were recorded and there was clear evidence of natural succession. In the first three years, light-demanding herbs and shrubs dominated the vegetation (Figure 1a). Herbs such as *Ageratum conyzoides*, *Erigeron erispus* and *Saccharum spontaneum* and small shrubs such as *Glochidion hirsutum* and *Glochidion laevigatum* predominated in the first year, while in the second year, large shrubs and pioneer small trees such as *Caesalpinia crista*, *Mallotus barbatus* and *Mallotus microcarpus* became equally dominant. The first timber tree species, *Melia azedarach*, was recorded in the second year. By the third year, the incidence of herbs and shrubs was much reduced and the vegetation became dominated by pioneer trees. In this year there appeared many species of climber (e.g. *Tetracera sarmentosa*, *Pueraria montana* and *Smilax ovalifolia*), and several shade-demanding ferns (e.g. *Lygodium conforme*, *L. japonicum*) and herbs (e.g. *Artemisia vulgaris*, *Apludia mutica* and *Aristida chinensis*). Nine timber tree species were recorded. By the sixth year, a multi-layered, secondary forest formation had developed, with a canopy of timber trees and large shrubs, an understorey of small shrubs and climbers and a ground layer of shade tolerant ferns, herbs and moss. Eleven tree species of timber trees were recorded.

Figure 1. The total number of species of each life-form in fallow fields of different ages, at two sites. Vegetation was recorded in three 30 m x 30 m plots, randomly established in fallow fields of each age.

a) Upper site (1,020 – 1,120 m).



b) Lower site (650 – 750 m).



Lower site at 650-750m elevation

In the lower site, 98 species belonging to 47 families were recorded during the first six years with a total of 106 species and 52 families during the first ten years. In this area, *Eupatorium odoratum* dominated the fallow fields for the first three years, with a frequency of 90%. Also present from year one were several species of climber (*Desmos chinensis, Tetracera scandes, Acacia megaladina)*, light-demanding shrubs (*Urena lobata, Sida rhombifolia*) and canopy trees (e.g. *Cratocylon maigayi, C. prunifolium, Lagerstroemia calyculata, Aporusa sp* and *Wrightia tomentosa*) with a combined frequency of 10-15%. In the third year the number of species of shrubs and canopy trees increased (Figure 1b) and several species of small tree began to regenerate, including *Trema orientalis* and *Mallotus philipensis*. In the fourth year, the incidence of *E. odoratum* declined to 60%, while the shrubs and trees began to form an open canopy, interspersed with bamboo (*Bambusa schizostachyoides*), which had a frequency of 20%. After ten years, the coverage of *E. odoratum* was greatly decreased (10%) and a closed tree canopy was beginning to emerge. Between four and ten years after fallow abandonment, the number of tree species remained relatively stable. Several timber tree species were recorded, including *Elaeocarpus griffithii, Aporusa sphaerosperma, Mallotus philipensis, Castanopsis* sp., *Cratoxylon prunifolium, Lagerstroemia calyculata* and *Phoebe lanceolata.*

In exploited forest surrounding the fallow sites, common tree species included *Engelhardtia roxburghiana, Aporusa* sp., *Vatica odorata, Lithocarpus pseudosundai, L. elegans, Schima sp.* and *Bambusa blumeana* (present with a frequency of c.20%), while *Cycas simplicipinna* occurred with a frequency of 10%.

Wildlife in the research areas

Interviews with local people indicated that several valuable and rare animal species were to be found in the regenerating fallow (Table 1). Of the 37 rare and endangered animal species present in Nghe An province, 16 species (43%) were reported as present in the research areas and of these, four were endangered species.

CONCLUSIONS AND RECOMMENDATIONS

1. In Ky Son district, there was clear evidence of natural forest regeneration in fallow fields, at both the upper and lower sites. Trees began to regenerate in the first or second year and had generally formed a canopy over the weeds and shrubs by the sixth year. The increasing tree cover was matched by a gradual decline in light-demanding herb and shrub species and an increase in shade tolerant herbs, shrubs, ferns and mosses.
2. Shifting cultivation in the research areas had a great effect on forest resources. People continuously exploited woody species before they had developed into stable forest cover, creating sub-climax communities dominated by shrubs and grasses.

Table 1. Animals in the Ky Son district[1], their rarity status and presence in research areas.

Vietnamese name	Scientific name	Rarity status[2]	Species present in research area (X)
Soc bay lon	*Petaurista petaurista*	2	
Soc den trang	*Hylopetes alboniger*	2	
Don	*Atherurus macsirurus*	1	
Te te	*Manis pentadactyla*	1	X
Chon doi	*Cynophalus variegatus*	2	
Cu li lon	*Nycticebus coucang*	1	
Cu li nho	*Nycticebus pygmaens*	1	
Khi mat do	*Macaca arctoides*	1	X
Khi moc	*Macaca assamensis*	1	X
Khi duoi lon	*Macaca nemestrina*	1	
Vooc xam	*Trachypithecus phayrei*	1	
Vooc va	*Pygathris nemaeus*	3	
Vuon bac ma	*Hylobates concolorleucogenis*	3	
Soi do	*Cuon abpinus*	3	
Gau cho	*Helarctos malayanus*	3	X
Gau ngua	*Selenarctos thibetanus*	3	X
Rai ca	*Lutra lutra*	1	
Cay muc	*Artictis binturong*	1	
Beo lua	*F. temmicki*	1	
Bao gam	*Neofelis nebulosa*	1	
Bao hoa mai	*Panthera pardus*	3	
Ho	*P. tigris*	3	X
Voi	*Elephans maximus*	3	
Sao la	*Pseudoryx nghetinhensis*	2	
Bo tot	*Bos gaurus*	3	
Son duong	*Capricornis sumatraensis*	1	
Mang lon	*Megamuntiacus vuquangensis*	2	
Cheo cheo	*Tragulus javanicus*	1	
Tac ke	*Gecko gecko*	1	X
Ky da, Rong dat	*Physignathus cocincinus*	1	X
Tran dat	*Python molurus*	1	X
Rua nuivien	*Geochelone impressa*	1	X
Rua hop tran vang	*Cuora galbinifrons*	1	X
Rua hop vach	*Cuora trifasciata*	1	X
Rua nui vang	*Indotestudo elongata*	1	X
Ran cap nong	*Bungarus fasciatus*	1	X
Ran ho mang	*Naja naja*	1	X
Ran ho chua	*Ophiophagus hannah*	3	X

[1] Species list from the Red Data Book of Vietnam (Ministry of Science, Technology and Environment, 1993).

[2] 3 = In danger of extinction; 2 = rare; 1= uncommon.

3. In comparison with regenerating areas in Con Cuong, another mountainous area in Nghe An province (TRONG CUC & HONG BAN, 1996; HONG BAN, 1997; VAN LUYEN, 1998; VAN SON, 1998), there were fewer timber trees regenerating in the fallow fields of Ky Son. The species composition of regenerating trees and shrubs was also different. This shows how variable regeneration patterns can be within the same region.
4. Although some trees were regenerating successfully in the undisturbed fallow fields, species of high economic value, such as *Chukrasia tabularis* and *Erythrophloeum fordii*, were rare. It is suggested that measures be taken to promote the regeneration of desired species, such as pruning back shrubs and lianas around naturally regenerating seedlings or alternatively introducing the species into regenerating areas through enrichment planting.
5. A successful technique traditionally used by the Tay people of Northwest Vietnam, is to scatter seeds of *Melia azedarach* in fallow fields before burning to remove the weed cover. Fire stimulates germination of the thick-coated seeds, which may otherwise have low percentage germination. In this way, the Tay people can harvest timber after five to seven years, while planting rice during the first to third years, while the *Melia azedarach* seedlings are small. The area ultimately develops into mixed forest.
6. Evidently, areas of regenerating forest can provide suitable habitats for some rare and endangered wildlife species.

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Appendix - Plant species recorded at the two sites.

Family	Species	Life form	Age of fallow where recorded (years)	
			1020-1120m	650-750m
Lycopodiophyta				
Lycopodiaceae	*Lycopodiella cernuna*	Herb		4
Selaginellaceae	*Selaginella uncinata*	Herb	1,2,3,6	2,4
Polypodiophyta				
Aspleniaceae	*Asplenium nidus*	Fern	6	
Athyriaceae	*Diplazium esculetum*	Fern	3,6	
Blechnaceae	*Blechnum orientale*	Fern	1,2,3,6	
Cyatheaceae	*Cyathea contaminuns*	Fern		4
Diksoniaceae	*Cibotium borometz*	Fern	1,2,3,6	
Lygodiaceae	*Lygodium conforme*	Fern	1,2,3,6	1,2,3,4,10
	Lygodium japonicum	Fern	1,2,3,6	1,2,3,4,10
	L. microphyllum	Fern		1,2,3,4,10
	Pteris ensiformist	Fern	1,2,3,6	
Thelypteridaceae	*Cyclosorus paraciticus*	Fern	1,2,3,6	
Gymnospermae				
Cycadaceae	*Cycas siamensis*	Fern		10
Angiospermae				
Dicotyledones				
Alangiaceae	*Alangium chinensis*	Tree		3
Amaranthaceae	*Amaranthus tricolor*	Herb	1	
Anacardiaceae	*Rhus javanica*	Tree	3,6	
Annonaceae	*Alphonsea tonkinensis*	Tree		4
	Desmos chinensis	Climber	3,6	1,2,3
	Xylopia sp.	Tree		1,2
Apocynaceae	*Alyxia kongtumensis*	Tree		4
	Strophanthus divaricatus	Climber	3,6	
	Wrightia pubescens	Tree		1
Asclepiadaceae	*Dischidia acuminata*	Climber	1,2,3,6	
	Streptocaulon juventas	Climber	1,2,3,6	1,2,3
Asteraceae	*Ageratum conyzoides*	Herb	1,2,3	1,2
	Artemisia vulgaris	Herb	1,2,3	1,2,3
	Blumea balsamifera	Herb	2,3,6	
	Eclipta scaber	Herb	1,2,3	
	Erechtites hieracifolia	Herb		4
	Erigeron erispus	Herb	1,2,3	
	Eupatorium odoratum	Herb	1,2,3	1,2,3,4,10

Family	Species	Life form	Age of fallow where recorded (years)	
			1020-1120m	650-750m
	Gynura crepidoides	Herb	3,6	
	Parthenium hysterophorus	Herb	1,2	
	Pluchea indica	Herb	1,2,3	
	Siegeshockia orientalis	Herb	1,2,3	
	Spilanthes acmella	Herb	1,2	
	Tithonia diversifolia	Herb	1,2,3	1,2,3
	Xanthium inaequilaterum	Herb	1,2	1,2
	Vernonia cinerea	Herb	3	3,4
	Wedelia biflora	Herb	1,2	
Betulaceae	*Betula alnoides*	Tree	3,6	
Bignoniaceae	*Oroxylum indicum*	Tree		1,2,3,4
Bombacaceae	*Gossampinus malabarien*	Tree		10
Burseraceae	*Canarium album*	Tree		10
Buddleiaceae	*Buddleia asiatica*	Shrub	3,6	
	Buddleia paniculata	Shrub	3,6	
Caprifoliaceae	*Sambucus hookeri*	Shrub	6	
	Viburnum coriaceum	Tree	6	
	Lonicera japonica	Climber	6	
Cuscutaceae	*Cuscuta australis*	Climber	1	
Dilleniaceae	*Dillenia heterosepata*	Tree		10
	Tetracera sarmentosa	Climber	2,3,6	
	Tetracera scandes	Climber	2,3,6	4,10
Dipterocarpaceae	*Hopea pierrei*	Tree		10
	Vatica dyeri	Tree		10
Ebenaceae	*Diospyros tonkinensis*	Tree		4
Elaeocarpaceae	*Elaeocarpus griffithii*	Tree		4, 10
	E. hainanensis	Tree		1,2,3,4,10
Euphorbiaceae	*Aleurites fordii*	Tree		3,4,10
	Antidesma montanum	Tree		4
	Antidesma anamense	Tree		4
	Antidesma sp.	Tree	3,6	
	Aporusa sphaerosperma	Tree	3,6	1,2,3,4,10
	Glochidion hirsutum	Shrub	1,2,3	
	Glochidion laevigatum	Shrub	1,2,3	
	Macaranga denticulata	Tree	1,2,3,6	
	Mallotus barbatus	Tree	1,2,3	
	Mallotus microcarpus	Tree	1,2,3	
	Mallotus repandus	Climber	1,2,3	
	Mallotus philipensis	Tree		2,3,4,10

Family	Species	Life form	Age of fallow where recorded (years)	
			1020-1120m	650-750m
	Phyllanthus emblica	Tree		1
	Phyllanthus reticulata	Shrub		4
	Securinega spirei	Shrub	1,2,3,6	
Fabaceae:				
Caesalpininoideae	*Bauhinia scandes*	Climber	1,2,3,6	
	Bauhinia variegata	Tree	3,6	1
	Caesalpinia bondue	Climber	1,2,3,6	
	Caesalpinia crista	Shrub	1,2,3,6	
	Caesalpinia minax	Climber	1,2,3,6	
	Cassia siamea	Tree	3,6	1,2
	Cassia alata	Shrub	3,6	
	Cassia tora	Herb	1,2	
	Tamarindus indica	Tree	1,2,3	
Mimosoideae	*Acacia megaladina*	Climber		2,3,4,10
	Archidendron clypearia	Tree	3,6	
	Mimosa pudica	Herb		2,3,4
Papilionoideae	*Desmodium triflorum*	Herb		3
	D. triquetrum	Herb		2
	Pueraria montana	Climber	1,2,3,6	1,2,3,4
	Ormosia balansae	Tree	3,6	
Fagaceae	*Castanopsis sp.*	Tree		3,4,10
	Lythocarpus elegans	Tree		10
Guttiferae	*Cratocylon maigayi*	Tree	1,2	3,4,10
	Cratocylon prunifolium	Tree	3,6	1,2,3,4
	Garcinia cowa	Tree		10
Juglandaceae	*Engelhardtia roxburghiana*	Tree		3,4,10
Lauraceae	*Litsea cubeba*	Tree	3,6	
	Litsea glutinosa	Tree		2
	Phoebe lanceolata	Tree		3,4,10
Lythraceae	*Lagerstroemia calyculata*	Tree		1,2,3,4,10
Malvaceae	*Urena lobata*	Shrub	1,2	3
	Sida rhombifolia	Shrub	1,2	3
Melastomataceae	*Melastoma normale*	Shrub	1,2,3,6	
	Melastoma saigonense	Shrub	1,2,3,6	
	Melastoma setigerum	Shrub	1,2,3,6	
	Memecylon edule	Tree		1,2,3,4
Meliaceae	*Chukrasia tabulasis*	Tree	6	
	Melia azedarach	Tree	2,3,6	1,2,3
Menispermaceae	*Cissampelos pareina*	Climber	1,2,3,6	2,4,10

Family	Species	Life form	Age of fallow where recorded (years)	
			1020-1120m	650-750m
	Cissampelos sp.	Climber		4,10
	Stephania longa	Climber	3,6	
Moraceae	*Broussonetia kazinoki*	Shrub	3,6	
	Broussonetia papyrifera	Tree		2
	Ficus cardiophilla	Shrub	2,3,6	
	Ficus hirta	Tree	2,3,6	
	Streplus asper	Tree		2,4
	Streplus inlicifolia	Shrub		2
Myristicaceae	*Knema sp.*	Tree	6	
Myrsinaceae	*Ardisia crenata*	Shrub		4
	A. aciphylla	Shrub		1,2,4
	Embelia ribes	Climber		4
	Maesa perlarius	Shrub	6	1
Myrtaceae	*Decaspermum parviflorum*	Tree		4
	Psidium gujava	Tree	1	
	Syzygium zeylanicum	Tree	6	3,4
Passifloraceae	*Passiflora foetida*	Climber		2,3
Piperaceae	*Piper betle*	Herb	6	
	Piper lolot	Herb	3,6	
	Piper pseudonigrum	Herb	6	
Polygonaceae	*Polygonum multiflorum*	Climber	2,3,6	
Proteaceae	*Helicia tonkinensis*	Tree		3
Rhamnaceae	*Ziziphus oenoplia*	Tree		1
Rhizophoraceae	*Carallia brachiata*	Tree		1
Rosaceae	*Prunus fordiana*	Tree		2
	Rosa longicuspis	Climber	1,2,3,6	
	Rubus alceaefolius	Climber	1,2,3,6	
Rubiaceae	*Cephalanthus tetradra*	Tree		3,4,10
	Morinda citrifolia	Tree		4
	Paederia lanuginosa	Climber	1,2,3,6	
	Randia tomentosa	Tree	3,6	1,3
	Paederia scandens	Climber	1,2,3,6	
Rutaceae	*Chusena dunniana*	Shrub		1
	Clausena excavata	Shrub	6	
	Euodia meliaefolia	Tree		1,10
Sapindaceae	*Pavieasia annamensis*	Tree	6	2,3,4,10
	Dimocarpus longan	Tree	3,6	
	Litchi sinensis	Tree	6	

Family	Species	Life form	Age of fallow where recorded (years)	
			1020-1120m	650-750m
Sargentodoxiaceae	*Sargentodoxia cuneata*	Climber		3,10
Simaroubaceae	*Brucca lavanica*	Tree		1
Solanaceae	*Solanum torvum*	Herb	1,2	
	Solanum verbascifolium	Herb	1,2	
	Solanum thruppii	Herb	1,2	
Sterculiaceae	*Helicteres angustifolia*	Shrub		2,3,4
	Streculia lanceolata	Tree		3
Umbelliferae	*Centella asiatica*	Herb	1,2,3	
Verbenaceae	*Clerodendrum philipinum*	Herb	1,2	
	Vitex pinnata	Tree		1,2,3,4,10
Vitaceae	*Ampelocissus martinii*	Climber	6	2
Monocotyledones				
Araceae	*Amorphophallus tonkinensis*	Herb		4
Commelinaceae	*Commelina bengalensis*	Herb	1,2	1,3
	Commelina communis	Herb		1,3
	Commelina diffusa	Herb	3,6	
	Floscopa glabratus	Herb	3,6	
Cyperaceae	*Carex sp.*	Herb	6	
Dioscoreaceae	*Dioscorea bulbifera*	Climber		3,4,10
	Dioscorea cirrhosa	Climber	1,2,3,6	
	Dioscorea membranacea	Climber	3,6	
	Dioscorea persinulis	Climber	1,2,3,6	1,2,3
Maranthaceae	*Phryrium placentarium*	Herb	6	
Musaceae	*Musa balbisiana*	Herb	6	
Palmae	*Calamus rudentum*	Climber		2,3
	Calamus tonkinensis	Climber	6	3,4
	Caryota mitis	Tree	6	
	Caryota sp.	Tree	3,6	
	Phoenix humilis	Shrub	6	
Padanaceae	*Pandanus tonkinensis*	Herb	1,2	
Poaceae	*Apludia mutica*	Herb	1,2,3,6	
	Aristida chinensis	Herb	1,2,3,6	
	Arundinella bengalensis	Herb		1
	Axonopus compressus	Herb		1,2
	Bambusa schizostachyoides	Shrub	6	3,4,10
	Capillipedum cinetum	Herb	1,2,3,6	
	Centotheca litifolia	Herb	1,2,3,6	1,2,3,4,10
	Chloris barbata	Herb	1,2	

Family	Species	Life form	Age of fallow where recorded (years)	
			1020-1120m	650-750m
	Dichanthium annulantum	Herb	1,2,3,6	
	Digitaria timosensia	Herb	1,2,3,6	
	Imperata cylindrica	Herb	1,2,3,6	
	Isachne miliaceae	Herb		1,2
	Leptocholoa filiformis	Herb	1,2,3,6	
	Miscanthus nepalensis	Herb		2
	Panicum brevifolium	Herb	1,2,3,6	
	Saccharum spontaneum	Herb	1,2,3,6	1,2,3
	Sinocalamus giganteus	Tree		3,4
	Thysanolaena maxima	Herb	2,3,6	
Smilacaceae	*Smilax ovalifolia*	Climber	1,2,3,6	3,4,10
	Smilax lanceifolia	Climber	1,2,3,6	3,4,10
	Smilax sp.	Climber	1,2,3,6	4,10
	Heterosmilax gaudichaudiana	Climber	2,3,6	
Stemonaceae	*Stemona tuberosa*	Climber	2,3,6	
Zingiberaceae	*Alpinia macroura*	Herb	2,3,6	
	Amomum tonkinensis	Herb	1,2,3,6	
	Costus tonkinensis	Herb		2
	Zingiber zerumbet	Herb	2,3,6	2,3,4

Community participation in the monitoring of natural regeneration in Northern Thailand.

ASSISTED NATURAL REGENERATION: METHODS, RESULTS AND ISSUES RELEVANT TO SUSTAINED PARTICIPATION BY COMMUNITIES

Patrick Dugan[1]

ABSTRACT

This paper presents a case study of assisted natural regeneration (ANR) at Kandis village, Puerto Princesa, on Palawan Island, Philippines and discusses the social issues that influence the success of the ANR approach. ANR hastens natural forest regeneration through a combination of fire prevention and weed control. The saplings that emerge as a result are used as nurse trees to foster climax forest tree species and shade-tolerant orchard species.

Despite the successful results obtained with this method, it has not been vigorously implemented. Reasons for this may include an habitual reliance on planting exotic tree species, a lack of understanding about forest ecology, an inflexibility of approach from funding bodies and lack of incentives for rural communities to protect the forests. The community forestry movement has had a positive impact on natural regeneration. Legitimising use of forest products and providing land tenure and appropriate training has enabled communities to find viable alternatives to slash-and-burn agriculture and, in the absence of disturbance, forests have regenerated on degraded fallow fields.

One of the main incentives for communities to protect forests is the desire to maintain water resources through catchment protection. Examples are given of instances where beneficiaries of environmental services provided by forests have made a direct financial contribution to forest conservation.

This paper presents a case study of assisted natural regeneration (ANR) at Kandis village, Puerto Princesa, on Palawan Island, Philippines and reviews social issues that influence the success of the ANR approach.

Kandis is the local name for *Garcinia lateriflora*, a fruit tree that grows wild in the natural forests of Palawan. While the village is named after this tree, the species itself is endangered due to slash-and-burn conversion of forests into upland farms. The project area covers a 1,000 ha catchment within a larger watershed. Ridgelines and a common drainage system define it. About 500 ha are forested. Approximately 250 ha are planted with rain-fed grains, pulses and root crops, a few orchards, some clumps of bamboo and a few irrigated rice terraces. The remaining 250 ha consist of grassland and brush land in fallow, interspersed with patches of degraded forest vegetation.

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Fifty-one families live in the village. Farming, fishing, seasonal employment outside the village and gathering forest products are the principal means of livelihood. Gathering forest products is illegal unless the government issues a permit under the Community Forestry Programme of the Department of Environment and Natural Resources (DENR). However, the procedures are very complex and bureaucratic, including preparation of a boundary map and vegetative cover map, inventory of all available forest products, computation of potential harvest volume on a sustained yield basis, organisation of a co-operative and registration of the same as a legal entity. Kandis does not yet have such a permit, but forest products are gathered surreptitiously while the application is being processed. In brief, conditions at Kandis typify what can be observed in thousands of upland villages in the Philippines, and indeed throughout many tropical countries.

At Kandis, the Bagong Pagasa (New Hope) Foundation, a non-government organisation, is implementing a small forest conservation-cum-rural development project financed by the Government of Japan through the Japan Overseas Forestry Consultants Association (JOFCA). Like most rural development initiatives, this one deals with a range of concerns including improvement of upland farming methods, community organisation, enhancement of skills, better access to markets and so on. Traditionally, the villagers have relied on slash-and-burn agriculture to supply many of their daily needs, but this system is no longer sustainable due to the prevailing land-to-population ratio. Other alternatives must be put in place, otherwise neither agricultural nor forest conservation objectives can be achieved. From the perspective of the funding agency, the principal task is to test methods that can help bring about more effective and efficient use of overseas development financial assistance in forest conservation.

Agro-forestry is a major project component. The project is also investing in reforestation and orchard development on grasslands and brush lands presently in fallow, implementing ANR as a first step in the process. The nurse trees that emerge and are maintained through ANR are used to foster the regeneration of natural forest and are also interplanted with several shade-tolerant crops including coffee, rambutan (*Nephilium lappaceum*), durian (*Durio zibethinus*) and lanzones (*Lansium domesticum*).

ANR combines fire prevention, ring-weeding of naturally-grown seedlings and saplings of pioneer trees and lodging of *Imperata cylindrica*, *Saccharum spontaneum* and other vegetation that competes with the pioneers. After approximately three years of implementation, grass and brush lands are giving way to more permanent vegetation. Thus far, 89 tree species in 37 families have been identified in monitoring plots and transects. These include early growth of several principal species found in undisturbed climax forests. Rapid accumulation of organic matter, earthworm castings, cooler soil temperature and other positive developments provide evidence that forest restoration through natural methods is succeeding.

These results are not surprising. Natural regeneration of forest cover is part of the fallow system that slash-and-burn farmers have practised since time immemorial. ANR merely hastens the process. The challenge is to prevent or at least significantly minimise subsequent interventions that would interrupt the process.

Given the results that are so easily and economically achieved through ANR, one can only wonder why this simple forest restoration method has never received a fraction of the attention or funding devoted to conventional reforestation technology. More than 25 years ago, some of the Philippine's most highly-respected environmental management scientists recommended adoption of ANR as a principal forest rehabilitation strategy. However, it was only in the early 1990s, after restoration of a democratic system, that the government officially approved ANR as a legitimate component of reforestation programmes. Sadly however, official recognition of the role ANR can play has not been followed by vigorous, widespread and sustained implementation in the field.

Many factors contribute to this unfortunate situation. One of the most serious constraints is a widely held misconception that conventional line-planting reforestation is the only reliable method for restoring forest cover. This view is shared by most sectors of the media, many environmental NGO's, church groups and the general public. Foresters and others attempting to restore forest cover are invariably asked how many trees they have planted. This is often the only acknowledged criterion of success or failure.

The pressure created by this mistaken notion spawns a whole range of problems. Soils in most of the degraded lands that need reforestation are low in fertility, organic matter content and moisture retention capability. Consequently, climax species that the public generally associates with forests and reforestation cannot thrive. These species evolved over millions of years on relatively fertile soil. Attempts at re-establishment on degraded lands almost invariably fail. As an alternative, exotics that can survive degraded conditions are introduced. It would be a waste of time to dwell here on the well-known negative impacts on water retention, wildlife habitat and other environmental values that follow.

Another issue, somewhat related to the one just discussed, is the simple fact that most forestry colleges do not teach comprehensive forest management. The curriculum consists primarily of subjects in timber management and plantation forestry. Young graduates go into the field with little or no understanding of the natural dynamics of plant succession, and little or no appreciation of the benefits that can be realised by working in partnership with Mother Nature. For example, very few are aware of the need to reduce soil temperature, thereby enhancing the proliferation of micro-biota, or of the relationship between these conditions and the potential to achieve success in forest restoration.

However, a misinformed public and poorly trained foresters are not the only problem. With very few exceptions, the tropical reforestation programmes financed by major donors are designed along the lines of an infrastructure project. They are generally characterised by a limited time frame, an unhealthy dose of the human ego that assumes quick fix solutions are possible and the inability or lack of will to follow a process approach.

Furthermore, traditional systems for monitoring the results of forest restoration work are impractical to use in respect of ANR. Recording survival rates after planting has to be replaced with more appropriate methods. Low cost evaluation using satellite imagery is one option. The ITTO has recently produced computer software that can accurately measure change in the forest canopy density through analysis of satellite imagery data. The software is available free or at cost on a compact disc containing a semi-expert system that facilitates rapid, user-friendly analysis. If canopy density, and thus forest cover, have increased, restoration is being achieved. If not, investments in forest restoration are being wasted. Another option is measurement of annual variation in stream flow during the dry season. This is perhaps one of the most useful parameters and one which we will return to later.

Currently in the Philippines, and perhaps in other tropical countries as well, the principal impediment to sustained success in forest restoration in general, and to vigorous implementation of ANR in particular, is the failure to create stable and reliable incentives for rural communities to conserve and sustainably manage the forests. Given the feudal history of many tropical countries, and the colonial systems that followed, governments and government-favoured institutions have generally established systems and policies that explicitly exclude or simply ignore the reality that forests and the human communities residing there are mutually inter-related components of the same ecosystem.

About twenty years ago, these obsolete attitudes started to change. Community-based concepts such as Joint Forest Management in India, Community Forestry in Nepal and Community-Based Natural Resources Management in the Philippines are a few, but not the only, examples. All of these initiatives challenged the feudal notion that responsibility for, and benefits derived from, forest management are the exclusive prerogatives of government and surrogate institutions such as timber concessionaires. In varying degrees, these new programmes sought to grant extraction privileges and allow the use of forest products by communities in exchange for commitment to protect and conserve forests.

Wherever the rhetoric of these programmes has been matched by sincere application in the field, forests are being restored at a rapid pace and the principal mechanism by which this has been achieved is natural regeneration. Legitimising the traditional use of forest products by communities, combined with tenure security, appropriate training and common-sense planning, have created viable alternatives to slash-and-burn conversion. In the absence of fire, forests will inevitably return.

Unfortunately in the Philippines, and elsewhere, there is resistance to the community forestry concept. Professional foresters feel threatened. Governments and vested interests fear the loss of power and perquisites from forest management. In addition, the general public, including many well-intentioned sectors, cannot seem to accept the reality that it is impossible to establish and maintain a virtual iron curtain around the forests wherever prevailing conditions are characterised by rural poverty and high population density.

About ten years ago, a group of senior foresters from the Philippines, Sweden and Finland conducted a nation-wide assessment of the factors that could help overcome the resistance just mentioned. Their conclusions can be summarised as follows. Some sectors are interested in forest conservation and others are not. Some worry about wildlife conservation, while others are not concerned. Some believe in people empowerment and decentralisation, while others oppose any change in the status quo. Many perceive rural poverty as a major impediment to national well being. Others would like to keep the poor where they are because they believe this will make them easier to control.

However, all sectors, without exception, are keenly concerned with the issue of water. Based on their findings, the group conducting the study recommended that water should be the core issue to incorporate in community forestry strategy. Developments over the last few years clearly attest to the validity and soundness of this recommendation.

For example, an upland community, which was granted forest management rights in the northern Philippine province of Cagayan, has offered to rehabilitate an old irrigation system and maintain the forests that sustain the system. However, they insist that lowland rice farmers who use the water should pay them for this work. Concurrently, in the southern

Philippine island of Mindanao, an upland tribal community wants to cut down a monoculture *Gmelina arborea* plantation established by the government, and replace it with a mixture of fruit trees, bamboo and timber species. Lowland rice farmers argue that cutting down the *Gmelina* will jeopardise their water supply. The tribal community contends that a mixed species plantation will improve water retention and supply. The community further points out that the government does not allow them to use the *Gmelina* trees even if they have protected the trees for many years without any compensation. Finally, they maintain that the lowlanders who use the water, produced as a result of community-based forest conservation work, should not continue to receive this benefit free of charge.

In the Philippines, some of the more serious and perceptive members of the forestry profession are taking the position that water, not timber, is the most important forest resource. They and others further contend that long-standing indigenous communities in watershed areas should be compensated for forest conservation work, because this helps ensure a reliable, sustained volume of the water that everyone needs and uses. Whether or not this will eventually result in policies and procedures that create incentives and strong motivation to conserve forests remains to be seen. Thus far, the concept has not encountered anything comparable to the resistance mentioned earlier. In fact, the Department of Environment and Natural Resources (DENR) has recently signed a memorandum of agreement along these lines with the Zamboanga City Water Authority (a quasi-government entity that operates the local waterworks system). The Water Authority has agreed to pay the DENR a fixed fee per cubic meter for the water it distributes and sells to consumers. Payments will compensate the DENR for the work it performs to conserve and protect a 6,000 ha watershed.

There are other examples. For instance, the City of Yokohama has signed a similar agreement with an adjacent prefecture. In Cagayan de Oro City in the southern Philippines, an electric power corporation is lobbying for permission to levy a conservation surcharge per kilowatt hour for the energy it produces from a hydro-electric generating plant. The money will be used to finance watershed management.

There are many hurdles to overcome. Among others, there is an urgent need for solid research that provides the basis for establishing a fair and acceptable price to pay for water under a range of edaphic and social conditions. Hopefully, the examples just cited may be the first steps in a process that ultimately results in broader application of the same concept, with communities playing a major role. Should this happen, natural regeneration may well become the norm, rather than the exception it is at present, in forest management.

POSTER ABSTRACTS

FOREST RESTORATION AND FACILITATING REGROWTH OF EVERGREEN SPECIES IN NORTHERN THAILAND

Laura Anne Johnson[1]

Background There is a need to restore dry evergreen forests in northern Thailand. Forest ecologists suggest that a way to restore degraded forestlands is to "accelerate" natural succession. Two approaches are suggested: 1) planting "hardy" pioneer tree species such as acacias, eucalypts and teak (PARROTTA, 1993); 2) planting "framework" species, those capable of both establishing quickly and attracting a variety of seed-dispersing wildlife (GOOSEM & TUCKER, 1995; FOREST RESTORATION RESEARCH UNIT 1998). Still, questions remain as to the degree to which these methods will encourage evergreen regrowth and about the length of time it will take.

Proposed Research To investigate when and under what conditions evergreen species enter the successional sequence in northern Thailand. Information on the recruitment of mature forest species will contribute to efforts to re-establish dry evergreen forests by providing additional insights on the nature of natural succession.

Methodology

- Identify "indicator" dry evergreen forest species
- Select study area – dry evergreen forest vegetation
- Select successional sites with sequential ages (5, 10 , 15 years) – satellite images
- Observe and record indicator species present on various aged successional sites
- Document site conditions (cover, humidity, soil)

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PLANT SUCCESSION AND SPECIES RICHNESS DURING THE REGENERATION OF DEGRADED EVERGREEN BROAD-LEAVED FOREST ON GUANGXI DAMING MOUNTAIN.

Han Jin and Ma Chuo[1]

Daming Mountain is located at 23° 10' - 23° 38' N latitude and 108° 10' - 108° 45' E longitude, on the tropic of Cancer. The total area is about 1,100 km^2. As a result of mankind's economic activities, biodiversity has been destroyed on a large scale on Daming Mountain. Ecological and environmental studies in this area have theoretical and practical significance for the conservation and utilisation of biodiversity, for understanding the laws of plant succession and for developing methods of restoring the degraded forest ecosystem.

The key to the recovery of degraded forest ecosystems is the restoration of species richness and diversity. The process of plant succession and the rate of increase of species richness were studied at two elevations in regenerating degraded evergreen broad-leaved forest on Daming Mountain. In the mid-mountain area, all plant species were recorded within an area of 600 m^2 in 20-year-old *Cunninghamia lanceolata* plantations, which had been established after controlled burning. In the lower foothills, species were surveyed in a 400 m^2 area in 20-30 year-old restored forest. The main results were as follows:

1. The rate of increase in species diversity following forest rehabilitation was very different at the two sites. At the mid-mountain site, 178 species were recorded, including 58 species in the tree layer. A forest community consisting of light demanding broad-leaved pioneer trees and semi-shade-tolerant broad-leaved trees regenerated within about 20 years and developed into semi-shade-tolerant evergreen broad-leaved forest in 60-100 years. At the lower site, the rate of increase in species richness was much slower, with only 22 species recorded in the plots in 20-30-year-old restored forest, including only 3 species in the tree layer. *Pinus massoniana* forest in this district was disturbed continually by human actions and had difficulty in recovering, remaining in a relatively stable, but degraded state.

2. Total species richness in regenerating forest ecosystems tended to increase quickly and climaxed in the early stage of recovery (2-20 years), decreased in the mid stage (50-60 years) and remained stable in the late stage (over 150 years).

3. Changes in the density of individuals differed according to the structural layer of the community. In the tree layer, density increased from 1 to 20 years and decreased later. However, shrub density tended to increase continuously during the regeneration of the degraded ecosystem. Density in the herb layer decreased in a non-linear fashion.

Keywords: evergreen broad-leaved forest; species diversity; degraded ecosystem restoration; Daming Mountain

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FACTORS LIMITING REGENERATION OF ABANDONED AGRICULTURAL CLEARINGS IN TROPICAL MONTANE FOREST

K. A. Hardwick[1], N. C. Garwood[2], J. R. Healey[1], S. D. Elliott[3] and V. Anusarnsunthorn[3]

Degraded and fragmented forests can be restored by accelerating tree regeneration through natural succession (accelerated natural regeneration or ANR). In seasonal tropical montane forest in northern Thailand, abandoned agricultural clearings were studied to identify limitations to tree regeneration so that optimal ANR techniques could be devised. Seed dispersal and establishment of tree seedling species were monitored in three clearings. Species were classified into three groups: D, failed to disperse; R, dispersed but failed to recruit seedlings and E, successfully established. Mean seed length of species in each group was (D=E)>R. Only species with seeds between 2 and 14 mm established.

The effects of seasonal drought on germination of groups D, R and E and of weed competition on seedling establishment of groups D and E were determined experimentally. Drought tolerance did not explain the recruitment failure in group R. Weed cover improved dry season survival, but decreased rainy season growth, with no difference between groups.

Large-seeded, drought-tolerant species were limited by poor dispersal and may be suitable for direct sowing in cleared areas. Small-seeded and drought-sensitive species were limited by poor recruitment and should be introduced as nursery-raised seedlings. Further research is needed on the timing of weed control in relation to season.

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PART FOUR

SPECIES SELECTION AND TECHNOLOGIES FOR GROWING AND PLANTING SEEDLINGS

Editor

David Blakesley

Students at the ASEAN Seed Centre in Muak Lek, Thailand, learn how to monitor seedling performance in the nursery. Nursery technology in Southeast Asia is well advanced for commercial tree species. Can similar expertise be used to propagate indigenous forest tree species for ecological restoration?

David Blakesley and Sudarat Zangkum teach participants at one of FORRU's workshops how to produce perfect seedlings of framework tree species to restore forest ecosystems on northern Thailand's degraded forestland.

INTRODUCTION

David Blakesley[1]

With the exception of accelerated natural regeneration (ANR), all methods of forest restoration involve tree planting (either seedlings or seeds). In any programme involving planting native trees, primary concerns include selecting appropriate species to plant, identifying individual trees, from which to obtain seed or cuttings and nursery production of planting material. If chosen species cannot easily be propagated, or the quality of the planting material is low, or if the species are not suited to the site being planted, the planting will probably fail. Consequently, species selection and technologies for growing and planting seedlings are crucial to the success of any natural forest restoration programme.

The first paper in this part concerns nursery technology and tree species selection for restoring forest biodiversity in northern Thailand. It draws on experiences gained from the Forest Restoration Research Unit's programme to illustrate the complexity of the task faced by any project aimed at restoring tropical forest to severely degraded land. Tropical forest ecosystems are complex and many contain large numbers of tree species; the example given is 626 species in Doi Suthep-Pui National Park. BLAKESLEY *ET AL.* describe the "framework species method", originally developed in Australia by Nigel Tucker and his co-workers (GOOSEM & TUCKER, 1995; LAMB *ET AL.*, 1997) and show how this has been applied locally in northern Thailand. It is essential, of course that, whatever its other attributes, any framework species must be relatively easy to propagate in a low-technology tree nursery. The importance of quality is also discussed, since it is essential that any nursery-produced seedling must have the best chance of survival following planting. One crucial aspect of nursery production is scheduling; this is introduced by BLAKESLEY *ET AL.*, with more information on specific examples given by KUARAK *ET AL.*

A specialised area of nursery production that could be very important in future planting programmes is the use of mycorrhizal inoculum. Symbiotic mycorrhizal fungi are important because they colonise the tissues of fine roots and help plants obtain mineral nutrients from soil. Arbuscular mycorrhizae (AMF) discussed in SETIADI's paper, can help to produce high quality planting stock. SETIADI describes his work in Indonesia over recent years which illustrates the potential for AMF application, both to enhance the performance of tree seedlings in the nursery, and also their establishment and growth in restoration sites. Other factors affecting establishment and survival of seedlings in restoration sites include competition with weeds, spacing, shade and fire control. ELLIOTT *ET AL.* specifically address the issue of fertiliser application. There is very little data available to guide the timing or amounts of fertiliser that should be applied to aid establishment and growth of the majority of native tree species. ELLIOTT *ET AL.* present a preliminary study on the effect of different

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fertiliser regimes on the performance of six native tree species, planted to restore degraded forest in northern Thailand.

The final two papers in this part focus on the selection of species for planting. NGHIA, discusses the use of native tree species in various planted forest types and considers the importance of biodiversity conservation in future decisions on species selection. PEDERSEN presents a case study of several workshops organised by FORGENMAP in Thailand to identify 'priority' tree species for different uses. It is interesting to note that although some 200 species were identified as having potential conservation value, the FORGENMAP workshop participants could envisage little demand for planting material. This example demonstrates that, outside of this conference, many people do not consider planting native tree species for conservation purposes. There is clearly much further scope for conservationists to raise awareness of the value of species selection and planting for forest restoration for wildlife conservation.

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NURSERY TECHNOLOGY AND TREE SPECIES SELECTION FOR RESTORING FOREST BIODIVERSITY IN NORTHERN THAILAND

David Blakesley[1], *Vilaiwan Anusarnsunthorn*[2], *Janice Kerby*[2], *Puttipong Navakitbumrung*[2], *Cherdsak Kuarak*[2], *Sudarat Zangkum*[2], *Kate Hardwick*[3] *and Stephen Elliott*[2]

ABSTRACT

The Forest Restoration Research Unit (FORRU) was established in 1994 to develop methods to restore forest ecosystems in degraded areas for the conservation of biodiversity in northern Thailand. A research programme was carried out to screen nearly 400 native forest tree species for their potential usefulness in forest restoration programmes. Studies on each species included observations of flowering and fruiting phenology and experiments on seed germination and seedling growth in the nursery. Nursery trials were essential, because very little data on seedling performance were available for most of the native species being screened. Ease of propagation was one of the key criteria used for subsequent selection of thirty "framework species" for planting trials. Larger numbers of seedlings of these framework species are now being produced for field trials. This requires more research on nursery production, planning and ultimately the drafting of "production schedules".

This paper focuses on the application of nursery technology to native tree production for a forest restoration programme. It highlights key issues related to the technology and its management for further discussion, including introduction of larger scale production to a research programme. It also emphasises the selection criteria for framework species, including the relative importance of propagation.

INTRODUCTION

Southeast Asia, in common with other tropical regions, is continuing to lose its forests and their associated biodiversity. In Thailand for example, forest cover has been reduced from about 53% in the early 1960's (BHUMIBAMON, 1986) to about 23% today (FAO, 1997). Unofficial estimates, however, put Thailand's natural forest cover at less than 20% (LEUNGARAMSRI & RAJESH, 1992). Commercial logging was banned by the government in 1989, resulting in a reduction in the rate of deforestation to approximately 0.3% per year. In recent years, this rate has started to increase again, currently to about 1% per year. Deforestation results from logging and agricultural expansion (HIRSCH, 1990). The increase

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in the rate of deforestation in recent years is indicative of continued logging, shifting cultivation and development of infrastructure. Consequently today, large areas of Thailand, including considerable parts of the extensive system of national parks and wildlife sanctuaries, comprise secondary forests subjected to differing degrees of disturbance. In northern Thailand, populations of large vertebrates have been severely depleted and many species of large birds have become extirpated from the region. As a consequence of deforestation throughout the country, biodiversity is now severely threatened.

Restoration of conservation forests

A positive development in Thailand has been the rapid increase in public awareness of the problems caused by deforestation. It is now generally accepted that further loss of forest will cause more extreme floods and droughts, damage to watersheds, loss of biodiversity and impoverishment of rural communities (ELLIOTT *ET AL.*, 1995). Complete protection of all remaining primary forest and important areas of secondary forest is unlikely, due to economic and legal constraints. Therefore, to maintain the current forested land area, or indeed to increase it, deforested areas must be converted back into forest. This need is reflected in the National Forest Policy, which stipulates that 40% of the country should be under forest cover, with 25% of the country targeted as conservation forests. This policy was implemented by designating sites of many former logging concessions as national parks or wildlife sanctuaries, which now cover approximately 13% of the country, or more than half of the total forest area (BOONTAWEE *ET AL.*, 1995). Consequently, large parts of many national parks and wildlife sanctuaries had already been degraded or deforested before they acquired protected status. If such areas are to fulfil their functions of conserving biodiversity and protecting watersheds, they must be reforested.

Within national parks and wildlife sanctuaries, where the primary objectives are conservation of wildlife and protection of watersheds, reforestation efforts should ultimately aim to restore natural forest ecosystems permanently. Rehabilitation and restoration of degraded ecosystems are extremely important components of *in situ* conservation as identified in the Convention on Biodiversity (WORLD CONSERVATION MONITORING CENTRE, 1996), but research on the biological aspects of the problem has been neglected. Large-scale restoration of forest ecosystems requires close co-operation between government agencies and local people; the development of new and technically sound methods of tree propagation and planting and the provision of resources and expertise to all participating organisations.

High biodiversity and complexity hinder attempts to recreate natural forest ecosystems in the tropics. Any individual forest type may contain several hundred tree species, each of which may have evolved intricate relationships with hundreds of other organisms, such as herbivores, pollinators and seed dispersers. Restoration of natural forest ecosystems, therefore, requires a vast amount of ecological information, of which only a small fraction is currently known. We need to understand how forests regenerate naturally, identify the factors limiting regeneration and develop effective methods to counteract them and thus accelerate regeneration (HARDWICK *ET AL.*, 1997). Planting nursery-grown seedlings is just one of several complementary options, where natural regeneration is very poor; others include cultivation and husbandry of seeds, seedlings and saplings which are already present, or prevention of fire by maintaining a network of fire breaks.

Species selection for planting

It would be difficult to implement a forest restoration programme that proposed replanting a substantial number of tree species from a complex forest ecosystem, such as the dry tropical forests of northern Thailand. Most studies to date have concentrated on more focused rehabilitation programmes which aim to catalyse vegetation recruitment, although there is still a paucity of data related to the restoration of complex tropical forests. KNOWLES & PARROTTA (1995) worked with 160 Brazilian native tree species of upland moist forest in Amazonia, and developed a species rating system relative to propagation and suitability for reforestation. Their numerical scoring system focussed on (i) seed germination, (ii) alternatives for production of planting stock and (iii) adaptability to plantation site environment and early growth rates. This was used to rank and classify 160 species evaluated in the study with respect to their suitability for planting on a rehabilitation site. Their studies demonstrated that, at a practical level, it is possible to evaluate a large number of native tree species systematically at relatively low cost. This evaluation could include fruiting phenology, seed biology, nursery practice and seedling performance following planting in the harsh environments of rehabilitation plots.

The "framework species method" of forest restoration (GOOSEM & TUCKER, 1995; LAMB *ET AL.*, 1997) was developed in Queensland, Australia in the late 1980's. It relies on the premise that early successional vegetation produced by ecological rehabilitation can be utilised by many species and provides a suitable 'framework' for rebuilding biodiversity. Essentially, native tree species are planted to "capture" the site by shading out weeds. The planted trees re-establish basic forest structure and attract wildlife by providing perches for birds and fruit as bait for seed-dispersing animals. It is this wildlife which, in its role as seed-dispersers, establishes other species in the rehabilitation areas. The principal advantages of the method are that it involves a single planting and is then self-sustaining, relying on the local gene pool to increase diversity of species and life forms. This is a great benefit in softening potentially degraded or abandoned areas to enhance the local habitat matrix and in improving overall landscape heterogeneity. In Australia, the method is very successful. For example, seven-year-old rehabilitation plots, contiguous with forest, recruited up to seventy-two plant species across all growth forms and successional phases (TUCKER & MURPHY, 1997). Seed collection, germination and the production of container-grown seedlings are all essential prerequisites of these studies on replanting.

Nursery technology available in Thailand

In Thailand, nursery technology for the propagation of woody perennial species, both by seed and cuttings, is quite advanced. However, the development of this technology has largely focused on exotic and commercial plantation trees, often associated with genetic improvement programmes. Much research has been carried out at the ASEAN Forest Tree Seed Centre, Muak Lek, where, for example, cost-effective methods for the commercial propagation of tree seedlings have been developed using coconut husk (KIJKAR, 1991a). The centre has also developed seed testing standards for commercial species such as *Dipterocarpus alatus, D. intricatus* and *Hopea oderata* (KRISHNAPILLAY, 1992) and vegetative propagation techniques for dipterocarps in general (KANTARLI, 1993). Vegetative propagation of exotic species such as eucalypts, acacias and acacia hybrids has been extensively researched, resulting for example in the production of a handbook for the propagation of *Eucalyptus camaldulensis* (KIJKAR, 1991b).

However, very little work has been carried out on the vast majority of Thailand's estimated 3,600 native forest tree species. Furthermore, the technological requirements for the nursery production of native species for forest restoration must address issues concerned with lack of knowledge, the requirement for low-tech input, maintenance of genetic diversity and handling of relatively small numbers of many different species. The requirements of this technology are clearly quite different from those of a nursery producing trees for timber or biomass, where the emphasis is on clonal propagation and seed harvested from superior trees of few species. Many of the conventional techniques developed for these species would be inappropriate for isolated small-scale 'forest conservation' nurseries and could not be directly transferred to such operations.

THE FOREST RESTORATION RESEARCH UNIT NURSERY: A CASE STUDY

The Forest Restoration Research Unit (FORRU) was established in Doi Suthep-Pui National Park (DSPNP) in northern Thailand in 1994. The unit is addressing technical problems related to the re-establishment of natural forest ecosystems on degraded sites within conservation areas (ELLIOTT *ET AL.,* 1995). FORRU's facilities include a research tree nursery, a village community tree nursery and experimental planted plots at Ban Mae Sa Mai, an Hmong hill tribe village in the north of the DSPNP. A detailed study has been carried out of tree flowering and fruiting phenology, involving some 350 species, which represent more than 50% of the tree flora of DSPNP. Descriptions, drawings and photographs were made of fruits and seedlings. An herbarium collection of dried seedling specimens was established, along with computer databases of seed, fruit and seedling morphology. Without such basic background information, it would have been impossible to make sensible choices as to which tree species to use in forest restoration projects. Key elements of FORRU's research programme related to the selection and propagation of tree species for forest restoration, including: (i) screening a large number of tree species for their ease of propagation from seed; (ii) identifying species suitable for planting to complement natural seedling establishment (so-called "framework species") and (iii) developing appropriate methods to propagate such framework tree species.

Seed germination studies

Early on in FORRU's propagation programme, a strategic decision was made to carry out a preliminary screening as many of the native tree species as possible, rather than to attempt to select a small number of species initially for more detailed study (ELLIOTT *ET*

AL., 1995). Consequently, seed germination experiments were initially designed to identify tree species that germinated easily without any special treatments. Seeds were removed from fruits and planted in modular plastic trays under two shade treatments: partial shade (40% of full sunlight, similar to the quantity of light in partially regenerating gaps) and deep shade (less than 1% full sunlight, similar to the quantity of light under an evergreen forest canopy). For the partial shade treatment, seed trays were placed on top of concrete benches, under a transparent plastic roof, whilst for the deep shade treatment, trays were placed underneath the same benches, which were screened around the sides with black plastic shade netting. For each of the two shade treatments, 72 seeds were divided into three replicate batches of 24, which were randomly assigned to different benches and watered daily. Each replicate consisted of 24 adjacent modules (3.5 x 3 x 7cm) in one seed tray, containing a forest soil-based compost, mixed with coarse sand to improve its structure. Where possible, germination experiments were repeated in subsequent years. Germination trials were checked every few days, and the dates of the first, median and last seed to germinate were recorded.

Ease of nursery propagation is one of the key criteria for selection of framework species. Consequently, data on propagation were important in drafting a provisional list of framework species. When the list was first drafted in May 1997, germination trials had been carried out with approximately 350 species. These data demonstrated that approximately 50% achieved a germination rate of 50% or more in one or both shade treatments (unpublished data). Some 29% germinated significantly better in partial shade, whilst only 2% germinated significantly better in deep shade (paired t-test, $p \leq 0.05$). The remainder showed no significant difference in germination between treatments.

Selection criteria for framework species

Based on the "framework species method" described by GOOSEM & TUCKER (1995) and LAMB *ET AL.*, (1997), a series of criteria were compiled which we believed would be important for the selection of framework species in the seasonally dry tropical forests of northern Thailand. These were:

- ease of propagation in the nursery
- seedling survival in the rehabilitation plots
- seedling growth rate in the rehabilitation plots
- crown architecture and the ability to shade out weeds in the rehabilitation plots
- ease of natural dispersal
- attractiveness to frugivores
- age of fruiting
- rarity

In May 1997, we screened all of FORRU's databases and anecdotal information to produce a provisional list of framework species. At that time, not all of the relevant data were available for many of the species. Members of the Moraceae (figs), Leguminosae and

Fagaceae (oaks and chestnuts) are prominent amongst these species. The candidate framework species have been described elsewhere (ELLIOTT *ET AL.*, 1998).

Germination of framework species

Propagation data are presented for a selection of the framework species from the germination trial in partial shade, all of which have been considered as candidates for framework species (Table 1).

Table 1. Seed germination of selected framework species in partial shade

Framework species	Month of seed collection	Season of dispersal	Mean % Germination (SD)	Germination of median seed (days)
Schima wallichii	Mar	Late dry	54.2 (8.3)	12
Erythrina subumbrans	Apr	Late dry	38.9 (2.4)	7
Castanopsis diversifolia	Sept	Late rainy	45.8 (25.0)	221
Glochidion kerrii	Oct	Early dry	38.9 (4.8)	134
Diospyros glandulosa	Dec	Early dry	77.8 (6.4)	69
Manglietia garrettii	Oct	Early dry	73.6 (4.8)	81

Data have not been presented for germination in deep shade, as in none of the framework species was this significantly higher than that obtained in partial shade. In view of this observation, these species should not be germinated in deep shade, due to an increased risk of seedling mortality caused by higher incidence of pests and diseases. Whilst most species had germination percentages in partial shade well in excess of 50%, there were several exceptions. However, several such exceptions had other characteristics that outweighed any disadvantage of a lower germination percentage. An example of this category was *Erythrina subumbrans*, which scores highly for the other characteristics of framework species, but has a germination percentage of 39% in partial shade, and 28% in deep shade[4]. Not all of the candidate framework species identified however scored highly in all other categories. Therefore the list is continually modified as new data become available.

The production schedule: a nursery management tool

Following initial selection of framework species, it was necessary to scale up seedling production, not only to understand how to manage nursery production, but also to test the suitability of the selected potential framework species for planting out in degraded sites. For the latter, large numbers of seedlings were required. This required changes in FORRU's research nursery, from one dealing primarily with large numbers of species being germinated in small replicated trials, to a nursery capable of managing the production of large numbers of seedlings of a smaller number of species.

[4] Editor's note: as this paper went to press, additional germination trials achieved rates of up to 63% over 21 days for this species (WOODS, unpublished data).

Consequently, FORRU is in a position to advise other nurseries, whether they are attached to schools, villagers or national parks, not only how to propagate tree seedlings but also how to manage production on whatever scale might be required.

Seasonal dormancy is common in some semi-deciduous forests (GARWOOD, 1983) and will inevitably affect nursery operations. FORRU has a data set for some 350 species, which is being analysed to study seed germination at the community level (manuscript in preparation). However, a simple analysis of the phenology and germination data for the framework species as a group is extremely useful for nursery managers responsible for producing large numbers of seedlings of perhaps 30-50 framework species. Compilation of a production schedule is needed to plan space and labour requirements throughout the year. Without such a nursery management tool, it is very difficult to produce seedlings of an acceptable quality, when they are required for planting.

Data on dormancy and germination were used to help formulate a production schedule. NG (1978, 1980), in a similar study of Malaysian tropical rainforest tree species, used the first and last day of germination of each species to categorise them into one of three groups; rapid (all seeds germinate within 12 weeks), delayed (all seeds germinate in 12 weeks or more) and intermediate. This apparently arbitrary division was actually related to forest management and the period of time defined by Ng as rapid germination was just sufficient to include all species of the Dipterocarpaceae. Of 200 species examined, 65% fitted into the rapid category. Therefore, in the tropics, soil seed banks have a relatively short viability and cannot contribute much to the restoration of forest to sites that have been severely degraded over a long time. More recently, GARWOOD (1983) published an elegant study of seed germination in a seasonal tropical forest in Panama. Whilst she assessed her community data using the categories proposed by NG (1980), her primary analysis related to the identification of three germination syndromes based on the season of seed dispersal and the mean length of dormancy: delayed-rainy, intermediate-dry and rapid-rainy.

In the present study, we noted the time to germination of the first, median and last seed. If the median germination time is compared with the time of seed dispersal, a very interesting pattern emerges. In almost every month there are some framework species which, have a relatively short dormancy period within the nursery environment. However, the seeds of species dispersed towards the end of the dry season or start of the wet season tend to germinate relatively quickly under nursery conditions (e.g. *Erythrina subumbrans* and *Schima wallichii*). Seeds of species dispersed towards the end of the rainy season or start of the dry season are more likely to have a much longer period of dormancy (e.g. *Glochidion kerrii* and *Castanopsis diversifolia*), although there are exceptions, such as *Mangletia garrettii* and *Diospyros glandulosa*. Based on this single group of framework species, there is a clear indication that germination syndromes, similar to those reported by GARWOOD (1983), exist. This begs the question: 'Is this a problem that should concern the nursery manager?'

In the monsoon climate of northern Thailand, container-grown seedlings are planted out in the restoration plots only at one time of year, the start of the rainy season. The nursery manager is faced with the challenge of producing a crop of seedlings of some 30-50 native tree species, all to be dispatched at the same time of year. This production exercise is made very difficult by seasonal variation in seed dispersal, dormancy/germination and growth rates amongst the framework species. A provisional production schedule was produced for all of the framework species and an example is illustrated in Table 2 (see also FORRU, 2000). The production schedule contains all the basic information, which nursery managers need to plan activities throughout the year, including time of seed collection, germination period, and hence pricking out time, and dispatch time.

Variability amongst framework species means that nursery managers may need to exert some control over growth rates, to produce crops of tree seedlings of particular species that reach the ideal size for planting at the right time of year. Re-examining some of the examples above; *Erythrina subumbrans* is ideal for nursery production in this context, because, following seed collection early in the year, it germinates rapidly (median germination time of 10 days). After pricking out, it reaches the required size for hardening and planting out in time for the start of the subsequent rainy season in June.

In contrast, *Prunus cerasoides* produces seed in March-May, providing insufficient time to produce a plantable tree before the June planting date. However, *P. cerasoides* seeds germinate relatively quickly[5] and its seedlings grow rapidly in containers. Therefore, seedlings are ready for planting by November-December, 6 months ahead of the planting season. Consequently, nursery managers have three options: i) to hold the plants in the nursery until dispatch time, which wastes time and space; ii) to store seeds and sow them at an appropriate time nearer to the dispatch date or iii) to sow seeds in a sterile (zero nutrient) mix. In the latter case, seedlings can be held in the tray, for up to 12 months before pricking out. Although we are not aware of *P. cerasoides* seed being stored for any length of time in Thailand, there are reports that it can be dried and stored for up to 6 months.

Other species are more problematic. For example *Glochidion kerrii* seed ripens late in the year, but germination is slow (median germination time of 134 days) and growth of seedlings in containers is also relatively slow. Therefore, seedlings will not be ready for planting at the start of the following rainy season. This means that after pricking out, they may be kept in the nursery for more than 15 months.

Table 2. A provisional production schedule for three framework species

Species	Month																										
	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D
Erythrina subumbrans				S	S C	S C	S C		H	P						S	S	S C	S C		P						
Prunus cerasoides						S	S	S C	C	C										H	P						
Glochidion kerrii	S	S	S C	C	C	C														H	P						

S-seed sowing; C-pricking out into containers; H-hardening; P-planting

[5] Editor's note: recent results show that germination is accelerated by cracking open the pyrenes and removing the tough endocarp surrounding the seed (WOODS, unpublished data).

Nursery production of high quality seedlings; knowledge and expertise

The production schedule described above allows the nursery manager at FORRU to plan all activities in the nursery to produce high quality seedlings, which are strong, healthy and able to withstand the stress of transplantation into degraded sites. This, of course, is based on current knowledge. For some species we are close to the optimum production schedule, for others, more research is required to improve the efficiency and quality of production. The combination of seasonal patterns of germination and dormancy, variable growth rates between species and the narrow window for planting can create complex problems for nursery management. The next logical step is to review nursery practices applied to individual framework species and identify areas that may require further research. This process involves appraisal of nursery research requirements. It should be carried out for any nursery operation that is part of a forest restoration programme.

Some nursery practices have been extensively documented elsewhere and can be considered as 'standard', for example:

- grading and quality control
- pest and disease identification and control
- potting
- compost
- watering
- weed control

Whilst these factors deserve careful consideration in any nursery operation, they do not require a major research effort. In contrast, other aspects relating to nursery production of native tree species are not well understood and should be carefully considered in any nursery research programme. The identification of parent trees to supply seed and the implications for genetic diversity are particularly important in forest restoration projects for the conservation of biodiversity and are poorly understood, but are outside the scope of this paper[6]. Other key aspects, directly relating to nursery production, that require further consideration are discussed below.

Fertiliser application

The compost used in small-scale container nurseries varies considerably and usually depends on raw materials that are available locally and cheaply. The main bulk ingredient is often local forest soil, which will be highly variable both in its structural attributes, such as 'available water holding capacity' and 'air filled porosity', and its pH and nutritional qualities. It may also contain feral earth and flat worms, antagonistic fungal and bacterial species, as well as weed propagules. Coarse amendments are usually added to the bulk ingredient, such as sand, rice or coconut husks, to improve the structure of the compost.

[6] Editor's note: however, this topic did receive considerable attention during discussion sessions; see Part 7 proposal 4.2.

Whatever the final compost mix, seedlings of most native tree species may still require the application of nitrogen, phosphorus and potassium, even where forest soil constitutes the bulk ingredient. This is especially true of soil-less mixes. Application of the total fertiliser requirement as soluble fertiliser at the time of pricking out could damage seedlings and later lead to nutrient deficiencies due to leaching. In practice, these nutrients are supplied at regular intervals, either as a dilute soluble feed, or in a controlled release form (CRF, e.g. Osmocote). When applying CRF, the nursery manager may intend to influence plant quality, or actual growth rates, as discussed earlier with the production schedule, of many different species with different requirements. However, there will be a choice of several formulations, designed to last for different periods of time, typically 3 to 19 months. The rate of release, which is dependent on temperature, and the distribution of the granules within the relatively small volume of the container will need to be measured according to the manufacturers recommendation.

An alternative strategy that may offer more potential for manipulating framework species on an individual basis is liquid feeding. Using this method it should be possible to more precisely control amounts of nutrient applied and vary applications to suit different growth rates. However, such an approach requires skilful application and the performance of the seedlings must be continually and closely monitored.

Manipulation of root growth

In temperate forestry nurseries, the ratio between root and shoot dry mass is widely used as an index of plant quality. Seedlings with large, healthy fibrous root systems are better able to supply shoots with water. A high fibrous root:shoot ratio enables seedlings to withstand periods of drought stress after planting. This could be especially important in the manipulation of growth of tropical seedlings, prior to planting in the harsh environments of degraded sites. Large, woody roots are likely to offer the best direct resistance to desiccation, but must themselves have a good network of young, fine roots in order to take up further water from the soil. The period needed to develop an efficient root system needs to be known, to allow sufficient time for root development following final manipulation of root form prior to hardening and planting. This applies particularly to open ground seedlings, but also to some extent to container-grown seedlings. It is also known that temperate tree species differ in their abilities to i) withstand damage to their 'nursery' root system during transplantation and ii) regenerate new roots after transplantation. This might also be true for Thai framework species, but very little is known. Clearly, it is important for nursery managers to have this basic understanding of the functional morphology of root systems and factors affecting it.

Manipulation of shoot growth

Shoot pruning is rarely practised, usually when plants require holding back in the nursery. Its effects are not known for most Thai framework species. For species with strong apical dominance, removing the leading shoot might not affect final form. For other species, removing the leader might stimulate axillary bud break and a more densely branching crown; a desirable trait for shading out weeds on degraded sites.

Containers

An absence of root spiralling and other root deformities is an essential requirement of container-grown plants. Root morphology is strongly influenced by container design. Most seedlings produced in small nurseries are grown in black polythene bags. Whilst such bags are basically acceptable, better rigid containers are available, which produce better root form. Ridges or grooves are basic design features of such containers. They direct root growth downwards and prevent spiralling. Such containers work best with air-pruning, but the combination of more expensive containers, with a raised standing down area may not be feasible for low-budget nurseries. The volume of containers needed to accommodate species with different growth rates and propagule sizes is another important consideration.

Alternative propagation methods

Trees are not only raised directly from seed. Many nurseries obtain material as natural seedlings (wildlings) transplanted from elsewhere, and others use vegetative propagation, particularly for economically important species. Difficulties with clonal propagation relate to the loss of rooting ability with maturity of woody perennial species. This requires root-inducing treatments such as auxin application, and pruning to stimulate young, vigorous shoots, e.g. stooling and hedging. Key questions for nursery managers relate to clonal propagation. Is planting clonal material useful, in terms of uniformity? If so, how many different genotypes would be considered suitable for propagation? How much effort would be needed to develop an efficient propagation system?

It is unlikely in nurseries, where some 50 framework species are being produced, that all these variables could be optimised for every tree species. Even if the resources were available, it would lead to unmanageable production schedules. All factors are important and should be carefully considered for the 'framework tree crop' as a whole. However researchers should give more attention to individual species that are problematic, in terms of timing of seed availability, dormancy and growth rates in containers.

Seed storage

Short-term seed storage of up to a year would be a useful tool, both for managing the nursery production schedule of species such as *Prunus cerasoides* (as described earlier) and for transporting seeds to nurseries where local seed is unavailable due to forest clearance. In other cases, it may be desirable to store seed for several years when a species' fruit production follows a 'masting' pattern, i.e. fruit is only produced at intervals of several years (JANZEN, 1978). For such species, seed will be abundantly available one year, far exceeding the nursery's capacity to utilise it all, but will be scarce or unavailable in the following years. It would clearly be useful to be able to store such seed and stagger the production of seedlings over several years until the following masting year.

Successful storage must maintain viability, whilst preventing germination. This is usually achieved by drying seeds to a low moisture content and/or cooling to about 4°C (KRISHNAPILLAY *ET AL.*, 1993). Seeds that are tolerant of drying and cooling are classed as 'orthodox' and are easiest to store. Unfortunately, many tropical forest species have 'recalcitrant' seeds that do not tolerate desiccation or low-temperature storage. Recent research suggests the existence of a third, 'intermediate' category. Such seeds can be dried but not cooled, and quickly deteriorate in storage (KRISHNAPILLAY *ET AL.*, 1993). The long-term storage of recalcitrant seeds is a difficult problem, which remains unsolved despite attracting considerable amounts of research funding. An important first step is to identify species, which can tolerate storage and this is still not known for the majority of forest tree species in south-east Asia. In the case of FORRU for example, this might involve experiments with a small number of framework species such as *P. cerasoides*, whose production would immediately benefit from short-term storage.

Concluding remarks

This paper has focused on FORRU's application of nursery technology to native tree production, to demonstrate a successful and continuing research programme. It has summarised the selection criteria for framework species and described issues relating to their propagation. The final section of this paper aims to stimulate discussion on those areas of nursery production technology for native tree species that are not well understood and should be carefully considered in future forest restoration programmes.

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COMMENT

Jens Granhoff

One of the main concerns of FORGENMAP is seed supply. We must supply quality seed; we need genetic diversity; seeds must match between the site of origin, and the planting site; the seed source needs to be well documented. Further, the seed source needs to be from a broad genetic base, this is important. The seedlings must also be flexible and well adapted. Biodiversity is not important for FORGENMAP but it is clearly embraced at FORRU. The use of framework species is a very good shortcut to forest restoration. One thing that has not been mentioned is that these framework species are specific to certain forest types. For example, we can not use highland species for lowlands. Therefore, we need more research in this area[7].

[7] Editor's note: this topic stimulated much discussion and was subsequently proposed as a research priority; see Part 7, proposal 4.1.

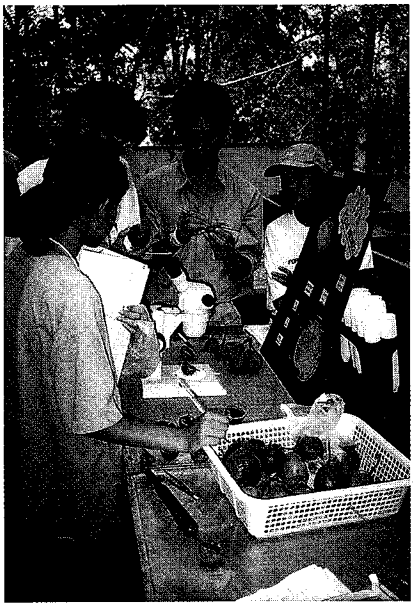
NURSERY TECHNIQUES

FORRU's community tree nursery at the Hmong hill tribe village of Mae Sa Mai, where villagers grow seedlings of native forest tree species to restore the degraded watershed above their village. Ideally nursery technologies for this situation must be low tech and practicable as well as scientifically sound.

The correct containers and media are crucial for the success of tree nurseries. Here FORRU's research nursery manager, Sudarat Zangkum and nursery officer, Jumpee Bunyadit, engage Royal Forest Department nursery staff in a debate on the pros and cons of various locally available materials.

PASSING ON THE KNOWLEDGE

Sarting young! Children have the most to gain from forest restoration and are more open to new ideas than adults. Here FORRU researcher Cherdsak Kuarak teaches Hmong primary school children at Ban Mae Sa Mai how to grow native forest trees.



At one of FORRU's many workshops, researcher Puttipong Navakitbumrung shows secondary school children how to prepare seeds for sowing.

TREE SPECIES SELECTION IN THAILAND: VARIOUS SPECIES FOR VARIOUS PURPOSES

Anders P. Pedersen[1]

ABSTRACT

A series of workshops across Thailand were conducted in September 1998 to identify priority tree species for different end-uses. Furthermore, estimates were quantified to the extent possible, in order to examine the relative importance of each species. The workshops resulted in a final list of 458 different species in four regions for five major end-uses, divided into a number of sub-end-uses. Most species were listed for several end-uses and in several regions.

Different end-uses and different regions identified different species. A pronounced interest for a greater number of species was seen in the quite deforested South, showing increasing species interest with diminishing forest resources. The demand for seedlings for soil and water conservation programmes will be concentrated in the North in the near future, although the total seedling demand for reforestation and planting seems fairly well distributed throughout the country. Species choice and rank clearly differ from region to region. There is very little correlation between number of end-uses for a particular species and its overall quantitative demand. Species number increases steadily from industry over local wood-use to non-wood-use and soil/water conservation. However, not surprisingly, for biodiversity and gene conservation end-uses, the registered number of species was the highest.

Results reflect new trends and attempts to handle "new" species. *Eucalyptus camaldulensis* is still in overwhelming demand, except in the south, where rubber is preferred. Pines are only important in the North and are now less popular than before. Teak, yang, rubber, neem, bamboo and Australian acacias are all extremely important, although demand varies among the regions. There is substantial demand for indigenous hardwoods, varying from ornamentals, fencing and fruit trees to "classic" timber species. A new trend is the interest for mangrove species in the south and central Thailand.

BACKGROUND

Tree planting in Thailand still relies to a large extent on erratic seed supply. This is the situation in both the private and public sectors, despite tree improvement programmes, which have been ongoing for up to 30 years. However, there is clearly a growing concern

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about the importance of the quality of available seed and seedlings. Farmers and other seed users find, in practice, that it is difficult to procure well-documented seed of high quality (e.g. high vigour seed and germinants; good growth; productive, adapted material). There is an acute need to develop an integrated national tree seed programme to meet the demands of different tree planters. This involves use of improved genetic resources already developed as well as further genetic improvement, particularly of indigenous species.

Forest Genetic Resources Conservation and Management Project

Implementation of the Forest Genetic Resources Conservation and Management Project (FORGENMAP) is based on existing organisational structures in Thailand. Initiated in 1997, the project aims to:

i) ensure the presence of an effective, public seed supplying organisation;
ii) support community and co-operative based activities in order to make sustainable use of genetic resources, whilst, at the same time, protecting them;
iii) support the private sector and make its material and techniques generally available and
iv) support and promote biodiversity and forest rehabilitation.

FORGENMAP co-ordinates, procures and supplies seed to meet the demand for seed of better quality for the country as a whole. Furthermore it deals with the management of genetic resources, including domestication, biodiversity and conservation of forest tree species and provenances. The project has the immediate objective of providing seed and plant material of good genetic and physiological quality from selected seed sources of indigenous and exotic tree species. This plant material will meet present and future needs for tree seed in Thailand in a sustainable way by strengthening national institutional capacity. Danish support for the first phase of the project ends in September 2000, but a further two-year extension is now expected. Although the project was initially concerned purely with conservation of tree seeds and genes, the future focus will likely concentrate more on biodiversity and rehabilitation.

METHODS

As a primary step towards achieving its objectives, FORGENMAP conducted a series of four three-day workshops across Thailand in September 1998 to identify priority species for different end-uses. The approach of diversifying priority selection into different end-uses facilitated the workload and increased precision in the working groups. By diversifying the end-uses it was hoped that fewer species would be overlooked, forgotten or otherwise disregarded, which easily could happen in short, hectic workshops.

Delegate categories

A total of 153 delegates were convened at the workshops from the following major FORGENMAP stakeholders, representing 32 separate interest groups:

Table 1. Number of stakeholders represented at the four workshops held. Thirty-two different stakeholder groups were present.

Stakeholder groups	Part of country				Total	%
	North	North-East	Central, West, East	South		
RFD (FRO/ NRCO/ RO/ FPRO) (Share of Regional Offices / Reforest. and ext.)	21 (6)	18 (5)	23 (6)	14 (4)	76 (21)	51
NGO's with DANCED Support (CORD, CARE, IMPECT, PDA, KNCC, NKYF, FFF)	5	7	5	0	17	11
RURAL COMMUNITIES (In Co-operation with NGO's)	5	10	2	0	17	11
TREE FARMERS (Co-operatives and Private)	2	8	5	3	18	11
PRIVATE NURSERIES	1	2	2	0	5	3
INDUSTRIAL ENTERPRISES (with tree planting)	2	3	2	1	8	5
UNIVERSITIES (KUFF, CMU, MAEJO University)	5	0	0	1	6	4
SPECIAL PROJECTS (QSBG, HKK, ALRO,OEPP)	3	0	2	1	6	4
TOTAL DELEGATES	44	48	41	20	153	100

The major groups represented at the workshops were:

1. Farmers (small scale subsistence farmers and private land owners)
2. Enterprises engaged in tree planting for industrial purposes.
3. Communities, active in reforestation (associated with NGO's)
4. NGO's associated with tree farming and community forestry, including conservation
5. GOT/RFD (Government of Thailand, Royal Forest Department) agencies engaged in extension to farmers and communities
6. Representatives of major private nurseries as well as nurseries of RFD / Reforestation Office - Nursery Division.
7. Representatives of major agencies, Universities, RFD - Research Office, Conservation Office and projects involved in Biodiversity Conservation of Genetic Resources.

Provision of background material

Prior to the workshop, delegates were provided with numerous existing lists of priority species. This was meant to activate and support, but not limit the delegates. Although many organisations and institutes had issued such lists in the past, many of these covered only limited and conservative groups of few species. The following lists were distributed:

The Forest Research Office, 1998:
The Seed Management Programme (72 species)
The Gene Bank Conservation Programme (27 species)

The Reforestation Office, 1998:
The Economic Plantation Extension Programme (56 species)
The Community Forest Development Programme (75 species)

The CARE rural development based Programme, 1998:
The Rehabilitation of highland watersheds (32 species)
The Community Forest Development (7 species)

The OEPP, 1996:
Biodiversity conservation priority species of endemic angiosperms (36 species)

FAO / RAP, 1997:
Important priority or endangered Tropical SE Asia Palms (16 species)
Rattans (23 species)

The National Research Council, 1994:
Multipurpose tree species (16 species)

Specific end-uses

Working groups were formed in five "major end-use" groups, each considering specifically the following sub-uses, in order to cover all the demand, seen from all likely uses for tree planting:

Group1: Industrial Wood Uses
Energy wood, for industrial uses
Pulp and paper, MDF board
Flooring
Veneer and furniture
Sawn timber

Groups 2: Local Wood Uses
Fuel for local consumption

Tools
Handicraft
Construction
Agro-forestry

Groups 3: Non-wood products
Ornamental
Amenity (shade, fencing, etc.)
Fruit, fodder
Medicinal / Aromatic

Groups 4: Soil and Water conservation
Highlands
Lowlands

Groups 5: Biodiversity & Conservation of forest genetic resources
Biodiversity (in relation to ecosystems and ecotypes)
Conservation for genetic broadness to ensure flexibility and robustness in future plantings

Only the North and Central regions considered biodiversity and conservation of genetic resources, but all regions covered the other end-use groups. Delegates examined the lists in relation to major end-use categories. They were free to substitute or add new or more relevant species, based on local experience. This was a major reason for convening the workshop in four separate regions. Criteria on species choice, quality, quantification methods and modality of group operation were given. The groups were asked to consider a specific major end-use purpose within the end-use category of their group. Each group worked systematically: district by district, organisation by organisation, sub-use by sub-use. A group consisted typically of 5-15 delegates. They listed, quantified and summarised all species related to the end-use within their region only. If representatives of a delegate category were not represented in a group, the remaining delegates estimated species priorities on behalf of the organisation in order to obtain a complete picture.

RESULTS AND DISCUSSION

Participants were asked to identify priority species related to each end-use and to estimate seedling demand for each species. The seedling demand exercise was intended to provide an indirect and thus non-competitive ranking of the priority species. The results of the workshops enabled the author to analyse the future demand for seedlings and assess species priorities by main and sub-use. Comparisons among regions, their similarities and discrepancies, were feasible as well. Further analyses will enable us to identify trends in species choice as compared with previously released RFD species priority lists, which developed from mainly 'top-down' approaches. In practice, the lists are already used to guide the identification of proper and sufficient seed sources.

The initial results identified over 500 species. This number was reduced by identifying species that were listed more than once by synonymous, local or spelling variations of the same name or by various names referring to different parts of the tree. The final list identified a total of 458 species identified in the four regions for the five end-uses. Almost every species was mentioned under more than one end-use and in more than one region. Of the final list, 188 species could not be identified by their scientific name, and many of these species were listed under the end-use category on biodiversity and gene conservation.

A pronounced desire for a greater number of species lies in the mostly deforested South. This indicates an increasing species interest with diminishing forest resources. Soil and water conservation programmes in the North will consume a huge quantity of seedlings in the near future. However, total reforestation and planting needs seem fairly well distributed throughout the country. Species choice and rank clearly differs from region to region. There is very little correlation between the number of end-uses for a particular species and its overall quantitative demand. Of the five categories of end-use identified, each contained more than 100 species. However, the highest number of species was associated with biodiversity (see below).

i) Industry 109 species
ii) Local 125 species
iii) Non-wood 157 species
iv) Conservation 167 species
v) Biodiversity 200 species

End-use groups 1 to 4

In each of the four major regions of Thailand, species were ranked according to seedling demand (Table 2). Only the top 25 are presented in this paper, and the actual seedling demand created requires further analysis. The species not included in the table (those of rank 26 and less) are numerous and far from unimportant. For the species shown, a few points are clear; *Eucalyptus camaldulensis* is still in considerable demand, except in the South, where rubber is the preferred tree. Pines are only important for the North and seem less popular compared with earlier priorities. Teak, yang, rubber, neem, bamboo and Australian acacias are all extremely important, although varying from region to region.

Many species of indigenous hardwoods are in demand, varying from ornamentals, fencing and fruit trees to 'classic' timber species. The requirement for mangrove species in the south and central regions is a new trend.

The top 25 species for each of four major end-uses are presented in Table 3. Each end-use has a very distinct species choice, especially within the first six ranked species, which are almost unique in each case. The interest in biodiversity and conservation species was considerable, but participants could not quantify it in terms of seedling demand. Many of the species in this category were identified solely as components of natural forest systems.

End-use group 5: Biodiversity and Gene Conservation

A list of 200 species was drawn up for biodiversity and gene conservation (not included in the proceedings, but available from the author). Of these, about 100 were proposed by the North and Central region respectively, indicating almost no species overlap between the two regions. The large number of individual tree species suggested by the participants indicates an overwhelming interest and concern for biodiversity and conservation. However, although about 200 species were named, seedling demand was still relatively low in comparison to the other end-uses, reflecting little or no interest in most of the species when decisions are made concerning forestation and planting programmes. This may reflect a lack of knowledge on handling, propagation, storing etc., due to the severe lack of research on these species. It may also indicate the participants' desire to plant only species of known practical use, even in projects where conservation is the main objective. Thus, although the importance of a diverse range of indigenous species was acknowledged, forest managers clearly felt unable or unwilling to use these species in practice. A valuable outcome of this workshop would be that some of these suggested species are researched more fully, allowing them to be promoted and more easily utilised in the future.

Weaknesses

The present survey is not scientific and has, to some extent, the characteristic of being an academic exercise. The stakeholder groups as a whole represent users or influential parties who, as such, have an important opinion on priority species and level of demand. However, the representation was not consistent from workshop to workshop. The absolute figures given without a clear mandate are not directly usable. However, their relative values are less questionable, because they do not possess one-sided errors. Only limited information was gained on the requirements for seedlings for biodiversity and conservation, although a long list of species was compiled.

Lessons learnt

Reliable, absolute figures are difficult to obtain from workshops such as the ones described. The criteria and modality of group operation must be very clear to avoid misunderstandings and to make effective use of time. Delineation of the country into regions becomes delicate, when it comes to actual species and seedling estimates. Formation of groups with more than five persons seemed to amend the more extreme estimates before convening into plenary discussions. An investigation like the one in question is not scientific due to a number of uncontrollable factors. The composition of delegates is decisive. Results like the ones presented are, however, useful in different ways. Firstly, they may be instrumental in forming a forest policy, initiating planting programmes and allocating funding for expressed needs. Secondly, they act as a well-defined starting point for the project in question. Thirdly, they may be useful in guiding development of gene conservation, seed procurement, forest research, plant (seedling) production units, tree improvement and biodiversity conservation.

Table 2. Priority species for each of four major regions of Thailand, ranked in order of seedling demand.

Rank	North Scientific Name	Uses[1]	South Scientific Name	Uses	Northeast Scientific Name	Uses	Central Scientific Name	Uses
1.	*Eucalyptus camaldulensis*	1, 2	*Hevea brasiliensis*	2	*Eucalyptus camaldulensis*	1, 2	*Eucalyptus camaldulensis*	1, 2
2.	*Pinus kesiya*	1, 4	*Azadirachta excelsa*	1,2, 3	*Azadirachta indica siam.*	1, 2, 3	*Bambusa* spp.	1, 2, 4
3.	*Tectona grandis*	1, 2	*Acacia mangium*	1, 2	*Pterocarpus macrocarpus*	1, 2	*Hevea brasiliensis*	1
4.	*Prunus cerasoides*	4	*Dipterocarpus alatus*	1,2, 4	*Tectona grandis*	1, 2	*Calamus* spp.	2, 4
5.	*Betula alnoides*	3, 4	*Eucalyptus camaldulensis*	1	*Acacia mangium*	1, 2, 3	*Alstonia scholaris*	1, 2, 3
6.	*Azadirachta indica siam*	1, 2, 3, 4	*Hopea odorata*	1, 2, 4	*Albizia saman* (*Samanea s.*)	1, 2, 3	*Azadirachta indica siam*	1, 2
7.	*Peltophorum dasyrachis*	1, 2, 4	*Avicennia* spp.	1, 4	*Bambusa* spp.	1, 2, 3	*Pterocarpus macrocarpus*	1, 2, 4
8.	*Acacia mangium*	1, 2, 3, 4	*Rhizophora apiculata*	1, 4	*Alstonia scholaris*	1, 3	*Thyrsostachys siamensis*	1, 2, 4
9.	*Acacia auriculiformis*	1, 2, 3	*Rhizophora mucronata*	1, 4	*Xylia xylocarpa* (*X. kerrii*)	1, 2, 4	*Hopea odorata*	1, 2, 4
10.	*Michelia floribunda*	1, 2, 4	*Fagraea fragrans*	2, 4	*Pithecellobium dulce*	2, 3, 4	*Tectona grandis*	1
11.	*Castanopsis acuminatissima*	4	*Melaleuca leucadendra*	1, 2	*Afzelia xylocarpa*	1, 2	*Lagerstroemia tomentosa*	2, 3
12.	*Bambusa* spp.	1, 2, 4	*Dialium cochinchinense*	1, 3	*Cassia siamea*	2, 3	*Casuarina junghuhniana*	1, 2
13.	*Albizia saman* (*Samanea s.*)	1, 2	*Rhizophora* spp.	2	*Euginia cumini*	3, 4	*Acacia mangium*	1
14.	*Dipterocarpus alatus*	1, 2, 4	*Parkia speciosa*	3, 4	*Dipterocarpus alatus*	1, 2	*Dipterocarpus alatus*	1, 2, 4
15.	*Thyrsostachys siamensis*	1, 3	*Bambusa* spp.	1, 2, 3	*Hopea odorata*	1, 2	*Dendrocalamus strictus*	2
16.	*Toona ciliata*	4	*Casuarina equisetifolia*	1, 2, 4	*Acacia auriculiformis*	1, 2, 3	*Casuarina equisetifolia*	1, 2
17.	*Pterocarpus macrocarpus*	1, 2, 4	*Alstonia scholaris*	1, 3	*Calamus* spp.	2, 3	*Bambusa nana*	2
18.	*Combretum quadrangulare*	1, 2	*Toona ciliata pterocarpum*	1, 2	*Peltophorum*	2, 3	*Toona ciliata .*	2, 4

Rank	North		South		Northeast		Central	
	Scientific Name	Uses[1]	Scientific Name	Uses	Scientific Name	Uses	Scientific Name	Uses
19.	*Peltophorum pterocarpum*	2, 3	*Mangifera caloneura (M. pentandra)*	1	*Mimusops elegi*	3	Yah Fag (Gramineae family)	4
20.	*Bauhinia variegata*	4	*Mimusops elegi*	1	*Dalbergia oliveri*	1, 2	*Rhizophora* spp.	1
21.	*Cassia siamea*	2, 3, 4	*Sandoricum koetiape*	1	*Leucaena leucocephala (X. kerrii)*	2, 3	*Xylia xylocarpa*	1, 4
22.	*Alstonia scholaris*	2, 3	*Alstonia spathulata*	3	*Dalbergia cochinchinensis*	1, 2	*Holoptelea integrifolia*	4
23.	*Leucaena leucocephala*	1, 3	*Shorea* spp.	4	*Peltophorum dasyrachis*	1, 3	*Tamarindus indica*	2, 4
24.	*Gmelina arborea*	2	*Albizia saman (Samanea s.)*	1, 2	*Tamarindus indica*	2, 3	*Afzelia xylocarpa*	1,
25.	*Dendrocalamus asper*	2	*Intsia palembanica*	2, 4	*Albizia lebbeck*	2, 3	*Leucaena leucocephala*	1

[1] 1 = Wood industry 2 = Local wood consumption 3 = Non-wood uses 4 = Soil and water conservation

Table 3. Priority species for each of four end-user groups, ranked in order of seedling demand.

Rank	1. Industrial Wood Uses	2. Local Wood Uses	3. Non-Wood	4. Soil/Water Conservation
1.	*Eucalyptus camaldulensis*	*Hevea brasiliensis*	*Azadirachta indica siamensis*	*Prunus cerasoides*
2.	*Tectona grandis*	*Eucalyptus camaldulensis*	*Alstonia scholaris*	*Betula alnoides*
3.	*Acacia mangium*	*Bambusa* spp.	*Eugenia cumini*	*Pinus kesiya*
4.	*Azadirachta indica*	*Acacia mangium*	*Mimusops elegi*	*Peltophorum dasyrachis*
5.	*Pinus kesiya*	*Dipterocarpus alatus*	*Pithecellobium dulce*	*Castanopsis acuminatissima*
6.	*Pterocarpus macrocarpus*	*Azadirachta indica siam.*	*Cassia fistula*	*Michatia floribunda*
7.	*Acacia auriculiformis*	*Tectona grandis*	*Samanea saman*	*Dipterocarpus alatus*
8.	*Dipterocarpus alatus*	*Pterocarpus macrocarpus*	*Azadirachta excelsa*	*Toona ciliata*
9.	*Bambusa* spp.	*Azadirachta excelsa*	*Melodorum fruticosum*	*Hopea odorata*
10.	*Samanea saman*	*Cassia siamea*	*Aquilaria crassna*	*Pterocarpus macrocarpus*
11.	*Alstonia scholaris*	*Peltophorum pterocarpum*	*Peltophorum pterocarpum*	*Bauhinia variegata*
12.	*Hevea brasiliensis*	*Samanea saman*	*Cassia siamea*	*Parkia speciosa*
13.	*Hopea odorata*	*Hopea odorata*	*Leucaena leucocephala*	*Rhizophora apiculata*
14.	*Azadirachta excelsa*	*Acacia auriculiformis*	*Millingtonia hortensis*	*Rhizophora mucronata*
15.	*Afzelia xylocarpa*	*Xylia xylocarpa*	*Lagerstroemia* spp.	Yah Fag (Gramineae family)
16.	*Mangifera* spp.	*Rhizophora* spp.	*Wrightia religiosa*	*Eugenia cumini*
17.	*Peltophorum dasyrachis*	*Calamus* spp.	*Bambusa* spp.	*Shorea* spp.
18.	*Casuarina equisetifolia*	*Afzelia xylocarpa*	*Sapondias pinnata*	*Azadirachta indica siamensis*
19.	*Casuarina junghuhniana*	*Dalbergia oliveri*	*Tamarindus indica*	*Bambusa* spp.
20.	*Hopea ferrea*	*Alstonia scholaris*	*Acacia auriculiformis*	*Xylia xylocarpa*
21.	*Xylia xylocarpa*	*Wrightia tomentosa*	*Acacia mangium*	*Persea kurzii*
22.	*Leucaena leucocephala*	*Fagraea fragrans*	*Lagerstroemia tomentosa*	*Intsia palembanica*
23.	*Toona ciliata*	*Dalbergia cochinchinensis*	*Thyrsostachys siamensis*	Pra Dong Leuat (sci. name unknown)
24.	*Mimusops elegi*	*Melaleuca cajuputi*	*Alstonia spathulata*	*Hopea ferrea*
25.	*Sandoricum koetiape*	*Albizia lebbeck*	*Calamus* spp.	*Cassia siamea*

The interest and demand for these findings has been expressed from many levels. Valuable side effects from the species prioritisation process have been:

i) liaison with private sector (difficult to reach for a government-based project!);
ii) establishment of new contacts;
iii) exchange of information and
iv) the discovery of bottlenecks in seed availability (supply) and in expression of seed and seedling needs.

From a regional perspective, Thailand is now in a position to compare and relate seed procurement and seed demand at a practical level to neighbouring countries. This could save duplicating efforts on minor species by co-ordination and making use of species already taken care of. For maintenance of gene conservation and biodiversity point, regional co-ordination may be even more needed. Further information and a full summary of the workshop results, including list of priority species, are available from the project.

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QUESTION AND ANSWER

David Lamb

I am interested in the list of species in the soil water conservation group. Can you comment on whether species at the top of the list share anything in common with those at the bottom in terms of watershed protection?

Anders Pedersen

I have not yet tried to analyse different species, or why they are ranked as such. However, I can forward the entire list for further analysis.

Yadi Setiadi contributes to one of the discussion groups on tree planting in the field.

MYCORRHIZAL SEEDLING PRODUCTION FOR ENHANCING REHABILITATION OF DEGRADED FOREST IN INDONESIA

Yadi Setiadi[1]

ABSTRACT

Tropical deforestation has become an extremely important global environmental issue over the past five years. The range of the annual deforestation rate in Indonesia is between 0.9-1.2 million hectare and about 13.2 million hectares of degraded tropical rain forest in Indonesia are classified as critical sites, urgently needing re-vegetated. The Indonesia government has an ambitious programme to accelerate efforts to re-vegetate deforested areas. Reforestation however is not an easy task. Adverse edaphic and climatic conditions and low activity of soil microbes are major constraints limiting success of this activity. Transplanted seedlings often have poor growth and low survival rates. To ensure successful tree establishment under such conditions, producing more planting stock of improved quality and introducing effective mycorrhizal fungi onto the seedlings in the nursery are required. Improvement of planting stock quality by manipulation of seedling containers, potting media, inoculation with selected and effective mycorrhizal fungi and nursery management are discussed. This paper provides an overview of techniques to produce mycorrhizal planting stock for enhancing rehabilitation of degraded forest in Indonesia.

Key words: degraded tropical lands, forest restoration, nursery techniques, seedling quality

INTRODUCTION

Tropical deforestation has become an extremely important global environmental issue over the past five years. The causes of deforestation are varied, for example population pressure, shifting cultivation, agricultural development, transmigration, forest fires and unsupervised, poor logging practices (WORLD RESOURCES INSTITUTE, 1990; BARROW, 1991). By the end of the 1980s, the annual deforestation rate in Indonesia was between 0.9-1.2 million hectares or about 0.8% of the total forested area (FAO, 1990; FRIENDS OF THE EARTH, 1991).

The negative impact of deforestation leads to increased soil erosion, loss of biological diversity, damage of wildlife habitats, degradation of watershed areas and deterioration in the quality of life (UNCED, 1992). Actions that can help to reduce the rate of deforestation of the tropical Indonesian forest and help to support preservation and restoration of existing

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different forest ecosystems are urgently needed. Concern about the negative effects of deforestation has lead to a reforestation programme becoming a top priority of the Indonesian government and of private companies involved in the forest industry. The government has stepped up efforts to re-vegetate about 13.2 million hectares of critically deforested areas. However, the proposed target will be difficult to achieve due to several major constraints, which are related to the unfavourable environmental conditions existing at the chosen reforestation sites. Edaphic factors (low nutrients, acidic soils), climatic factors (high levels of solar radiation and high temperatures) and biological factors (aggressive competition from the predominant grass *Imperata cylindrica*, a high chance of fire and low soil microbial activities) combine to reduce performance of planted trees.

Edaphic factors

Most reforestation zones and industrial plantations are located in Sumatra and Kalimantan, both dominated by Oxisol and Ultisol soils. About 15 million hectares of potential reforestation sites in Indonesia are acidic, supporting *Imperata cylindrica* grassland (FA0, 1990). These soils exhibit an imbalance in nutrient availability. While they are generally low in nitrogen, phosphorus and bases, such as calcium, magnesium and potassium, they often contain appreciable amounts of exchangeable aluminium, manganese and iron, which may reach toxic levels. Due to this imbalance in nutrient supply, the establishment and growth of tree seedlings is often problematic.

Climatic factors

Climatic factors include a high level of solar radiation, temperature extremes and periods of high wind velocity. These factors promote a fast transpiration rate in newly planted seedlings in reforestation sites. The relative inability of newly planted seedlings to absorb enough water during early establishment, especially during dry periods, can often result in drought stress and increased seedling mortality.

Biological factors

The most significant biotic factor inhibiting the growth of tree seedlings in reforestation sites in the tropics is dominance of the invasive grass *Imperata cylindrica*. This weed has a high competitive ability for water, nutrients and space and also releases allelopathic substances into the rhizosphere. It also has an ability to thrive either in fertile or infertile soils. The inability of tree seedlings to compete with this weed during their establishment has a significant effect on their growth. As a result, seedlings are often stunted and show symptoms of nutrient deficiency.

To improve chances of tree establishment in such adverse sites, production of high quality seedlings and application of mycorrhizal fungi have been tried. The beneficial effects of mycorrhizae in improving seedling performance are widely recognised. This paper reviews techniques of mycorrhizal seedling production for enhancing rehabilitation of degraded land in Indonesia and suggests some directions that it might take in the future.

PLANTING STOCK PRODUCTION

Species selection

To increase reforestation success, planting stock should comprise seed or clonal plant material able to tolerate prevailing site conditions. However, the adaptability and growth of the majority of native tree species in new sites in Indonesia are not well known. Consequently, tree species should be selected for drought resistance, an ability to recover after fire, strong competitive ability against invasive grasses, relatively fast growth rate, allelopathic and acid tolerance, ability to absorb nutrients from infertile soil (nitrogen-fixing and form mycorrhizae) and pest tolerance.

Attempts to evaluate species adaptability on degraded forest land have been carried out, for example in a semi-arid area, with a mean annual rainfall of 370 mm; altitude 49 m asl; sandy-clay soil and pH 6.8-7.2. Among the species tested, highest survival after 16 months was achieved by *Cassia siamea* (89%), followed by *Acacia arabica* (77%), *Eucalyptus* spp. (69%) and *Aleurites mollucana* (59%). Other species (*Sesbania grandiflora, Paraserianthes falcataria, Artocarpus heterophylla* and *Gmelina arborea*) had a low survival rate (below 40%) and the growth of surviving plants was poor (SETIADI, 1991). Experiments in humid tropical forest (mean annual rainfall 3,900 mm, altitude 60 m asl, poor nutrients, pH 4.6-5.2, vegetation cover dominated by *Imperata* grass) evaluated the survival of 8-month-old trees of five species. Highest survival was achieved by *Vitex pubescens* (88%), followed by *Gmelina arborea* (72%), *Peronema canescens* (68%) and *Swietenia macrophyla* (63%). *Ochroma bicolor* exhibited a low survival (below 40 %) and poor growth. Similar studies of nickel mining sites (SETIADI, 1992) identified *Paraserianthes falcataria, Acacia mangium, Eucalyptus* spp, *Trichospermum burretii* and *Pinus merkusii* as the most adaptable of 17 species tested after 22 months.

Mycorrhizal seedling production

An increase in denuded areas, which need to be re-vegetated, has increased the need to produce high quality planting stock. Sites in Indonesia targeted for reforestation include those with P-deficient acid soil, where seedling growth is limited. In addition, seedlings may be exposed to adverse environmental conditions and may be susceptible to damage from drought, fire, competition and insects. Therefore, it might be expected that production of high quality seedlings combined with the application of mycorrhizal technology might improve the success of reforestation.

BIODIVERSITY AND PLANT STATUS OF MYCORRHIZAL FUNGI

The novel functions of arbuscular mycorrhizal fungi (AMF), as biological agents for improving growth and health of plants; bioremediation of soil contaminated with heavy-metals and seedling establishment on degraded sites are well recognised (SETIADI, 1995a). Most tree species in tropical regions are colonised by AMF (LEAKEY & NEWTON, 1994).

However, little attention has been paid to the potential application of AMF in tropical silviculture (MICHELSEN, 1992).

A survey of local AMF's and plant mycorrhizal status in disturbed ecosystems such as disturbed forest, grass land, secondary forest, spoil mine sites, tailings, peat forest and semi arid forest has been conducted (SETIADI, 1998a). An initial assessment of mycorrhizal-root interaction of different plants growing in different disturbed ecosystems demonstrated that of 112 trees species assessed, almost 87% of them had mycorrhizal associations. Most pioneer plants establishing on adverse sites are colonised by arbuscular mycorrhizal fungi (SETIADI, 1998b). This may indicate that mycorrhizae are required for the establishment of plants on degraded sites. Spores of AMF have been found in all forest ecosystems studied, except in swamp and mangrove forest. Among the forest ecosystems studied, the number of AMF spores found in converted peat forest was the highest, whilst the number of AMF spores found in Alpine/sub-alpine forest (3,200-4,255 m asl.) was the lowest. Over 23 different spore types were found in a range of Indonesian forests and the AMF species richness (based on spore types) varied among the ecosystems studied. Species richness of AMF was higher in re-colonised tailings and *Imperata* grassland ecosystems, compared to other environments. The genera of *Glomus, Sclelocystis, Acaulospora, Scutelospora* and *Gigaspora*, and AMF species of *Glomus oculltum* and *Acaulospora morrowaiae* were commonly found in all ecosystems. Information regarding diversity of indigenous AMF, their distribution and the frequency of occurrence of specific AMF in different tropical soils in Indonesia is scarce. Further investigation into the biodiversity of these fungi is urgently required.

CULTURING INDIGENOUS TROPICAL ARBUSCULAR MYCORRHIZAL FUNGI

Procedures for establishing pure pot cultures of AMF have mainly been developed for temperate species, collected from soils of neutral pH with moderate to high fertility. The adoption of similar procedures for culturing AMF, collected from tropical conditions (especially from acidic poor soils), is not always satisfactory. Using a modified test tube culture technique, more than 14 indigenous AMF isolates were successfully obtained in pure cultures (SETIADI, 1995a; 1996). These AMF cultures were routinely maintained on the host of *Pueraria phaseoloides,* grown in a soil-less medium of zeolite. Presently more than 50 species of AMF are maintained at the BTIG (Bank of Tropical Indigenous Glomales) of IUC-Biotech-IPB as a germplasm collection.

Inoculant production of indigenous arbuscular mycorrhizal fungi

Arbuscular mycorrhizal fungi are obligate biotrophs. Although several attempts at axenic culturing of these fungi have been made, sustained axenic culture has not yet been achieved. Thus, they cannot be propagated on artificial media without a living host (SIEVERDING, 1991). SETIADI (1995a) compared nine host-substrate treatments on spore production of *Glomus manihotis* (INDO-1), *Acaulospora tuberculata* (INDO-2), *Acaulospora delicata* (EJ-01) and *Glomus mossea* (PAL-03). The highest spore densities of isolate INDO-1 (81 spores g^{-1} of substrate) were produced with a combination of sand and sorghum, whilst lowest spore densities (24 spores g^{-1} of substrate) were produced in sand-bahia grass. Highest spore production of INDO-2 was achieved either in sand-kudzu (83 spores g^{-1} of substrate) or in zeolite-kudzu (61 spores g^{-1} of substrate) combinations. Kudzu-inolite was significantly the best combination for producing spores of both *Acaulospora. delicata* and *Glomus mosseae* (216 spores g^{-1} of substrate and 62 spores g^{-1} of substrate respectively). Combinations of sand and bahia grass had been used previously as a substrate medium and plant host respectively for establishing open pot cultures of AMF at IUC-IPB in Indonesia. This finding suggested that selection of the best combination of host and media for producing mycorrhizal inoculum is crucial, because this will determine the quality and potential of the inoculum.

Further work was carried out with The International Institute of Biotechnology, Kent University UK. Different physical and chemical conditions (types of soil-less media, particle size, pH, nutrient composition) and appropriate hosts were studied, to improve the inoculum quality of selected AMF for reforestation. Using this information, selected AMF were successfully bulked-up in open pot culture using *Sorghum bicolor* as a host, grown in soil-less medium of zeolite, and the mycorrhizal inoculum produced was registered as BIOGROW.

Selection of indigenous AMF as potential inoculum

The possibility of using beneficial attributes of AMF in forestry to promote performance of transplanted seedlings and help re-establish mycotropic plant species will depend on preliminary assessments of whether inoculation is a suitable management option. The greatest immediate potential for AMF as inoculants is where indigenous populations of AMF have been eradicated or drastically reduced, such as in reforestation zones (JEFFRIES & DODD, 1991; SETIADI, 1998a). Reforestation sites in Indonesia are usually P-deficient acidic soils, where seedling growth is limited. Therefore, application of AMF technology might relieve problems of seedling establishment in such areas. All AMF species, however, are not equally effective at promoting seedling growth. Consequently pre-assessment of the effectiveness of AMF species in improving seedling performance in targeted soils is crucial before their use can be recommended. Studies on selecting the most effective indigenous AMF isolates for promoting plant growth in P-deficient acidic soils have been carried out (SETIADI, 1996). Among the AMF tested, *G. manihotis* (INDO-1) and *A. tuberculata* (INDO-2) were best at promoting early growth of seedlings of fast growing tree species. It was suggested that collection and selection of AMF isolates for use for inoculation in reforestation programmes should be made from the target areas. For a beneficial effect from AMF inoculation, selected AMF isolates should be applied in locations with edapho-climatic conditions that are similar to those where the isolates were first collected.

MYCORRHIZAL INOCULATION TECHNIQUES AT THE NURSERY STAGE

An effective method of raising colonised seedlings of trees for reforestation in the nursery has been developed (SETIADI, 1998b). There are four options for practising mycorrhizal inoculation in the nursery; layering pre-inoculation, mixed pre-inoculation, direct local inoculation and direct mixed inoculation. The two former techniques have been used successfully for small seeds that are pre-germinated prior transplanting into poly-bags; these techniques minimise the bulk quantity of inoculum needed for seedling inoculation. Two weeks after pre-germination, roots of 80-100% of seedlings are colonised with an intensity range of 40-60%. In contrast, only 10-15% root colonisation was obtained using the two latter techniques.

Until recently our inability to culture AMF in axenic conditions hampered the production of inoculum on a large scale. The total amount of inoculum required per hectare in forestry, however, is much smaller than in agriculture. The rates of application of inoculum reported in previous publications was 20-30 ton ha^{-1} (BAGYARAJ, 1992). In contrast, rates of only 15-30 kg ha^{-1} inoculum are required in forestry. This inoculum requirement can now be further reduced by up to 50-70% by improving the inoculum potential (high propagule density) and by adopting pre-inoculation techniques (SETIADI, 1996; SETIADI, 1998b). Thus, progress in forestry would not necessarily be hampered by a lack of sufficient inoculum. These studies have also shown that selection of the most appropriate combination of host and fungus, growth medium, appropriate pH and control of the nutrient regime (especially P) during open pot culture establishment can produce a high quality AMF inoculum. This approach, combined with the use of the pre-germination inoculation technique, can overcome many of the difficulties inherent in producing large quantities of inoculum. Thus, realistic large-scale application of AMF inoculation in the forestry sector should be feasible.

MYCORRHIZAL SEEDLING PERFORMANCE IN THE NURSERY

It was reported (SETIADI, 1996) that inoculation did not confer a beneficial growth response on *Eucalyptus* sp., *Melaleuca leucadendron*, *Ochroma bicolor* and *Pometia pinnata*. In contrast, inoculation with selective AMF isolates promoted growth of leguminous tree seedlings such as *Acacia mangium, Acacia crassicarpa, Paraserianthes falcataria, Enterolobium cyclocarpum, Pterocarpus viladianus, Prosopsis* sp., *Casia siamea* and *Sesbania.grandiflora*, and non-legumes such as *Duabanga moluccana, Gmelina arborea, Tectona grandis, Vitex* sp. *and Trichospermum burretii*. The responsiveness of these species to inoculation indicates that they would not grow well in degraded reforestation sites unless inoculated with effective AMF. Thus AMF inoculation technology can be chosen as a management practice during the nursery phase.

Liming the soil to raise the pH, combined with the application of commercial phosphate fertiliser are common practices used in reforestation sites in Indonesia to overcome P-deficiency. However, these practices do not always achieve their aim of stimulating early seedling growth, especially for highly mycotrophic plant species such as *Sesbania grandiflora*, *Pterocarpus* sp., *Duabanga moluccana*, *Gmelina arborea*, and *Prosopsis* sp. Non-inoculated seedlings, receiving fertiliser, remain small and stunted. Growth of these plants markedly increases when the soil is inoculated with selected and effective AMF.

Soil fertilisation is commonly used to stimulate plant growth in the nursery, as well as in field conditions. SETIADI (1995a) showed that inoculation with AMF alone in the nursery stimulates greater growth of mycotrophic tree seedlings than conventional phosphate fertiliser treatments. Thus, the costs required for use of commercial P-fertiliser can be reduced. In addition, promotion of growth of seedlings in the nursery resulting from inoculation with AMF can also reduce the time that seedlings need to stay in the nursery. Thus labour costs for maintenance of seedlings in nurseries can also be reduced.

MYCORRHIZAL SEEDLING PERFORMANCE AFTER TRANSPLANTING

It has been suggested that a much greater effort is required to investigate the effect of AMF under field conditions (ABBOTT & ROBSON, 1991) to accelerate tree establishment in disturbed ecosystems. The effectiveness of *G. manihotis* (INDO-1) and *A. tuberculata* (INDO-2) in improving the early growth of fast growing leguminous and non-leguminous trees in nurseries has already been shown (SETIADI, 1996). However, it was not known if this beneficial effect would also be found in field conditions. Consequently a study was designed to examine whether inoculation with *G. manihotis* (INDO-1) and/or *A. tuberculata* (INDO-2) could also increase performance of fast growing leguminous and non-leguminous trees after the transplantation of pre-inoculated seedlings into the field (acidic grassland, post-nickel-mine sites and degraded land after fire).

Initially, inoculation of nursery seedlings with AMF significantly increased stem diameter and height of 3 month-old, fast growing, leguminous trees i.e: *Acacia mangium, Acacia crassicarpa, Paraserianthes falcataria, Enterolobium* sp. and *Cyclocarpum* sp. Similar results were obtained with non-legumes i.e: *Gmelina arborea, Trichospermum burretii* and *Eucalyptus pelita.* No effect was noted with *Swietenia macrophylla* seedlings. The stem diameter and height of seedlings inoculated with a single inoculum of either (INDO-1) or (INDO-2) or with a mixed inoculum of both were significantly increased compared with the controls. The percentage of inoculated seedlings surviving 1 month after transplanting was relatively higher (91-95%) than for non-inoculated seedlings (80%). This trend continued 3 and 5 months after transplanting. However, the percentage of plants surviving after 8 months was variable. The survival rate of plants inoculated with the mixed inoculum was still high (88-90 %) for *Paraserianthes falcataria, Acacia crassicarpa* and *Swietenia macrophylla,* whilst 70-80% of plants inoculated with single fungal inoculum survived, and 60-68% of non-inoculated plants survived.

One month after transplanting on acidic grassland soil, the stem diameter and height of the seedlings inoculated with the mixed inoculum was significantly greater than all other inoculation treatments, including the non-inoculated controls. Eight months after transplanting, seedlings of *P. falcataria, A. mangium, E. cylocarpum, A. crassicarpa,* and *G. arborea* inoculated with the mixed inoculum still showed significantly greater stem diameters and greater height.

This study has shown that the beneficial effects of seedling inoculation with AMF in the nursery could not always be demonstrated after inoculated seedlings were transplanted into the field. However, growth of seedlings of certain species, inoculated with a mixed inoculum, was consistent and significantly better than that for non-inoculated plants, both in the nursery and in the field.

Field trials of inoculated seedlings of trees used for reforestation are still limited. To encourage a wider application of AMF in the forestry sector, large-scale inoculation trials are needed under a variety of field conditions, using different host-fungus combinations. In addition, the edapho-climatic conditions, the status of the indigenous AMF population and their effectiveness in targeted sites should also be determined.

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QUESTIONS AND COMMENTS

Kate Harwick

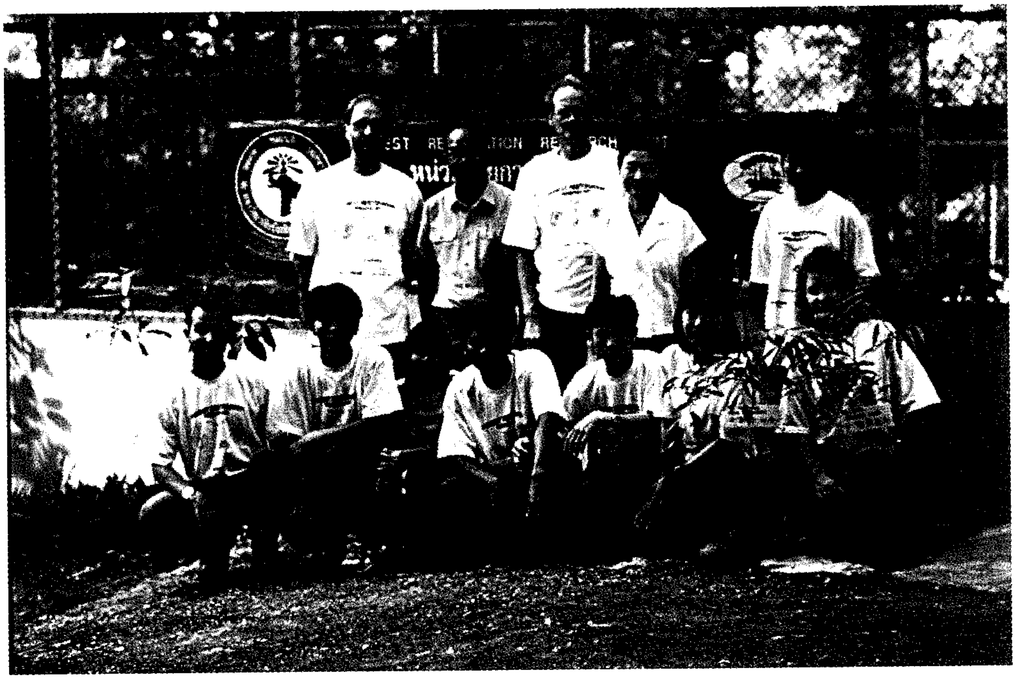
Do you think that mycorrhizal inoculation would increase seedling performance on less degraded sites, such as abandoned agricultural areas?

Yadi Setiadi

Mycorrhizae can be used on agricultural sites and may have a positive effect.

Ulfah Siregar

Not all species are compatible with mycorrhizae. Mycorrhizae provide most benefit in poor soil conditions. Consequently, positive growth benefits may be difficult to see where fertilisers have been applied. Furthermore, mycorrhizae can have negative effects in very dry conditions.



The Forest Restoration Research Unit team

PERFORMANCE OF SIX NATIVE TREE SPECIES, PLANTED TO RESTORE DEGRADED FORESTLAND IN NORTHERN THAILAND AND THEIR RESPONSE TO FERTILISER

Stephen Elliott[1], Puttipong Navakitbumrung[1], Sudarat Zangkum[1], Cherdsak Kuarak[1], Janice Kerby[1], David Blakesley[2] and Vilaiwan Anusarnsunthorn[1]

ABSTRACT

The performance of six native forest tree species, planted to restore forest in a degraded watershed in Doi Suthep-Pui National Park, Thailand and their responses to four fertiliser treatments are reported. The species were chosen for their potential to i) shade out competing weeds rapidly and ii) enhance tree species richness by attracting seed-dispersing wildlife.

All species planted, except *Gmelina arborea,* performed well. Relative performance indices, which combined survival and relative growth rate, were 87.5 for *Erythrina subumbrans*, 45.3 for *Melia toosendan*, 36.9 for *Prunus cerasoides,* 32.5 for *Sapindus rarak,* 22.2 for *Hovenia dulcis* and 3.5 for *Gmelina arborea.*

Application of fertiliser at the time of planting and twice during the first rainy season after planting resulted in much higher performance than application of fertiliser only at the time of planting, for all species except *Prunus cerasoides.* Although the highest dosage of fertiliser (200 g at the time of planting and twice during the rainy season) resulted in the highest growth rates, it also lowered survival of planted saplings. For planting mixtures of native tree species, the recommended fertiliser treatment is therefore 50-100 g fertiliser, applied at the time of planting and at least twice during the first rainy season after planting. Further research is needed to determine whether more frequent fertiliser application would further improve performance.

Key words: forest restoration, reforestation, silviculture, fertiliser

INTRODUCTION

Deforestation is probably the greatest threat to Thailand's biodiversity. Whilst increased protection of remaining forest must remain an essential part of any policy for biodiversity conservation, protection alone is clearly not enough. Since Thailand's first conservation areas were established in the early 1960's, forest cover has been reduced from 53% of the country (BHUMIBAMON, 1986) to 22.8% or 111,010 km^2 (FAO, 1997). Now, more than a decade since a ban on commercial logging was introduced, the annual rate of deforestation

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remains approximately 1,000 km^2 (CHATWIROON, 1997) or just under 1%. To counteract this apparently unstoppable deforestation, restoring forest to degraded forestland must complement stricter protection of remaining forest.

Forest restoration within wildlife sanctuaries and national parks should aim to recreate the original forest ecosystems that were present before deforestation occurred. This would provide optimal habitat for wildlife and help to restore original levels of biodiversity. One way to achieve this might be to complement natural regeneration by planting native forest tree species that grow rapidly, shade out weeds and attract seed-dispersing animals into planted areas. Wildlife, especially birds and bats, attracted by the planted trees, would disperse the seeds of other, non-planted tree species into replanted sites and thus accelerate the recovery of biodiversity. This is the so-called 'framework species' method of forest restoration, which has been used very successfully to restore forest in Queensland's Wet Tropics World Heritage Area (GOOSEM & TUCKER, 1995; LAMB *ET AL.* 1997, TUCKER & MURPHY, 1997). In Queensland, 30-60 cm tall saplings of 20-30 framework tree species are planted, spaced 1.6-1.8 m apart. In addition to careful species selection, the method includes intensive care for the trees after planting i.e. weeding and application of fertiliser. Such practices maximise the performance of the planted trees and bring about rapid canopy closure. Once canopy closure occurs, no further maintenance is required and the replanted forest becomes self-sustaining.

In collaboration with Doi Suthep-Pui National Park, Chiang Mai University's Forest Restoration Research Unit (FORRU) has been carrying out research since 1997 to identify potential framework tree species from amongst the native tree flora of the national park and to develop effective methods to propagate them. With sponsorship from the Biodiversity Research and Training Programme (BRT 240002), FORRU established experimental field plots in 1998, to assess whether the framework species method could be adapted to restore deforested sites in northern Thailand.

Within these plots, the performance of 29 indigenous species of forest tree is being monitored. Here we report on the early performance of six of the fastest-growing species. In many degraded upland areas, applying fertiliser can accelerate tree growth, since soil nutrients are often depleted following cultivation. For forest restoration projects in Australia, GOOSEM & TUCKER (1995) recommend applying 100 g of inorganic fertiliser when trees are planted and subsequently every 4 weeks during the rainy season. However, for native forest trees in Thailand, the optimal dosage and frequency of fertiliser application have not yet been determined. Therefore, in the experiments reported here, four different fertiliser treatments were also tested.

Study area

Experimental plots were established in the north of Doi Suthep-Pui National Park, in a degraded watershed (18° 52'N, 94° 51'E), 1,207-1,310 m above sea level. The locations of the plots were decided in collaboration with the villagers of Ban Mae Sa Mai, an Hmong hill tribe community about 2 km from the plots. The villagers were also closely involved with planting, maintaining and monitoring the plots.

The area has two main seasons: the wet season (May - October) and the dry season (mean monthly rainfall below 100 mm, November - April). The dry season is subdivided into the cool-dry season (November to January) and the hot- dry season (February to April). Average annual rainfall, recorded at the nearest weather station to the study site at similar elevation (Kog-Ma Watershed Research Station), was 2,094.9 mm. Temperatures varied from a minimum of 4.5°C in December to a maximum of 35.5°C in March (Fig. 1).

Originally the study site had been covered in evergreen forest, but the forest was cleared approximately 20 years ago and the area cultivated for cabbages, corn, potatoes etc. Frequent fires have caused additional degradation. Compared with soil in undisturbed evergreen forest at a similar elevation, soil in the study site was significantly more acidic and it had significantly less organic matter, less nitrogen, more sand and less silt and clay (Table 1, $p<0.05$). Although a few scattered mature trees remain, the area is now dominated by herbaceous weedy vegetation such as *Pteridium aquilinum* (L.) Kuhn (Dennstaedtiaceae), *Bidens pilosa* L. var. *minor* (Bl.) Sherf, *Ageratum conyzoides* L., *Eupatorium odoratum* L. and *E. adenophorum* Spreng. (all Compositae), *Commelina diffusa* Burm. F. (Commelinaceae) and grasses e.g. *Phragmites vallatoria* (Pluk. ex L.) Veldk., *Imperata cylindrica* (L.) P. Beauv. var. *major* (Nees) C.E. Hubb. ex Hubb. & Vaugh. and *Thysanolaena latifolia* (Roxb. ex Horn.) Honda (both Gramineae).

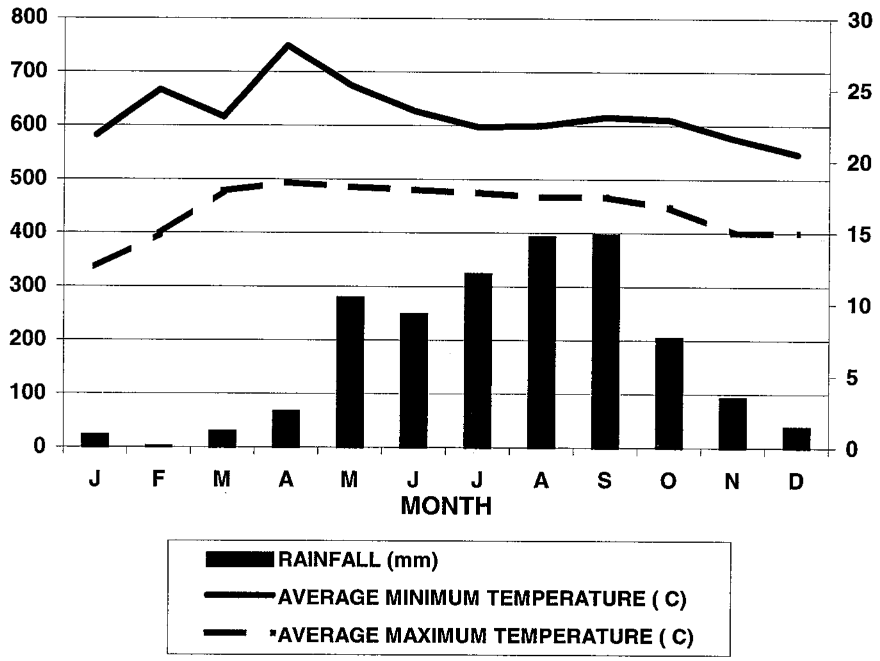

Figure 1. Average monthly rainfall, minimum and maximum temperature at Kog-Ma Watershed Research Station (elevation 1,400 m) approximately 9 km from the study site (1966-83).

Table 1. Soil characteristics of the study site (degraded area) (n=16) compared with those in undisturbed evergreen forest (Tum Reusi, elevation 1,100 m about 9 km from the study site) (n=20).

	Degraded Area		*Evergreen Forest*		t-test[1]
	Mean	*SD*	Mean	*SD*	p values
ph	5.44	0.423	6.22	0.545	0.001
Organic Matter (%)	5.35	0.997	7.30	2.480	0.010
Nitrogen (%)	0.26	0.045	0.37	0.121	0.002
Potassium (ppm)	274.84	137.637	295.67	72.093	ns[2]
Moisture at field capacity (%)	34.76	2.571	35.35	4.363	ns[2]
Sand (%)	68.52	6.290	52.13	17.872	0.010
Silt (%)	18.26	3.090	22.04	5.473	0.020
Clay (%)	13.22	3.880	25.83	16.343	0.010

[1]Two-tailed Student's t-test, variances assumed equal, [2]ns = not significant at $p>0.05$

METHODS

Trees planted

The saplings planted were grown from seed, collected within Doi Suthep-Pui National Park. Seeds were germinated in open plastic trays and potted into 9 x 2.5 inch black plastic bags in a medium of forest soil, coconut husk and peanut husk mixed in the ratio of 2:1:1. Saplings were grown for 3-18 months (depending on species) at FORRU's research nursery at the national park HQ (at about 1,000 m above sea level). They were 30-100 cm tall at the time of planting. Brief information about the six species covered in this report is provided below. For further details see Forest Restoration Research Unit (1998 & 2000).

Erythrina subumbrans (Hassk.) Merr. (Leguminosae, Papilionoideae) is an exceptionally fast-growing, deciduous tree, up to 25 m tall, with a dense, spreading crown, branching near the base. It is found in evergreen forest and mixed evergreen-deciduous forests from 350 to 1,700 m elevations, especially along stream valleys at lower elevations (CMU Herbarium Database). The stem is thorny which may protect saplings from herbivores. The attractive red flowers produce copious quantities of nectar, which attract wildlife, and the seeds are eaten by various bird species.

Gmelina arborea Roxb. (Verbenaceae) is a common, fast-growing, medium-sized (up to 30 m tall), deciduous tree, found in all forest types, especially in disturbed areas at elevations ranging from 350 to 1,500 m (CMU Herbarium Database). Its dense spreading crown is particularly effective at shading out weeds. About 3-4 years after planting, it produces fleshy fruits (drupes) which are avidly eaten by deer and cattle. This species is widely used as a plantation tree for pulp and paper production.

Hovenia dulcis Thunb. (Rhamnaceae) is a rare, exceptionally fast-growing, deciduous tree, up to 20-30 m tall, with a spreading crown, restricted to evergreen forest, especially near streams, from 1,000 to 1,300 m elevations (KOPACHON *ET AL.*, 1996). The fruits (capsules) are very attractive to birds (pigeons and bulbuls) (HITCHCOCK & ELLIOTT, in press) and rodents and it rapidly resprouts after fire damage. The fruit stalks are used in a traditional treatment of hangovers (MABBERLY, 1987).

Melia toosendan Sieb. & Zucc. (Meliaceae) is a common, fast-growing, deciduous tree, up to 30 m tall, capable of rapid regeneration after damage, found in evergreen forest and mixed evergreen-deciduous forest, at elevations of 550 to 1,450 m (CMU Herbarium Database). Fruiting can occur on saplings as young as 2-3 years old.

Prunus cerasoides D. Don (Rosaceae) is a medium-sized, fast-growing, deciduous tree, up to 20 m tall, with conspicuous pinkish-purple flower petals and small red fruits, which are attractive to birds. It grows in evergreen forest and disturbed areas, at 1,000-2,000 m elevation (CMU Herbarium Database). This species has become particularly popular for tree planting projects, mostly because of its attractive flowers. It is often planted as an ornamental, especially along roadsides. The fruits are edible but rather acidic (Bunyadit, pers. com.).

Sapindus rarak DC. (Sapindaceae) is an uncommon, medium-seized, deciduous, fast-growing, resilient, canopy tree, reaching heights of 10-25 m. It grows in evergreen forest and mixed evergreen-deciduous forest, often in disturbed areas at elevations ranging from 625 to 1,620 m (CMU Herbarium Database). Soapy substances, extracted from the fruits, are used to make soaps and shampoos. The wood is used for general construction, furniture, boards and combs.

Establishment and monitoring of planting trials

Three replicated blocks of sub-plots were established on gently sloping sites on ridge tops above Ban Mae Sa Mai. The blocks were spaced approximately 0.5-1 km apart, to encompass natural variability in soil conditions, slope, aspect etc. Sub-plots were prepared by weeding with hand tools, followed by a single application of the non-residual herbicide, glyphosate, care being taken not to spray naturally established trees. On 28th June 1998, the sub-plots were planted randomly with 29 potential framework tree species at a density of 3,125 trees per ha (approximately 1.8 x 1.8 m spacing). For each species, the same number of trees was planted in each sub-plot.

In the sub-plots, four fertiliser treatments were applied. The fertiliser used was "Rabbit Brand" NPK 15-15-15. The treatments were: i) 100 g fertiliser mixed with soil in the planting hole at planting time, but no subsequent fertiliser application; ii) 50 g fertiliser at planting and two further 50 g applications during the rainy season; iii) 100 g fertiliser at planting and two further 100 g applications during the rainy season and iv) 200 g fertiliser at planting and two further 200 g applications during the rainy season. Hereafter, these treatments are referred to as FP, F50 F100 and F200 respectively. Sub-plots were 20 x 20 m for each treatment. The sub-plots were weeded as necessary during the rainy season. Fertiliser was spread in a ring at least 30 cm from the stem of each sapling immediately after weeding in September and December (except for the FP treatment). The plots were monitored 2 weeks after planting on 15th July 1998 and on 5th March 1999. Monitoring included recording numbers of surviving trees and their heights (measured from root collar to apical meristem).

RESULTS

Survival

Overall, the mean survival of planted saplings was 81.9%. The mean values for individual species ranged from 72.4% for *Gmelina arborea* to 93.2% for *Erythrina subumbrans*. Within individual treatment sub-plots, however, the range was 58.3 to 100.0% (Table 2.). The effects of the fertiliser treatments on survival varied among the species. With the exception of *Gmelina arborea*, there was no difference in survival percentages obtained with the FP treatment for the other 5 species, all between 80 and 87.5%; with the F50 treatment, the highest survival of >95% was recorded for *Sapindus rarak*, *Melia toosendan* and *Erythrina subumbrans*; similarly for the F100 treatment, the latter species also had survival percentages of >93.3%. Averaging across all species, the F100 treatment gave the highest survival and the F200 treatment gave the lowest. A Mann-Whitney U-test revealed significant differences in treatment medians only between F100 and F200 ($p < 0.05$).

Table 2. Percentage survival of 6 native forest tree species over the first growing season with 4 fertiliser application treatments (initial sample sizes ranged from 9 to 21 saplings per treatment).

Species	Treatments				Species means
	FP	F50	F100	F200	
Erythrina subumbrans	80.0	100.0	100.0	92.9	93.2
Gmelina arborea	58.3	66.7	91.7	72.7	72.3
Hovenia dulcis	87.5	60.0	80.0	76.9	76.1
Melia toosendan	84.6	100.0	93.3	85.7	90.9
Prunus cerasoides	85.7	61.5	80.0	62.5	72.4
Sapindus rarak	84.2	95.0	95.2	70.0	86.1
Treatment means	80.1	80.5	90.0	76.8	81.9

Growth Rates

Relative height growth rate (%RGR month^{-1}) was calculated for each individual sapling that survived the period July 1998 to March 1999. An analysis of variance, performed on the mean %RGR of each species and of each treatment showed no significant differences among the three blocks ($p<0.05$). Therefore, %RGR's for all individual saplings were pooled across all blocks for each treatment. Averaging over all species and treatments, the mean relative growth rate was about 8% month^{-1}. The effects of the fertiliser treatments on mean %RGR varied among the species. *Erythrina subumbrans* gave the highest mean %RGR in all treatments, followed by *Prunus cerasoides* (Table 3). With the exception of the FP treatment, relatively high growth rates were also obtained with *Melia toosendan* and *Sapindus rarak.*

Table 3. Mean relative height growth rates (% month^{-1}) of 6 native forest tree species over the first growing season with 4 fertiliser application treatments.

Species	Treatments								Species means	
	FP		F50		F100		F200			
	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*	Mean	*SD*
Erythrina subumbrans	17.80	6.39	14.29	10.57	17.99	5.23	17.74	7.70	16.95	7.47
Gmelina arborea	-0.71	4.39	3.81	1.86	0.05	1.97	0.49	4.14	0.91	3.09
Hovenia dulcis	3.52	3.82	5.25	7.87	6.45	3.16	5.98	3.67	5.30	4.63
Melia toosendan	2.35	9.24	10.82	3.41	9.71	4.52	12.49	5.25	8.84	5.61
Prunus cerasoides	9.33	4.45	8.76	2.79	7.80	9.12	11.12	3.80	9.25	5.04
Sapindus rarak	2.92	7.59	8.10	3.60	7.91	11.61	8.18	7.37	6.78	7.54
Treatment means	5.87	5.98	8.50	5.02	8.32	5.94	9.33	5.32	8.01	5.56

Averaging across the species, the highest growth was obtained with the F200 treatment and lowest with the FP treatment. However, an analysis of variance performed on pooled %RGR's from all blocks, for each species, failed to show that differences in mean %RGR among fertiliser treatments were statistically significant, except for *Melia toosendan.* For this species alone, differences among fertiliser treatments were highly significant (F=6.45, p=0.001), but this was due entirely to the differences between FP and the other treatments. T-tests showed that the FP treatment significantly reduced %RGR compared with all other treatments (F50, t=3.16, p<0.01; F100, t=2.59, p<0.02; F200, t=3.13, p<0.01). There were no significant differences among the treatments involving application of fertiliser twice during the rainy season for *Melia toosendan.*

Performance

Combining survival with %RGR provides an index of relative performance and enables comparisons among species. Therefore, a relative performance index (RPI, no units), with a maximum value of 100, was calculated to determine the optimal fertiliser treatment:

$$\text{RPI} = \frac{\text{mean \% survival x 10}}{\text{max. mean \% survival}} \times \frac{\text{mean \%RGR x 10}}{\text{max. mean \%RGR}}$$

Averaging across fertiliser treatments, differences among species were statistically significant (Table 4, p<0.05). *Erythrina subumbrans* was significantly the best-performing species, followed by *Melia toosendan, Prunus cerasoides, Sapindus rarak* and *Hovenia dulcis* (Table 4). *Gmelina arborea* performed inadequately in this experiment. Applying fertiliser only at the time of planting clearly resulted in the poorest performance compared with application of fertiliser at planting and twice during the rainy season. All species tested, except *Prunus cerasoides*, showed minimum performance with the FP treatment. Averaging across species, mean RPI was lowest with the FP treatment. However, differences among all treatment means were not statistically significant (at p<0.05) and were only marginal among the other three treatments. Three of the species tested attained maximum RPI with the F50 treatment (*Melia toosendan, Sapindus rarak* and *Gmelina arborea*), two (*Hovenia dulcis* and *Erythrina subumbrans*) with the F100 treatment and one (*Prunus cerasoides*) with the FP treatment.

Table 4. Mean RPI of 6 native forest tree species over the first growing season with 4 fertiliser application treatments.

Species	Treatments				Species means[1]
	FP	F50	F100	F200	
Erythrina subumbrans	79.1	79.4	100.0	91.6	87.5[a]
Gmelina arborea	-2.3	14.1	0.3	2.0	3.5[c]
Hovenia dulcis	17.1	17.5	28.7	25.6	22.2[b]
Melia toosendan	11.1	60.1	50.4	59.5	45.3[b]
Prunus cerasoides	44.4	30.0	34.7	38.6	36.9[b]
Sapindus rarak	13.7	42.8	41.9	31.8	32.5[b]
Treatment means	27.2	40.7	42.6	41.5	

1 Means not sharing same superscripts are significantly different (Student's t-test, two tailed, p<0.05, variances assumed equal)

DISCUSSION

All species, except *Gmelina arborea,* performed well in this experiment and can be recommended for planting to restore forest ecosystems in highland areas in northern Thailand. Three of the species can also be grown at lower elevations e.g. *Erythrina subumbrans* (down to 350 m), *Melia toosendan* (550 m) and *Sapindus rarak* (625 m). The poor performance of *Gmelina arborea* can probably be attributed to various insect pests that attacked the leaves. This problem seems to vary from year to year, since *Gmelina arborea* saplings planted by FORRU in the same watershed in 1997 grew very well.

Compared with a single application of fertiliser at planting time, applying fertiliser twice during the rainy season marginally or substantially increased the performance of five of the six species of planted saplings and significantly increased growth rate of *Melia toosendan.* Only *Prunus cerasoides* appeared to fair better without repeated applications of fertiliser during the rainy season.

Although the maximum fertiliser dosage (F200) resulted in the highest %RGR, averaged across the species, it increased %RGR only marginally compared with the F50 and F100 treatments, by 9.7% and 12.1 respectively. Therefore, in view of the high sapling mortality caused by the F200 treatment and its high expense, it cannot be recommended.

The recommended fertiliser treatment, when planting mixtures of native tree species in degraded upland watersheds in northern Thailand, is therefore 50-100 g fertiliser applied at the time of planting and at least twice during the first rainy season after planting.

The advantages of using 100 g, compared with 50 g, however, appear to be marginal. Therefore, 50 g is probably the most cost-effective treatment. Further research is needed to determine whether more frequent applications of fertiliser would yield further benefits. A possible exception to this general guideline is *Prunus cerasoides*, which performed best with minimal fertiliser application. This species had higher survival and growth rates with the FP treatment than with both the F50 and F100 treatments.

%RGR of height was a highly variable measure of growth. This may have reflected variability in site conditions or genetic variation among the saplings planted. Further research is needed to attain a more uniform response from the planted saplings.

The experiment is still being monitored and we hope to report on the performance of the planted trees after 2-3 years of growth in a subsequent paper.

ACKNOWLEDGEMENTS

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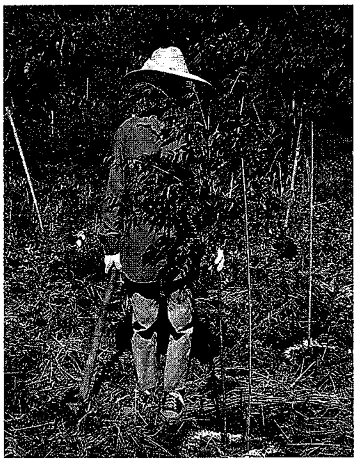
FERTILISER CAN ACCELERATE FOREST RESTORATION

An Hmong hill tribe woman applies fertiliser around trees planted in FORRU's experimental plots, 1 month after planting.

Fertiliser is applied in a ring 30 cm away from the stem of a young *Ficus altissima* tree 3 months after planting.

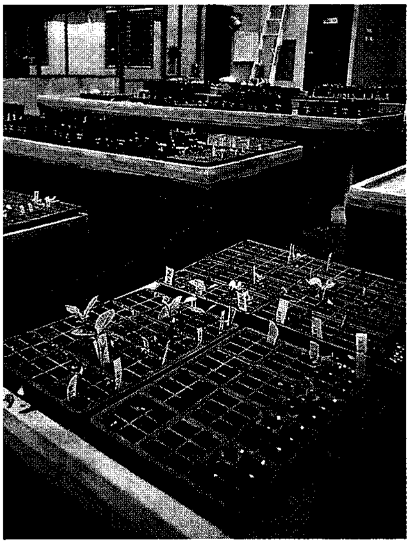


Fertiliser can accelerate growth and canopy closure, thus reducing weeding costs.This *Melia toosendan* tree is nearly 2 m tall just 3 months after planting.

Three years after planting with fertiliser application, these framework species have closed canopy: *Gmelina arborea* (centre); *Hovenia dulcis* (left) and *Prunus cerasoides* (right).

PROPAGATING NATIVE FOREST TREES

Visitors learn how to schedule the growth of healthy seedlings of native forest tree species at FORRU's research nursery.



At FORRU, seed germination is monitored in modular plastic trays.

FORRU researcher, Cherdsak Kuarak monitors growth of seedlings at all stages of nursery production to formulate production schedules.

PROPAGATING NATIVE TREES TO RESTORE DEGRADED FOREST ECOSYSTEMS IN NORTHERN THAILAND

Cherdsak Kuarak[1], Stephen Elliott[1], David Blakesley[2], Puttipong Navakitbumrung[1], Sudarat Zangkum[1] and Vilaiwan Anusarnsunthorn[1]

ABSTRACT

Producing a wide range of native forest tree species to restore forest ecosystems for conservation of biodiversity is beset with nursery scheduling problems. Different species produce seeds at different times of the year and they have different growth rates, yet all seedlings must reach a plantable size at the same time of the year. A research programme was begun in 1997, to formulate production schedules for various forest tree species indigenous to northern Thailand and to determine optimum propagation methods. Basic data were collected on performance in the nursery from seed collection to planting out. In this short report, we present detailed results for four tree species suitable for forest restoration plantings (*Bischofia javanica, Castanopsis tribuloides, Ficus semicordata* and *Dalbergia rimosa)* and a summary production schedule for 35 species. Of these, 12, 22 and 1 species respectively reached plantable sizes by the 1st, 2nd and 3rd planting season after seed collection. The amount of nursery time required ranged from 6 to 25 months.

Key words: seedling production or propagation, forest restoration, tropical tree nursery methods, Thailand

INTRODUCTION

Deforestation is one of the most serious environmental problems in Thailand today, causing rural poverty, watershed degradation and loss of biodiversity. In the past, efforts to solve the problem usually meant establishing single-species plantations, which are of little value for wildlife conservation and watershed protection. Recently, however, the idea of restoring original forest ecosystems has rapidly gained ground. Some senior Royal Forest Department officials are actively promoting "enrichment planting", using a wide range of native tree species and a random planting pattern (CHATWIROON, 1997).

In 1993 a nation-wide project, involving the government, NGO's and the private sector, was launched to replant 8,273 km^2 of deforested land, to celebrate His Majesty King Bhumibol Adulyadej's Golden Jubilee. The project stipulates use of a wide range of native forest tree species. Consequently, tree-planting programs, using mixtures of several native

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forest tree species, have become very popular in Thailand. However, the results of such tree-planting programs are often disappointing. Their success depends on selecting suitable tree species and on the size and the quality of the trees planted. In the past, most tree nurseries grew very few, mostly commercially valuable species such as teak (*Tectona grandis* L. f. (Verbenaceae)) and *Eucalyptus* spp. (Myrtaceae). Now, to satisfy the growing interest in restoring forest ecosystems for wildlife conservation, there is an urgent need to propagate a much wider range of native forest trees in nurseries.

Growing a wider range of tree species, however, is beset with scheduling problems. Different tree species produce seeds at different times of the year and their seedlings grow at different rates, yet they must all reach a plantable size (40-60 cm tall) at the same time of the year, i.e. the beginning of the rainy season, May-June, in northern Thailand. The vast majority of the approximately 1,200 tree species indigenous to northern Thailand have never been propagated in nurseries. Lack of information about how to grow them has limited their use in forest restoration programmes.

In 1997, staff at the Forest Restoration Research Unit (FORRU) began collecting data on the performance of a wide range of native trees in the nursery. FORRU is a joint initiative between Chiang Mai University and the Headquarters of Doi Suthep-Pui National Park (under the Royal Forest Department). Its aim is to develop suitable techniques to restore forest ecosystems for wildlife habitat in conservation areas in northern Thailand (FOREST RESTORATION RESEARCH UNIT, 1998). This preliminary report presents the results of four species, which were part of larger experiments to propagate a wide range of native forest tree species. The objective was to prepare production schedules to raise trees to a plantable size from seed and to determine optimum propagation methods.

METHODS

Seeds of *Bischofia javanica*, *Castanopsis tribuloides*, *Ficus semicordata* and *Dalbergia rimosa* were collected and sown in baskets in a germination medium of forest soil and coconut husk mixed in the ratio 1:1. All seedlings were pricked out of the germination trays when they had the first pair of leaves and transplanted into black plastic bags 2.5 inches in diameter by 9 inches in depth. The potting mix consisted of forest soil, peanut husk and coconut husk mixed in the ratio of 2:1:1. Seedlings were shaded inside the nursery under a plastic roof (approximately 20% full sunlight), for about 2 weeks. During this time, they were given nitrogen fertiliser (45-0-0) every 2 days. Approximately 20 g of fertiliser was mixed with 10 litres of water and applied to the seedlings using a watering can. After two weeks, the seedlings were moved out of the nursery and placed under black shade netting (approximately 50% of full sunlight).

Fifteen seedlings of each species were randomly selected for monitoring of health and measurement of relative growth rate (RGR) of height and root collar diameter. These measurements were repeated every 45 days. Ten granules of Osmocote slow-release fertiliser (15-15-15) were applied to selected species every 3 months. Weeds, pests and diseases were controlled, as necessary for each species. Growth rate measurements ceased when the seedlings were ready for planting out, i.e. when they had grown at least 40-60 cm tall (30 cm for the fastest-growing species) and appeared healthy and vigorous. Seedlings were hardened off in full sunlight for 4 weeks in May and dispatched for planting in June each year.

RESULTS AND DISCUSSION

Here, results for four species that typify three main types of production schedule (Table 1) are presented. Details for more species are summarised in Table 2.

Table 1. Three main types of production schedule.

Seed Collection	Ready for Planting	Time in Nursery (months)	Examples
Late rainy season	1st planting season after seed collection	7-9	*Bischofia javanica*
Late rainy season	2nd planting season after seed collection	19-21	*Ficus semicordata* *Castanopsis tribuloides*
Late dry – early rainy season	2nd planting season after seed collection	14-16	*Dalbergia rimosa*

Bischofia javanica Bl. (Euphorbiaceae)

Seeds were collected from the ground beneath a parent tree on 19th October 1997 and sown on 21st October. Germination commenced after 13 days. Of 1,500 seeds sown, 1,270 germinated (a germination rate of 85%) by 30th December (70 days after sowing). However, damping off killed many seedlings, such that only 312 were suitable for pricking out and potting on 30th December. Of these 250 (80%) grew into plantable saplings. Plants received Osmocote fertiliser in January and April. No pruning was carried out. The mean annual RGR was 861% for height and 437% for root collar diameter. Potted seedlings grew to a mean height of 36.4 cm by mid-June 1998. Because this species is fast growing, it can be planted out when 30 cm or taller. Therefore, most seedlings were ready for planting at the beginning of the first planting season following seed collection, i.e. after about 8 months in the nursery. RGR was slow during the cool season and accelerated during the hot season. Several potted plants suffered from a disease that caused leaf curling, but otherwise they remained in good health.

Recommendations for further research: treatments to prevent damping off of germinating seedlings; treatment of leaf curling disease in larger seedlings.

Castanopsis tribuloides (Sm.) A. DC. (Fagaceae)

Seeds were collected from the ground beneath a parent tree on 20th November 1997 and sown on 22nd November. Of 1,500 seeds sown, 814 germinated (a germination rate of

54.3%) by 13th February 1999 (85 days after sowing). Germination was very asynchronous, with a long taproot developing before the shoot appears. Seven hundred and two seedlings were suitable for pricking out and potting on 13th February. Of these 631 (89.9%) grew into plantable saplings. Application of Osmocote fertiliser and pruning were not considered necessary for this species and were not carried out. The mean annual RGR was 213.4% for height and 164.4% for root collar diameter. Potted seedlings grew to an average height of only 6.8 cm by May 1998 and were therefore not ready for planting. By May 14th 1999, the seedlings had grown to a mean height of 50.2 cm and were therefore ready for planting in the second planting season after seed collection (i.e. after 19 months in the nursery). RGR was fairly constant throughout the year, except for a slowing of growth during the cool season. Seedlings remained in good health throughout their growth in the nursery.

Recommendations for further research: although seeds are available from August to November, the experiment above was performed on seeds collected in November. Experiments should be carried out with seeds collected earlier, using fertiliser to see if it is possible to grow the trees to a plantable size by the first planting season after seed collection (i.e. after about 10 months of growth in the nursery).

Dalbergia rimosa Roxb. var. *rimosa* (Leguminosae, Papilionoideae)

Seeds were collected from the parent tree on 15th May 1998 and sown on 20th May. Germination commenced after 5 days. Of 1,500 seeds sown, 591 germinated (a germination rate of 39%) by 15th June (26 days after sowing). Five hundred and sixteen seedlings were suitable for pricking out and potting on 15th June. Of these 452 (87.6%) grew into plantable saplings. Plants received Osmocote fertiliser in October, January and April. No pruning was carried out. The mean annual RGR was 173.1% for height and 160.9% for root collar diameter. Seedlings grew to a mean height of 55.2 cm by May 31st 1999. Most seedlings were therefore ready for planting at the beginning of the second planting season following seed collection (i.e. after 14 months in the nursery). Growth was mostly constant throughout the year, but slightly higher than average at the end of the rainy season. Seedlings remained in good health throughout their growth in the nursery.

Recommendations for further research: investigate treatments to improve germination rate.

Ficus semicordata B.-H. ex J.E. Sm. var. *semicordata* (Moraceae)

Seeds were collected from the parent tree on December 15th 1997 and sown on December 16th. Germination commenced after 31 days. Of 1,500 seeds sown, 770 germinated (a germination rate of 51.3%) by 13th July 1998 (210 days after sowing). However, damping off killed many seedlings, such that only 120 were suitable for pricking out and potting on 13th July 1998. Of these 72 (60%) grew into plantable saplings. Plants received Osmocote fertiliser in January and April. No pruning was carried out. The mean annual RGR was 284.1% for height and 190.3% for root collar diameter. Potted seedlings grew to a mean height of 53.5cm by June 10th 1999 and were therefore ready for planting in the second planting season after seed collection (i.e. after 19 months in the nursery). RGR was fairly constant throughout the year, but slightly higher during the rainy season.

Recommendations for further research: treatments to prevent damping off of germinating seedlings.

A provisional production schedule has been compiled for 35 potential framework species, based on data collected in the FORRU nursery (Table 2). The amount of time required to grow seedlings to a plantable size ranged from 6 months for *Melia toosendan* Sieb. & Zucc. to 25 months for *Eurya acumminata* DC. var. *wallichiana* Dyer. Only 12 species reached a plantable size by the beginning of the first planting season after seed collection. Most of these species fruited in the mid- to late rainy season and exhibited rapid growth in the nursery. Twenty-two and 1 species reached plantable sizes by the 2nd and 3rd planting seasons after seed collection respectively. These species fruited at all times of the year, except June-July.

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Table 2. A provisional production schedule for 35 potential framework species.

Species	Family	Year 1 (months)												Year 2 (months)												Year 3 (months)					
		J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J	J	A	S	O	N	D	J	F	M	A	M	J
Acrocarpus fraxinifolius Wight ex Arn.	Leguminosae (Caesalpinioideae)			1			2											3	4												
Afzelia xylocarpa (Kurz) Craib	Leguminosae (Caesalpinioideae)								1	2																				3	4
Balakata baccata (Roxb.) Ess.	Euphorbiaceae							1		2								3	4												
Bischofia javanica Bl.	Euphorbiaceae										1		2					3	4												
Castanopsis acuminatissima (Bl.) A. DC.	Fagaceae											1			2															3	4
Castanopsis tribuloides (Sm.) A. DC.	Fagaceae											1			2															3	4
Cinnamomum caudatum Nees	Lauraceae		1			2												3	4												
Dalbergia rimosa Roxb. var *rimosa*	Leguminosae (Papilionoideae)					1	2											3	4												
Diospyros glandulosa Lace	Ebenaceae										1		2					3	4												
Eugenia albiflora Duth. ex Kurz	Myrtaceae					1				2								3	4												
Eurya acumminata DC. var. *wallichiana* Dyer	Theaceae					1				2																				3	4
Ficus capillipes Gagnep.	Moraceae		1					2										3	4												
Ficus glaberrima Bl. var. *glaberrima*	Moraceae	1					2											3	4												
Ficus microcarpa L. f. var. *microcarpa* forma *microcarpa*	Moraceae											1									2									3	4
Ficus semicordata B.-H. ex J.E. Sm. var. *semicordata*	Moraceae												1							2										3	4
Garcinia mckeaniana Craib	Guttiferae						1			2																				3	4
Glochidion kerrii Craib	Euphorbiaceae										1			2																3	4

1 = seed collection; 2 = potting; 3 = hardening off; 4 = planting

Table 2. (Continued)

Species	Family	Year 1 (months)												Year 2 (months)												Year 3 (months)					
		J	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**	**J**	**A**	**S**	**O**	**N**	**D**	**J**	**F**	**M**	**A**	**M**	**J**
Gmelina arborea Roxb.	Verbenaceae					1	2											3	4												
Helicia nilagirica Bedd.	Proteaceae							1	2									3	4												
Heynea trijuga Roxb. ex Sims	Meliaceae											1			2															3	4
Hovenia dulcis Thunb.	Rhamnaceae											1			2			3	4												
Lithocarpus craibianus Barn.	Fagaceae										1							2												3	4
Lithocarpus fenestratus (Roxb.) Rehd	Fagaceae									1			2																	3	4
Macaranga denticulata (Bl.) M. -A.	Euphorbiaceae								1				2					3	4												
Manglietia garrettii Craib	Magnoliaceae										1		2					3	4												
Melia toosendan Sieb. & Zucc.	Meliaceae												1	2				3	4												
Mesua ferrea L.	Guttiferae											1		2																3	4
Michelia baillonii Pierre	Magnoliaceae							1				2						3	4												
Nyssa javanica (Bl.) Nees	Lauraceae									1		2						3	4												
Prunus lanceolata (Nees) Nees	Lauraceae								1			2																		3	4
Prunus cerasoides D. Don	Rosaceae				1		2											3	4												
Quercus semiserrata Roxb.	Fagaceae							1	2									3	4												
Rhus rhetsoides Craib	Anacardiaceae												1			2														3	4
Sapindus rarak DC.	Sapindaceae								1	2																				3	4
Spondias axillaris Roxb.	Anacardiaceae								1	2								3	4												

POSTER ABSTRACTS

PEST AND DISEASE PROBLEMS OF NATIVE TREE SEEDLINGS IN NORTHERN THAILAND: SOME EXAMPLES

Tim Rayden[1]

ABSTRACT

The Forest Restoration Research Unit (FORRU) is identifying 'framework' tree species for the restoration of northern Thailand's upper watershed forests. Since 1994, research at FORRU has focussed on collecting seeds of native species, and testing germination and growth rates in nursery conditions. However, the current emphasis is on improving nursery technology and increasing the production of high quality seedlings for planting. Large productivity step-downs occur at germination and potting stages, but losses to pests and diseases are also significant. It has been noted that the incidence of phytophagous insect outbreaks has increased with the age of the nursery, and that certain seedling species have encountered recurring problems with disease. Little information is currently available on the scale of these problems, or the types of disease that are present. This survey has highlighted areas for concern, with a view to developing elementary and cost effective management strategies. Some such strategies are suggested. With further monitoring of the prevalent pests and diseases, together with a more detailed assessment of the recommended treatments, it will be possible to make well informed decisions about seedling production targets and the overall suitability of certain tree species for forest restoration schemes.

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EFFECT OF CONTAINER TYPE AND MEDIA ON THE PERFORMANCE OF NATIVE TREE SPECIES TO RESTORE DEGRADED FOREST ECOSYSTEMS IN NORTHERN THAILAND

***Sudarat Zangkum, Stephen Elliott and Puttipong Navakitbumrung*[1]**

ABSTRACT

Biodiversity in Thailand is fast disappearing because of deforestation. Restoring forests by planting native tree species can help promote biodiversity. Producing high quality planting stock can be achieved by using root-trainers. Furthermore, tree seedlings need a potting medium which encourages root growth and good root form. In this poster, we report on the performance of 2 native tree species; *Micromelum hirsutum* Oliv. and *Archidendron clypearia* var. *clypearia*, grown in a nursery under 6 treatments of container and medium type and then planted to restore forest in degraded areas in Doi Suthep-Pui National Park,

REX tray root-trainers with a mixed medium produced the best seedling performance in the nursery. Mean heights achieved in the nursery from seed germination to planting time of *Micromelum hirsutum* and *Archidendron clypearia* were 31.0 cm. and 25.9 cm. respectively. However, there was no significant difference in field performance after planting out. Relative performance indices, which combined survival and relative growth rate were higher for seedlings grown in with mixed medium, except in REX tray root-trainers. When container types were compared, plastic bags produced seedlings that performed best in the field after planting out. Further research is needed to determined whether container size would affect performance.

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CONTAINERISED SEEDLINGS FOR BETTER REFORESTATION

Sumet Sirilak[1]

ABSTRACT

The objective of this poster is to exhibit one of the activities of the Reforestation and Extension Project in the Northeast of Thailand (REX Project) in which JICA collaborated with the Royal Forest Department. The aim was to promote forest rehabilitation on deforested state land and private land by producing and distributing more than 89 million seedlings in 8 years from 1991 to 1998. The text focuses on the technique of growing seedlings in plastic-bags compared with multi-cavity containers, especially REX trays, which were introduced to improve seedling morphology and efficiency. More than 30 species of tropical hardwoods were grown in REX trays and various other containers with the appropriate nursery cultural practices. It has been found that 'rigid' containerised seedlings have better root development and lower costs than seedlings grown in plastic-bags in several aspects of tending, transportation and out-planting on the sites. This was then related to reforestation success.

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GENETIC CONSIDERATIONS IN FOREST RESTORATION AFTER DISTURBANCES

Ulfah J. Siregar[1]

ABSTRACT

The accelerating rate of deforestation in the tropics has raised global concerns regarding the conservation of forest genetic resources. In order to assess the loss of forest genetic diversity through deforestation, a study of the impact of logging on genetic diversity of several important timber species was made. The investigation showed a significant population structure for all timber species studied, which indicated a non-random distribution of genetic diversity within a population. The population structuring started at the sapling stage and continued to mature trees. Restoration of such forest must ensure the occurrence of gene flow in the regeneration process. Several management practices can be carried out; such as avoidance of the complete removal of a forest block which creates fragmentation, generating "stepping stones" between forest fragments, maintaining considerable genetic diversity within populations by retaining heterozygous individuals in logging activities and conducting enrichment planting in severely disturbed areas.

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BIODIVERSITY AND STATUS OF MYCORRHIZAE ON TROPICAL TREES IN INDONESIA

Yadi Setiadi[1]

ABSTRACT

Arbuscular mycorrhizal fungi (AMF) have novel functions as biofertiliser inoculum for improving growth and health of plants. They may also be an agent for bioremediation of soil contaminated by heavy-metals by fostering early seedling establishment on degraded sites. A survey of the status of local species of arbuscular mycorrhizal fungi and plant mycorrhizal in different disturbed forest ecosystems (disturbed forest, grassland, secondary forest, mine sites, peat forest and semi-arid forest) was conducted. Representative soil and root samples were collected from different rhizosphere trees. Using standard methods, the roots were stained, and the AMF spores were extracted from the soil, isolated and identified.

Spores of AMF were found in all forest ecosystems except in swamp and mangrove forest. Among the forest ecosystems studied, the number of AMF spores found in degraded peat forest were highest, whilst the number of AMF spores found in alpine/sub-alpine forest (3,200-4,255 m asl.) were the lowest. More than 23 different spores types were found in a range of Indonesian forests and the AMF species richness (based on spore types) varied among the ecosystems. The species richness of AMF was higher in recolonised tailings and *Imperata* grass-land compared to other ecosystems. The genera *Glomus, Sclelocystis, Acaulospora, Scutelospora* and *Gigaspora*, and AMF species *Glomus ocultum* and *Acaulospora morrowaiae* were commonly found in all ecosystems. Root staining indicated that, of 112 forest trees assessed, 87% formed mycorrhizae, indicating that mycorrhizae may be required for their establishment on degraded sites. Using a test tube culture technique, more than 14 indigenous AMF isolates were obtained in pure cultures and maintained in the Bank of Tropical Indigenous Glomales-IUC-IPB as a tropical indigenous culture collection.

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RAINFORESTATION FARMING: AN ALTERNATIVE TO FOREST RESTORATION

Paciencia P. Milan[1]

ABSTRACT

Efforts to preserve the biological diversity of the Philippine islands and to simultaneously sustain human food productivity led to the development of a "Closed Canopy and High Diversity Forest Farming System", popularly termed "Rainforestation Farming". The system aims to replace the more destructive forms of "kaingin" or slash-and burn practices, form a buffer zone around the primary forests, conserve biodiversity, help maintain the water cycle of the islands and provide farmers with a stable and higher income.

Contrary to the conventional paradigm of farm management, the concept works with the hypothesis that a farming system is increasingly more sustainable the closer its physical structure and species composition is to the original local rainforest. Consequently, the biological and physico-chemical diversities of remaining forests of Leyte are being studied in detail. This reforestation scheme utilises local tree species, particularly Dipterocarps and high premium tree species, whilst incorporating fruit trees and agricultural crops in accordance with farmers' need.

Species monitoring in rainforestation sites showed that birds, reptiles, arthropods and other organisms readily inhabited the newly established forest. Species composition, particularly birds, insects, reptiles and mammals was monitored. In the sixth year after the establishment of a rainforestation farm on formerly degraded grassland and shifting cultivation area, the Samar Tarictic Hornbill (*Penelopides samarensis*) and flying lemur (*Cynocephalus volans*) from the nearby forest visited the farm regularly. The highly diverse tree plantation likewise allowed re-establishment of arthropods, Philippine Tarsier (*Tarsius syrichta*), birds and lizards, which derive food, nesting places and moist, cool microclimates from the newly forming ecosystem.

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EARLY SURVIVAL AND ESTABLISHMENT OF TEN NATIVE TREE SPECIES PLANTED IN THREE DEGRADED HILLSIDE SITES IN HONG KONG, CHINA

Hau Chi-hang[1]

ABSTRACT

Early survival and growth of 10 native tree species planted in upland grassland, lowland grassland and lowland shrub-land were studied for two years. The survival of all species at all sites was very high in the first three months, which shows that good post-nursery care can effectively reduce the transplantation shock and minimise transplantation losses. All species except *Sapium discolor* had high survival rates over two years in both grassland sites (70 – 100%) and most species showed no difference between the two grassland sites. In the shrub-land, survival varied from zero in *Sapium* to 100 % in *Cinnamomum camphora*. The relative growth rates of *Cyclobalanopsis neglecta*, *Machilus breviflora*, *Choerospondias axillaris* and to a lesser extent, *Schefflera octophylla*, were higher than the other species at all three sites. *Cyclobalanopsis* and *Choerospondias* had the highest final mean stem height (96 – 140 cm and 100 – 156 cm). The final mean stem heights of *Machilus* (50 – 79 cm) and *Schefflera* (26 – 37 cm) were smaller than those of *Schima* (70 –129 cm), *Castanopsis* (57 – 81 cm) and *Mallotus* (102 – 119 cm), despite higher growth rates. Longer term monitoring is needed to determine if *Machilus* and *Schefflera* could maintain their high relative growth rates. If so, they will become taller than these three species in a few years time and would be better choices for forest restoration in Hong Kong. In summary, all species except *Sapium* have the potential for wider use in forest restoration in Hong Kong, especially the four faster growing species.

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A GLIMPSE OF ONGOING CONSERVATION PROGRAMMES OF FOREST GENETIC RESOURCES IN THAILAND

Anders Pedersen[1]

ABSTRACT

This poster briefly outlines the contribution to biodiversity and environmental stability made by the Forest Genetic Resources Conservation and Management Project (FORGENMAP). The poster lists FORGENMAP's criteria for species conservation and those sites selected for in-situ conservation activities. The nature of gene conservation activities in Thailand, carried out within the last 30 years, under the Thai-Danish co-operation programme, are described.

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GROWTH PERFORMANCE OF TEN INDIGENOUS TIMBER SPECIES ON DEGRADED FOREST LAND IN NEGERI SEMBILAN, MALAYSIA

Mohamad Azani Alias, Nik Muhamad Majid and Norsafaaizah Mohd Jaafar[1]

ABSTRACT

A study on the growth performance of ten indigenous timber species was undertaken in June 1998 on trial plots that were established in August 1995. The objective of the study at Compartment 121, Pasoh Forest Reserve, Negeri Sembilan, Malaysia was to evaluate growth performance of timber species planted on degraded sites by an open planting technique. Plots were arranged using a randomised complete block design. The species used in this study were *Azadirachta excelsa*, *Cinnamomum iners*, *Dryobalanops aromatica*, *Hopea pubescens*, *Neobalanocarpus heimii*, *Shorea acuminata*, *Shorea bracteolata*, *Shorea leprosula* and *Shorea parvifolia*. Twenty six months after planting, the survival rate of all species planted ranged from 17 to 85%, with *C. iners* attaining the highest rate, while the lowest was recorded by *S. acuminata*. Growth increments in diameter and height were significantly different ($P \leq 0.05$) for all species tested. *A. excelsa* exhibited the highest growth increment, both in terms of basal diameter (13.00 mm (dMAI = 24.18 mm y^{-1}) and total height (82.79 cm (hMAI = 173.06 cm y^{-1}). This was followed by *C. iners*, with a growth increment of 7.71 mm (dMAI = 16.19 mm y^{-1}) and a total height of 35.41 cm (86.29 cm y^{-1}). *S. acuminata* showed the lowest basal diameter and total height increments, with only 1.93 mm (5.31 mm y^{-1}) and 14.70 cm (56.42 cm y^{-1}), respectively. The growth and survival rates attained in this study indicate that an open planting technique of some of indigenous timber species can be adapted to rehabilitate degraded forest lands.

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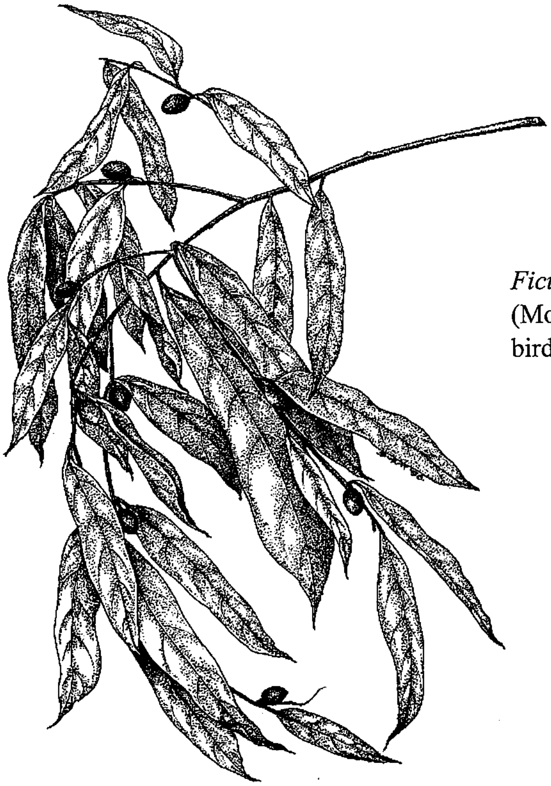
PART FIVE

WILDLIFE

Editor

Stephen Elliott

Restored forests must attract dispersers of large seeds, such as hornbills, if they are ever to recover their original tree species diversity.



Ficus subulata Bl. var. *subulata* (Moraceae) – produces figs eaten by birds within 1 year after planting.

Ficus altissima Bl. (Moraceae) – figs are excellent framework tree species for forest restoration plantings because they provide a keystone food resource.

INTER-RELATIONSHIPS BETWEEN WILDLIFE AND FOREST RESTORATION

Stephen Elliott[1]

Implicit in the workshop's title was the assumption that restoring tropical forests benefits wildlife. However, in SE Asia, this assumption has not been tested in restored forests. The purpose of this session was to consider all possible interactions between wildlife and forest restoration programmes; both benefits and potential disadvantages.

POSITIVE EFFECTS OF FOREST RESTORATION ON WILDLIFE

There is no doubt that forests support more wildlife species than deforested areas and that deforestation reduces biodiversity. To illustrate the magnitude of this effect, evergreen forest higher than 1,000 m elevation in Doi Suthep-Pui National Park in northern Thailand supports five times more vascular plant species than deforested areas at the same elevation. Deforested areas contain a greater percentage of herb species than evergreen forest. Herbs comprise 66% of the plant species in deforested areas, compared with only 59% in evergreen forest. Furthermore, most of the species in deforested areas are common or abundant (66%), whereas in forest 52% of the species are ranked as rare (CMU herbarium database).

Therefore, deforestation not only substantially reduces biodiversity, but deforested areas support mostly abundant, ubiquitous weeds, many of which are widely distributed throughout the tropics. Rare species of high conservation value are the first to disappear when deforestation occurs. The main questions to examine are to what extent can species loss be reversed by forest restoration? How fast can wildlife species return to restored areas? To what extent will the species composition of restored forests resemble that of the original forest and what might limit the return of species to restored areas? Once these questions have been answered, better forest restoration techniques can be devised to counteract any processes that might limit the return of wildlife to restored areas.

In this part of the proceedings, Nigel Tucker provides an encouraging account of the return of wildlife to restored forests in Queensland, Australia. Such effects can only be identified through regular wildlife surveys in restored areas. However, to quote from Nigel Tucker's paper: "monitoring is a badly neglected facet of restoration but is crucial to the survival of target species and the long term development of the science of tropical restoration for wildlife habitat". This deficiency was acknowledged by workshop participants and subsequently incorporated into the research agenda presented in Part 7 (proposal 1.4).

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Bharat Lal's paper presents a clear example of how focussing attention on a charismatic endangered species, the Asiatic Lion, can help to generate broad public support for forest restoration and conserve lesser-known species that benefit from increased forest cover. In this case, forest restoration may have prevented the imminent extinction of a large mammal with wide appeal. Crucial to gaining the support of local people for forest restoration is the provision of resources, such as a reliable water supply. By complementing forest restoration with the development of water resources, the project described by Bharat Lal demonstrates how forest restoration benefits both human and wildlife populations.

NEGATIVE EFFECTS OF FOREST RESTORATION ON WILDLIFE

Forest restoration converts a habitat dominated by herbaceous weeds into one dominated by a diverse community of trees. Weeding is essential to this process. Weeding immediately removes a large part of the biomass of the herbaceous ground flora, whereas the provision of many wildlife resources by the planted trees e.g. pollen, nectar, fruits and seeds, happens only after the trees reach maturity and for some tree species this can take many years. Is this an important phenomenon? If it is, what research is needed to generate knowledge to help forest managers minimise any potential negative effects of tree planting programmes and associated management activities?

Initial evidence from forest restoration plots in Doi Suthep-Pui National Park, northern Thailand suggests that bird species diversity was reduced for 1-2 years after tree planting. This was possibly due to lack of food resources for birds that are characteristic of open areas dominated by herbaceous weeds. Colonisation of the restored sites by forest birds will take time, but how long? And is there anything that can be done to encourage forest birds to colonise restored forests with less delay? Rebecca Scott *et al.* suggest that simple provision of artificial bird perches can encourage birds to visit restored forest sites and might reduce the negative effects of weeding.

POSITIVE EFFECTS OF WILDLIFE ON FOREST RESTORATION

Seed dispersal is one of the most important ecological services carried out by wildlife in restored areas. In this part or the proceedings, the paper by Richard Corlett and Billy Hau provides a thorough review of the subject, whilst Rebecca Scott *et al.* present clear evidence that seed dispersal into restored forest sites can be significantly enhanced through the provision of bird perches.

In addition to seed dispersal, wildlife carries out many other ecological functions that help the process of forest restoration. Birds and bats pollinate flowers, soil invertebrates improve soil texture and help recycle nutrients and a diverse range of wildlife species are involved in biological control of pests. What research needs to be done to monitor these positive effects and enhance them? Nigel Tucker suggests several ways to hasten colonisation of restored forest sites by plants and animals and encourage the ecological services they perform.

The positive effects of wildlife on forest restoration are threatened by extirpation of certain wildlife species over very large parts of SE Asia. For example, very large seeds can only be dispersed from forest into deforested areas by large animals. The extirpation of elephants, rhinos and wild cattle species over most of SE Asia has left many large-seeded tree species without a dispersal mechanism. Is this an important problem? If so, how should we solve it? Is it feasible to re-introduce these large animals into key conservation areas? If not, how should forest restoration programmes be designed to duplicate the crucial seed-dispersing functions of these animals?

NEGATIVE EFFECTS OF WILDLIFE ON FOREST RESTORATION

If direct seeding is being considered as a preferred restoration technique, seed predators, especially small mammals, can be a serious constraint. Planted trees, in their early stages of growth, are vulnerable to a wide range of potential pests, both large and small. In FORRU's experimental plots, moles and Siamese hares have increased. Both these animals attack the planted trees, but so far only very few trees have been affected. Larger animals might trample young trees and there is a wide range of insect pests that might cause significant damage to planted trees. What research is needed to monitor these effects? If they turn out to be serious constraints, what further research is needed to devise effective measures to protect planted trees until they are large enough to fend for themselves?

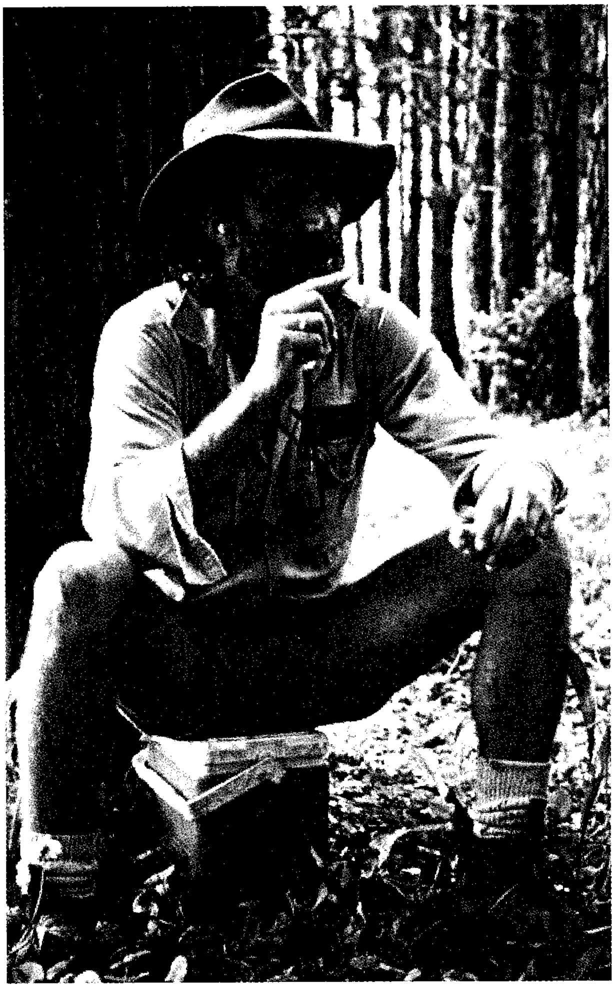
CONCLUSION

One of the prerequisites of managing forest restoration programmes for wildlife conservation is to know what interactions are taking place between the trees being planted and the wildlife using those trees as habitat. Therefore, serious consideration must be given to establishing effective monitoring programmes. Secondly, once monitoring has identified the interactions between wildlife and forest restoration activities, research programmes are needed to devise management strategies to enhance the positive interactions and reduce the negative ones. Not all the questions posed above were answered at the workshop, but participants did propose research to encourage wildlife to colonise forest restoration sites (Part 7: 1.3, 2.2, 2.3 and 4.1) and responded to the need for better wildlife monitoring (see Part 7: 1.1, 1.2, 1.3 and 1.4).

COMMENT

Jens Granhoff

In Sumatra, improving habitat for tigers involved strategic planning which promoted the whole food chain, providing open grasslands for deer as well as closed forest. The same situation exists in Khao Yai National Park here in Thailand, where the abandoned golf course now provides grassland for deer.



Nigel Tucker takes a brief rest after planting trees along a creek in Queensland, Australia.

WILDLIFE COLONISATION ON RESTORED TROPICAL LANDS: WHAT CAN IT DO, HOW CAN WE HASTEN IT AND WHAT CAN WE EXPECT?

Nigel I. J. Tucker[1]

ABSTRACT

With many tropical species facing an uncertain future because of habitat loss and fragmentation, restoration will likely become an increasingly important facet of wildlife management and conservation. Colonisation and utilisation of formerly degraded tropical lands, by a range of local life forms / species, is the acid test of successful restoration. Understanding the dynamics of these processes will assist in more informed strategies for management and a more positive future for tropical biodiversity. This paper briefly describes some of the roles played by wildlife in newly restored tropical areas, the benefits that may accrue from this interaction and suggests ways to hasten and sustain this interaction. Colonisation of one restored area by insects, birds and small mammals is outlined. This shows that colonisation can be quite rapid once threatening processes are removed and restoration works are self-maintaining.

Key words: wildlife, ecological restoration, rain forest, colonisation

WILDLIFE AND RESTORATION

Australia has the dubious honour of recording over twenty mammal extinctions over the past two hundred years and many more species face an uncertain future. Having recognised the need to counter the effects of fragmentation and habitat loss, the removal of threatening processes and the re-building of new habitats offers one means to secure the future of the national store of biodiversity. Whilst increasing habitat will be beneficial for wildlife, benefits can also flow to restored areas as organisms play increasingly complex roles in these developing systems. Several positive benefits accrue from the colonisation of restored areas by native wildlife. Recognition and manipulation of these benefits should be considered an essential part of the restoration process (TUCKER & MURPHY 1997; HARDWICK *ET AL* 1997).

In this paper I describe some of the roles played by wildlife in the restoration of degraded lands, suggesting ways to hasten and sustain this interaction, based on work within the humid wet tropics of north-eastern Queensland, Australia. To demonstrate the

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colonisation process, I provide examples from a restored habitat linkage in the same area. Data relating to four species of small mammals, bird communities and one ecological group from one insect order are presented. Colonisation by other groups is also under study and the reader is referred to TUCKER (2000a/b) for further detail on this linkage.

1. Wildlife colonisation: What can it do?

Seed and spore dispersal

Effective dispersal will be essential in promoting a greater diversity of life forms and species. Dispersal adds important resource and structural complexity as recruits grow and develop. By encouraging wildlife visitation and habitation the process of dispersal can be enhanced and increased diversity of many life forms can be expected (TUCKER & MURPHY 1997, Parrotta *ET AL* 1997).

Pollination

Many tropical plants have very irregular flowering and fruiting cycles and their reproductive ability may be linked to the availability of specialised pollination mechanisms. Many of the insects involved in these mechanisms are relatively slow moving and their ability to re-colonise quickly may be limited (HILL 1995). Because of their size and relative ease of collection, these organisms are good candidates for translocation providing autecological needs have been met. Limited studies indicate bird visitation to restored areas can be rapid, and their contribution to successful pollination is likely to be important.

Regulating pest populations

Birds can also play important roles in regulating populations of herbivorous insects and the damage they cause to planted seedlings. This benefit can also assist in adjacent agricultural crops and commercial forestry plantations. Restoration can also play a key role in regulating populations of vertebrate pests. In north Queensland, restoration of weed infested stream banks has been shown to reduce damaging populations of Canefield Rats (*Rattus sordidus*) in sugar cane (author *unpubl. data*), and potentially other species in other agricultural crops.

Nutrient cycling and soil conditioning

Colonisation by invertebrates and megapodes such as Scrub Turkey (*Alectura lathami*) and Scrub Fowl (*Megapodius reinwardt*) accelerates litter decomposition and nutrient cycling, potentially improving soil porosity, aeration, soil organic matter and moisture retention. This is particularly important in formerly degraded areas where soil structure, nutrient status and stability have often been significantly altered. Tree cover substantially improves soil stability and guards against splash erosion.

2. How can we hasten it?

In designing restoration for wildlife several potential problems must be recognised and managed in order to maximise the value of these areas for wildlife conservation. Ecological restoration is about more than just tree planting, it is just as much about creating complex physical niches for the animals which will perform key roles in the long term development of these areas into self sustaining communities. Factors influencing this development and strategies to enhance (or mitigate) these factors, may include:

Species matrix

All plants established should be local species of local provenance as these are likely to be the most attractive to local wildlife and perform best in local conditions. As well as selecting many life forms, from many individuals to maximise genetic variety, other considerations may include:

***Keystone food plants e.g.* Ficus**

Keystone food plants are those that provide a critical supply of wildlife resources at times when there are few or no other plants to sustain local wildlife populations, and in this way are crucial or keystone species on which much of the ecosystem depends in some way or another. Figs provide a year round source of wildlife resources and can be focal points for natural recruitment and regeneration (GUEVARA & LABORDE 1993). Growing these plants from cuttings can overcome delays in provision of food resources, as cuttings may produce fruits at only six months old. By collecting from many individuals, whether they are fruiting or not, increased genetic variety can be easier to achieve. In plantings undertaken by the Centre for Tropical Restoration in north Queensland, figs represent between ten and twenty percent of all species established. Other plant families will also be important in providing a consistent supply of food resources. In north Queensland the laurel (Lauraceae) family is one of these families; a diverse range of species producing highly nutritious fruits through most of the year.

Framework species (GOOSEM & TUCKER 1995, LAMB ET AL 1997)

The primary purpose of this group is to rapidly capture a site and accelerate natural regeneration at that site through the dispersal process. However, an equally important task is to establish nodes of framework species that are able to colonise surrounding degraded areas and promote establishment of new habitat nodes. The value of most habitat types, whether restored areas or intact reserves, is likely to be in their degree and quality of connectivity. Framework species are able to enhance habitat heterogeneity at the local landscape scale because of their reliable germination in degraded areas, and attractiveness to dispersal vectors at local sites.

Favoured food plants of target wildlife species

Many restoration projects are driven by the need to preserve a particular species or group of species. Focusing on a target such as this requires a greater understanding of species autecology. However, this will be of great benefit as it forces us to examine much more closely the most desirable biotic and abiotic attributes, and to plan for their installation. For most wildlife this means a wide range of their favoured food plants whether it is the foliage, fruit or nectar which attracts them, or in the case of predators, the organisms feeding on these resources. In north Queensland, larger bodied species, such as arboreal folivores, are often the targets in restoration works, and known food plants of this group are always included.

Large fruited species

Dispersers of these fruits are often the larger bodied wildlife, species themselves most often at risk from forest fragmentation. Studies have shown the lack of regeneration of large fruited tree species (TUCKER & MURPHY 1997, PARROTTA *ET AL* 1997), often attributed to the loss of key dispersal vectors and a reduction in available habitat (THEBAUD and STRASBERG 1997). For frugivores such as Madagascar's lemurs (HOLLOWAY 1999) and Australia's cassowary (CROME & BENTRUPPERBAUMER 1993), the inclusion of large fruited species in restoration plantings benefits both the plant and its dispersal vectors.

Nitrogen fixers

In severely degraded areas these plants may be required to enhance soil physical and chemical properties prior to, or as an adjunct to, establishing other species.

Rare / threatened species

Restoration permits the immediate re-establishment of endangered plants into areas of their former range. The conservation status of these plants can be dramatically improved if concerted efforts are made to include them in all restoration works. This also adds significantly to our understanding of the propagation and cultivation requirements of these plants.

Cultural plants

The incorporation of plants with medicinal, spiritual or other traditional uses brings into sharp focus the need to recognise and value the place of people in the restoration process. The success or failure of restoration works depends largely on its relevance to and acceptance by, the local human population (JAFFEE 1997, FORRU 1998). By encouraging participation in the restoration process, local communities are far more likely to feel a sense of ownership and responsibility (MURPHY & TUCKER *in press*), perhaps adopting a more sympathetic attitude.

Once a suitable species matrix has been prepared and propagated, several features must be considered to maximise the value of these areas for wildlife habitat.

Niche provisioning

Restored areas in the wet tropics of north-eastern Queensland have similar structural complexity and resource availability to early successional forest and for this reason, niche features such as hollow and decaying logs, nesting hollows / dens and rock piles are installed prior to planting, and as trees grow and develop. Similarly, vines are included in the initial planting phase to guarantee the creation of vine tangles and thickets for wildlife species requiring this habitat feature (GOOSEM & TUCKER 1995, TUCKER 2000*a*).

Edge effects

Many wildlife species avoid forest margins and these are most often the plants and animals at risk. Reducing edge effects in restorations can be achieved by planting wide belts (x hundreds of metres), 'sealing' the new margin with a specially selected range of taxa that are able to dominate a forest margin and be more or less resistant to weed invasion (GOOSEM & TUCKER 1995), or by planting buffer zones / strips of agro-forestry species adjacent to restored vegetation (TUCKER 2000*a*). Other edge exacerbated phenomena such as predation and parasitism may be partially overcome by provision of niche cover features and use of buffer zones. Plantings, especially wildlife stepping-stones, should minimise edge to area ratios by establishing circular plots, rather than linear strips.

Weed and pathogen management

The establishment of restored vegetation can sometimes facilitate spread of weeds (in particular vines), rendering areas unsuitable as wildlife habitat. Surveys should be undertaken to identify potentially invasive weeds and a strategy developed to deal with infestations on a regular basis. Nursery facilities should be maintained in a hygienic condition at all times to ensure weeds, feral worms and pathogens are not introduced into areas where they are not already present (GOOSEM & TUCKER, 1998).

Generalists vs. specialists

Ecological specialists are often the target species for restoration efforts because of their susceptibility to the effects of fragmentation (LAURANCE 1990, TUCKER 2000*a*). These species will be difficult to attract in the short to medium term because of the biological and structural complexity of tropical forests, and the long recovery time before this complexity is achieved in a restoration planting. However, closer attention should be paid to the feeding and nesting requirements of the specialists to at least limit this problem. Generalists appear to colonise restored habitats very quickly, particularly if the extra resources installed for specialists are already in place.

3. What can we expect?

Wildlife colonisation of restored areas in the Wet Tropics of north Queensland

The humid wet tropics of north Queensland contains a number of plant communities classified as either endangered or vulnerable (GOOSEM *ET AL* 1999) and many of the well-studied vertebrates occurring in these assemblages are equally at risk. Forest types on the most productive agricultural lands have been especially prone to non-random deforestation, some reduced to as little as 2.5% of their original extent, and a number of vertebrate species playing key ecological roles are no longer present in even the largest remnants (>500 ha). Restoration works have commenced to reverse this biodiversity decline, and the monitoring of these restoration works is now beginning to provide some insight into the colonisation process (TUCKER & MURPHY 1997). As functional groups begin to establish and simple food webs become ever more complex, restored systems may function as stepping stones or as habitat per se. The provision of stepping-stones greatly increases the value of the landscape to small and sedentary species as well as migratory species during travel seasons.

Providing new habitat areas or restoring habitat connectivity to isolated reserves is likely to be an increasingly important component of sound regional conservation strategy.

How are we to know whether wildlife uses restored areas unless we monitor and evaluate the response to our work? Monitoring is a badly neglected facet of restoration but is crucial to the survival of target species and the long-term development of the science of tropical restoration for wildlife habitat (TUCKER 2000*b*). Whilst a target species may be the obvious choice it may be decades or hundreds of years before these species naturally re-colonise, depending on their niche requirements. In such instances, it may be possible to re-locate captive-bred animals into restorations to hasten this re-colonisation, providing the area contains sufficient quality habitat.

Several bio-indicators can be used to provide feedback on the dynamics of restored tropical areas. Some studies have examined invertebrates (JANSEN, 1997), though there are an increasing number of studies examining colonisation by other life forms including plants and vertebrates (TUCKER & MURPHY 1997, PARROTTA *ET AL* 1997). Monitoring plant colonisation can reveal the likely dispersal vectors visiting the site and an assessment of the microclimatic and physical changes that permit plants of different successional stages to establish and grow. Plants are also easy to sample and measure and if identification is not possible at juvenile stage, it can usually be made as the plant grows and identification characters are more recognisable. A combination of these bio-indicators may produce a more comprehensive picture of early trends that can then be interpreted to provide long-term management prescriptions.

Very limited data is available on colonisation of restored tropical areas by wildlife, though corridor restoration projects in the Wet Tropics of north Queensland are now beginning to provide land managers with some insight. One such project is the Donaghy's habitat linkage, established to link the isolated Lake Barrine reserve (491 ha) with the 1.5 kilometre distant Gadgarra State Forest (80,000 ha). Over 20,000 plants were used to replant the linkage, which was severed by land clearing over sixty years ago. Commenced in 1995, the linkage was established over four years, establishing blocks of 5,000 trees annually, and a three row windbreak has been established either side of the linkage. The linkage averages 100 metres in width, excluding the adjacent windbreak (TUCKER 2000*a*).

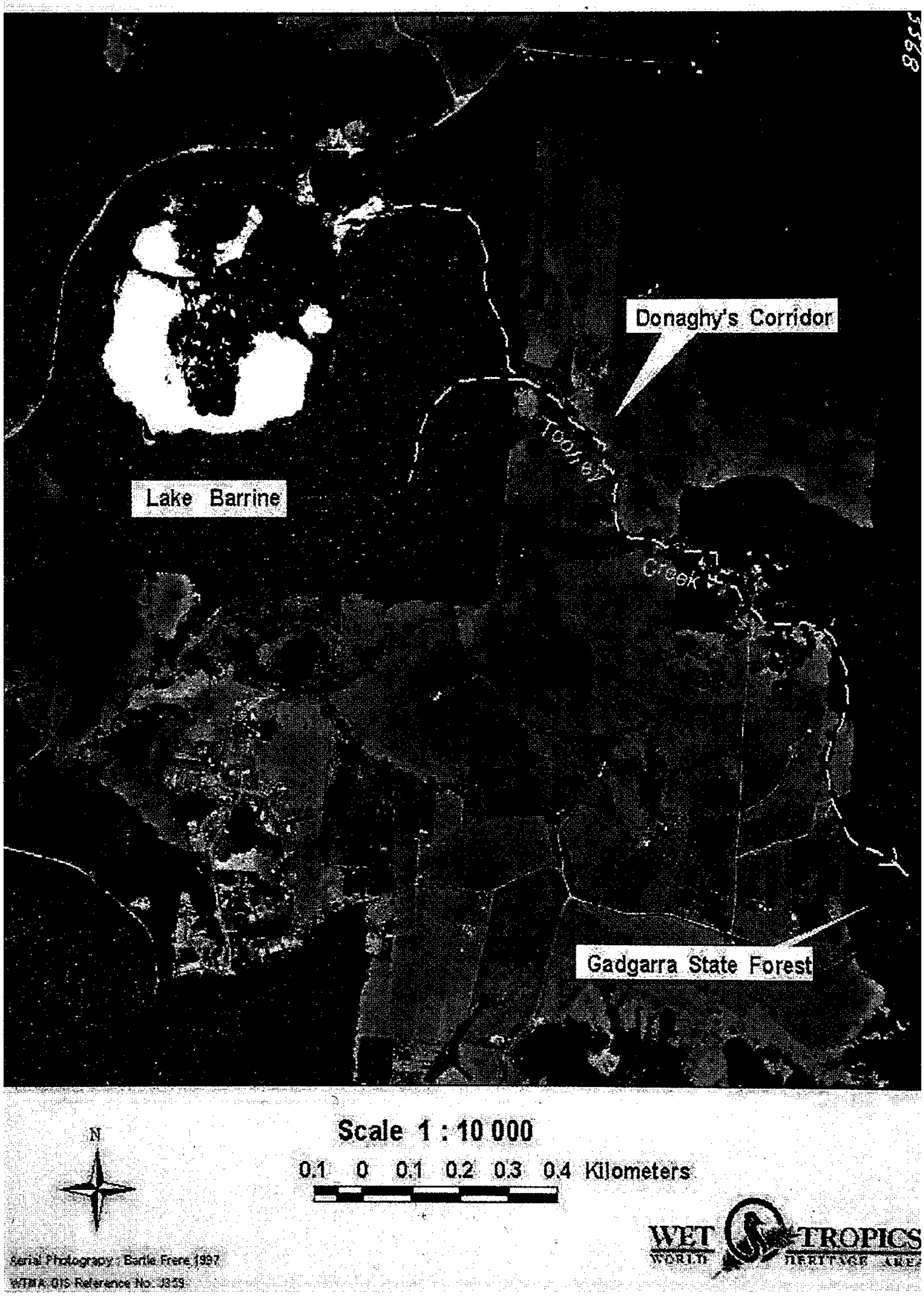
Small mammal colonisation

Trapping commenced in January 1998 with the completion of the linkage. Since this time, quarterly surveys have been undertaken at 11 sites throughout the linkage (see map), in intact and edge affected forests at either end; in the adjacent open paddocks and in each of the 4 yearly plantings. In each quarter, 20 Elliott box traps and four wire cage traps are set over three nights, baited with a rolled oats / peanut butter / vanilla mixture, in a 30m x 30m grid design. All captures are weighed, sexed with an evaluation of breeding condition, ear-tagged with an identifying number, and released. Captures described here represent a total of 5,544 trap nights.

Trees planted in 1997 to form the Donaghy's Corridor at 3 years of age.

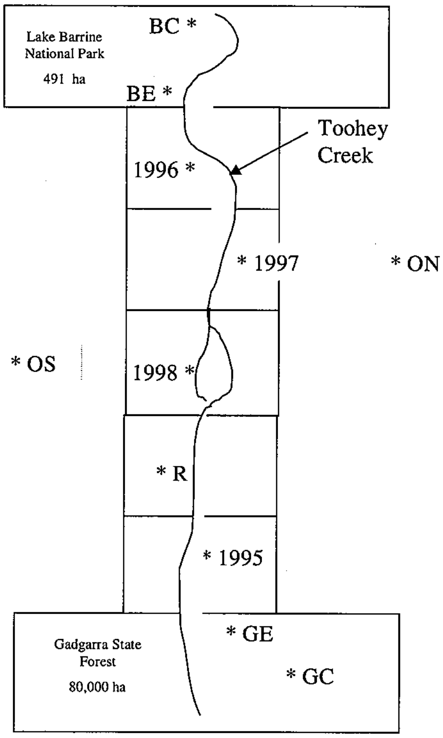
Donaghy's Corridor, January 1998.

DONAGHY's CORRIDOR



The grassland Melomys, *Melomys burtoni*, is a common grassland / pasture rodent, which is also found in grassy clearings in rain forest habitats (STRAHAN 1995). This preference for grassland and disturbed habitats, similar to early regrowth vegetation, is reflected in Figure 1, where the species is absent from the forest sites at either end of the linkage, but abundant at most other sites. Conversely the Fawn-footed Melomys (*Melomys cervinipes*) is primarily a forest dweller and, whilst it occasionally ventures into disturbed areas with a woody weed / grass component, it is not found in grassland habitats. This is evidenced by the species' distribution in Figure 2., where it is absent from the grassland habitats adjacent to the linkage.

Figures 1 and 2 show sympatry occurring in what are generally considered allopatric species. This is especially the case in the 1997 block where high densities of both species have been consistently recorded. In this case the two species have access to resources common to both grassland and forest habitats, though *M. burtoni* is likely to be displaced as its grass / weed habitat becomes increasingly shaded out, and *M. cervinipes* will probably dominate as a more complex forest structure begins to develop.



* Trapping Grid

Schematic diagram for trapping grids for Small Mammal Monitoring in Donaghy's Corridor.

Figure 1. Cumulative number of *Melomys burtoni* trapped at Donaghy's Corridor, January 1998 to January 2000.

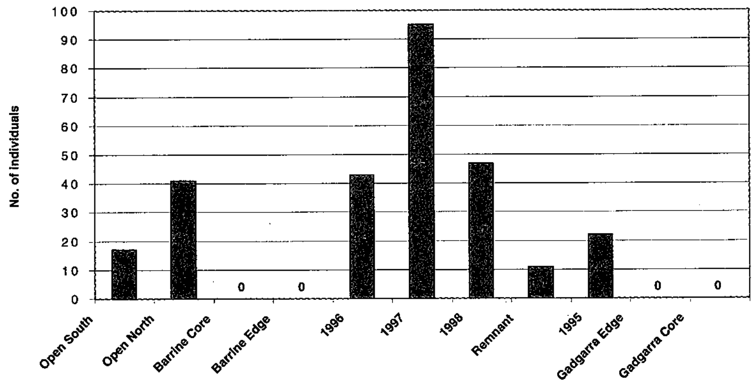


Figure 2. Cumulative number of *Melomys cervinipes* trapped at Donaghy's Corridor January 1998 to January 2000.

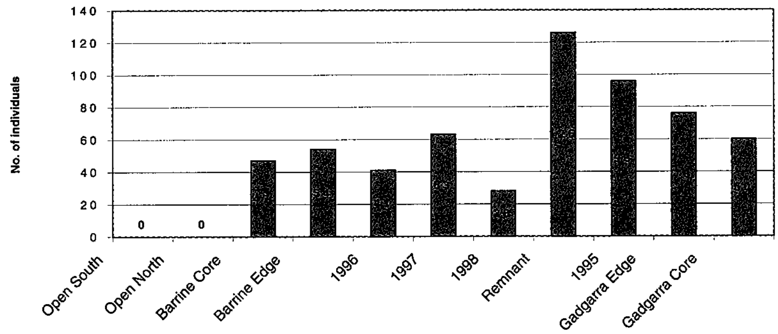
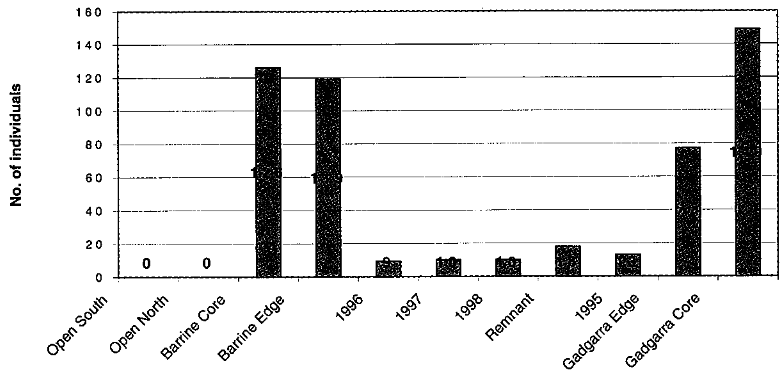


Figure 3. Cumulative numbers of *Rattus fuscipes/leucopus* trapped at Donaghy's Corridor January 1998 to January, 2000.



This structural development also introduces forest dwelling species such as Cape York rats (*Rattus leucopus*) and Bush rats (*R. fuscipes*), which appear to move into planted areas when plots are around 18 months old. Figure 3 shows the abundance of these two rodents in all trapping grids, also demonstrating avoidance of non-forest habitats; relatively high densities in forest habitats and establishing populations in the linkage proper.

Table 1 shows the total number of species captured at all sites, and shows the prevalence of generalists over the ecological specialists. Species such as the Musky Rat Kangaroo (*Hysiprimnodon moschatus*) are not even present in edge-affected forests adjacent to the restoration, and their appearance in restored areas may take many decades. For arboreal mammals, such as the Lemuroid Ringtail Possum (*Hemibelidius lemuroides*), which rely on nest hollows in mature trees, colonisation may take significantly longer, perhaps 100 years or more. There is also an obvious lack of diversity in the open paddocks adjacent to the restored areas and a sharp contrast between the faunas of these two habitats. Only *Mus musculus, Melomys burtoni, Rattus sordidus* and the feral Cane Toad *Bufo marinus,* have been trapped in these structurally simple pasture habitats.

Table 1. Species present in grids at Donaghy's Corridor

Species	OS	ON	BC	BE	1996	1997	1998	R	1995	GE	GC
Mus musculus House mouse	•	•			•	•	•	•			
Melomys burtoni Grassland Melomys	•	•			•	•	•	•			
Rattus sordidus Canefield Rat	•	•				•	•	•			
Melomys cervinipes Fawn-footed Melomys			•	•	•	•	•	•	•	•	•
Rattus fuscipes Bush Rat			•	•	•	•	•	•	•	•	•
Rattus leucopus Cape York Rat			•	•	•	•	•	•	•	•	•
Isoodon macrourus Brown Bandicoot				•		•		•		•	
Perameles nasuta Long-nosed Bandicoot			•		•	•	•		•	•	•
Uromys caudimaculatus White-tailed Rat			•	•	•	•	•	•	•	•	•
Antechinus flavipes Yellow footed Antechinus			•	•	•		•			•	
Antechinus stewartii										•	•
Hypsiprimnodon moschatus Musky-rat Kangaroo											•

Location Key: OS – Open South, ON – Open North, BC – Barrine Core, BE – Barrine Edge, R – Remnant, GE – Gadgarra Edge, GC – Gadgarra Core.

Species diversity is greatest in developing restorations, reflecting the diversity of resources available for a range of habitat generalists, common to both highly disturbed forest fragments and adjacent pastures.

Insects

There is limited data available on invertebrate re-colonisation in tropical restorations and limited studies in north Queensland have shown variable results. JANSEN (1997) showed a return of some orders in a restoration plot near Lake Barrine though there was a clear differentiation between wet and dry seasons. It is interesting that this study detected very few wood-boring beetles (Coleoptera). The inclusion of dead wood is now seen as an important structural element in restoring habitat linkages, and logs of various sizes were put in place prior to re-planting the Donaghy's linkage (GROVE & TUCKER 2000).

Table 2. Wood boring beetles (Coleoptera) present in logs placed in restoration plots aged 1-4 years at Donaghy's Corridor. (Source: From GROVE & TUCKER – *unpubl data*)

Species / Year of transplant	1995	1996	1997	1998
Staphylinidae sp. 1		+		
Staphylinidae sp. 2	+	+	+	
Staphylinidae sp. 3			+	
Staphylinidae sp. 4		+		
Staphylinidae sp. 5		+		
Leidodidae sp. 1	+	+		
Throscidae sp. 1	+			
Corylophidae sp. 1	+	+		
Corylophidae sp. 2		+		
Corylophidae sp. 3	+			
Lathridiidae sp. 1				+
Lathridiidae sp. 2			+	
Monotomidae sp. 1	+			
Ciidae sp. 1	+			+
Ciidae sp. 2		+		
Tenebrionidae sp. 1				+
Tenebrionidae sp. 2		+		
Anthribidae sp. 1		+		
Total **18**	7	10	3	3

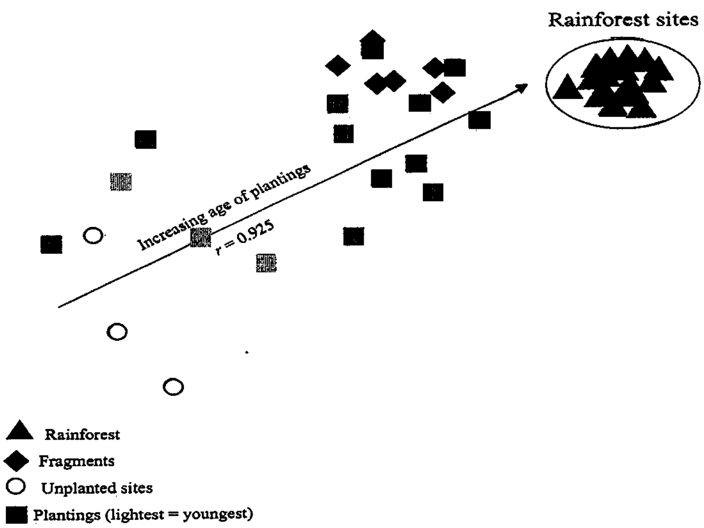
The effect of this placement on 'morpho-species' of wood-boring Coleoptera, recorded in a one-off survey in September 1999, is shown in Table 2. A full description of the methods used in this survey can be found in GROVE & TUCKER (2000). Table 2 indicates eighteen morpho-species of Coleoptera typically associated with dead wood habitat, though once again there are no families such as *Passalidae,* more typically associated with mature forest dead wood habitats. This is a one-off study and results should be interpreted with caution. However, the insects are a likely target to evaluate the efficacy of transplanting, or re-locating, organisms into restored areas and these early signs of colonisation are encouraging.

Birds

JANSEN'S studies in the Donaghy's linkage show a much more rapid return of many birds more typically associated with mature forest, assemblages in older plantings being very similar to adjacent rain forest communities (Figure 4). Likely factors implicated in this return include the inherent mobility of birds, the proximity of forest at either end of the linkage, and the relative paucity of forest specialists in Australia's tropical avifauna (CROME 1990). This study is consistent with other observations in the local area. Considering the demonstrated importance of birds as dispersal vectors in these forests, this is highly desirable.

Nevertheless, species such as Chowchilla's (*Orthonyx spaldingii*), a ground storey insectivore generally only associated with larger forest blocks, have not yet been recorded within the plantings. This is hardly surprising considering the specialised niche of species such as Chowchilla's, which require significant leaf litter depth and moisture, as well as the ground storey cover afforded by structurally diverse habitat.

Figure 4. Non-metric multi-dimensional scaling plot of sites according to their bird communities in the dry seasons of 1996 to 1998 (Stress - 0.11) at Donaghy's Corridor, North Queensland. (Source: JANSEN unpubl.)



CONCLUSION

Though not replicated, the early results from this project are generally consistent with other local studies, for example small mammal studies by CROME *ET AL* (1994) and LAURANCE & LAURANCE (1996), and plant colonisation surveys by TUCKER and MURPHY (1997). Not surprisingly, there is a general trend toward increasing species diversity and abundance in older plots, and in sites close to existing forest at the Donaghy's site. This trend is consistent for both plants and animals and reflects increasing structural complexity and resource availability within developing plantings, though it is too early to tell whether these patterns will be sustained. Results should be interpreted with caution, although results are encouraging with the oldest plot at the Donaghy's site only five years old, and colonisation by some species is clearly quite rapid.

Wildlife are often the targets for ecological restoration efforts, but they are moving targets in more ways than one. However, only by focusing on targets are we likely to hit the mark. If we are serious about reversing habitat loss, then we must concern ourselves with re-building complex habitats, not just planting trees or controlling weeds. Once these factors are considered, on-going monitoring programs will be essential to assess the community dynamics of restored areas, and their suitability for the organisms our efforts are directed toward.

ACKNOWLEDGEMENTS

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QUESTIONS AND COMMENTS

Yadi Setiadi

When establishing a corridor do you conduct screening to decide which tree species to plant or will any species do?

Nigel Tucker

We look closely at target wildlife species, especially patchily distributed arboreal folivores e.g. musky kangaroos and possums. We look at their diets and include the tree species they feed on. Many of the tree species that we plant have multiple uses; e.g. figs are eaten by arboreal animals and have utilitarian values.

Yadi Setiadi

How did you decide upon 100 m for the width of the corridor? Is it wide enough?

Nigel Tucker

A very good question; corridor width is a controversial question. For large carnivores, such as the Florida panther, corridors need to be several kilometres wide, but for us it is not practical to establish such wide corridors on privately owned land. A general rule proposed by Lawrence is that corridors should be 10% of their length. I see it as being twice as wide as the potential height of the forest. Our corridor width is approximately 10% of its length i.e. 1.2 km long and 100-130 m wide. There are no hard and fast rules.

Somsak Sukwong

I believe that in the Southeast Asian landscape the corridor idea is difficult to implement because it is difficult to find enough land. The idea could be adapted to include forest gardens, like in southern Thailand, with fruit trees e.g. durian. In Southern Thailand when landslides and fire destroyed plantations, the forest gardens survived. The same thing happened in Malaysia and Indonesia. Many forest gardens exist between wildlife sanctuaries and national parks and they may also increase movement of wildlife between conservation areas, although they may not be as corridors.

George Gale

Given the controversy concerning the effectiveness of corridors, I think this is the best paper yet, providing proof that they work. Do you have any data that indicate any negative effects of corridors?

Nigel Tucker

No negative data; these corridors are established on private land with a nature conservation agreement that goes with the land. If the land is sold, the new owners cannot clear or alter the forest. I am working on several corridor projects to try to replicate the results reported here. The problem is that we don't yet have other corridors to show that this is not a one off thing.

Asiatic Lion - The pride of Girnar.

GREATER GIR ECOSYSTEM: ECO-RESTORATION OF GIRNAR FOREST & RECAPTURE OF LOST TERRITORY BY *PANTHERA LEO PERSICA* (ASIATIC LION)

Bharat Lal IFS [1]

ABSTRACT

The Asiatic Lion (*Panthera leo persica*) once roamed freely in central Europe and west Asia. It migrated to India and is presently confined to the Gir Forest, in the semi-arid region of western India. Although, it once ranged throughout the whole of central and north India, by 1880, its population had dwindled to about 12. Since then, sustained conservation measures, including formation of the Gir Protected Area (PA) in 1965, increased the population of Asiatic Lions to 305 by 1995. Since all wild Asiatic Lions were confined to Gir PA, it was felt that another suitable habitat should be established to reduce inbreeding and prevent extinction of the species. In Girnar forest, a 180 km^2 patch of degraded forest, about 60 km from Gir, the Asiatic Lion was reported to be present until 1963, but later the whole population disappeared due to destruction of forest and loss of habitat. In 1992, determined eco-restoration efforts, combining watershed development and habitat protection with people's participation and a campaign to increase public awareness, resulted in regeneration of the degraded forest. The habitat improved beyond recognition, with increased populations of herbivores. Asiatic Lions that migrated from Gir recaptured the lost territory. Within 3 years, the lion population rose to 13 and now many cubs have been observed in Girnar. During this period, Asiatic Lions have made Girnar forest their permanent home and the population, along with herbivores, is on the increase. Of course, this has resulted into a new set of problems, because Girnar forest is located at the doorstep of Junagadh City and encompasses many religious places. Eco-restoration of Girnar forest and the return of the lions to other neighbouring areas have increased lion habitat from 1,400 to 2,000 km^2. This approach and the success of Girnar provide a model for other regions, where local economic interests and forest restoration can be combined with restoration of habitat and faunal diversity.

INTRODUCTION

The Asiatic Lion *(Panthera leo persica)* is confined to the Gir forest of Gujarat, in the western part of India (Map I). Low and erratic rainfall and extreme temperatures characterise the whole region, which is popularly known as Saurashtra and also Kathiawar,

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thus failing in the semi-arid zone. The region is drought prone and is often affected by cyclones and floods, since it is a peninsula surrounded by the Arabian sea on three sides. Gir forest, which is a dry deciduous teak forest, has been declared a Protected Area (PA) and thus varying degrees of protection and management are applied for managing the National Park and Sanctuary. The central part of the Gir forest comprising 258.71 km^2, has been declared a National Park (NP) and the surrounding area of 1,153.41 km^2 is a Sanctuary. In the National Park, all human activities are prohibited unless permitted for some specific purpose, whereas in the Sanctuary, many human activities are allowed unless specifically prohibited by the management.

GIR FOREST: LAST ABODE OF THE ASIATIC LION

The Gir forest lies between the parallels of latitude 20° 40'N and 21° 50'N and meridians of longitude 70° 50'E and 71° 50'E. Gir falls in the Afro-tropical realms and '4–B Gujarat Rajwara' biotic province of the semi-arid zone. The forest area is rugged and hilly with elevations varying from 150.3 to 503.7 m above sea level. Slopes are generally moderate and the hills are of volcanic origin. The maximum and minimum temperatures are 44.4°C and 10°C respectively. Rainfall is quite erratic and irregularly distributed; the maximum annual precipitation is 186.6 cm and minimum 19.9 cm with an annual average of 98.0 cm. Wind blows mainly from north–west to south–east during October to March, changing to south–east to north–west during summer and monsoon.

Location of the Gir

Although the Gir forest is known as the last abode of the Asiatic Lion, it is also very rich in flora and other fauna. In this region, Gir is considered important for the conservation of not only biological diversity but also for the cultural diversity of the region. Due to a variety of reasons, much research and study has not been done on Gir, but as per available information, there are 450 recorded flowering plant species, 32 species of mammals, 26 species of reptiles, about 300 species of birds and more than 2,000 species of insects. The forest also harbours a variety of endangered and threatened species, and provides breeding grounds for many migratory and resident birds. In the 1,412 km^2 PA, there are two major carnivores i.e. Asiatic Lion (*Panthera leo persica*) and leopard (*Panthera pardus*), together numbering more than 500. Other carnivores are hyena (*Hyaena hyaena*), fox (*Vulpes benghalensis*), jackal (*Canis aureus*), jungle cat (*Felis chaus*), desert cat (*Felis libyca*), mongoose (*Herpestes edwardsi*) civet cat (*Viverricula indica*) and ratel (*Mellivora capensis*). The area is abundant with herbivores, viz. spotted deer (*Axis axis*), sambhar (*Cervus unicolor*), bluebull (*Boselaphus tragocamelus*), wild boar (*Sus scrofa*), four-horned antelopes (*Tetracerus quadricornis*), chinkara (*Gazella gazella*), etc. Other major animals found in the area are common langur (*Presbytis entellus*), porcupine (*Hystrix indica*), hare (*Lepus negricollis*), crocodile (*Crocodilus palustris*), pangolin (*Manis crassicaudata*), python (*Python molurus*), Star tortoise (*Geochilon elegans*), monitor lizard (*Varanus *bengalensis*), rusty spotted cat (*Felis rubiginosa*), etc. In India, Gir has probably the highest number of crocodiles and also has the highest population of spotted deer, numbering more than 32, 000 in the year 1995.

In the forest and surrounding areas, a huge population of cattle competes with wildlife for space, water and food. Bordering the Sanctuary, 97 villages within a periphery of 6 km, have more than 100,000 cattle. The villagers are totally dependent on the PA for their livelihood, including water, fodder, grass, soil and fuel-wood. There is a local tribe, called the Maldharis (cattle owners), who are basically pastorals and generally are known for practising a nomadic life. Their main livelihood is cattle rearing and selling milk and other dairy products. Thus they are dependent on resources within the PA for their day-to-day survival. As per the 1995 survey, there are 54 nesses (settlements) with 361 families of Maldharis inside the Sanctuary. In the National Park, there is no nesses. In addition, there are 14 forest settlement villages, covering an area of 5,176.44 ha. with 556 households and a population of 4,494 people and 4,242 livestock. Ever since their forefathers were settled in the area by the then Nawab of Junagadh to provide local labour in the forests, they have become accustomed to relying on the PA's resources.

In the coastal region many industries, such as cement and sugar, are dependent on the Gir forest for water. In fact, this forest is the major source of water to the whole region and 4 reservoirs have been built inside the PA. These reservoirs are a perennial source of water. During summer, they provide excellent habitat for ungulates, crocodiles, etc. Also many small dams and reservoirs have been built on the periphery of forest to store water for agriculture and domestic purposes.

Table I Wildlife Populations in Gir

S. No.	Name of animal	Population in the census year					
		1969	1974	1979	1985	1990	1995
1.	Asiatic Lion	-	180	205	239	284	304
2.	Leopard	-	155	161	201	212	268
3.	Hyaena	-	74	84	192	97	137
4.	Spotted Deer	4,100	4,517	8,431	10,466	27,600	32,061
5.	Sambhar	600	706	760	772	1,764	2,262
6.	Bluebull	400	1,528	2,033	2,081	1,524	1,856
7.	Chousingha	100	969	1,042	1,963	427	441
8.	Chinkara	50	195	330	311	972	387
9.	Wild boar	300	1,922	2,365	2,212	505	1,214

Based on regular censuses Table I. clearly shows an increase in the wildlife. This success has become the main cause of man-wildlife conflict, as all are competing for the limited space and resources of the PA.

ASIATIC LIONS AND THEIR POPULATION

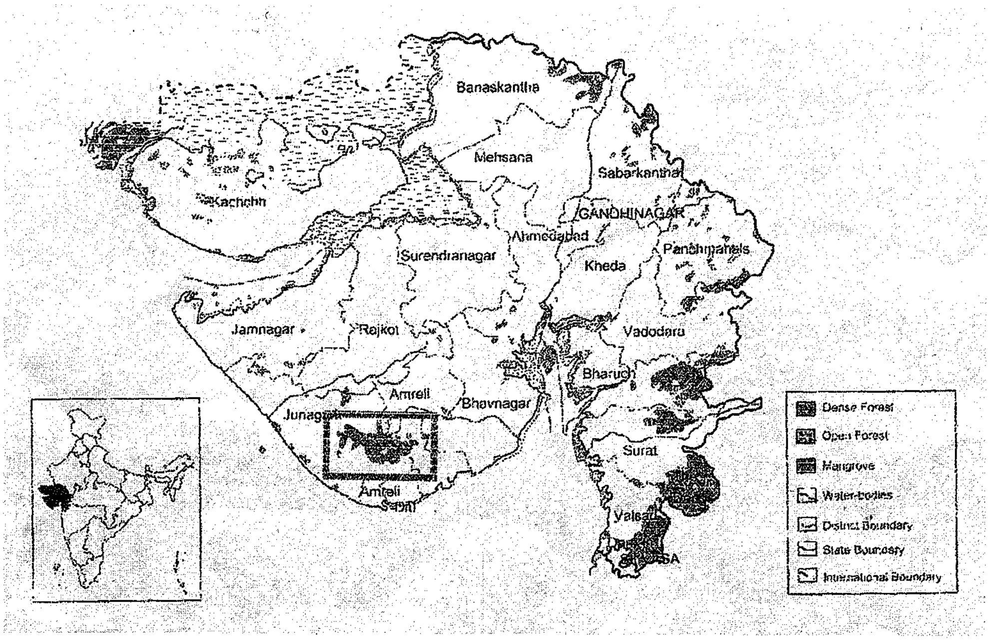
The Gir forest is known all over the world as the last abode of Asiatic Lions. Asiatic Lions were once widely distributed in Asia covering Mesopotamia, Arabia, Persia and the Indian subcontinent, where the species was fairly well distributed until the end of 18th century. The lions roamed throughout West and South Asia, entering India through the northwestern passes. They ranged over practically the whole of the northern and central part of the country, extending from Sindh (Pakistan) to Bengal and from the Ganges and the Indus to the northern bank of the river Narmada. Before the end of 19th century, the Asiatic Lion had become extinct from its whole range except the Gir. The probable years of its region-wise extermination are Bihar (1840), Delhi (1834), Bhagalpur (1842), eastern Vindhyas and Bundelkhand (1865), Central India and Rajasthan (1870) and western Aravallis (1880). Outside Saurashtra, the last surviving animal in the wild was reported in 1845. By the end of 19th century, the then Nawab of Junagadh indicated the number of lions to be about a dozen in the Gir. Probably, this low number was reported to save the lions from further extermination.

Lions struggled to survive during the severe drought and famine between 1901 to 1905, by killing many humans and livestock. In spite of this, the Nawab of Junagadh provided adequate protection to the animals and the population thus increased between 1904 to 1911. After the death of the Nawab, 12–13 lions were being shot annually. From the year 1911 onward, the British authorities rigidly controlled shooting, and during the year 1913, the Chief Forest Officer of Junagadh reported that there were not more than 20 lions left in wild. Gir was connected with the Girnar and Mitiyala hills by rough and semi-wooded corridors. Similarly, the area was also connected with the Barda and Alech hills and a wild wooded strip between Dhank and Chorwad along the seacoast. This enabled the Gir lions to roam freely through these pockets.

In the later half of 19th century, Asiatic Lions deserted the Barda and Alech hills, probably due loss of habitat and continuous disturbance caused by the British Army pursuing Wagher outlaws hiding in these hills. In 1879, a pride, consisting of a male, a female and a cub, was last seen in that area. However, before the then Porbandar State could take steps to protect these animals, the Rabaris and Nawanagar State police stationed there killed them.

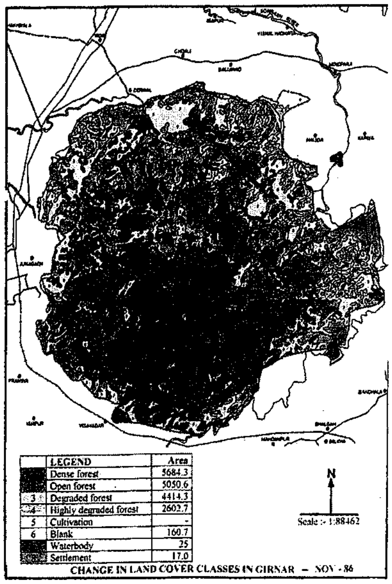
Table II Estimated Asiatic Lion populations in the past

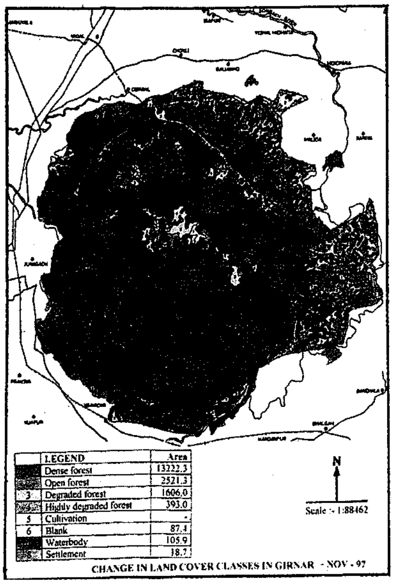
Year	Authority	Total
1880	Col. Watson	About 12 (E)
1893	The then Junagadh State	About 31 (E)
1905	Maj. Carnegy	About 60-70 (E)
1905	The then Junagadh State	About 100 (E)
1913	Mr. Wrangler	Not more then 20 (E)
1920	Mr. P. R. Cadel	About 50 (E)
1920	Mr. Ratnagar	At least 100 (E)



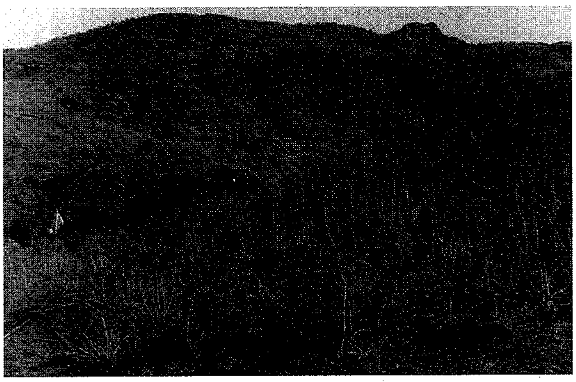
Map I Location of the Gir Forest

Asiatic Lioness with cubs - in search of a new home.

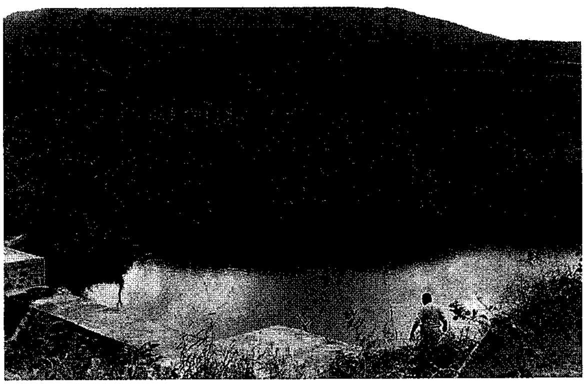




Maps showing an increase in dense forest (green) and decreases in open and degraded forests (orange and yellow) following eco-restoration at Girnar 1986-97.



Degraded Girnar forest in 1991, just before eco-restoration was launched



Naturally regenerated teak after integrated watershed development.

Asiatic Lions started appearing in the Mitiyala forests from 1917 onwards. Twenty-three lions were shot there between 1940 and 1946. Lions were last seen in small numbers in the Girnar hills adjoining Junagadh until 1963. Nine lions were captured there between 1944 and 1958. The roaring of captive lions kept in the Sakarbag zoo, located at the foothills of Girnar and maintained by the Forest Department often attracted wild lions. However, no lions were recorded from this area after 1963 until a few stray individuals were again located there during the 1974 census.

Table III Asiatic Lion populations based on census.

Year	Number of						Authority conducting the census
	Adults		Sub-adults		Cubs	Total	
	Male	Female	Male	Female			
1936	143	91	-	-	53	287	Junagadh State
1950	179	187	-	-	40	219–227	Mr. Wynter Blyth
1955	144	100	-	-	49	290	-do-
1963	82	134	-	-	69	285	Gujarat Forest Department
1968	60	64	-	-	51	177	do-
1974	40	52	13	25	50	180	-do-
1979	52	68	13	14	58	* 205	-do-
1985	66	75	27		48	239	-do-
1990	99	95	-	-	63	284	-do-
1995	94	100	18	21	71	304	-do-

* In 1979, total 50 sub-adults were seen but sex of the animals could not be identified.

Recorded history shows that in 1880, the Asiatic Lion population was reduced to 12. This alarming decline in population catalysed conservation measures. Once the Gir Sanctuary Project (1972) was implemented, the population of Asiatic Lions and other fauna grew steadily (Table I). This increasing population of all wild animals exacerbated wildlife–human conflicts. In fact, the situation reached the stage where Lions started visiting neighbouring villages and killing livestock.

The Gir Lion Sanctuary Project: The study conducted by JOSLIN (1972) and BERWICK (1972), revealed startling facts about the causes of decline in biological diversity, including the lion population in Gir. In view of these studies, the Gir Lion Sanctuary Project was launched in 1972, resulting in considerable improvement of habitat, despite a catastrophic cyclone in 1982 and severe droughts in 1987 and 1988. Due to clear policies and strategies, combined with research input and ensured participation of local people, the Gir PA has become one of the best managed Protected Areas in the country.

Predation pattern: JOSLIN'S study in 1969 revealed that 75% of food for lions came from predation of domestic livestock and only 25% was wild ungulates. Since 1969, especially after the implementation of the Gir Lion Sanctuary Project, conditions and habitat have changed drastically. All nesses in the National Park and the majority in the Sanctuary have been shifted outside the Gir. After strict control on grazing by domestic livestock, there has been a dramatic change in the habitat, resulting in a steep increase in ungulate populations, especially of spotted deer. In 1990, a study conducted by CHELLAM revealed some interesting facts about changes in the predation patterns of the lions. Scat analysis revealed that only 25.9% of items identified in lion's scats were livestock, indicating almost complete reversal in the predation pattern. About 75% of scats collected from areas outside the PA had livestock remains. In these cases, remains of wild ungulates were also detected. A seasonal pattern was also observed in the composition of lion kills during the monsoon and post-monsoon, which is probably due to changes in the density of vegetation. Furthermore, lions kill more spotted deer and Sambhar stags than was expected in the Gir. The diets of lion and leopard in Gir have an overlap value ranging from 0.61 to 0.71, with spotted deer being the top ranking prey for both carnivores. Within a period of 25 years, there has been a complete reversal in the predation patterns of lions in the Gir, which is probably because of changes in the availability of prey species and adaptability of the lions. The flexible nature of the Asiatic lion became very important for its survival even outside the Gir and colonising new areas.

Lion Home Range & Migration: During the monsoon, lions tend to move away from the interior dense Gir forests to more suitable open forest areas to escape flies and mosquitoes due to excessive humidity and dense growth. Migration of Asiatic Lions towards the coastal belt started in 1987–88. Similarly, during the early 90's, lions started frequenting Girnar as well as Mitiyala forests. A study by S. P. Sinha has revealed that a lion pride has a fairly well defined home range. One adult male lion has approximately 48-57 km^2 as a home range, whilst for adult lionesses, the range is about 20-25 km^2. Up to 15% of pride ranges overlap. However, CHELLAM (1992), using radio collars, showed that in the dry season, the home range of females was 84 km^2 and in the monsoon, it was 67 km^2. For males, it varied between 144 to 201 km^2. Dispersal of lions from Gir can be attributed to a population increase in the Gir forest.

GIRNAR FOREST

Gir and the surrounding forest areas are socio-economically very important because they provide sustenance to people especially during times of drought and resultant scarcity, which are quite common. About 60 km from the Gir forest, lies the Girnar (meaning 'king of mountains'), 18,000 ha of dry deciduous and dry scrub patches on mountainous, rocky terrain, on the doorstep of Junagadh city and surrounded by 39 villages. This patch of forest is the traditional water source of Junagadh City and neighbouring villages. The population of the city is estimated to be more than 250,000. In the past, Girnar forest was a dense, dry teak deciduous forest, comprising mainly teak, bamboo, *Acacia* and other associated species. The highest peak in the Girnar is more than 1,100 m above MSL and there are many hills and hillocks.

In the Girnar hills, there are many religious places. More than 1.6 million people visit the forest/ hills annually to offer their prayers to various deities. Every year, in November, people walk completely around one of the main hills, Girnar Parikrama, in the belief that after death, they will attain Moksha i.e. complete release from the birth and death cycle. Similarly, in February–March, people come to celebrate Shivaratri (the night of Lord Shiva, God of destruction, in Hindu Mythology). Also, once a year, very large numbers of Muslim (as well Hindu) devotees come to offer their prayers. Girnar is also considered a holy pilgrimage for followers of Jainism, another Hindu religion.

ISSUES AND PROBLEMS IN THE AREA

In the 1970's & 80's, the forest was ruthlessly exploited by illegal tree felling for timber, fuel-wood and bamboo. In many parts of the forest, legal as well as illegal mining also started. Due to a ban on liquor in the state and the proximity of the forest to the adjacent city, bootleggers started using Girnar and it's various resources, such as water, dead and dry fuel-wood and undulating terrain, for making illicit liquor. This caused immense damage to habitats, as quite often it led to forest fire, continuous disturbance and loss of water sources. Uncontrolled grazing and illegal cutting of trees for timber and bamboo, coupled with encroachment and mining caused rapid degradation of the forest. In fact, frequent and extensive forest fire became commonplace. At this stage, staff and officials responsible for management and development of the Girnar forest were highly demoralised. Woodcutters were so organised that they started attacking patrolling staff and incidents of attack on forest staff increased alarmingly.

Forest fires in Girnar and Gir reached such an alarming level, such that the Government had to appoint a High Powered Committee to identify the causes of fire and suggest remedial measures. The Committee included people's representatives as members, which went a long way to ensure the local people's co-operation and their subsequent participation in the whole eco-restoration programme. Later, the then Working Plan Officer of the region was asked to study and identify the factors responsible for forest degradation and suggest remedial measures for rehabilitation. Both these study reports became available at the end of 1991. They revealed that during the previous few decades, what was once, a very rich forest, had been degraded by illicit removal of wood, illicit distilling, mining, illegal grazing and other associated problems viz. soil loss, decreasing moisture etc. In his report, the Working Plan Officer (A. K. Sharma), identified the following major reasons as responsible for forest degradation:

1. Demoralisation of staff
2. Forest fire
3. Illegal cutting of trees by organised wood cutters
4. Non-responsive administration
5. Connivance of staff in certain cases
6. Edapho-climatic conditions
7. Lack of will to protect the forest
8. Encroachment
9. Illegal and uncontrolled grazing

The report also recommended that immediate steps be taken to arrest degradation of Girnar forest, as it had reached such a stage that any further delay in action would lead to complete loss of forest with no possibility of regeneration.

A NEW APPROACH

Acknowledging the gravity of the situation, in 1992, the Forest Department with the active support of local Non-Governmental Organisations (NGO's) took a fresh and bold initiative. A plan for the rehabilitation of the degraded Girnar forest was worked out and new strategies were decided. The cornerstone of this strategy was to capture the imagination of people and link forest rehabilitation with their socio-economic well being. In this drought prone semi-arid region, where animal husbandry is a major occupation, it was not very difficult to identify two most important spin-offs from rejuvenation of the forest. The two products i.e. water and fodder (including grass) became major benefits, instead of a typical timber oriented approach, for any future forest recovery.

Because Asiatic Lions were found in Girnar forest until 1963, there was every possibility that the area might again become suitable habitat for lions. Moreover, in many aspects, such as forest type and vegetation, edapho-climatic conditions, terrain, rainfall, culture and ethos of local people, etc. Girnar and Gir are similar. All these factors made it possible to regenerate the area as a future home of the Asiatic Lion. Since in Gir, remarkable forest recovery occurred after implementation of the Gir Lion Sanctuary Project in the 70's, this approach seemed feasible at Girnar, except for concerns about people's response in the event of lions returning to the regenerated area. However, management of Girnar, being adjacent to the Junagadh City and having many religious places, has always been a very sensitive issue, because the number of stakeholders is high, diverse, enlightened and quite powerful. In managing and developing such an area, the interests of all sections of society must be integrated. The participation of everyone must be ensured for successful implementation and sustainability of the programme.

Staff training

Staff were specifically asked to maintain a daily diary and record sightings of wild animals, killings, fire incidence, etc. In weekly meetings, all reports was then discussed. Highly participatory monthly meetings of staff and senior forest officials were held regularly, where a two-way exchange of ideas, problems and information, took place. Training and exposure through wildlife related films, visits from the doctor from the local Shakarbagh Asiatic Lion zoo etc. were regularly organised to increase the knowledge and information base of the staff. Relevant manuals and books related to forestry and wildlife management and technology were also made available to all staff. During this period, emphasis was also given to computerisation of records and development of a proper Management Information System (MIS).

To monitor wildlife, staff were also trained. In the case of lions, monitoring is easy because they are readily seen. In the case of panthers, recording of pug marks at water points became the definitive source of information. Initially, pug marks were also recorded for ungulates but later, when populations grew, direct sightings became more frequent. People also started coming to these checkpoints (Thanas) in cases where wild boar, sambhar or blue bulls damaged their crops. Staff were also asked to report sightings of lions on the wireless network, so that higher officials could go to the locality of the sightings and confirm them. As per State policy, regular, highly transparent and participatory censuses are also held.

Integrated Watershed Development

Thus, in the year 1992, well-planned efforts were made to not only reverse the process of degradation, but also to regenerate the highly degraded areas through integrated watershed development and improved habitat protection by enlisting the participation of local people. This programme was launched by forging effective partnerships between various stakeholders. Since the region falls into the semi-arid zone, and drought and scarcity is quite frequent and severe, people realised the importance of Gir and Girnar. These forests become the last refuges of a very large population of people and their livestock in the region, especially during severe droughts. After the severe droughts of 1987 and 1988, people understood the necessity of preserving their forests and started putting a higher value on conservation. They were also ready to contribute their efforts to the ongoing eco-restoration programme.

Whilst initiating the rehabilitation programme for the Girnar forest, top priority was given to effective communication and dialogue among the various stakeholders. As pointed out by the earlier report (SHARMA A. K. *ET AL*) on Girnar, staff working in Girnar and surrounding areas were highly demoralised and had lost the skills required to manage such a forest. First and foremost, effective communication was established among the staff and other forestry officials to ensure convergence towards a common goal. Various meetings, camps, discussions and training programmes were organised. To motivate staff and make them more focussed, lectures from successful people were also organised. It was ensured that officers and staff spent considerable time together in forests while patrolling, trekking, carrying out surveys, and implementing and monitoring various activities. All staff received training, especially to equip them for local planning, effective communication, execution and monitoring of work related to soil and moisture conservation, small masonry structures, raising planting stock of local species, raising plantations, silvicultural operations, fire control measures, wildlife monitoring and census etc. To achieve this, the help of well-trained, skilled people working in different fields was enlisted.

The demarcation exercise was implemented first, because in many places there was no clear-cut forest boundary. Since the forest is adjacent to the city and land values are high, people encroached onto forestland. After demarcation, many encroachers were removed. Similarly, the long standing problem of wood cutters (Kathiaras), numbering more than 1,000 who were entering the forests, cutting trees and bamboo and selling them in the local market was solved by creating alternative employment opportunities and strict enforcement of laws. Simultaneously, uncontrolled and rampant grazing was also controlled, and villagers and Maldharis (local graziers) were provided with the option of cutting grass and taking it away free of cost. Dead, dry and wind-fallen wood and material available in naturally regenerated forest areas after silvicultural operations were made available to local people to meet their fuel-wood requirements. Controls on grazing, collection of dead and dying material and grass collection eliminated the problem of forest fire. Different afforestation works, carried out in the past under community forestry and other programmes, also improved availability of fuel-wood and small timber. A large number of biogas plants were also installed in peripheral villages to reduce dependence on fuel-wood.

Throughout Girnar, large-scale soil and moisture conservation (SMC) works were implemented as priorities. Since the terrain is undulating and hilly, intensive work was required. Staff prepared the Treatment Plan (work plan) of each area with the help of local villagers, volunteers, NGO's and officials from other technical departments. In this endeavour, traditional water conservation and harvesting technology used by the people of the region became very useful. SMC work was planned in such a manner that maximum water is harvested and ground water recharge takes place to the optimal possible extent. Check-dams were constructed on rivulets and all drainage lines were treated. While planning the programme, it has been the endeavour that watershed development works should be taken up in such a manner that maximum work is done manually and local people get continuous employment. Most of the works have involved nala bunding, gully plugging, digging of pits and contour trenches, nursery raising, planting, etc. However, major structures were also constructed, while carrying out the watershed development work in Girnar, to retain maximum water:

Table–IV : Details of major structures constructed

Year	No. of major structures constructed				
	Check dams	Vantalavadi (ponds)	Raised causeway	Retaining walls	Total
1992-93	2	6	-	-	8
1993-94	21	19	5	3	48
1994-95	21	10	-	18	49
1995-96	2	-	-	-	2
Total	46	35	5	21	107

Wherever necessary, planting of local fruit and fodder-yielding plants, was also undertaken. Predominantly, *Ailanthus excelsa, Holoptelia integrifolia, Acacia senegal, Mitragyana parvifolia, Dalbergia sisso, Ficus bengalensis, Azadirachta indica, Emblica officinalis, Acacia catechu, Pongammia pinnata, Gmelina arborea, Tectona grandis, Madhuca indica, Annona asuamosa, Sapindus emarginatus, Terminalia tomentosa, Butea monosperma, Acacia nilotica, Dendrocalamus strictus, Bamboosa arundanasia* etc. were planted. Keeping in view the soil moisture conditions of various sites and for developing specific habitat for various wild ungulates, following types (Table V) of plantation were taken up under different schemes in the Girnar:

Table V Areas regenerated with different kind of plantations

S. No.	Plantation type/ Name of the scheme	Area taken up for plantation (ha)						
		90-91	91-92	92-93	93-94	94-95	95-96	Total
1.	Soil & moisture conservation plantation	75	50	100	150	100	10	485
2.	Afforestation in degraded areas	-	50	50	75	50	50	275
3.	People's participation in the regeneration of degraded forest areas plantation	-	-	-	50	100	110	260
4.	Plantation for development of tourist places	-	-	12.5	-	-	-	12
5.	Minor forest produce plantation	10	10	6	15	7	5	53
6.	Fuel wood & Small timber plantation	50	50	6	35	20	15	176
7.	Irrigated plantation	5	5	5	10	-	-	25
8.	Medicinal plantation	15	15	10	-	-	-	40
9.	Urban resource plantation	-	25	15	-	15	-	55
10.	Rural resource plantation	-	25	15	25	15	-	80
11.	Area oriented fuel wood & fodder plantation	-	-	100	-	-	-	100
12. (a)	MFP including medicinal plantation	-	-	-	5	-	-	5
12. (b)	MFP (minor forest) plantation	-	-	-	5	30	5	40
	Total	155	230	319.5	370	337	195	1606

Planting stock was raised in various decentralised nurseries. Seeds were collected from earmarked plus trees, selected on the basis of phenotype. Essentially, seeds from local forest trees were used. Except for teak, bamboo and grasses, seedlings were grown in polythene bags, of various sizes (10x10x15, 15x10x20 or 20x20x20 cm) depending on the duration for which seedlings were to be kept in the nursery and the sizes of the seedlings. In the field, pits were dug in such a manner to retain maximum moisture. Just after the first monsoon rain, planting was carried out in these pits and contour trenches. Post-planting care was carried out for three years including mulching, hoeing, weeding, watering and protection from fire and grazing. In planting areas and also other regenerating areas, other silvicultural operations like cutback and singling (especially in case of teak) was also done. Bamboo rhizomes, teak and local grasses were also planted on a large scale. Plantation operations are summarised in Table V.

Community Participation

The whole work was carried out on a watershed basis. Due to well-planned, large-scale soil and moisture conservation works and control of grazing and fire, availability of grass and fodder increased manifold. Availability of non-timber forest products (NTFP's) increased so much that they started providing an alternate livelihood to people from neighbouring areas, which helped in maintaining peoples' interest. Their participation, therefore, increased. Since Girnar is the only source of water for Junagadh city and the neighbouring 39 villages, increased availability of water and reduced siltation in reservoirs ensured not only the wholehearted support of local people but also attracted them to participate in ongoing efforts. By carrying out watershed development work, areas bordering the forest became more productive because soil loss and floods stopped and the water table increased. Within two years, the water table rose and around the periphery, water availability increased. Since in this region, water is normally supplied by tankers for 8-9 months per year, benefits from watershed management in the upper hills and regenerated forest became very apparent and immediate.

While carrying out SMC work, priority was given to construction of check dams and developing permanent water holes for wildlife. Because the area is highly undulating, such structures became very useful for water storage. There were 3 major reservoirs in the forest area, which became perennial due to watershed management and improvement in vegetative cover. In fact many rivulets originating in the Girnar started flowing for a longer duration than in the past and now water remains available in many parts of the forest throughout the year. This, coupled with improvements in vegetation and effective protection, resulted in recovery of habitat and increase in the population of herbivores.

Nature Education

Gujarat is a pioneer in the field of nature education especially in the form of Nature Education Camps, designed for school children, farmers, women, teachers and other special target groups. Since Girnar forest is very close to the city, it became much easier to develop many camping sites and treks to impart nature education and awareness to children. The Forest Department, with the help of local NGO's, schools, teachers, activists and a few very spirited scientists of Gujarat Agriculture University, started organising nature education camps. Due to the scale of SMC work, construction of check dams, nurseries, collection of NTFP's, grass, fodder, fuel-wood etc. staff and officials started staying in the forest areas and it became very difficult for anyone to indulge in illicit cutting and other illegal activities. Through the interest of local people and enlightened citizens, social monitoring started to take root.

Wildlife Monitoring

For wildlife monitoring, watch-towers were constructed and continuous patrolling was undertaken in the form of various teams at different levels, thus improving overall protection of the environment. After a proper survey, a highly effective wireless network was established throughout the forest. Every mobile and fixed station was named after a wild animal such as lion, panther, leopard, cheetal, sambhar, chinkara, blackbuck, rose (bluebull) etc. It brought a sense of belonging and staff felt proud that their station was named after wildlife. In fact, this started a race among staff for finding names of wildlife, as everyone wanted to be associated with wildlife. Despite very high wind velocity, a permanent wireless station was established at the highest peak of Girnar, which provided help to staff and officials in almost two-thirds of the state. All these wireless stations were manned continuously in shifts. This provided a sense of security among staff and allowed rapid detection of forest fires and reporting of lion sightings. All staff were provided with walkie-talkies and one-third of them were also given firearms. At these permanent wireless stations, all messages were recorded and regularly verified. This system became so effective that it was requested by the state level authorities to prepare a similar plan for the whole state, which was prepared and implemented immediately.

In the eco-restoration programme of Girnar, making water available to wildlife in association with forestry activities became paramount. In a forest area of 180 km^2, 39 water sources were identified. Furthermore, by constructing check dams, percolation tanks, storage tanks, retaining walls etc., perennial water sources were created. By improved habitat protection, illicit liquor manufacturing was stopped, which freed more water sources for wildlife. Control of grazing by cattle improved the fodder availability to wild herbivores and since the area is highly suited for sambhar, their population grew rapidly. Overall improvement in protection eliminated poaching, and wildlife visibility improved. Because Girnar forest is a compact block, it became much easier to construct various checkpoints on the periphery of the forest. At 14 places, permanent check points with residential staff quarters and reasonable facilities were constructed. At all these checkpoints, permanent nurseries and water sources were created. This ensured that staff presence and monitoring of wildlife became much easier. At all these stations, a register to record wildlife sighting was kept. Similarly, local people were asked to inform staff at any of these nearest checkpoints, if any carnivore killed or attacked people or their cattle. All records of such incidences are maintained, as the Forest Department pays *ex-gratia* compensation to affected people.

IMPORTANT OBSERVATIONS

During the rainy season, migration of lions from Gir is quite common. They go quite far, sometimes up to 90 km and have been frequently seen on the periphery of Gir in peripheral grasslands (Vidis) and coastal plantations etc. In 1993, they also reached Girnar and after finding suitable habitat, stayed there. Most of the lions who came to Girnar were sub-adult males, except for one full-grown male. During 1993-94, no cubs were seen. However, in 1995 a female also appeared after the monsoon. It can be safely presumed that due to fighting for territory, the dominant male of the pride had thrown out the sub-adults. In 1996 (Bharat Lal), 6 cubs were reported in the Girnar and sightings became quite frequent. During this period, the sambhar population in Girnar grew rapidly and spotting these animals became very easy. In 1991 (A. K. Sharma) a group of spotted deer was observed and photographed in the central portion of the Girnar forest. The wildlife census of 1995 showed that a large number of spotted deer are also present in the Girnar forest. The habitat of Girnar is best suited for sambhar. Due to plenty of fodder, water and security, bluebulls have also started to migrate in from nearby areas. In Girnar, leopards had always been present but after 1994, it appears that the leopard population also increased.

Due to increases in lion and leopard populations, killing of domestic animals also started to occur. On average, each lion kills about 9–10 domestic animals, mainly buffaloes, per year. The rest of the diet consists of wild ungulates. In Girnar, pride size varies from 1–4, but is mostly two or three. There is a fairly well developed system of recording killings, and a veterinary doctor examines each case and carries out a post-mortem so that compensation can be paid. In 1994, in a single night, two male lions killed seven buffalo in a nearby village on the periphery of the Girnar. Similarly, quite often, these lions sit on the roads or staircases leading to various temples in the forest and people ask for help from forest staff. Presence of lions and panthers reduced grazing and unauthorised entry of woodcutters, bootleggers, etc. especially during nights.

Table VI Distribution of the Asiatic Lion population (Lion Census, 1995)

S. No.	Area/ zone	Area (km^2)	Asiatic Lion Population			
			Male	Female	Cubs	Total
1.	Gir National Park	258.7	10	12	9	31
2.	Gir Sanctuary	1,153.4	72	92	50	214
3.	Gir Peripheral forests	60.0	10	5	2	17
Sub-total in Gir			92	109	61	262
4.	Mitiyala forest	19.4	2	1	-	3
5.	Coastal zone	110.1	8	8	10	26
6.	Girnar forest	179.5	10	3	-	13
7.	Barda forest	192.3	-	-	-	-
Total		1,973.4	112	121	71	304

Changes in forest cover

Gujarat is highly deficient in forest. Only 0.03 ha of forest is available per capita, compared with a national average of 0.7 ha. In the state, the recorded forest area is only 9.89%, compared with 23.28% for the whole country, whereas good forest covers only 6.4% of the total area, compared with a national average of 19.27%. However, community forestry, started in the 1970's has taken deep roots in the state. In fact, social forestry and coastal border plantations, to reduce the impact of sand-laden wind on inland farms, have given immense economic benefits to local people. Gujarat has a very long coastline measuring 1,600 km and ingress of salinity has been prevented to a large extent by establishment large-scale plantations on coastal land. In addition, due to influence of religion and culture, protection of wild animals is in the ethos of the people.

The Forest Survey of India regularly monitors changes in forest cover using satellite images, followed by verification by ground-truthing. According to the State of the Forest

Reports, published in 1993, 1995 and 1997, in Junagadh district, 139 km^2 of open forest (density less than 40%) was converted into dense forest (density 40% and above). In contrast, over the rest of the country, during the same period, forest cover hardly improved (see Table VII).

Table VII Comparative changes in forest cover

Name of the district/ State/ Country	Change in forest cover (In sq km)			
	1991	1993	1995	1997
Junagadh district (open to dense forest)	-	+35	+104	-
Gujarat State (including mangroves)	-14	+137	+276	+258
India (all)	+560	+22	-507	-5,482

According to the State of the Forest Report (1995), in Junagadh district 104 km^2 of open forest (density 10-40%) was converted into dense forest (density >40%), whereas in rest of the country, during the corresponding period, only 76 km^2 of open forest was converted into dense forest. Furthermore, in Gujarat there was an increase of 270 km^2 of mangrove forest, whereas in the rest of the country, only a 7-km^2 area was added to mangrove forests during the corresponding period. Similarly, the State of the Forest Report of 1997 revealed that there was a further increase of 302 km^2 of mangrove forest, whereas the figure for whole of the whole country was only 294 km^2. This means that in other areas of the country, mangrove forest is still being lost.

Currently, forest cover in Girnar has increased. Degraded, open rain–shadow areas have regenerated. Due to increased moisture and retention of soil, regeneration is very good. All natural species have regenerated. Since, at present, the Forest Survey of India monitors change in forest cover using satellite images at the macro-level above 40% density, all forests are grouped together, so a new study (GEER Foundation) was implemented to determine block-wise changes in forest cover of Girnar. That study (1998) compared forest cover in 1986 with that in and 1997. Details of the satellite data used are given in below (Table VIII).

Table VIII Details of satellite data used

Satellite	Path	Row	Product	Date
LAND SAT	150	45	TM FCC	November 23, 1986
IRS – IC	91	57	LISS-III FCC	November 01, 1997

For this study, changes in forest cover were classified as per the Forest Survey of India classification. According to that classification, forests are termed as dense forest (density more than 40%), open forest (density 30-40%), degraded forest (density 10-30%) and highly degraded forest (density less than 10%). Analysis of satellite data showed dramatic changes in dense forest cover of Girnar between 1986 and 1997 (Table IX). In 1997, 73.6% of the Girnar forest could be classified as dense, whereas in 1986, dense forest covered only 31.6% of the area. On the other hand, during the same period, open, degraded or highly degraded forest was reduced from 66.9% in 1986 to 25.0% in 1997. One of the most interesting changes, apart from the change in dense forest cover, is a more than four times increase in water bodies. Although in 1997 rainfall was good, nevertheless watershed development in Girnar resulted in reduced run-off, revived rivulets and longer retention of water, which helped in solving water problems in the region.

Table IX Changes in forest cover of Girnar

S. No.	Category	1986		1997	
		Area (ha)	% of the total area	Area (ha)	% of the total area
1.	Dense forest	5,684.3	31.6	13,222.3	73.6
2.	Open forest	5,050.6	28.0	2,521.3	14.0
3.	Degraded forest	4,414.3	24.5	1,606.0	8.9
4.	Highly degraded forest	2,602.7	14.4	393.0	2.1
5.	Cultivation	-	-	-	-
6.	Blank	160.7	0.8	87.4	0.4
7.	Water bodies	25.0	-	105.9	0.5
8.	Settlement villages	17.0	-	18.7	-
	Total	17,954.6	100%	17,954.6	100%

Due to large–scale watershed development work, the microclimate inside Girnar has changed. Due to increased moisture and reduced temperatures, the whole area has naturally regenerated with minimal planting and most of the wildlife, originally present, has returned. The Rusty Spotted Cat has probably colonised the Girnar. This species is normally found in the moist deciduous/evergreen forest of the Western Ghats. In 1996, an abandoned cub was captured in the Girnar forest, illustrating the change in the microclimate of the Girnar, due to SMC work and regeneration of natural species.

CONCLUSION

In India, like in many other countries, current policy is to manage forests sustainably, whilst accommodating cross–sectoral interests. Eco-restoration of Girnar Forest in Junagadh has given new hope of reversing degradation and restoring the area to its original condition. Forest restoration has shown that wildlife habitat can also be increased, provided a strong will is there. In Gujarat, this has been further strengthened after 1996, when throughout the state, such work has been taken up on a large scale under the OECF-Japan aided Integrated Forestry Development Project (IFDP). In fact, increases in forest cover due to coastal plantations and mangroves have given further impetus to ongoing efforts. The success of Girnar provides a solution to the problem of finding suitable habitat for the growing population of Asiatic Lions. It seems that the lion population in Gir forest may have reached its carrying capacity, because dispersal is frequent. The fact that lions migrate to and settled in Girnar, demonstrates that lion habitat can be increased and suitable management policies can be adopted. Based on the Lion Census of 1995, during preparation of the Management Plan of Gir PA, we mooted the idea to form a **Greater Gir Ecosystem,** comprising peripheral grasslands, coastal plantations, Mitiyala, Barda and Girnar forests. Once the concept of the Greater Gir Ecosystem is adopted, the home of Asiatic Lion will be increased from the present area of 1,4121 km^2 to 1,973.4 km^2 (Table VI). This additional 560.3 km^2 will accommodate these lions with a proper prey base and also reduce threats to this species.

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QUESTIONS AND COMMENTS

Anders Pedersen

This work has the narrow aim of creating habitat for a single species, in contrast with the approach of Nigel Tucker, which tries to create ecosystems for a broad range of species.

As far as I know the lion likes open grassland for hunting, as its prey mainly live in such habitat, but the panther prefers dense forest. How do you reconcile these different needs?

Bharat Lal

Yes, lions prefer open forest, but in Gir, there is no typically open grassland, it's more like scrub. In the Girnar area, the forest had become so dense that some kind of thinning is required. However, such thinning might set a bad example. In the state, panthers kill few people each year. We have to combine many factors, including socio-economic in the restoration of such areas. In the forest, we try to have some more open areas too for lions.

John Parrotta

This seems to be an exceptional success story, set against extreme local hardship and degradation. It overcomes socio-economic problems and carries out good restoration, whilst harnessing human resources within a multi-agency organisation. It also involves the local community. The key to gaining such large support is the focus on water. The subject of water has arisen repeatedly in this discussions and presentations during this workshop[2]. Deforestation disrupts hydrological cycles and depletes both rural and urban water supplies. By stressing the issue of water resources, project directors can be persuaded to use intensive restoration techniques, particularly on heavily degraded sites, such as mines. I wonder if this work has been repeated in other national parks in India? Are similar projects being implemented to conserve elephants or tigers?

Bharat Lal

Project Elephant and Project Tiger launched by the Government of India are very famous. Project Tiger increased the tiger population in the last 25 years from about 1,200 to 4,000. The number of elephants have also increased. Poaching is still a problem for tigers, but fortunately not for lions. There are also problems of tigers killing domestic animals and elephants causing crop damage. One factor has been the liberal conservation programmes of the government with generous funding. Funds are transferred to local governments and also to local communities and committees for watershed management.

Abdur Rashid

What methods were used to census the lions after the restoration in 1993?

Bharat Lal

The census was made by direct sightings. Water and prey were provided to attract the lions for counting at different stations all over the park. In Girnar forest the last lion was seen in 1963. In the 1974 census only 1 pair was recorded. In the 1995 census, 10 males and 3 females were seen but only 1 male was fully-grown. In 1996, 6 cubs were observed with 3 more this year.

[2] Editor's note: this resulted in research proposal 5.2, outlined in Part 7.

SEED DISPERSAL AND FOREST RESTORATION

Richard T. Corlett[1] *and Billy C. H. Hau*[2]

ABSTRACT

Most trees in the tropics reach their place of growth via the gut of an animal. Thus the fruit choices of local disperser fauna can have a major influence on which tree species arrive at a site and how quickly. In degraded landscapes, the major dispersers of large seeds and large-seeded fruits (such as, in Asia, large fruits bats, gibbons, elephants, rhinoceroses, hornbills and imperial pigeons) have usually been eliminated. Small frugivorous birds (such as bulbuls) and small fruit bats (often *Cynopterus* spp.) ensure that both small fruits and larger, soft fruits with many small seeds are still dispersed. However, the absence of food and suitable perches greatly reduces the movements of these tolerant dispersal agents into treeless grassland sites. In such situations, active planting of trees or shrubs may greatly speed the early stages of forest succession, and the resulting enhancement of seed dispersal can lead to diversification of initially low-diversity plantings. In theory, tree species that provide suitable fruits would be expected to attract more seed dispersal agents and thus more seeds than tree species with unattractive, non-fleshy, fruits. However, all the more tolerant fruit-eating birds are at least partly insectivorous and fruit bats use non-fruiting trees as feeding roosts, under which they drop seeds, so the choice of trees for planting may not be crucial. Whether or not some trees are initially planted, tree species with large-seeded fruits are unlikely to arrive at degraded sites of their own accord. Including some of these species in the planting mix will both ensure their survival in the landscape and provide food for their dispersal agents if these later re-invade or are reintroduced to the area.

INTRODUCTION

Tropical deforestation is not a one-way process. Most of the uses for which forest is cleared are not sustainable and the majority of the cleared area is sooner or later abandoned. Unless succession is prevented by continued disturbance such as fire, most of this abandoned land will eventually revert to secondary forest (CORLETT, 1995). The rate at which woody vegetation develops on cleared sites is related to the frequency, duration and intensity of disturbance (NEPSTAD *ET AL.*, 1996; HUGHES *ET AL.*, 1999). On highly degraded sites, such as most non-forest areas in Hong Kong, succession can be very slow. In places with a distinct dry season, there is a long period of vulnerability to fire in grassland sites (over 10 years in Hong Kong), before a closed, woody canopy suppresses the fire-promoting grasses. In addition, most of the various biotic and abiotic processes, which control the rate

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of succession, are highly selective. As a result, only a subset of the mature forest flora occurs in secondary forests even after several decades of succession (FINEGAN, 1996; TURNER *ET AL.*, 1997; FERREIRA & PRANCE, 1999). This is particularly apparent in Hong Kong, where most of the original forest remnants are confined to remote upland ravines and the dispersal agents of forest dominant species, such as the Fagaceae, are apparently lacking (DUDGEON and CORLETT, 1994). Forest succession is thus more successful at restoring forest biomass than floristic diversity, and is more successful on less degraded sites.

Despite massive planting efforts in the last century, plantation cover in the tropics as a whole was only 0.8 % of the natural forest cover in 1990 (WORLD RESOURCES INSTITUTE, 1999). It seems generally agreed that we will have to rely on succession as the main means of forest restoration in the tropics (ALIAS *ET AL.*, 1998; ELLIOTT *ET AL.*, 1995; FOREST RESTORATION RESEARCH UNIT, 1998; GOOSEM & TUCKER, 1995; GOMEZ-POMPA & BAMBRIDGE, 1995; KARTAWINATA, 1994; KOLB, 1993; MOLINE, 1999; PONE, 1997). Thus, it is important that we understand the factors, which limit its rate and control the species composition of the resulting secondary forest. If these barriers – or, more accurately, filters - to succession can be understood, it may be possible to accelerate and diversify succession over large areas at a much smaller cost than that required for artificial planting. Even if this does prove possible, understanding the factors that control natural succession will help formulate strategies for the use of native tree species in reforestation.

Whilst the intensity and duration of disturbance will influence on-site survival of tree propagules as seeds, seedlings, stumps and roots, through changes in the microclimate and fauna, the first and the major problem of forest succession on highly degraded sites is recruitment by post-disturbance dispersal (CORLETT, 1995). However, one should not overlook the fact that dispersal, while necessary for succession to take place, is not by itself sufficient. Prolonged cultivation or frequent fires can degrade the soil to such an extent that succession is slow irrespective of the availability of seeds. Nevertheless, we now attempt to summarise the characteristics of post-disturbance seed dispersal on degraded tropical forestlands in tropical Asia and make suggestions to overcome this initial filter-barrier to forest succession.

SEED DISPERSERS

The probability of a particular species arriving at the site will depend on the number and proximity of adult fruiting trees, and the mode of dispersal. Most of the tree species in the tropics are dispersed by animals rather than wind, water, or other forms of dispersal (WUNDERLE, 1997). Seed dispersal by vertebrates is a key process in the dynamics of natural vegetation and in forest succession on degraded tropical forestland (CORLETT, 1998a). Studies of frugivory and seed dispersal in tropical Asia have concentrated on primates, fruit bats and a few families of birds, but many other vertebrates consume some fruits and disperse some seeds. Degraded landscapes in the tropics typically lack many of the best-studied dispersal agents, such as gibbons and hornbills. The detailed behaviour of individual animal species and the impact of hunting, which typically concentrates on larger animals, become crucial in determining what tree species are dispersed. Few forest birds and mammals are willing to enter open areas. The open country fauna in previously forested areas is usually dominated by small animal species. In deforested Asian landscapes, the relative importance of vertebrate seed dispersers can be ranked as birds, bats and then non-flying mammals.

Birds

The relative importance of different frugivorous bird families varies with the stage of forest succession or restoration. Frugivorous birds that can tolerate degraded landscapes are more important at the initial stage of forest succession or reforestation (CORLETT, 1998a). They include passerine birds belonging to the Corvidae (magpies, jays, orioles etc.), Muscicapidae-Turdinae (thrushes), Muscicapidae-Saxicolini (robins and chats), Sturnidae (starlings and mynas), Pycnonotidae (bulbuls), Zosteropidae (white-eyes) and Sylviidae-Garrulacinae (laughingthrushes). Note that none of these birds are strict frugivores and all depend on insects for a significant part of their diet. Other bird families, which are tolerant of fragmentation and disturbance and could make use of secondary and disturbed habitats, will become increasingly important as forest succession or reforestation proceed, notably the highly frugivorous non-passerines Megalaimidae (barbets) and some Columbidae (fruit-pigeons). The more tolerant species of Bucerotidae (hornbills) may also appear if there is primary forest nearby and no hunting. These birds vary in gape width and therefore the largest fruits they can utilise: from less than 1 cm in the white-eyes to greater than 3 cm in the larger hornbills and fruit pigeons.

Bats

Old World fruit bats (Pteropodidae) are not only abundant and diverse in the Oriental Region, but also extremely varied ecologically (FLANNERY, 1975). All species are largely or entirely frugivorous. Fruit bats feed on very large, soft fruits *in situ*. For smaller fruits, the treatment depends on bat size (CORLETT, 1998a). With small bat species, either a single large fruit is plucked or several small fruits. The bat then usually flies away to a feeding roost where the fruit or fruits are processed, 20-200 m from the fruiting tree, (MARSHALL, 1983; PHUA & CORLETT, 1989; BHAT, 1994). Small fruit bats can fly with more than their own weight in fruit. The larger species can carry more than 200 g (VAN DER PIJL, 1982). However, they seem more likely to process fruit in the fruiting tree, dropping seeds underneath (ROBERTS, 1977; RICHARDS, 1990; UTZURRUM, 1995).

Fruit processing can be complex and the fate of the seeds depends on bat, fruit and seed characteristics. For fruits which are removed from the parent plant, seed fate seems to be influenced by both seed size and pulp texture (CORLETT, 1998a). Most large seeds are dropped under feeding roosts by all species, although some may also be dropped, apparently by accident, in flight. Some or all of the smallest seeds may be ejected from the mouth in a fibrous wad, but others may be swallowed with the juice and defecated in flight. Although gut passage is normally rapid, a proportion of the seeds may be retained in the gut for much longer, so long distance seed dispersal is possible (SHILTON *ET AT.*, 1999). The threshold for seed swallowing is reported as less than 4 mg for *Rousettus* in Israel (IZHAKI *ET AL.*, 1995), less than 2.4 mm diameter for 35 g *Cynopterus* in Singapore (PHUA & CORLETT, 1989), and less than 3.2 mm diameter for a 600 g *Pteropus conspicillatus* in Australia (RICHARDS, 1990). The proportions of seeds swallowed seem to be greatest for fruits with semi-fluid interiors (PHUA & CORLETT, 1989) or very slippery seeds (UTZURRUM & HEIDEMAN, 1991). Although the pteropodids as a whole consume a wide variety of fruits, there is a distinct 'bat fruit' syndrome: medium to large, drab colour, strong odour, held away from the foliage (MARSHALL, 1983).

Fruit bats are often the most important dispersers of seeds to abandoned pastures in the Neotropics but their role in the Asian tropics has been relatively little studied. On highly degraded sites in Singapore, forest succession is dominated by the exclusively bat-dispersed *Adinandra dumosa* (Theaceae), which has greenish fruits with a semi-fluid interior, and tiny seeds which are defecated in flight by *Cynopterus brachyotis* (PHUA & CORLETT, 1989). However, birds disperse the majority of tropical Asian pioneer trees, including the many species in the important pioneer genus *Macaranga*. The role of fruit bats in forest restoration is still unclear.

Non-flying Mammals

While large mammals, especially primates, are very important seed dispersers in intact forests, they are usually rare or absent in deforested landscapes. Macaques are the most disturbance-tolerant primates, and several species can survive in partly deforested areas (LUCAS & CORLETT, 1998). The most tolerant, medium-sized, partial frugivores are the civets (Viverridae), several species of which can persist in largely deforested landscapes, if they are not hunted. They are potentially important dispersal agents for large seeds (DUDGEON & CORLETT, 1994).

Even the most degraded tropical landscapes support one or more species of rat (Muridae). These have been regarded more as seed predators than dispersers, but seed dispersal may occur via ingestion and defecation. Many intact small seeds are found in the faeces of all three non-urban rat species in Hong Kong (CORLETT, 1996). In the Neotropics, scatter-hoarding caviomorph rodents are also very important dispersal agents for large seeds, but there have been no reports of such behaviour in tropical Asia (CORLETT, 1998a). However, at least one Old World rat species caches large numbers of big seeds in Australian rainforests (HARRINGTON *ET AL.*, 1997) and it is possible that such behaviour has simply been overlooked in tropical Asia. Squirrels (Sciuridae) may also cache seeds in places suitable for subsequent germination and growth, but again, there is very little evidence for this behaviour in tropical Asia.

SEED/FRUIT SPECIES

Fruits differ in many ways that might be expected to influence their interactions with potential dispersal agents (CORLETT, 1998a). The most obvious of these are: seasonality of production, protection (i.e. the presence of an inedible rind which must be removed to get at the flesh), colour, the amount and nutritional value of the fruit flesh, and the size of the fruit and the seeds it contains. Small fruits tend to be better dispersed than larger ones in most situations because they have more potential dispersal agents, although the attractiveness of small fruits to animals is influenced by many factors other than size. Large soft fruits with many seeds may also attract a wide array of dispersal agents. Large-seeded, large fruits are dispersed by a small number of relatively large birds and mammals, and the presence of a protective outer rind reduces this number even further.

SITE CHARACTERISTICS

The attractiveness of a site to tree seed dispersers determines the quantity and quality of seeds dispersed into it. The availability of perch sites and fleshy fruits and the structural complexity of the vegetation tend to affect the attractiveness of a site to animal seed dispersers, especially avian seed dispersers (HOLL, 1998; STILES, 1992; WUNDERLE, 1997). Many studies have demonstrated that the seed rain beneath perches is significantly higher than in nearby sites without perches (DEBUSCHE & ISENMANN, 1994; GUEVARA *ET AL.*, 1992; KOLB, 1993; MCCLANAHAN & WOLFE, 1993; NEPSTAD *ET AL.*, 1991; WILLSON & CROME, 1989). Abundant seed input under perches can be related to the observation that most regurgitation and defecation of seeds by avian frugivores occurs when birds perch or immediately after they take off, rather than during flight (GUEVARA & LABORDE, 1993).

The presence of fleshy fruits in a site tends to attract more avian seed dispersers, which in turn bring in other seeds. Seeds carried into abandoned pastures in the Amazon are concentrated beneath fruiting treelets (NEPSTAD, 1989). The observations of NEPSTAD *ET AL.* (1990) show that seeds are concentrated beneath shrub-like lianas and trees that produce fruits throughout the year. LEVEY (1988) found that the abundance of fruit-eating birds in lowland Costa Rican rain forest followed the same general patterns of spatial and temporal variation in fleshy fruit abundance. KOLB (1993) found that seed flow was positively correlated with fruit availability on island vegetation and negatively correlated with spatial isolation in abandoned pasture in tropical America. However, TOH *ET AL.* (1999) show that whether or not a tree offers a fruit reward appears less important than its structure and suitability as a bird perch. In a bird perching study in abandoned pasture in Costa Rica, artificial perches baited with banana did not increase either bird visitation rates or seed rain (HOLL, 1998).

Structurally complex vegetation has been demonstrated to be attractive to avian seed dispersers in studies of old field succession (Wunderle, 1997). Structurally complex vegetation cover would have either or both of the above two site traits that attracts avian seed dispersers. In addition, it provides more refuges from predators for avian seed dispersers and alternative food resources for partial frugivores. In Puerto Rico, PARROTTA (1992) attributed much higher species richness of woody seedlings and vines in a 4.5-year-old *Albizia lebbek* plantation, compared with an adjacent control area with no tree cover, to increased propagule availability by provision of roosting and nesting sites for bird species. KOLLMANN (1995) reported an increasing gradient of seed rain with progressive shrub development and successional time in dry grassland with interspersed shrubs in central Europe. HOLL (1998) showed that branch perches had significantly higher bird visitation rates and seed rains than crossbar perches placed in abandoned pasture in Costa Rica.

5. DISCUSSION

There is no doubt that animal seed dispersal has the potential to speed up the succession- restoration process and enrich the resulting forests. This is clearly shown by the diversity of native tree and shrub species that appear spontaneously in exotic plantation monocultures throughout the tropics. If restoration efforts are designed to rely mainly on natural seed dispersal, careful consideration should be given to the tree species that are planted at different stages of the restoration process. Studies in Hong Kong suggest that the apparent matching of bird and fruit characteristics in the secondary shrub-land community is probably a result of "selection" by the bird fauna from the regional species pool (CORLETT, 1998b). Only species that can be dispersed by the surviving avifauna (or by wind or other less important vertebrate seed dispersers) have been able to participate in secondary succession. (Note that almost all forests in Hong Kong are secondary and most of the true forest fauna is locally extinct). This hypothesis is supported by the presence of a much wider range of fruit sizes and types in the flora as a whole than in the secondary shrub-land and forest in Hong Kong. Much of the tree flora may no longer be effectively dispersed and is thus not represented in succession.

Assuming that covering the whole restoration site (especially large and rugged ones) with tree seedlings by planting is not cost-effective or is financially impossible in some cases, the crucial point in the initial stage of forest succession-restoration is to maximise tree seeds dispersed into the site. The site conditions at this stage normally favour pioneer trees. These pioneers come from few genera and share some or all the following characteristics: rapid height growth, low density wood, sparse branching, indeterminate growth, often large, simple leaves, flowering while young, producing abundant, small fruits, well dispersed by birds, bats or wind, and seeds usually with dormancy (CORLETT, 1995). Pioneers on the most degraded sites, however, may be relatively slow growing and have high-density wood. The provision of perch sites, either as artificial perches or by planting tree islands, the planting of trees, which produce fleshy fruits, and increasing the structural complexity of the vegetation, could all raise the attractiveness of the site to animal seed dispersers. Most woody pioneers in tropical East Asia have bird-dispersed fruits with sizes within the gape-limits of all the common frugivorous birds, while a minority are dispersed largely or entirely by small fruit bats, so the species composition of the disperser fauna is probably not an important factor at this stage.

Pioneer trees are typically short-lived with maximum life spans in the range 7-25 years. Life spans are longer on highly degraded sites and shorter on less degraded sites. Subsequent to the establishment of a pioneer tree cover, the site conditions will gradually become more suitable for the more shade-tolerant mature forest tree species. The poorly dispersed primary forest plant species are normally characterised by large seeds (WUNDERLE, 1997). At this stage the species composition of the disperser fauna becomes crucial. The provision of wildlife corridors linking the restoration site with nearby forests is desirable, especially for non-flying mammal seed dispersers but also for the many forest bird species which are unwilling to cross large open spaces. However, the effectiveness of such measures depends on the availability of both nearby forest and suitable seed dispersers. In unfavourable sites – including all those in Hong Kong - planting seedlings of large-seeded species or direct seeding (with precautions against seed predation) may be necessary (GOOSEM & TUCKER, 1995). In the longer term, the reintroduction of locally extinct dispersers of large seeds may be necessary. Such reintroductions are likely to be easier if restoration of a species-rich forest cover has already started and local support for such conservation initiatives has been built up.

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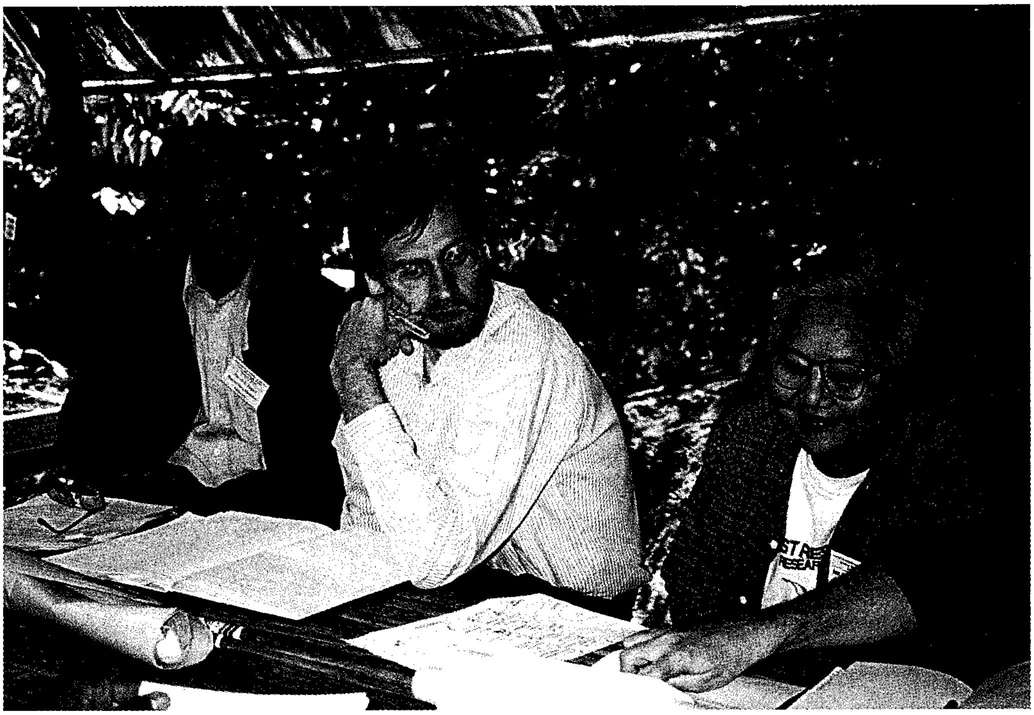

George Gale (centre) works on a research proposal with Patrick Dugan (left) and M. R. Smansnid Svasti (right) during a workshop discussion group at FORRU's community tree nursery, Ban Mae Sa Mai.

THE EFFECT OF ARTIFICIAL PERCHES AND LOCAL VEGETATION ON BIRD-DISPERSED SEED DEPOSITION INTO REGENERATING SITES

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ABSTRACT

Knowledge of the role of birds in natural regeneration could be used to accelerate and reduce the costs of forest restoration. The objectives of this study were to determine: (1) whether artificial bird perches placed in sites in various stages of natural and human-assisted regeneration could be used to increase seed deposition, and (2) which local vegetation features influence input of bird-dispersed seeds. The seed rain under perches on six plots located in two different sites in northern Thailand was examined. One site contained three naturally regenerating plots, ranging from nearly treeless and grass-dominated to > 25% shrub cover. The second site contained three, one-year old experimental forest restoration plots. The species richness and density of bird-dispersed seeds were significantly higher below perches than at control points at both sites. After seven months, seed input under the perches was greatest at a restoration plot that contained two fruiting trees, *Debregeasia longifolia* and *Clerodendrum glandulosum*, which were regularly visited by at least five bird species. However, the median input of bird-dispersed seeds was significantly higher on the three naturally regenerating plots (13.5 versus 0 seeds/trap). Total species richness of birds visiting perches was also higher on the naturally regenerating plots (15 versus 8 species). Although landscape variables have not been quantified, all of the naturally regenerating plots were closer to remaining forest patches compared to the restoration plots. Our preliminary results suggest that perches offer a useful technique for potentially increasing seed deposition by birds. Our circumstantial evidence also suggest that in the absence of nearby forest, the presence and specific characteristics of fruiting trees used for restoration plantations can have a significant impact on the ability of plantations to attract seed-dispersing birds.

INTRODUCTION

In Thailand, as in most other tropical countries, large-scale deforestation is a serious problem (FAO 1997). Currently, less than 20% of Thailand remains forested, compared with an estimate of 53% from the early 1960's (LEUNGARAMSRI & RAJESH 1992). Large-scale deforestation increases soil erosion, diminishes watershed quality, destroys wildlife habitat

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and interferes with rural development (LEUNGARAMSRI & RAJESH 1992). Without restoration efforts, denuded landscapes may remain in a stage of primary succession for an indefinite period (ROBINSON *ET AL.* 1992). One challenge to ecologists is to develop a cost-efficient means of restoring the original ecological function of such degraded areas.

While it is theoretically possible to replant large, deforested areas, current methods in Thailand are labour-intensive and expensive ($600 to $4700 US per hectare [S. ELLIOTT, unpubl. data]). Strategies that encourage natural regeneration could reduce the need for such plantings. Manipulating plant reproduction strategies and using pre-existing seed sources may also promote vegetation succession (DALAMACIO 1987, JENSEN & PFEIFER 1989, GOOSEM & TUCKER 1995). However, insufficient seed dispersal is a constraint to succession of degraded areas. Therefore, attracting seed-dispersing animals might accelerate natural regeneration (PICKETT 1982, ROBINSON *ET AL.* 1992, ROBINSON & HANDEL 1993).

While some plant species offer seed-dispersers fruit rewards, structural complexity of the vegetation is also an attractant (MCDONNELL & STILES 1983). ROBINSON & HANDEL'S (1993) studies of experimental plantations showed a positive correlation between vegetation height and the density of new seedling recruits, suggesting that fruit-eating birds are drawn towards taller plants in early successional habitats. This supports the finding, based on a study conducted in the north-eastern United States, that frugivorous birds using early successional fields prefer perches that are taller than the surrounding vegetation (MCDONNELL 1986).

In separate studies, MCCLANAHAN & WOLFE (1993) and MCDONNELL & STILES (1983) reported that forest birds use perches placed in unplanted, primary successional landscapes. In both investigations, the number of bird-dispersed seeds was significantly higher under perches than in control seed traps (in areas without perches). Similar results were also reported for Costa Rica (HOLL 1998). MCCLANAHAN & WOLFE demonstrated that the diversity of plant genera was also higher beneath perches. Their study went on to follow seedling recruitment beneath perches, which was double that of control areas.

Although erecting perches in deforested areas is likely to increase the input of bird dispersed seeds, frequencies of perch use by birds may also depend on characteristics of the local landscape. The number and species richness of birds visiting perches might vary with distance from reproductive trees, proximity to fruit rewards, amount of forest cover, or amount of human disturbance.

The goal of this study was to assess the potential influence of birds in the regeneration of forest in areas undergoing forest regeneration, either natural or human-assisted, in northern Thailand. Birds have the potential to assist forest restoration in this region because: (1) they are important seed dispersers in tropical forests (WUNDERLE 1997), including evergreen forests in Thailand (WONG 1992) and (2) as stated above, birds use natural or artificial perches in open fields and increase seed deposition beneath perches (MCCLANAHAN & WOLFE, 1993; MCDONNELL & STILES, 1983; MCDONNELL, 1986; HOLL, 1998). Specifically we wanted to determine whether the deposition of bird-dispersed seeds from forest tree species could be enhanced in early successional fields, through the use of artificial bird perches. Secondly we wanted to assess which structural characteristics of the vegetation may help or hinder input of bird dispersed seeds into regenerating areas.

STUDY AREA

This study was conducted at two deforested sites to compare the effects of perches on seed deposition at (1) a site where natural regeneration was being manipulated by planting saplings of a diverse mixture of indigenous forest tree species (Ban Mae Sa Mai) and (2) a site undergoing unassisted natural regeneration (Pah Dang). Ban Mae Sa Mai (BMSM) is a Hmong hill tribe community at the north end of Doi Suthep-Pui National Park, Chiang Mai Province (18° 52' N, 94° 51' E), approximately 1,207-1,310 m in elevation. The BMSM plots (1-3) were located on 40 m x 40 m sections of three, 0.64 hectare "framework species" plantations established by the Forest Restoration Research Unit (FORRU) in June of 1998 (see FORRU 1998, ELLIOTT *ET AL.* 2000 for additional site description and planting methods). Most of the 29 species of planted trees were between 0.5 and 2.5 meters tall at the start of the experiment in June 1999. The ground flora of all plots was mostly herbs particularly *Pteridium aquilinum* and composites, e.g. *Eupatorium* sp. The percent composition of these species changed seasonally and as a result of weeding for plantation maintenance. Planted plots were weeded every four to six weeks in the rainy season (June - October). Our observations also suggested that weeding reduced the density and species richness of birds (R. SCOTT and S. ELLIOTT, unpubl. data). All BMSM plots were protected by firebreaks and surrounded by either FORRU plantations or fields dominated by *Imperata cylindrica*, *Thysanolaena latifolia*, and *Pteridium aquilinum.*

Pah Dang (PD) is a Lahu hill tribe community approximately 30-km north of BMSM of similar elevation and forest type (Maxwell 1988, 1989). The PD plots (4-6) were in deforested areas approximately 1 to 2 km from the village. These plots were closer to the surrounding forest, i.e., degraded mixed evergreen/deciduous and hill-evergreen forest, than those at BMSM (P. PATTANAKAEW, unpubl. data), but the formal assessment has not been completed. Plot 4 was established in November of 1999 (later than the other plots because the original plot, established in May 1999, had to be moved due to a disagreement amongst the villagers). Approximately half of this site had been planted with corn and harvested in October 1999, just prior to plot establishment (see Table 2 for vegetation characteristics). Plot 5 was established in May 1999 in a recently (1-2 years) abandoned agricultural field dominated by *Thysanolaena*, *Imperata*, and *Phragmites vallatoria.* Plot 6 was established in May 1999 in a recently cleared (< 1 year) patch of bamboo forest. Bamboo, shrubs, and young or coppicing trees were slashed and burned just before the site was claimed for research. Vegetation structure of this plot was the most complex and bamboo grew to a height of over 3m before being cut back to 1m in November of 1999 (see Table 2).

METHODOLOGY

Plot construction

Within each site, plots were placed at least 400 meters from each other to ensure some habitat variation and some spatial independence in bird usage. All plots had 12 perches spaced 10 meters apart (3 rows x 4 columns) intermixed with control points without perches, such that within a row the distance between perches and control points was 5 m. Rows were 10 m apart. The total dimensions of each plot were 35 x 20 meters. Plots were designed with 6 treatments (four of which will not be discussed here): 1) perches with weeds removed, 2) perches with weeds present, 3) perches with seed traps, 4) control sites with weeds removed, 5) control sites with weeds present, and 6) control sites with seed traps. Three perches with seed traps on each plot were used to monitor seed dispersal directly. Three control traps per plot (without perches) were used for comparison.

Perch design

Perch construction was simple and inexpensive, using locally available materials. The main part of the perch consisted of one 3-m vertical bamboo pole, approximately 7 cm in diameter. In addition, two 0.8-m pieces of bamboo had been fitted through holes cut into the vertical pole, 0.30 m and 0.25 m below the top. These two pieces were placed at right angles to form four perpendicular "branches". The base of each perch was buried 0.5 m below ground for support. After placement in the ground, the "branches" were approximately 2.25 and 2.20 m above the ground and clearly visible above the surrounding vegetation for most of the year[1]. The top "branch" was pointed in a direction parallel with the long axis of the plot.

Seed-trap construction and seed collection

Seed-traps were circular, 1 meter in diameter, and built from 1.7-mm mesh, plastic netting secured to a wire frame. Four or more, 0.3-m high bamboo legs supported each trap. The main pole of the perch was fitted vertically through a small hole cut in the centre of the trap and the netting was then sewn tightly to the shaft such that seeds could not pass through. Traps of the same design were placed at points without perches. For each plot, seeds were collected on the same day from both control and perch seed-traps once per month. Collected seeds were placed either in alcohol for later identification, while a subset was germinated in the FORRU greenhouse to confirm identification. Species thought to have been dispersed by birds (either by being enclosed in bird faeces or by showing clear signs of digestive decomposition) were described.

Bird surveys

Observers were trained by conducting preliminary bird surveys of experimental plots and surrounding areas before the perch plots were established. Once surveys were initiated, bird species on all plots were surveyed once per month. Two plots were surveyed for 1.5 hours each per day, beginning 15 minutes after sunrise. Observers recorded all bird species and the number of individuals of each species on site, and the time each spent on perches. Because weather can significantly affect bird activity (HAMEL *ET AL.* 1996), counting was only done under acceptable weather conditions. Furthermore, since birds tend to be most

[1] Vegetation was cut back on plots 5 and 6 to keep perches visible.

active shortly after sunrise, the survey order was changed each day and each month to avoid time-activity biases.

Vegetation measurements

We measured vegetation features around and within plots that may have influenced seed dispersal. (However, because plot 4 had to be relocated, vegetation measurements have yet to be completed for this plot). We used simple counts of woody stems > 1 m in height, and used the BRAUN-BLANQUET (1951) scale to estimate the abundance and cover of lower vegetation. Measures included: (1) number of planted trees, (2) number of naturally established woody species > 1.0 m in height, (3) abundance naturally established woody species < 1.0 m in height, (4) cover and abundance of bamboo shrubs, (5) cover, abundance, and height of herbaceous ground flora, and (6) canopy cover of woody plants.

RESULTS

Seed rain

Fifteen perches and 15 controls were monitored between June 1999 and January 2000 with three additional perches and controls monitored between November 1999 and January 2000. A combined total of 1,598 bird-dispersed seeds from 29 species were found in all 36 traps, 1,563 seeds under perches and 35 in controls. Twelve seed taxa have been positively identified to genus or species (Table 1). The remainder is awaiting final identification from ongoing germination trials. *Debregeasia longifolia* was the most common species found in the traps and accounted for 49.4% of all seeds. This species and most of those identified thus far, usually grow in open (partial canopy) mixed evergreen / deciduous forest, as well as in degraded forest (Table 1).

Due to the small number of sample points on each plot we pooled the data to compare seed deposition at perches with that at control points within the two sites (BMSM and PD) and among all plots combined. A median of 28.5 seeds and 3 species were found under perches, while a median of 0 seeds and 0 species were found in controls. These differences were large both within sites and among all plots combined. (At PD, Mann-Whitney U test $W = 119.5$, $P < 0.01$ for species, $W = 123$, $P < 0.01$ for seeds; at BMSM, test not possible when all values are zero and for all plots combined, $W = 449.5$, $P < 0.001$ for species, $W = 455.0$, $P < 0.001$ for seeds). The median input of bird-dispersed seeds for all traps combined (controls and perches) was significantly higher at the three naturally regenerating plots (PD), compared with the plantation plots (BMSM) (13.5 versus 0 seeds/trap, $W = 271.0$, $P = 0.05$).

Vegetation factors

The numbers of FORRU planted trees, unplanted trees/saplings and unplanted woody species, less than 1.0 meter tall, varied among the BMSM plots, with the latter two highly variable at PD (see Table 2). After seven months of study, seed input under perches was greatest at BMSM plot 3 (613 seeds) which had two fruiting trees (*Debregeasia longifolia* and *Clerodendrum glandulosum*) growing naturally (not planted) on the site. These trees came into fruit in November and were regularly visited by Grey Bushchats (*Saxicola ferrea*), Sooty-headed Bulbuls (*Pycnonotus aurigaster*), Red-whiskered Bulbuls (*Pycnonotus jocosus*), Flavescent Bulbuls (*Pycnonotus flavescens*), and a Dusky Thrush (*Turdus naumanni*). The plot with the second highest seed input was at the naturally regenerating site (PD plot 4, 457 seeds). Although the vegetation of plot 4 has not been quantified, the number of woody stems was clearly less than at PD plot 6. Plot 6 had the largest number of naturally occurring woody stems > 1 m tall, particularly bamboo (Table 2). In addition 362 seeds were recorded there, including 34 seeds in the control traps. Plantation plots 1 and 2 had the lowest seed input (45 and 2 seeds respectively). Plot 2 had the smallest number of woody stems on the plot and the smallest number of large trees adjacent to the plot compared to the other BMSM plots (Table 2). Furthermore, no trees were observed fruiting during the study period in plot 2 (although there was no systematic method of recording which species were or were not fruiting). Although landscape variables were not quantified, all of the naturally regenerating plots were closer to remaining forest patches compared to the plantation plots.

Bird visitation

During 129 hours of observation, 125 observations of birds visiting perches (Table 3) were recorded. A total of 17 bird species visited perches, 15 at PD and eight at BMSM. The number of visits was higher at PD (96) than at BMSM (29). The species that visited the perches were largely insectivorous (LEKAGUL & ROUND, 1991, CORLETT 1998), but many of them were observed occasionally eating fruit or have been reported to do so in the literature (Table 3, CORLETT 1998). These bird species are tolerant of disturbance and generally forage in open habitats and degraded forests (LEKAGUL & ROUND 1991).

DISCUSSION

Although not all of the seed-dispersing bird community is likely to use perches, preliminary results suggest that perches increase seed deposition in restoration sites. It is clear from this study, as well as previously cited studies, that birds do not disperse seed randomly. Approximately 45 times more seeds were deposited under perches than in the controls. Naturally regenerating sites (PD) had greater bird density and bird species richness than the plantation sites (BMSM), presumably because the remaining forest patches were closer to the plots at PD than BMSM. These patches of forest probably offer complex habitat, and therefore more food and nest resources, as well as cover for birds than are currently available in young plantations, particularly when plantation vegetation structure is simplified through weed removal.

Table 1. Species and numbers of bird-dispersed seeds found under perches and in controls at both study sites ordered by total number of seeds (see text for site descriptions). The number of unidentified species is 8 for BMSM, 7 for PD perches and 2 for PD controls.

Family	Species	Growth form[1]	Location[2]	BMSM Perch	BMSM Control	PD Perch	PD Control	Total Seeds/ species
Euphorbiaceae	*Antidesma acidum* Retz.	S, T	F	26	0	52	7	85
Euphorbiaceae	*Antidesma bunius* (L.) Spreng	S, T	F, C	3	0	0	0	3
Euphorbiaceae	*Antidesma sootepense* Craib	T	F	0	0	24	10	34
Cyperaceae	*Carex baccans* Nees	H	O	10	0	0	0	10
Verbenaceae	*Clerodendrum glandulosum* Colebr. ex Lindl.	S	F, O	23	0	0	0	23
Urticaceae	*Debregeasia longifolia* (Burm. f.) Mett. ex Khun	S	F, O	520	0	270	0	790
Myrsinaceae	*Embelia sessiliflora* Kurz	V	F, O	0	0	1	0	1
Myrsinaceae	*Embelia subcoriacea* (Cl.) Mez	V	F, O	0	0	1	0	1
Moraceae	*Ficus* sp.	T	F?	1	0	39	0	40
Lauraceae	*Litsea cubeba* (Lour.) Pers.	T	F, O	6	0	0	0	6
Curcubitaceae	*Mukia maderspatana* (L.) M. J. Roem	V	O, C	0	0	393	0	393
Solanaceae	*Solanum nigrum* L.	S	O, C	50	0	107	11	168
Unidentified				21	0	16	7	44
	Total Seeds / Treatment			660	0	903	35	1598

[1] Growth form: H, herb; S, shrub, T, tree; V, vine.

[2] Location where a species is found: O, open degraded forest; F, forest; C, cultivated. (from MAXWELL 1988, 1989)

Table 2. Vegetation characteristics of 5 of the 6 study plots[1]. Estimations of naturally established woody shrubs < 1.0 m, bamboo, and herbaceous coverage are indicated by Braun-Blanquet Total Estimate Score.

	BMSM 1	BMSM 2	BMSM 3	PD 5	PD 6
No. of planted trees	183	143	159	0	0
No. of wild woody species > 1.0 m	56	17	18	10	76
Total woody species > 1.0 m	239	160	177	10	76
Naturally established woody species < 1.0 m	plentiful, but coverage small	plentiful, but coverage small	plentiful, but coverage small to 5%	scarcely present	covering 26 - 50 % of plot
Adjacent forest type	none[2]	none	none	bamboo forest bordering one edge	secondary mixed evergreen/deciduous forest bordering one edge
Bamboo shrub cover	none	none	none	none	covering 26-50% of plot
Grass cover & height	covering 6-25%, < 1.0 m high	covering 5-6%, < 1.0 m high	covering 5-6%, < 1.0 m high	76-100% coverage, 1-2 m high	scarcely present, 1-2 m high
Canopy cover (%)	6.25	0	0	0	37.5

[1] Plot PD 4 not yet surveyed.

[2] Plots 1-3 did have 5, 2, and 4 large (> 25 m in height) trees respectively, approximately 100 m from their borders. Some of these appeared to be common perching / roosting areas for birds (R. SCOTT, pers. obs.).

Table 3. Number of bird visits to perches per hour during 129 hours of observation (72 hours BMSM, 57 hours PD) listed from most to least frequent visits[1].

Scientific Name	Common Name	Diet	Habitat	Visits/hour	
				BMSM	PD
Saxicola ferrea	Grey Bushchat	I, F	O	0.11	1.05
Prinia hodgsonii	Grey-breasted Prinia	I	O	0.14	0.14
Pycnonotus aurigaster	Sooty-headed Bulbul	F	F, O	0.01	0.14
Anthus hodgsonii	Olive-backed Pipet	I	O	0.03	0.09
Saxicola caprata	Pied Bushchat	I, F?	O	0.06	0
Pycnonotus jocosus	Red-whiskered Bulbul	F	F, O	0.03	0.02
Pomatorhinus schisticeps	White-browed Scimitar-Babbler	I, F?	F, O	0	0.05
Muscicapa dauurica	Asian Brown Flycatcher	I	O	0.01	0.02
Emberiza rutila	Chestnut Bunting	G	F, O	0	0.04
Lanius cristatus	Brown Shrike	I, F?	O	0	0.04
Cyornis banyumas	Hill Blue Flycatcher	I, F?	F, O	0	0.02
Lanius schach	Long-tailed Shrike	I, F?	O	0	0.02
Macronous gularis	Striped Tit-Babbler	I, F?	F, O	0	0.02
Phylloscopus inornatus	Inornate Warbler	I, F?	F, O	0	0.02
Timalia pileata	Chestnut-capped Babbler	I, F?	F, O	0	0.02
Chrysomma sinense	Yellow-eyed Babbler	I	O	0.01	0
Muscicapidae	Unidentified Flycatcher	?		0	0.02

[1] Dietary preferences are listed based on direct observation and CORLETT (1998). Species names and habitat preferences are based on Lekagul and ROUND (1991).

Furthermore, preliminary analyses of other bird survey data suggest that bird density and richness were lower in the planted plots compared to adjacent, unplanted (and non-weeded) areas. However, bird density, richness, and diversity of these adjacent areas of BMSM have yet to be compared with the PD plots.

In summary, these tentative results suggest that in the absence of nearby forest, the presence of fruiting trees on restoration plantations can have a significant impact on the ability of these plantations to attract seed-dispersing birds. However, the vegetation structure of the plot itself, including the density of trees, appears to have a limited influence on seed deposition compared to the presence of fruiting trees and the presence of nearby forest patches. However, greater study is needed to determine the spatial scale at which these factors operate. In addition, the reasons for the large differences among plots remains circumstantial at best until we have quantified the vegetation surrounding the plots and conducted a more complete study of the fruiting phenology of nearby trees.

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Building support for forest restoration - school children at Ban Mae Sa Mai enjoy learning how to grow trees to restore their watershed.

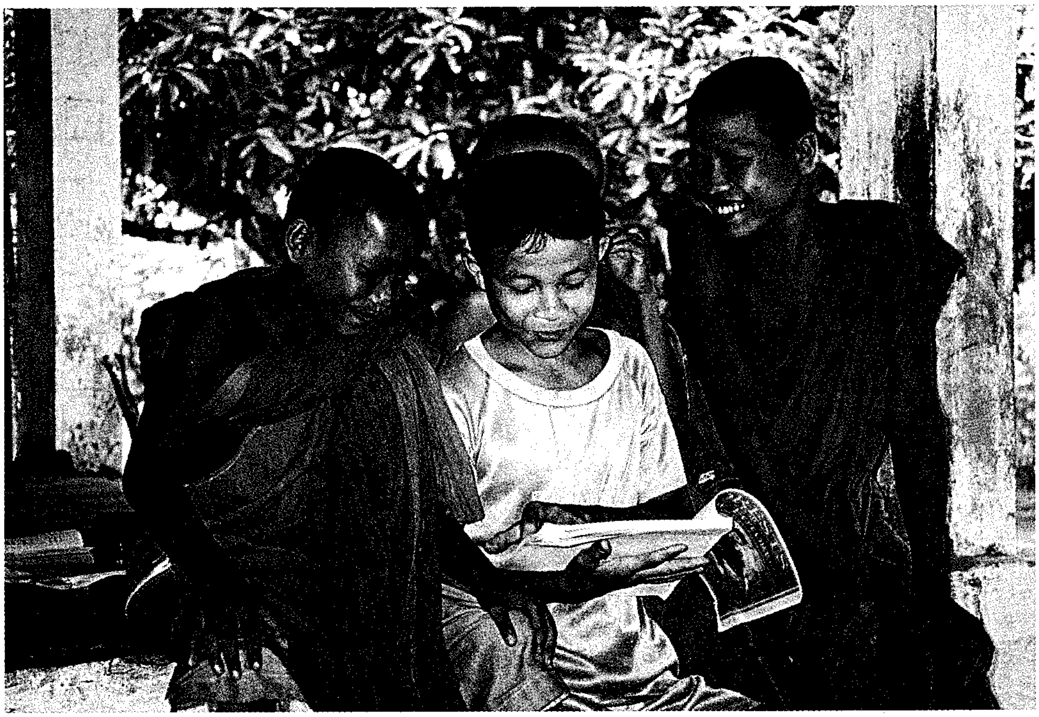
PART SIX

COMMUNITY ASPECTS OF FOREST RESTORATION

Editor

Kevin Woods

At Ban Mae Sa Mai in Doi Suthep-Pui National Park, Hmong villagers have organised themselves into a conservation volunteer group. Here Kuhn Nikom explains the activities of the group to visitors.



Providing information – novices at a temple in southern Laos
peruse one of FORRU's publications.

INTRODUCTION

Kevin Woods[1]

Communities occupying degraded land often complicate forest restoration. Resolving such complications requires combining scientifically sound techniques with socio-economic management of communities. In the past, plantations of single, commercially valuable, often exotic tree species were established for timber production. Such plantations, however, did not address community needs, as they did not perform the same ecological roles, nor offer the same diversity of forest products, that are crucial to villagers' lives. Currently, with increasing opportunities for the public to become involved with forest policy, a more holistic approach involving communities in decision-making has taken precedence. Conservation has become inevitably linked with sustainable rural development, with participatory management. In order to integrate science with community development, technologies must be implemented that are both cost effective and that provide benefits to the community. By focusing on the local knowledge and needs of communities, villagers become valuable partners in forest restoration and wildlife conservation.

Working models of sustainable forest and community management are described in the three papers presented here. To be successful, a positive relationship between villagers and project co-ordinators must be established. This can be achieved by working with a pre-established organisation that has already established trust among local people and authorities. In turn, this fosters community cohesion and empowerment, creating self-esteem and pride in local resources. The initial step in successful conservation is alleviating village poverty. This establishes a good rapport among villagers and project co-ordinators, strengthens the community and reduces pressure on remaining forests.

In the first paper in this part of the proceedings, Dr. Somsak Sukwong describes a village revolving fund to introduce agro-forestry and community forestry at Khao Paeng Ma. Thereafter, McQuistan and Wright present alternative income-generating activities in order to decrease forest exploitation. Information exchange must be included in projects to reveal local motivation based on the needs of communities. During group discussions, workshop participants revealed numerous motivating factors for villagers to become involved in forest restoration projects, such as improved food security, increased opportunities for financial support, security of land tenure, employment, augmented income and improved quality and quantity of water. This bottom-up approach must involve villagers from all parts of communities, not just local leaders and officials, as described in McQuistan and Wright's paper. This includes the poorest villagers, as they are usually the ones most reliant on forest resources. Finally, to achieve sustainable rural development and conservation capacity building must be undertaken and community organisations established so that villagers can develop their own ideas and take the initiative in managing their resources.

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The recent development of "Rainforestation Farming", as described in Dr. Paciencia Milan's paper, attempts to simultaneously fulfil both forest restoration goals and improved food security. Her research on the impact of providing structural diversity in Rainforestation Farming areas has generated much valuable scientific data for restoring forests, while also satisfying the needs of communities.

Many problems are frequently encountered in community forestry. Authoritarian management where confrontation, rather than co-operation, is adopted and where activities are dictated according to state ambitions will fail. Long-term monitoring of changes in the sustainable use of forests is essential for assessing project success, but is often prematurely terminated due to limited funds. Inequalities in the village can appear if everyone does not benefit from the scheme, causing community dissension. Villagers from all social and economic levels must be involved so that relevant needs, such as motivating factors, can be identified and incorporated into project objectives. The fact that community development does not necessarily follow conservation of forests indicates that many problems still need to be addressed.

Evidence of flaws in community forestry management, such as villagers continuing to practice slash and burn (in McQuistan and Wright's paper), prompt a critical need for more research in several areas. For example, zoning systems need redefining and reclassifying to reduce land-use conflicts, an issue identified as a major obstacle in both of Dr. Somsak Sukwong's case studies. The needs of local people must be taken into account when choosing tree species, by selecting those both useful to local people as well as to wildlife, a subject touched upon in the poster abstract contributed by the Upland Holistic Development Project. We need to seek alternatives to government funding for community-based forest restoration, such as NGO's like the YMCA and the Northern Development Foundation (see poster abstracts). It is necessary to investigate effective methods to exchange information among all social and economic levels to better understand local communitys' needs and problems, as conveyed in McQuistan and Wright's paper. Appropriate criteria for assessing whether project goals have been achieved must be developed, so that community responses can be evaluated after implementing forest restoration. Baseline data collection before starting projects and monitoring during and after project implementation are crucial to identify which activities are appropriate for the villagers and to confirm the relevance of projects to local people. Sound scientific tools must be further enhanced, as seen in Dr. Paciencia Milan's paper, to maximise the success of systems to restore both forest ecosystems and livelihoods of rural communities. More field data must be collected to determine the effect of restoration and community development efforts on forest and wildlife, making changes as necessary.

Through community participation, villagers should be able to take responsibility for sustainable forest management and in turn preserve Earth's precious resources.

FOREST RESTORATION AND COMMUNITY PARTICIPATION: CASE STUDIES IN THAILAND

Dr. Somsak Sukwong[1]

ABSTRACT

Local people are often left out of decision-making with regards to forest restoration and are only asked to 'participate' once implementation has begun. This model has been used in most reforestation projects in Thailand. The results are low tree performance, lack of interest by local people to assist in protecting forest plantations and relatively low biodiversity. While many have often cited this as evidence that villagers are not interested in participating in forest protection, it actually reveals that local people were not involved in planning and decision-making. This paper describes two instances where villagers were involved in the full planning and implementation of forest restoration activities and explains why they were successful. Once local people are given a meaningful decision-making role, the results can often be surprising.

INTRODUCTION

Far too often in Asian countries the potential role of people in successful planning and implementation of restoration projects is underestimated. The state, as sole manager of forest resources in most Asian countries, has tended to limit the role of local people and community involvement in forest rehabilitation activities. The result has been poor success in forest rehabilitation and ongoing resource degradation. In Thailand there are numerous examples where state plantations have been cut down, uprooted and burned. Reforestation is progressing slowly. At the current rate of plantation establishment, the total plantation area over the past 100 years is less than one year of forest loss during the last three decades (JANTAKAD & GILMOUR, 1999).

While media coverage and technical reports have been critical of villagers for their role in deforestation and burning of forest lands, the fact is that many conflicts arise because local people were not involved in the planning and design of forest restoration efforts. Villagers may want to restore local forests but the state's approach to reforestation with single tree species commonly runs contrary to community needs (cf. JANTAKAD & GILMOUR, 1999). Monotypic plantations neither perform the same role nor offer the same products as natural forests and commonly villagers are not permitted to use the wood produced. Conflict arises out of villagers' desire to protect the land they use and their livelihoods.

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Recent studies are beginning to show the benefits of including villagers in restoration and conservation activities. STEINMETZ (1998), working in protected areas in Southern Laos, found local people in and around parks were highly knowledgeable about local biodiversity and ecosystem processes. Furthermore, he found that by working equally with local people, western scientists and local park staff a partnership could be forged which resulted in identification and protection of natural resources.

The purpose of this paper is to highlight two case studies from Thailand, which demonstrate the importance of fostering trust and positive relationships with and within communities in community-based restoration efforts.

TWO CASE STUDIES IN THAILAND

From *Imperata* Grassland to Wildlife Conservation

Khao Paeng Ma, a denuded mountain covered with *Imperata* grass (forming a part of the Lampra Proeng watershed area flowing into the Mun River in Amphoe Wang Nam Kheo, Nakhon Ratchasima Province) was named "mountain of fire" because of widespread fires every dry season. The area was originally covered with dry evergreen forest, but was extensively logged and cleared for cattle grazing and cash crops such as corn and cassava during the late 1970's. Currently, this area is the forest reserve surrounding Khao Yai National Park.

In 1994, Wildlife Fund Thailand implemented a Forest Restoration Programme as part of the five million Rai Golden Jubilee Project (WILDLIFE FUND THAILAND, 1999). Prior to 1994, Wildlife Fund Thailand had implemented a rural development-conservation project in surrounding villages: Ban Klong Sai, Ban Klong Ee-Paew, Ban Poh Thong Watana, Ban Klong Durian and Ban Khao Paeng Ma. Due to poverty, the project first attempted to solve debt problems by supporting a village revolving fund and introducing agro-forestry (including fruit tree and bamboo production to replace mono-cropping of cassava and corn) as well as community forests. Supporting these processes built up rapport and trust between the villagers and project workers. The denuded forest reserve totalled 11,250 rai (1 ha = 6.25 rai). Most denuded areas had been claimed and used by local influential people. It took some time to negotiate and resolve land use conflicts with this group, as some parts of this denuded forest had been used for a long time. Therefore, only 5,000 rai out of 11,250 rai could be used for the forest restoration.

Supplementary planting was the chosen method of planting. Clearing by slash and burn was not implemented. The area includes native plant species and food species for wildlife such as *Ficus, Eugenea, Flacourtia, Muntingia, Sandoricum, Parkia* and *Baccaurea.*

Fire protection is the most important factor in forest restoration on this *Imperata* grassland. Therefore, the project created fire crews, fire detection and fire education campaigns in the surrounding villages. Fire breaks and patrols were set up to prevent the spread of fire. Protection measures were easier to negotiate because some rapport had already been built between the project manager and the villagers. The community agreed to inform the project manager prior to burning farmlands to reduce the threat of fire in the restored areas.

Cattle-grazing is another factor, which promotes *Imperata* grassland. Farmers burn the grassland to produce new shoots and for fodder. Negotiations were made with cattle graziers to find alternatives, such as assigning designated grazing areas, alternative fodder types, etc. Hunters, another interest group, like to start fires to flush out game, and so have been frequently included in the project activities, with some being employed by the project. By maintaining positive relationships between the project and community, (e.g. organising social events together) and showing commitment of project staff to the serious nature of the project, the number of fires has decreased significantly. This has allowed not only the plant community to change, but also the animal community. *Eupatorium odoratum, wild banana, bamboo, herbs, shrubs and many species of vines that are palatable to wild mammals now replace Imperata grass*. Gaur (*Bos gaurus*) numbering 2-3 individuals at the outset of this project now can be seen in herds as big as 39. Other animals frequently found are wild pig (suid), deer, bear, jungle fowl, viverrids, mustelids and snakes. Large herds of wild pigs encourage seed germination by churning up the soil through their natural behaviour of rooting around for food. Other tree species like *Anthocephalus, Macaranga* and *Dipterocarps* are also found. Currently, there are no rifles in Khao Paeng Ma, which aids animal protection measures. The people's attitudes have changed with time from collaborating in forest restoration programmes through fire protection to enhance natural regeneration and wildlife protection. Now visitors come to these areas to observe the big herd of gaur on the regenerated forestland. Villagers are proud of their resources.

This case clearly shows strong support of a local community for a restoration programme. This happens because positive relationships have been built up through attending to local developmental needs and resolving land-use conflicts. Villagers are aware of the benefits of restoration, including a reliable water supply and the potential for developing ecotourism.

Pred Nai Village: Returning of Wetland Birds and Macaque Monkeys

Pred Nai Village is situated near a mangrove swamp in Trad Province next to the Cambodian border. The village has been occupied for more than one hundred years.

In 1985, the villagers observed that the company granted the mangrove logging concession was not following regulations. Trees were still being over-cut. Logging also caused many other problems, such as reduction of local fishery products and villagers were prohibited from harvesting crab, shells, fish and other non-timber products in the concession areas. Illegal logging also took place outside the concession area. At the same time, a group of local influential men converted the mangrove into shrimp farms and built a water gate to block seawater. In 1986, the villagers formed a group to stop the logging and shrimp farming. The villagers' effort was successful in destroying the gate blocking the seawater and they were able to keep forestlands equalling about 12,000 rai.

In 1987, the villagers planted the logged over and denuded mangrove areas, totalling about 700 rai, with the support of both the Royal Forest Department (RFD) and Provincial Authority. Though villagers put a stop to the concession and shrimp farming, uncontrolled cutting by villagers and outsiders continued. Fortunately, by 1995 conflicts within the village were resolved by their open dialogue. The villagers of Pred Nai agreed to start using grass canes for supporting cucumber and bean vines instead of mangrove trees.

After villagers formed the Village Saving Fund Group in 1995, they were trained by a monk, Pra Subin Pyuto, and formed the Mangrove Forest Management group as well as other production activities like the housewife group, youth group and women volunteer group.

Through the Social Investment Fund, villagers of Pred Nai procured a patrol boat and built a bridge for seedling transportation to the interior degraded parts of the forest. The Ministry of Environment also allocated some funds from the Environmental Fund to the community for the villagers to manage their own mangrove reforestation programme. Since mangrove crabs are an important source of income to the villagers (this kind of crab is popular for Som Tam or papaya salad), the community has now established rules to collect crabs. There will be no harvesting in October during the reproduction period. Some farmers reported that after management of mangrove forests and rehabilitation implementation, the crab harvest has increased from 5 kg/harvest to 8-10 kg/harvest.

Villagers have reported that shrimp, shells and fish have also increased. Many birds like *Mycteria leucopephala, Porphyris poliocephalus, Ardea purpurea, A. cinerea, Dendrocygna javanica* and *Haliastur indus* are returning (PETROLEUM AUTHORITY OF THAILAND, 1999). Just a week ago it was reported that monkeys (*Macaca fascicularis*) were seen passing the villagers' houses. During the logging period, the monkeys had migrated to other distant parts of the province. School kids and urban people from nearby areas visit the restored areas at night to view abundant fireflies. In helping the villagers with management plans and forest resource mapping, villagers revealed their knowledge of their resources. Resource maps have been completed and a management plan is now being developed.

Restoration is an ongoing process, which is depicted by the villagers expressing an interest in increasing their planting, carrying out experiments, thinning the dense natural stand of *Ceriops* and continuing to monitor and improve crab-harvesting regulations.

The Pred Nai Community received support from the Provincial Authority after their successful effort in stopping logging. The governor has expressed interest in seeing other villages in his province implement similar restoration activities. Consequently, this has empowered villagers to continue active forest restoration and wildlife conservation.

LESSONS LEARNED

Reforestation projects exclusively run by the government have faced many problems and achieved limited success. Rehabilitation for wildlife is a challenging undertaking that is made even more difficult without active participation of local communities. Restoration is likely to fail where resources and land-use conflicts remain unresolved. Fortunately, there is a growing trend in governments in Asia towards the decentralisation and devolution of power to local communities. The rights of local communities are now being openly considered. In Thailand, a statement which strengthens the rights of local communities to care for and use natural resources is now embedded in the newly reformed National Constitution.

Case studies in Thailand show how people can be mobilised to address local concerns and in doing so make substantial gains in restoring lost habitat and developing sustainable resource use systems. Community participation, capacity building and resolution of underlying resource and land use conflicts were the basis of these successful restoration efforts.

The role of community participation should be considered from the onset of any restoration effort. Gains made in the area of habitat restoration are likely to be based on the development of equal partnerships with local communities as well as effective support in the form of local community capacity-building and conflict resolution.

CONCLUSION

Several experiences have indicated that participation in forest restoration happens only after resolution of land-use conflicts. People want to maintain and restore their local environment, as it is vital to their daily life. By empowering villagers and focusing on the communities' local knowledge and needs, villagers are valuable partners in assessing, planning and managing their resources. This generates mutual trust and partnership, allowing villager's capabilities to extend from forest restoration to wildlife conservation and management of other resources.

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QUESTIONS AND COMMENTS

Somsak Sukwong

Rough data from recent surveys show us that in the mangrove forests many water and migratory birds are reappearing. Two weeks ago we visited a village where some villagers encountered a monkey in front of their house. This is very encouraging as these animals are coming back into the buffer zone. The people participate in not only tree restoration but also wildlife conservation.

Smansnid Svasti

I agree that development must take place along side conservation, which is the way we worked in Mae Soi. Once the villagers realise that it is their responsibility to take care of themselves, then everything falls into place. Somsak's project almost perfectly parallels the Mae Soi project I am currently working on. Who were the people, if any, which occupied the rehabilitation area in the uplands? What negotiations transpired to get the villagers to help you in reforestation, and did they express interest from the very beginning?

Somsak Sukwong

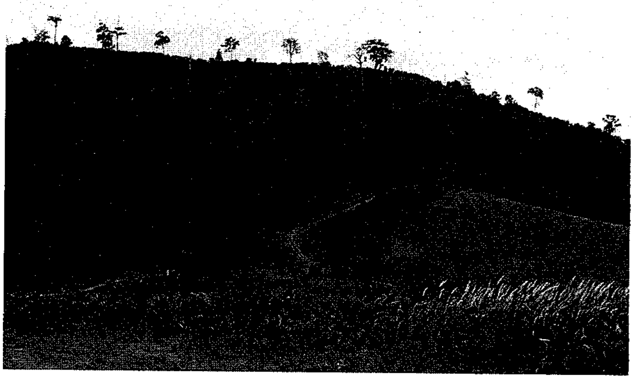
Sometimes it is necessary to have built up a previous positive reputation through an individual person or agency to help achieve success. We have been fortunate that Wildlife Fund Thailand (WFT) carries out our project. This organisation has already developed a good reputation. I am still learning how to build up partnerships. It is an art form. In the mountainous area, there is no water, and therefore no village was established on the denuded land. The village is located down the valley.

Nigel Tucker

Where did you get the money for the mangrove project, and is it an ongoing source?

Somsak Sukwong

The Environmental Fund gave us 15,000 Baht to rehabilitate the project area. I am interested in how they organise and manage it, as well as how we can use the fund efficiently so that the money is not wasted. Now the government is trying to fund the project, but the villagers are concerned that if they are sponsored by outside sources, the plantation will not belong to them.



Regenerating forest dominated by *Eupatorium odoratum* after fire protection as compared to the *Imperata* grassland outside the project area (courtesy of Wildlife Fund Thailand).

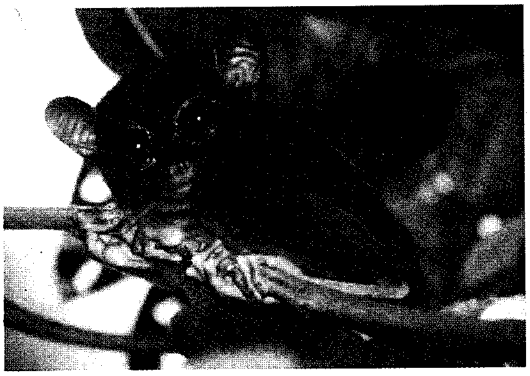
Forest restoration sparks the idea of community-based eco-tourism.

A herd of Gaur feeding in the regenerated areas, now an ideal place for calves (courtesy of Wildlife Fund Thailand).

RAINFORESTATION

A five-year-old RF Co-operator's farm shows the three-storey structure.

Takudo (*Xanthosoma* spp.), gabi (*Colocasia* spp.) and pineapple (*Ananas* spp.) are potential shade tolerant agricultural crops incorporated in Rainforestation farming.



The highly diverse tree plantation allows re-establishment of the Philippine tarsier.

RAINFORESTATION FARMING: AN ALTERNATIVE TO FOREST RESTORATION

Paciencia P. Milan[1]

ABSTRACT

Efforts to preserve the biodiversity of the Philippine islands and to simultaneously sustain human food production led to the development of a "Closed Canopy and High Diversity Forest Farming System", popularly termed "Rainforestation Farming". This system aims to replace the more destructive forms of "kaingin" or slash and burn practices, form a buffer zone around primary forests, protect biodiversity, help maintain the water cycle and provide farmers with a stable and higher income.

Rainforestation Farming works on the hypothesis that a farming system is increasingly more sustainable the closer its physical structure and species composition are to the original rainforest. This scheme utilises native tree species, particularly dipterocarps and high premium tree species, while incorporating fruit trees and agricultural crops in accordance with farmers' need.

Wildlife, such as birds, reptiles, arthropods and mammals, readily inhabited the newly established forest. In the sixth year after establishment, the Samar tarictic hornbill (*Penelopides samarensis*) and flying lemur (*Cynocephalus volans*) from nearby forest visited the farm regularly. The highly diverse tree plantation allowed re-establishment of arthropods, Philippine tarsier (*Tarsius syrichta*), birds and lizards which derived food, nesting places and moist cool microclimates from the newly formed ecosystem.

INTRODUCTION

Rainforestation Farming technology was developed by the ViSCA-GTZ Applied Tropical Ecology Program. The aim of rainforestation is to replace the more destructive forms of "kaingin" or slash and burn practices, form a buffer-zone around primary forests, conserve biodiversity, help maintain the water cycle and provide farmers with a stable and higher income.

To save and protect biodiversity of the Philippine rainforest, the reforestation scheme utilises local tree species. Research was conducted to determine which local tree species could thrive well in different soil and climatic conditions, while applying the basic principles of tree farming. This system also attempted to develop a farming system that closely resembles the structure of a natural Philippine rainforest ecosystem.

[1] ViSCA-GTZ Applied Tropical Ecology Program, Baybay, Leyte, Philippines.

METHODOLOGY

In 1992, a 7-hectare demonstration farm and nursery were developed to establish a "Closed Canopy and High Diversity Forest Farming System" in co-operation with the Department of Environment and Natural Resources (DENR) and several departments at ViSCA. The objective was to develop a farming system that closely resembles the structure of a natural Philippine rainforest ecosystem. Species monitoring was conducted to analyse and assess the impact of the structural diversity, provided by the re- established forest, on the abundance and diversity of mammals, birds, reptiles and arthropods. A preliminary assessment was done to determine which organisms were found within the farm. Subsequently, artificial nests for insects were set up randomly. The distance between nests ranged from 50-55 metres along the slope. Artificial nests for birds, on the other hand, were hung randomly on trees within the area.

Likewise, arthropod sampling was undertaken on three dipterocarp species, namely Apitong (*Dipterocarpus warburgii*), Dalingdingan (*Hopea plagata*) and Red Lauan (*Shorea negrosensis*). Sample trees in the Rainforestation farm were approximately 5-6 years old with an average height of 3 metres.

After setting-up artificial nests, qualitative and quantitative observations were made to monitor the number of organisms attracted to the nests. The number of birds, insects and the individual number of species attracted to every artificial nest were recorded. For arthropods, one or two individuals (depending on the population) represented by each species attracted to the nests were collected and preserved in 70% ethyl alcohol for sorting. Birds were not collected but rather identified in the field using binoculars, upon which sketches were created to show the body proportions and indicate colour patterns.

Arthropods found in the dipterocarp trees were collected through aerial net trapping and beating and were then brought to the laboratory for processing and identification. Those contained in the leaf litters were extracted through Tullgren funnel extraction before preserving in 70% ethyl alcohol for classification. Specimens were sorted according to site and tree species. The abundance of each arthropod species was recorded for each tree species with their respective sampling method. From the pooled data, some ecological indices were calculated to describe the arthropod community structure for each tree species.

RESULT HIGHLIGHTS

Among the various forest tree species in Leyte, some dipterocarps as well as premium and fast growing tree species were screened for their applicability in the rainforestation farming scheme. During the first year of tree farming, sun-loving tree species, as listed in Table 1, were planted at a close distance of 2 x 2 meters, allowing the canopy to close quickly and favour straight bole growth due to the competition for light. In the second year, shade-loving trees (Table 2) were planted under the established pioneer trees. The list in Table 2 includes highly valued timber trees of the family Dipterocerpaceae. Likewise, shade-tolerant crops such as ubi (*Dioscorea* spp), gabi (*Colocasia* spp), pineapple (*Ananas* spp), takudo (*Xanthosoma* spp), abaca (*Musa textiles*), mushrooms and a variety of ornamental plants such as orchids, anthurium, aroids and Zingibers can be incorporated.

It is necessary during planting to group the trees according to shape types (BALZER, 1994) in order to achieve a high diversity of compatible trees which are less competitive for resources than their adjacent trees but optimise the available resources through their tightly interwoven community structure. In addition, it is a good strategy to avoid pest outbreaks if the immediate neighbouring trees are not of the same species and the planting scheme aims for maximum diversity.

Table 1. Light-loving Philippine forest tree species tested for Rainforestation Farming at Project site in ViSCA arranged in systematic order of families recommended for first year of planting.

Official Local Name	**Scientific Name**	**Family**
Anabiong	Trema orientalis	Ulmaceae
Gumihan	*Artocarpus sericicarpus*	Moraceae
Agoho	*Casuarina equisetifolia*	Casuarinaceae
Mountain Agoho	*Casuarina nodiflora*	Casuarinaceae
Bitanghol	*Calophyllum blancoi*	Clusiaceae
Bitaog	*Calophyllum inophyllum*	Clusiaceae
Toog	*Petersianthus quadrialatus*	Lecythidaceae
Tindalo	*Afzelia rhomboidea*	Caesalpiniaceae
Kariskis	*Albizia lebbekoides*	Caesalpiniaceae
Ipil	*Intsia bijuga*	Caesalpiniaceae
Bahay	*Ormosia calavensis*	Fabaceae
Narra	*Pterocarpus indicus*	Fabaceae
Akleng-parang	*Albizia procera*	Mimosaceae
Rain tree	*Samanea saman*	Mimosaceae
Bagras	*Eucalyptus deglupta*	Myrtaceae
Malabayabas	*Tristania decorticata*	Myrtaceae
Talisay	*Terminalia catappa*	Combretaceae
Talisay Gubat	*Terminalia foetidissima*	Combretaceae
Kalumpit	*Terminalia microcarpa*	Combretaceae
Malugai	*Pometia pinnata*	Sapindaceae
Bogo	*Garuga floribunda*	Burseraceae
Dao	*Dracontomelon dao*	Anacardiaceae
Lamio	*Dracontomelon edule*	Anacardiaceae
Amugis	*Koordersiodendron pinnatum*	Anacardiaceae
Danupra	*Toona sureni*	Meliaceae
Philippine Teak	*Tectona philippinensis*	Verbenaceae
Lingo-lingo	*Vitex turczanihowii*	Verbenaceae
Banai-banai	*Radermachera pinnata*	Bignoniaceae
Hindang	*Myrica javanica*	Myricaceae

Table 2. Shade-loving Philippine forest tree species tested for Rainforestation Farming at Project site in ViSCA arranged in systematic order of families recommended for second year of planting.

Official Local Name	Scientific Name	Family
Palosapis	*Anisoptera thurifera*	Dipterocarpaceae
Hagakhak	*Dipterocarpus warburgii*	Dipterocarpaceae
Bagtikan	*Parashorea malaannonan*	Dipterocarpaceae
Manggachapui	*Hopea acuminata*	Dipterocarpaceae
Dalingdingan	*Hopea foxworthyi*	Dipterocarpaceae
Gisok-gisok	*Hopea philippinensis*	Dipterocarpaceae
Yakal-kaliot	*Hopea malibato*	Dipterocarpaceae
Almon	*Shorea almon*	Dipterocarpaceae
White Lauan	*Shorea contorta*	Dipterocarpaceae
Guijo	*Shorea guiso*	Dipterocarpaceae
Yakal-malibato	*Shorea malibato*	Dipterocarpaceae
Red Lauan	*Shorea negrosensis*	Dipterocarpaceae
Mayapis	*Shorea palosapis*	Dipterocarpaceae
Tangile	*Shorea polysperma*	Dipterocarpaceae
Talakatak	*Castanopsis philippinensis*	Fagaceae
Ulaian	*Lithocarpus pruinosa*	Fagaceae
Kamagong	*Diospyros philippinensis*	Ebenaceae
Dungan	*Heritiera sylvatica*	Sterculiaceae
Kulatingan	*Pterospermum obliquum*	Sterculiaceae
Balobo	*Diplodiscus paniculatus*	Tiliaceae

BIOLOGICAL DIVERSITY IN RAINFORESTATION FARMING SITES

Among the herbivores, the flying lemur (*Cynocephalus volans*), which feeds exclusively on leaves of jackfruit (*Artocarpus heterophyllus*), the big hornbill (*Bucerus hydrocorax semigaleatus*), a fruit eating bird and the Philippine tarsier (*Tarsius syrichta*), the smallest and only true carnivore among the primates, were among the first wildlife regularly heard and observed at the forest edges of the Rainforestation Farming sites.

Birds (Table 3), reptiles, rodents and arthropods (Table 4) readily inhabited the newly regrown forest ecosystems. A maximum high diversity was achieved by planting 166 different tree species with adjacent trees being different species.

Biodiversity protection and preservation was achieved in Rainforestation Farming system in two ways:

- through propagation and planting of endangered tree species
- creation of suitable habitat for a variety of macro-organisms and provision of a microclimate to which the species migrate from adjacent forests.

With the major primary producers actively planted, the other components of the nutrient cycle, like herbivores, predators and decomposers, were consequently favoured.

Biodiversity, therefore, increased with the number of tree species planted, with structural diversity growing over time.

Table 3. Birds observed within the Rainforestation Farming area from January 1997 to December 1998.

Family	Scientific Name	Common Name
Columbidae	*Treron vernens*	Pink-necked green pigeon
	Phapitreron leucotis	White eared brown dove
	Ptilinopus occipitalis	Yellow-breasted fruit dove
	Macropygia phasianella	Reddish cuckoo dove
	Streptopelia chinensis	Spotted dove
	Chalcophaps indica	Common emerald dove
Psittacidae	*Loriculus philippensis*	Philippine hanging parrot
Cuculidae	*Cacomantis merulinus*	Plaintive cuckoo
	Centropus bengalensis	Lesser coucal
Caprimulgidae	*Eurostopodus macrotis*	Great-eared nightjar
Apodidae	*Collocalia esculenta*	Glossy swiftlet
	Mearnsia picina	Philippine needletail
	Hirundapus celebensis	Purple needletail
	Cypsiurus balasiensis	Asian palm-swift
Alcedinidae	*Halcyon smynesis*	White-throated kingfisher
	Halcyon chloris	White-collared kingfisher
Meropidae	*Merops philippinus*	Blue-tailed bee eater
Bucerotidae	*Penelopides samarensis*	Samar tarictic hornbill
Capitonidae	*Megalaima haemacephala*	Coppersmith barbet
Pycnonotidae	*Pcynonotus goiaver*	Yellow-vented bulbul
	Hypsipetes philippinus	Philippine bulbul
Oriolidae	*Oriolus chinensis*	Black-naped oriole
Muscicapidae	*Hpothymis azurea*	Black-naped monarch
Laniidae	*Lenius cristatus*	Brown shrike
Sturnidae	*Aplonis panayensis*	Asian glossy starling
	Sarcops calvus	Coleto
Nectariniidae	*Anthreptes melacensis*	Plain-throated sunbird
	Nectarinia sperata	Purple-throated sunbird
	Nectarinia jugularis	Olive-backed sunbird
Dicaeidae	*Dicaeum bicolor*	Bicoloured flowerpecker
	Dicaeum australe	Red-keeled flowerpecker

Table 4. Summary of observed organisms from the artificial bird nests installed at the Rainforestation Farming Demonstration Farm, FORI, ViSCA, Baybay, Leyte in 1997-1998.

Organisms	ARTIFICIAL NESTS USED [1]				
	AW1	AW2	AB1	AB2	AB3
Insects – Formicidae	*	*	*	*	*
Rhinotermitidae	*	*	*		
Gryllotalpidae			*		
Gryllidae				*	
Tipulidae	*	*			
Vespidae				*	
Spiders – Lycosidae		*			
Salticidae		*			*
Thomisidae				*	
Reptiles- Gekkonidae		*	*	*	*
Scincidae	*	*		*	*
Pythonidae	*				
Rodent - Sciuridae			*	*	

[1]Artificial nests used: AW1 - small, wooden nest; AW2 - big, wooden nest; AB1 - small, brick nest; AB2 - big, brick nest; AB3 - biggest, brick nest; * - present

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Collecting firewood, one of the most important causes of forest destruction in southern Laos, but it can also provide a powerful incentive for forest restoration.

THE PHU KHIEO BUFFER ZONE PROJECT- SUSTAINABLE RURAL DEVELOPMENT THROUGH COMMUNITY MANAGEMENT[1]

Colin McQuistan and Arthur G. Wright[2]

ABSTRACT

This paper presents an overview of the processes involved in a project based on the theory that damage caused to Phu Khieo Wildlife Sanctuary by communities occurs as a result of their reliance on the forest resources in times of economic hardship. For the forest to survive, villagers must revise their relationship with both the forest and other resources, based on sustainable development. The objective of the project is to accomplish community-based protected area management. To achieve this, the number of families developing viable economic alternatives to unsustainable forest management has been increased. Concurrently, local interest has been mobilised to encourage involvement in environmental conservation and rehabilitation. Equal consideration has been given to institutionalise local management capacity and to enable communities to assume responsibility for sustainable management of resources in partnership with local government. Further research is needed to ascertain if sustainable development has been achieved.

INTRODUCTION

Policies and legislation, governing all aspects of forestry in Thailand, are being revised. In the past, emphasis has been on timber production. However, following public concern about devastation of natural resources, the emphasis of forest policy is now moving towards conservation and increasing opportunities to include the public in forest policy. Another reason for such a policy change in Thailand is that it is a member country of the International Tropical Timber Organisation (ITTO) and is therefore obliged to achieve sustainable forest management as prescribed in the Year 2000 Objective (ITTO, 1990). As a result of the redirection of forest policy two changes in particular have been proposed:

1. The Thai Forestry Sector Master Plan (ANON., 1993).
2. The Community Forestry Bill (HONGTHONG, 1997).

Both these significant pieces of legislation are awaiting passage through the bureaucratic system. However whatever the final form of these documents, their acceptance

[1] Presented by Dr. Chamniern P. Vorratnachaiphan, Director, Grassroots Action Programme, Thailand Environment Institute at the Regional Workshop on Forest Restoration for Wildlife Conservation, Chiang Mai, Thailand, 30th January - 4th February 2000.

[2] Sustainable Buffer Zone Development Project, Thailand Environment Institute, 210 Sukhumvit 64, Bangchak Refinery Building 4 Prakanong, Bangkok 10260, Thailand

will create more opportunities for local communities and government officials to work together for sustainable use and conservation of forest resources (MCQUISTAN, 1998).

In October 1994 the Thailand Environment Institute[3] (TEI) began implementing a project, as executants of the Government of Thailand and funded by the ITTO. The project, *Sustainable Forest Management Through Collaborative Efforts* (ITTO Project: PD202/91 (F) Rev.) involved creating a conservation buffer zone adjacent to Phu Khieo Wildlife Sanctuary, in the Northeast of Thailand (Figure 1.). The project was of limited success in contributing towards conservation of the protected area. However, as a result of phase 1 of the project, many valuable lessons were learned concerning the actions and approach required to succeed in making the conservation buffer zone effective. As a result of these lessons, phase 2 was implemented in 1997.

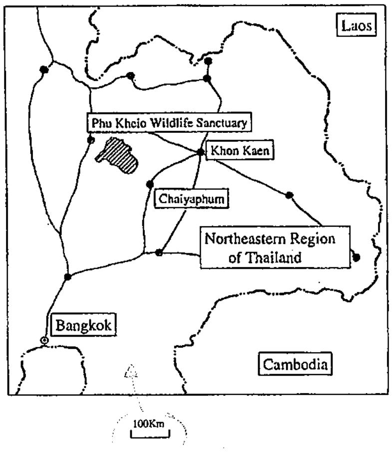


Figure 1. Location of Phu Khieo Wildlife Sanctuary

PHASE 1 OF THE PROJECT

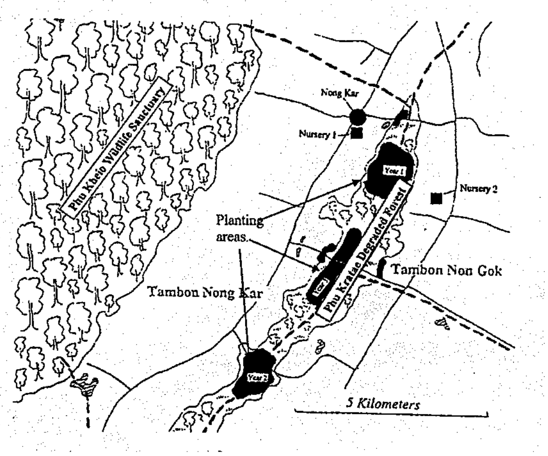
The original ITTO project was initiated in one village in Tambon (sub-district), Ban Nong Kar, Kasetsomboon District, Chaiyaphum Province. After project initiation, activities soon spread into additional villages in all four Tambons in the valley. All villages (Figure 2.) were located within 5 km of Phu Khieo Wildlife Sanctuary.

The project implemented activities in four main areas: social, economic, cultural and the natural environment. Tree planting and forest restoration were prolific during the three years of project implementation and provided a medium for improving community cohesion, implementing environmental education and income generation. By promoting

[3] Founded in May 1993, the Thailand Environment Institute (TEI) is a non-government organisation that works closely with the private sector, the government and local communities to link policy with action and facilitate progress in sustainable development and management of the environment.

villager empowerment via collaborative activities, the project attempted to encourage the communities to become more responsible for their environment. The project worked closely with a locally established group, the "Phu Kratae Conservation Committee", which was created by the District Governor (Ministry of Interior). The Governor designated a number of local government officials, including schoolteachers and forestry personnel, to organise conservation and forestry related activities in the reserved forest of Phu Kratae. This committee comprised 58 local officials and was organised into three separate committees to manage project activities. The management committee was responsible for planning and organising all activities, including educational activities in the schools and villages. These activities included tree planting for reforestation.

Figure 2. Area of the 'Phase 1'. Reforestation Project.



Critique of project action

This project achieved several valuable objectives in respect of both the community development and tree planting. At the end of December 1997, the project had facilitated planting of 50 ha of economic forest and 47 ha of community designated forest at its two project sites in Chaiyaphum and Uthai Thani Provinces. Altogether, 519 ha of conservation forest had been reforested. The total area falling under improved management by local communities, in a collaborative effort with the Royal Forest Department (RFD) and project staff, totalled more than 1,500 ha. More than 1,000 ha of this was protected project-facilitated agreements with the local Phu Kratae Rehabilitation and Protection Group. Firebreaks were cut and maintained around conservation forests. Cattle grazing, hunting, fuel-wood and collection of non-timber forest product were restricted. Weeding, fire prevention and replanting resulted in seedling survival rates approaching 90% in a few areas and averaging more than 75% after three years.

Planting native tree species enriched conservation forests. Fire prevention and selective weeding in degraded forests facilitated natural regeneration through maturation of existing stock, coppice recovery and protection of volunteer seedlings. Therefore, tree planting and forest conservation targets were met. The project established three nurseries with a combined production potential of around 1 million seedlings per year. Local villagers, who were both paid and trained by the project, operated nursery facilities. The project provided financial support for 189 families at the two project sites to develop several alternative income-generating activities, aimed at reducing forest exploitation by alleviating poverty.

The Final Project Review[4] concluded that income generation and poverty alleviation were of a secondary importance compared with tree planting and forest conservation. Furthermore, villagers involved in the pilot efforts were not the very poorest, who are most likely to engage in destructive practices in forests. This situation resulted from the income-generating activities being selected as a result of consultant input and recommendations by local leaders, a process that completely ignored the important link between forest use and development activities. Therefore, although the project worked hard to facilitate local communities, the pathway of the project into the local communities followed a top-down approach. Contact occurred between the lone project field team worker and selected villagers introduced via local leaders. The Review stated that the project worked hard to raise local environmental awareness via tree planting and forest conservation and that project-supported forestry activities in the buffer zone created widespread recognition that community action can be highly effective at improving the quality of local forest resources. While the primary motivation for these activities appeared to have been respect for local authority and encouragement of villager's participation by local leaders, the reforestation and forest conservation activities had reoriented the manner in which most people perceived their environment.

The project's collaboration with the Phu Kratae Conservation Group was intended to provide a mechanism to ensure that conservation activities would continue even after financial support from the project ended. However, in reality a very different local situation arose. The project mistakenly assumed that local authority figures were an appropriate conduit through which to reach the local population. Unfortunately this linkage was weak and also complicated by local politics. After the first phase ended, there was a two-month lag before the new project phase could be initiated in the communities. During this period a number of unfortunate events occurred which clearly illustrated the tenuous linkage between the villagers and local leaders.

Firstly, in January 1998, four disastrous fires occurred which destroyed a wide swath of replanted and improved forest. This occurred because village fire volunteers had not bothered to clear the fire breaks, due to lack of motivation and transportation. The second fire was deliberately started by a group of the poorest villagers to provide dead wood for later collection and conversion to charcoal. During three years of operation, the project had not addressed or acknowledged the local charcoal industry. This occupation was a welfare activity of the very poorest villagers, who collected dead wood for conversion to charcoal for sale. This oversight reflected the authoritarian management of the project with local

[4] Final Project Review by Mr. Andrew Mittleman and Dr. Sureeratna Lakaanavichian, July1977

activities being directed by six-monthly steering committee meetings that occurred between project management and forestry specialists in Bangkok.

Secondly, the partnership with the Phu Kratae grassroots environmental group proved to be heavily reliant upon the interest and involvement of the local administrative leaders with financial support coming directly from the project. This committee operated in a managerial fashion, resulting in activities being presented to the villagers to undertake and not activities actually desired by the local people.

At the end of the initial project phase all project-sponsored income-generating groups in the target area chose to cancel further activities and dissolve the group. This decision was made in the belief that if the group resigned, then no member of the group was responsible to the project for loan repayments. This behaviour replicates a common occurrence with development projects, where failure of the activity results in any outstanding loans being written off. This occurrence clearly indicated that these groups had no real desire for their selected activity, no long-term objectives and no genuine cohesion. In fact, when interviewed several months later, one group leader admitted to initiating the group as a hobby to alleviate boredom.

Although the project's reforestation and forest rehabilitation efforts had transformed the landscape, no change of the villager's relationship to the forest occurred. The project initially relied exclusively upon a consultant's report of the baseline situation in the communities to direct project action. Although this report was well written and presented, the overall recommendations were too general for accurate planning. Additionally, the recommended actions focused on agricultural activities, but presented no suggestions as to how these activities should be undertaken. The report overlooked analysis of the local communities, local leaders, facilitation structures and capacity or administrative problems. The methodology involved questionnaires on economic factors and overlooked the social structure of the village. Ultimately the project was unable to act upon the strong linkage the villagers had with their forest resources, because forest resource use was overlooked in the consultant's pursuit of monetary factors, which related solely to economic agriculture.

The project additionally relied heavily upon the Phu Kratae Conservation Group for extension into the communities and for the local decision-making function. This resulted in lack of continuation when the group disbanded due to the transfer of the District Governor and a local secondary school headmaster. Conservation activities and tree planting resulted from these local officials' personal ideas and did not represent a genuine desire of the villagers. Therefore, one very important lesson from this project was that while anybody can be encouraged to plant trees, tree planting will only be of real benefit to local people if they participate in the management of such activities. Forest restoration must grow out of a strongly felt local need, as this will provide motivation for communities to care for the trees once planted.

It seems that there is no single approach to promote collaboration in responsible natural resource and forest management. The appropriateness of any particular approach depends on the social and cultural values present in the village, enforced by local knowledge, skills and particularly personal experiences. Anthropogenic factors are related to local physical environmental conditions, especially limiting factors they present to communities in their day to day lives.

The overall recommendation from the ITTO project was that co-operation with the local population, rather than confrontation is the best method to ensure that forest destruction and associated environmentally damaging practices are reduced. Establishing peoples' involvement in local management is fundamental to this idea. It should be realised that this inclusion in the decision-making process must be accompanied by facilitation and capacity-building for such people.

Conclusions from 'Phase 1' of the project

In order for such projects to succeed, local people must be made aware that their involvement is necessary and their inclusion must be accepted by government agencies, especially at the local level. This process is long and slow and relies on encouragement and stimulation to promote their input. This inclusion will be minimal at first, but as encouragement continues and experience is gained, people will become effective managers of their local resources. Local people must also perceive tangible benefits from inclusion in this process. Initially this will act directly via income-generating projects, but eventually benefits will become more diffused as assistance is provided via facilitation and encouragement, especially to build upon the strengths inherent in the local communities and as partnerships and co-operative ventures are started at the community level.

The overriding focus of the ITTO project upon forestry aspects reduced the emphasis of the project to involve villagers in a dialogue, to identify local economic problems and to enlist recommendations regarding how these problems could be solved most effectively. The project focus, which attempted to alleviate poverty and strengthen community resolve to rehabilitate and conserve forests, was accurate. However, top-down management greatly reduced the project's effectiveness in the villages. Project staff learned that community structure greatly influences participation in project activities.

PHASE 2 OF THE PROJECT

In order to build upon the valuable lessons learned by the ITTO-funded project, TEI wrote a proposal for a second, three-year project – phase 2. To revise the method of project implementation, advice was sought from established and respected forest management and community development specialists in Thailand. Thus a meeting between the TEI Project Director, experts from the Regional Community Forestry Training Centre (RECOFTC) and senior staff from the Royal Forest Department (RFD) was convened. RFD personnel included individuals from the Community Forest Division, Natural Resource and Conservation Office and the Forest Research Office.

The summary recommendations from this meeting were:

1. Increase project presence at the project site and select staff with suitable extension experience.
2. Undertake extensive Participatory Rural Appraisal (PRA) in all target villages and ensure project staff, not hired consultants, undertake data collection.

3. Identify via PRA the current economic, social and environmental status and flows at the project site at all scales from village to district.
4. Ensure resulting local community plans are developed, which identify specific activities linked to definite environmental and social benefits.
5. Facilitate local capacity-building and organisational improvement.
6. Promote community forestry within independent villages and explore and develop mechanisms by which communal or district wide forest areas can be jointly managed.
7. Develop activity-focused groups, village-based groups and district-wide networks to ensure collaboration and partnerships at all levels.
8. Ensure that the project encourages local responsibility and that local people respect the integrity of the wildlife sanctuary, which the project is designed to conserve.
9. Ensure the project works closely with local government agencies to promote local collaboration.
10. Buffer zone activities must occur outside the boundary of the protected area and not encroach within the boundary.

The new project was funded exclusively by the Royal Netherlands Embassy, Development and Co-operation section and entitled *Participatory Buffer Zone Management for Forest Conservation and Sustainable Rural Development* (Activity Number TH003302). Acting as project executants, the Thailand Environment Institute initiated the three-year project on 1st January 1998.

Phase 2 project strategy was clearly indicated within the detailed project proposal which outlined a proactive, facilitatory, development and conservation project, which would act in a flexible and adaptive way to implement activities and overcome problems when they arose. This was very different to the rigid work plan oriented process of the previous project. The goal of the project was to ensure long-term conservation of Phu Khieo Wildlife Sanctuary by mobilising interagency co-operation and building the capacity of the local partners to manage forest resources sustainably, and develop sustainable livelihoods for residents of the protected area buffer zone.

This goal was to be achieved by establishing a solid and capable project management capacity for both the project team and local area partners. The partners included formal and informal community leaders, members of both the project facilitated and existing local community organisations and representatives of involved government line agencies.

The project management prowess was to focus on successfully implementing a set of integrated conservation and development oriented activities associated with three central project components. These components formed a tripartite and closely inter-linked set of complementary activities aimed at ensuring accomplishment of conservation, development and enhancement of local capacity which are integrated for long term project sustainability. The three project objectives and their sub-components were:

Objective 1: Forest conservation and rehabilitation

"Conservation of Phu Khieo Wildlife Sanctuary by facilitating community agreements and action to conserve protected area forests, increase forest cover in the buffer zone and generally improve the status of local forest resources by replanting and regenerating degraded forests and promoting and supporting the development of farm and community forestry in the project area."

Objective 2: Sustainable development of local communities

"Enhance the income-generating capacity of participating farm families enabling their full-time residence in the project area (precluding the need for urban labour migration) and revitalise social cohesion and the sense of community."

Objective 3: Organisational development and capacity building

"Enhance capacity and organisational prowess to design, support and implement sustainable resource management, forest conservation and integrated community development among participating villages and implementing partners."

Implementing Phase 2

The project target area was selected on the basis of recommendations of the superintendent of Phu Khieo Wildlife Sanctuary, who had 15 years experience in these villages. A consensus was reached by the project steering committee regarding the location before the project commenced. The area was situated within four sub-districts of Kasetsomboon District of Chaiyaphum Province, which included a total of 43 villages.

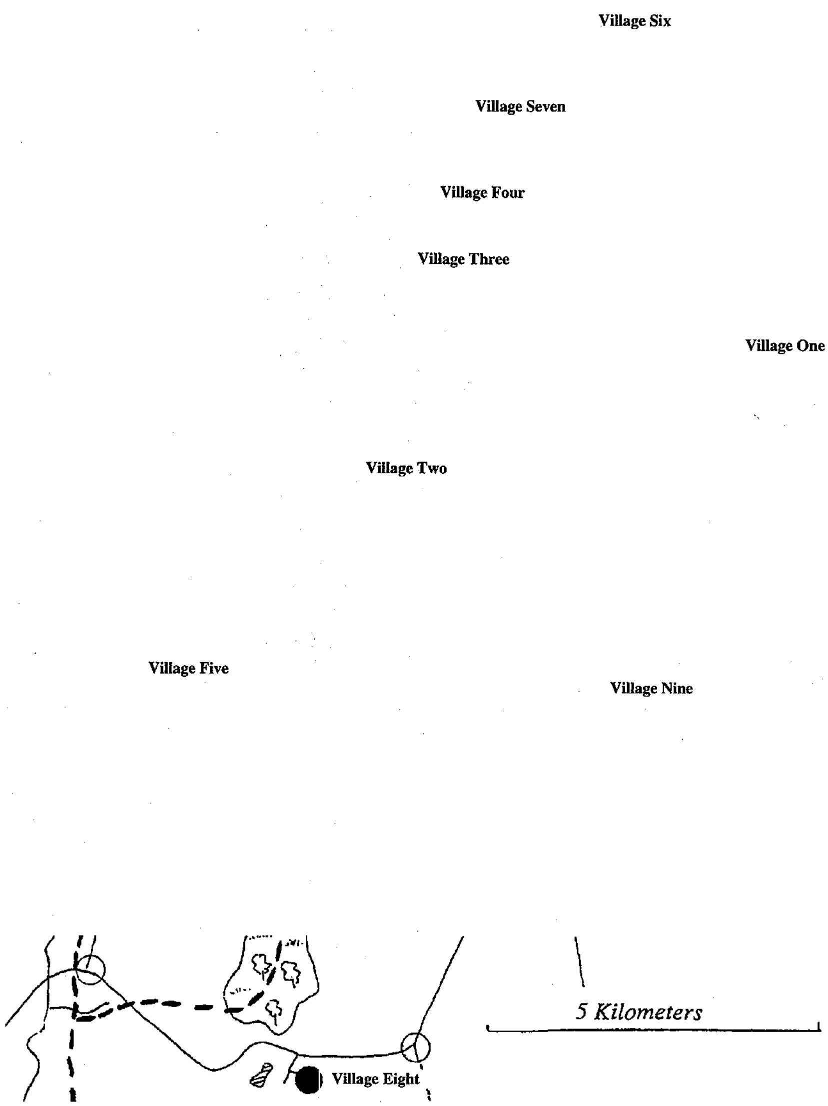
Participatory Rural Appraisal

After consulting RECOFTC for advice concerning the number of villages that would be practical for the project to work with, it was originally decided to select a total of 23 villages during the three-year project period. However, once the project was initiated it became evident that this figure was over-ambitious due to the relatively small field staff team (four in number). The number of target villages was therefore reducwed to 19. The project began by initiating 9 villages (Figure 3.) into the project in the first year. It was decided that an additional five villages were to be initiated into the project in the second year and a further 5 in the third and final year.

In order to implement such a broad-based, community-focused project and select the particular villages with which the project was to work, a strong understanding of the communities and their current socio-economic situation, their relationship to the forest and social dynamics was required. Therefore, detailed Participatory Rural Appraisal (PRA) was undertaken. However, this could not be attempted until the project had developed a team of field workers with the necessary skills, and most importantly, the project had established trust with the villages. This could only be achieved by a gradual introduction process, both formal and informal and through dialogue and skilled recognition of and contact with stakeholders to ensure that no village group was excluded from this preparatory process.

Once trust and rapport was present, the project visited each village on several separate occasions and collected data verbally concerning: family structure, education, provenance, land holding, socio-economic situation, current occupations and practices and relationship to the environment and forest utilisation, including both traditional practices and current usage. The PRA process visited 25% of the resident families in each village interviewing all members of each family to develop a composite picture of community life. In total, 324 separate data sets where created for the nine target communities, representing a total population of 3,906 people, with 102 separate issues covered in each questionnaire set.

Figure 3. The Phase 2 – '1st Year' Project Target Villages.



Local Government Administrative Structure

The local situation was complex. In all villages, from the smallest to the largest, there was a social structure with a recognised local administration present. Each village had a village headman, two village assistant headmen and two sub-district council representatives. All four sub-districts had a nominated government chief administrator and the representative local government unit, known as the Tambon[5] Administration Organisation (TAO). There was also development infrastructure present with electricity reaching all villages.

All four sub-districts included six health stations, twenty-five primary schools, three schools to secondary grade 9 and one secondary school, grade 6 to 12. The Ministry of Agriculture had one designated extension worker for each sub-district. A number of water development projects, most notably reservoirs, had been initiated during recent years. The 'success' rate for these was less than 50%, which local people mostly blamed on poor design. The average village size was 94 families, with a mean family size of 4.5 people. The average village contained around 400 people. Population growth rate was 1.5%, which is insignificant when compared with the national average. The majority of villages were established 50-70 years ago by gradual migration.

In addition to basic community data (Table 1.), information was also collected concerning villagers' incomes. As with any development project looking at community use of natural resources, the link between income and degree of destructive practices is often cited (Tongpan *et al.*, 1990). Therefore, the project attempted to calculate villagers' income, identify what income sources were available and what relationships occurred between sources.

Table 1. Project Basic Community Data.

Tambon	Village	Village size Households	Mean Education	Immigrants from outside the: Village		
				Village	**Province**	**Total**
Nong Gok	One	147	grade 5	33.3%	11.1%	44.4%
Nong Kar	Two	96	grade 4	26.1%	65.2%	91.3%
	Three	135	grade 5	23.7%	2.6%	26.3%
	Four	78	grade 5	27.0%	8.1%	35.1%
	Five	80	grade 4	60.0%	35.0%	95.0%
Bua	Six	75	grade 4	54.3%	6.2%	60.5%
	Seven	149	grade 4	60.5%	0	60.5%
Dua	Eight	30	grade 5	66.6%	33.3%	100%
	Nine	78	grade 4	60.0%	20.0%	80.0%

Furthermore, the project focused on the extent to which villagers relied on nearby forest (Table 2.). Incomes derived from agriculture, manual labour, other sources and

[5] Tambon - an administrative grouping of villages.

dependence on forest were calculated in monetary terms. Forest 'Income' (Table 2.) was derived from data collected during the PRA. The majority of products collected from the forest were for household consumption; therefore the average quantities reported were converted into monetary terms, based on local market price.

Table 2. Mean Annual Family Income within Project Target Villages (Baht).

Village	Labour[1]	Forest 'Income'[2]	Average Debt
One	12,833	5,855	19,844
Two	5,917	2,087	29,567
Three	13,157	19,107	22,381
Four	15,324	19,411	20,000
Five	17,850	14,120	12,100
Six	6,468	2,125	8,387
Seven	8,055	8,903	15,763
Eight	9,666	6,204	10,000
Nine	22,700	5,850	16,675
Mean	12,441	9,295	17,190

[1] Expressed in terms of cash paid as wages.
[2] Represents the equivalent local market value of the products collected and consumed by the households, not cash income generated from their sale.

Table 3. Percentage of Villagers Engaged in Labour and Forest Product Collection.

Village	Seasonal Labour	Forest products collection	Debt
One	69.4%	86.1%	69.4%
Two	47.8%	73.9%	95.7%
Three	86.8%	89.8%	84.2%
Four	83.8%	81.1%	67.6%
Five	90.0%	90.0%	90.0%
Six	43.8%	87.5%	81.3%
Seven	57.9%	76.3%	73.7%
Eight	77.8%	100%	77.8%
Nine	85.0%	85.0%	70.0%
Mean	**71.4%**	**85.5%**	**78.9%**

The majority of the products collected from the forest were for home consumption, although some items, especially charcoal, were produced for sale. Therefore, the average quantities reported were converted into monetary terms based on local market price, with seasonal price fluctuations taken into account. In addition, an assessment of the percentages of those villagers engaged in both seasonal labour and also subsidising their income from the collection of forest products was undertaken (Table 3.).

Gender Distribution

If the data is assessed in terms of permanent village residents, (i.e. not including those individuals who work elsewhere and only return for important festivals), then the population is dominated by females (62.7%). It is predominantly women and girls who go into the nearby forest to collect non-timber forest products (NTFP's), whereas males work on the farms. Women play a minor role in traditional village-based decision-making organisations.

Findings from the Appraisal

Overall half the total local income generated resulted from labour, with construction work and sugar cane cutting being the two dominant activities undertaken. Within these occupations, two trends were apparent. The first group includes villagers who choose sugar cane cutting because they have some land but wish to increase their income. This is because it occupies only a short period of time and therefore does not intrude upon their traditional agricultural practices. The second group of people, who work in the service sector, seek employment of a more permanent nature. These people have no land and support their family by sending a substantial portion of their wage home to their relatives. They only return home for major ceremonies or to help the family to harvest the rice from the fields

After seasonal labour, the second most important local additional income source was the forest. Utilisation of the forest was variable, some products being utilised by the majority of the population, others only being partially or seasonally utilised. This situation reflects to some extent local variation in external factors such as rainfall and labour opportunities and indicates the villagers close association with annual cycles. Their activities are synchronised with the seasons that affect agriculture and the productive status of the forest.

All use of the forest stops once the fields are prepared and the rice seedlings are ready for planting. The villagers are then employed in a period of hard work with all members of the family working together in the fields. Many of the short-term seasonal labourers return to help with the planting. Once the rice is in the fields, these workers return to the cities and the older and younger members of the family remain in the village. During the rice-planting period, the families use savings and cached supplies, including bamboo shoots, having no time or energy to enter the forest and collect products. The linkage between forest usage and seasonal activity appears to indicate a strong association.

On analysis of the data, there appeared to be a strong relationship between periods of collection of forest products and agricultural inactivity. The communities appeared to utilise the forest areas, not simply because of a lack of income, but also because they have traditionally collected forest produce during non-productive periods. It seemed reasonable to assume that, if income-generating activities were to increase the participants' free time, then an increase in forest resource use would probably occur. For example, traditional rice farmers at the project site were actively engaged in the cultivation of rice for only six months of each year and they therefore had plenty of free time to enter the forest to collect various products. Therefore development activities were implemented in such a way as to extend the productive phase of the village so that employment and supply could be distributed more evenly throughout the year. The purpose of initiating income-generating activities was not therefore solely to increase monetary income.

It therefore appeared likely that, by extending the agricultural season, the farmers timetables would become more equally distributed throughout the year. The agricultural production of the village would become more diversified, reducing reliance upon external markets and promoting a strong local village market. Villagers would therefore produce their communities' requirements first and then market the excess, rather than producing crops for sale and surviving, for the remainder of the year, on external products purchased with their savings.

Selection of Target Communities

Using the data collected from the PRA, a ranking system was employed to select the project target villages using the following criteria:

1. Proximity to forest
2. Dependence on forest
3. Knowledge relating to local forest
4. Access to community
5. Poverty status
6. Village size
7. External influences
8. Community strengths
9. Village cumulative knowledge
10. Village leadership
11. Development potential
12. Acceptance of project concepts

The nine highest-ranking villages were initiated into the project during the first year. The five villages with the next highest ranking joined the project in the second year and five additional villages were to be initiated into the project in the final year.

Once target villages were selected, the next stage of implementation involved establishing economic-generating activities within those communities. Before this could be done, it was necessary for the field staff team to identify which types of activity were appropriate for the respective target villages. Appreciation Influence Control (AIC) (planning sessions) were initiated with the villagers by posing such key questions to the villagers as: what do you wish to include in your village development plan; how can this be initiated and who will be responsible for implementation? In order to provide examples of potential income-generating activities, study tours were provided for the villagers by the project. These enabled villagers to visit sites where organisations had been involved in development projects and had formed village groups identified with specific activities within communities. The project encouraged diversification between the income-generating activities and included occupations to provide the communities with adequate income throughout the year. The purpose of this action was to address the strong relationship between periods of collection of forest products and agricultural inactivity, thereby reducing the extent to which the communities relied on the local forest. On completion of the study tours the villagers were asked by the field staff to summarise their visit, identify the activities they found most useful, the lessons they learned and select activities for their respective villages.

This exercise resulted in the formation of income-generating group activities in each target village including: integrated farming, cattle raising, water bore-well drilling construction (to reduce agricultural dependency on seasonal rainfall), soil-cement brick production (to reduce reliance on timber used in local house construction) and women's groups, producing silk, shampoo and household detergent.

Developing Community Organisations

The project implemented development of the communities by starting small activity groups and progressing through a process of accretion and mutual assistance until these groups develop into a village organisation and ultimately the Community Network Organisation. This approach was intended to ensure that ultimately the majority of the population within the project target communities were both involved in and represented by the processes concerned with management of the buffer zone area. The organisational development and capacity building of the project target communities included four specific fields:

***1. Project Activity Groups*:** democratically elected within the first six months of each village, having been initiated into the project to develop and ultimately manage each of the income-generating activities. Revolving funds were provided to individuals within the target communities for implementing project activities such as integrated farming.

2. Village Development Committees: the objective of these democratically elected groups was the general management and co-ordination of their respective villages and in particular the formulation of Sustainable Community Development Plans. The inclusion of women in each of these groups was promoted by the field staff to ensure that they had equal opportunities to participate in the project. These groups were to assume responsibility for vetting applications from villagers for project financing of income-generating activities.

3. Community Forestry Management Committees: the objective of establishing community forest management plans was originally identified during the PRA and AIC undertaken at the beginning of the project. In July 1999 members of the project field staff and RECOFTC organised a three-day training course on the subject of community forestry. The objective of the course was to establish Community Forest Management Committees in the project target villages and facilitate the members of such in developing management plans for their respective forests. RFD officials who were invited by the project and attended the training course included the Superintendent from Phu Khieo Wildlife Sanctuary. The training course marked the beginning of the development of strategies for community forest development within project target communities, which was in effect the first stage in their developing village resource zoning plans.

4. A Community Network Organisation (CNO): formed during the second year of phase 2 of the project, with 56 members consisting of four representatives from each target village. The purpose of these groups was to co-ordinate the respective Village Development Committees, in order to create a cohesive and holistic approach to manage the buffer zone on a sustainable basis. The CNO also represents all villages in negotiations with government officials or other organisations and will ultimately manage the buffer zone area after project completion this year. The project provided members of the network with the necessary training to develop their management skills to the levels required to independently manage the buffer zone area. The field staff and project management has included the CNO in meetings to review and manage project progress. The network has been working closely with the project field staff team in the management and development of the majority of project activities, including the final year work plan.

Participatory Management

Both the project executants and the CNO recognise that, to be successful, the process of participatory management of the buffer zone area must include government authorities. With this in mind the CNO has developed working relationships with the Tambon Administration Organisations (TAO's) by including officials from each of the four sub-districts in the project target area within its membership. The CNO and project field-staff team has developed working relationships with the Ministry of the Interior, Ministry of Agriculture, Royal Forest Department and Ministry of Education at a district level.

Integrating Development and Conservation

The most challenging aspect of the project to date has proved how to ensure that development and conservation are integrated within the buffer zone. Throughout phase 2 of the project, the field staff have made a conscious effort not to over-emphasise the importance of any one particular activity, such as tree planting or income generation. Instead they have concentrated on developing the capacity of the target communities to adopt a holistic approach to the management of their environment.

The CNO has gained verbal agreement from the RFD for permission for certain villages within the buffer zone to use areas of land under the jurisdiction of the RFD as community forests. The ultimate objective of both the project and the CNO is to strengthen these agreements and also to gain permission from the RFD to allow local communities to participate in the management of areas of land within Phu Khieo Wildlife Sanctuary.

To ensure that future management of the buffer zone is effective, the CNO will need to develop and implement methods of participatory monitoring and evaluation. The project has therefore arranged for RECOFTC to initiate on-site training for the CNO in the subject of participatory monitoring and evaluation. In addition, the project has initiated nineteen schools within the area into the project, with the objective of establishing a youth community network organisation. The purpose of this is to raise awareness amongst the local youth concerning sustainable development of their communities and involve them in monitoring and evaluation of activities within the buffer zone.

It is intended that the CNO will continue to function and manage all activities within the buffer zone after completion of the project at the end of this year. The CNO will eventually establish and manage one central revolving fund with the money originally supplied to each target village by the project for funding of income-generating activities. This will enable these funds to be employed amongst new villages in the buffer zone, which the network may decide to include in their membership and assist with the development of economic-generating activities in order to achieve sustainable development. Construction of a community centre is underway, which will serve as the headquarters of the network, which is developing plans to run the centre as a regional training centre for sustainable development for community organisations.

DISCUSSION

Phase 1 of the project demonstrated that, to achieve sustainable development of the buffer zone, organisational development and capacity building of the local population is essential. Therefore phase 2 of the project specifically included three processes: firstly, to increase awareness, knowledge and understanding of local communities with regard to the rational and logic on which the project is based. Secondly, to empower communities in the management of their villages and the buffer zone through development of community organisations at both village and district levels. Thirdly, to encourage and facilitate community organisations in developing their own ideas and direction in terms of both economic and social development of their communities and the buffer zone area.

Considerable progress has been made in achieving these objectives with the result that the management capability of the community organisations has reached a stage where they are now able to offer advice and training to others. For example, field staff consider that the nine villages which were initiated into the project during the first year of phase 2 of the project are now capable of assisting new villages joining the project in developing community organisations of their own. The project has therefore reached a stage where the target communities themselves can assist other non-target villages in participating in management of the buffer zone.

CONCLUSIONS

The fundamental lesson learned from the Phu Khieo project is that development of communities surrounding the wildlife sanctuary is not an assurance of conservation of that area. If rural development activities target the wrong sectors of those communities, and especially if they exclude members of those communities who utilise forest resources, such development will not reduce the impact of those individuals upon the forest area.

Phase 1 of the project may prove to be only part of a long learning process for all those concerned in achieving the ultimate objective of sustainable development of the buffer zone. Further research is required in order to ascertain if the project is achieving such development and subsequent long-term conservation of Phu Khieo Wildlife Sanctuary. Up until now, TEI has initiated such research. However, for the process of participatory management of the buffer zone to be successful in the long-term, local communities must possess the ability to conduct their own research and development.

FUTURE DIRECTIONS

There remains much work to be done before the activity of forest restoration for wildlife conservation becomes a significant part of the buffer zone management regime. The project has made great progress in identifying the underlying causes of the damage, which is occurring to local forests. It has also succeeded in recognising the underlying reasons for those causes. The challenge remaining is how to integrate conservation and development within the buffer zone to the extent that it not only includes conservation, but also restoration of local forests.

The district Community Network Organisation has stated that they intend to maintain a working relationship with TEI after completion of the current project. TEI is now in the process of developing one method of doing so by including the CNO in a new national initiative it is developing, entitled the Thai Forest Watch Network (TFWN). The overall objective of the TFWN is to develop a national network to facilitate participatory management of Thailand's forests. It is intended that network members would include local communities, NGO's, the scientific community and the Government. The ultimate objective of the TFWN is to build partnerships around solution-orientated approaches in order to achieve sustainable participatory forest management, thereby reversing the process of deforestation in Thailand. The TFWN intends to raise public awareness about the need for and the potential of participatory forest management in sustainable development. This will be achieved by implementing and co-ordinating a forest monitoring network and conducting research on sustainable forest management. It is intended to create a database concerning forest resources and their sustainable development and use it to develop the potential of TFWN members. In this way, participatory forest management can be developed with the ultimate objective of contributing toward sustainable development of the region, including forest restoration for wildlife conservation.

ACKNOWLEDGEMENTS

This paper is based on research conducted by Colin McQuistan who was manager of phase 2 of the project until May 1999. Most of the content of this paper has been adapted from unpublished material written by Mr. McQuistan. Development of many of the ideas in this paper was done by project field staff including: Mr. Saksith Meunkul, Mr. Krasae Katakul, Mr. Samrong Yothakeng, Mr. Rattaphon Pitaktapsombut, Mr. Jirachai Arkajak, Ms. Maysa Kositkiertikhum and Ms. Suangkana Kaewboonruang. I thank the International Tropical Timber Organisation and also the Royal Netherlands Government, Development and Co-operation Section who funded phases 1 and 2 of the project respectively.

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QUESTIONS AND COMMENTS

Marlea Munez

How much investment was given to the project and for how many years? Also, how many people were on staff and involved in the community?

Chamniern Vorratnachaiphan

ITTO supported our project, which is unusual because they rarely support rural development. This support was just for the first three years for a total of 20 million Baht. The northern government has supported phase 2 of the project by spending 15-20 million Baht. So for the first 6 years more than 30 million Baht has been invested. Currently we have 8 permanent field staff.

Marlea Munez

How can you do it in a way that it can be replicated in some other areas where you may not be able to provide so much investment while still keeping with the community approach with putting in village scientists, foresters, etc.?

Chamniern Vorratnachaiphan

In the 1st phase we had only 3 villages, but now we have expanded to 14 villages because we have extended our target group. But we are still not satisfied, so under the established network, we are hoping to work with other organisations so that we can expand even further. We are providing training, collaborating with the Thai Forest Network and trying to use existing regional organisations.

Payong Chatwiroon

Forestland in Thailand is governed under 5 Acts. The first act, known as the Forest Act, was established in 1941. The second is the National Park Act 1961, the third is the National Reserved Forest Act 1964 and the fourth is the Wildlife Sanctuary Act 1992. Finally the fifth, the Community Forestry Act, is currently under review. According to the laws, people are forbidden to live inside forested areas within national parks and wildlife sanctuaries in Thailand. The people in the villages misunderstood the laws, so they invaded the land, cut down trees, destroy buildings and try to sell the land. The Community Forestry Act is presently being drafted, but this is causing much debate, because villagers want to have unlimited access to national parks and wildlife sanctuaries. There is a rush to occupy areas that might be declared community forests under the Community Forestry Act. Presently, there is conflict between the villagers wanting to carry out activities inside national parks and wildlife sanctuaries and others wanting to protect them for conservation and watershed management. That is why we do not want to let anyone inside these areas. We are also sure that people who get into the protected areas will want to stay there. The Community Forestry Act focuses on planning, so that anyone who wants to declare a community forest must submit a plan to the concerning agency. The problem with this is that there is only one word for plan in Thai, but at least ten in English, e.g. master plan. So we need to know exactly what this plan is about; for instance, is it for only one year or ten years? I used to be involved in an investigation committee in Thailand and teach law at Kaset University. The Community Forestry Act is not yet ready. There is a long debate between the forestry sector and NGO's, because NGO's want to get inside the land because they misunderstood the role of the act. Villagers can obtain benefits from the forest and at the same time conserve the area for other people.

Chamniern Vorratnachaiphan

I agree with what you said. There are too many plans. There is no enforcement of the implementation of these proposed plans that pose problems in Thailand. Also there are too many researchers doing research that is not applicable. The problem that we experience is a lack of integration of plans. The plan has no vision, no clear-cut mission and no interest in others' plans. What needs to be done is an integration of all the plans both horizontally and vertically. We need to deal with land issues, as this is the reason we experience conflicting laws and people wanting to invade the land. Planning is still just a plan; nothing is accomplished. Many plans, zones, etc. are created, but they are only good to hang on the wall. So what we now must do is to come back to the realities of implementation. The problem now is that the task has become so immense, as we must now restore forests, and not only the trees but also the animals. How do we protect the land, and what is the most effective way? One organisation is too small for this big task. So we must work in partnership if we are to succeed.

POSTER ABSTRACTS

THE POTENTIAL OF INTEGRATING INDIGENOUS FOREST SPECIES INTO AGROFORESTRY SYSTEMS FOR NORTHERN THAILAND

Richard Burnette and Jamlong Pawkham[1]

Controversy rages as to whether hill tribe inhabitants of northern Thailand are really friends or foes of the region's fragile and fragmented upland forests. Some groups advocate that these forests must become completely free of human presence and interference, with the exception of forest management and tourism. Yet, other sectors, also concerned with healthy, upland forests, advocate a continued forest-based lifestyle for the region's indigenous people. However, to better position upland residents to participate in forest stewardship, as well as to reduce human pressure in protected forest areas, allowances must be made for the primary needs of the forest inhabitants (e.g., adequate agricultural land and access to traditional forest products). Therefore, in addition to its ongoing emphasis on sustainable upland agriculture, the Upland Holistic Development project has recently begun partnering with hill tribe villagers in northern Chiang Mai province to evaluate potential agro-forestry systems. Such systems are located on degraded forest plots in which the majority of existing forest trees and shrubs are preserved. Within the plots, narrow strips of undergrowth (approximately 1.5 meters wide) are removed in 6 meter intervals to facilitate the establishment of various indigenous forest species of local value (e.g., nutritional, economic, medical and other). To further supplement incomes from such plots, selected, non-invasive horticultural crops that tolerate forest conditions are incorporated. Additional evaluation is needed to determine a wider range of indigenous species that are suitable for integration into local, upland agro-forestry systems.

[1] Upland Holistic Development Project, Amphur Mae Ai, Chiang Mai, Thailand.

THE SCIENCE AND PRACTICE OF COMMUNITY BASED TROPICAL FOREST REHABILITATION IN FAR NORTH QUEENSLAND

Nigel I. J. Tucker[1]

The need for tropical forest rehabilitation drives research direction and motivates government and community involvement in groundwork. Three major landscape linkage projects and a range of other smaller projects are currently underway and focus on biodiversity conservation and improved land management practices in highly strategic conservation areas. In recognition of the importance of nature conservation outside protected areas, The Centre for Tropical Restoration works closely with agricultural land managers to demonstrate the mutual benefits of revegetation for conservation and primary production. Our nursery facility at the centre currently produces around 50,000 trees per year, which are established in degraded areas using the 'framework species method' developed by the centre.

A range of collaborative and independent research projects are undertaken by the centre, in conjunction with other research institutions and assisted by community volunteers. Research topics include investigations into recolonisation of flora and fauna in revegetated areas, potential gene flow through re-established linkages and efficacy of different revegetation methodologies in weed management.

An extensive education and training programme is delivered by centre staff and TREAT (Trees for the Evelyn and Atherton Tableland) volunteers. Programmes range from environmentally-based learning activities for school children to intensive 6 month training packages for international forestry or restoration students. TREAT members take advantage of the varied and interesting field and training days where they can increase their knowledge of their local environment, nature conservation and better land management.

The centre has an almost 20 year history with the community tree planting group TREAT. This unique relationship manifests itself in a range of hands-on activities for the 500 TREAT members to get involved in. Activities include nursery working bees, tree plantings, field trips, school programmes and monitoring birds and small mammals in revegetated areas. TREAT members carry out the majority of nursery tasks and pot up on average 1,200 tree seedlings every Friday morning.

[1] Centre for Tropical Restoration: Queensland Parks and Wildlife Service, Lake Eacham, North Queensland, Australia.

THE YMCA FOR NORTHERN DEVELOPMENT FOUNDATION COMMUNITY FOREST PROGRAMME

Regine Nordern and Monkolsak Maichundang[1]

By using an innovative multi-religious and multi-cultural approach, the YMCA for Northern Development Foundation seeks to mobilise the energies of the traditional beliefs and wisdom of northern Thailand in combination with the benefits of modern technologies:

- to use natural resources in a sustainable way
- to combat slash-and-burn agriculture and deforestation
- to reduce destruction of watershed areas and contamination of soil.

In the Community Forest Program, the YMCA for Northern Development Foundation supports small communities of different ethnic groups by strengthening community solidarity and self-management capabilities of villagers to manage and protect their own forest resources.

Cultural and religious events or ceremonies like tree ordination, offering ceremonies for the forest spirits and also thanks-giving ceremonies are utilised to revive spiritual feelings of the people and to enhance their respect for nature.

Through the promotion of agro-forestry and organic farming, it is hoped that villagers will move towards more self-sufficient life styles, which will help reduce their expenditures and at the same time ensure a better protection of the environment and its resources.

The Foundation facilitates dialogue and co-operation among Buddhist monks, villagers, government officials, military and NGO's to create understanding and appreciation of nature and to enhance mutual support for the Community Forest Program.

Since 1993, the Foundation has assisted in the establishment of 10 Community Forests in Chiang Dao District of northern Thailand. The Love Chiang Dao Community Forest Group, which was created with support of the Foundation, acts as the network centre and co-ordinates all activities of the program; for example organising exhibitions and campaigns, establishing new community forests, administrating forest control and providing training on sustainable forest management.

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[1] YMCA Northern Development Foundation, 103 Korklang Rd., Nonghoi, Muang, Chiangmai 50000, Thailand.

COMMUNITY FORESTRY IMPACT MODEL FOR THE NEPAL-UK COMMUNITY FORESTRY PROJECT

David Young[1]

The aim of the project is to develop a conceptual model which demonstrates the benefit of moving from a relatively passive, protectionist level of community forestry management, to active intervention by communities. It was initially developed for the Nepal-UK Community Forestry Project in 1994 as a toll to inform policy-makers on the need for ongoing support to Forest User Groups so that the forest resource under community management could provide its potential biodiversity and socio-economic benefits. The model focuses on the transition from the former to the latter management system. It has three purposes:

1. To improve the understanding of the potential benefits which communities might realise in order to inform and improve their decision-making.
2. To maintain a strategic model of the community forestry intervention, initially for Koshi Hill, but potentially for the whole of Nepal, in order to inform policy makers and others of the relative importance of community forestry in the national economy.
3. To maintain an evaluation tool to determine the cost and benefits of interventions and to inform project advice.

The conceptual model is of use for other practitioners to use to help identify the ecological as well as the socio-economic implications of community forestry.

[1] Rural Forestry Development Consultant (currently working for VSO Thailand, Apartment 301, 233 Hydon Compound, Sukhumvit Soi 4, Watthana)

Melia toosendan Sieb. & Zucc. (Meliaceae) – one of the fastest growing tree species used in forest restoration. Can grow to 10 m tall within two years, providing excellent perch sites for birds.

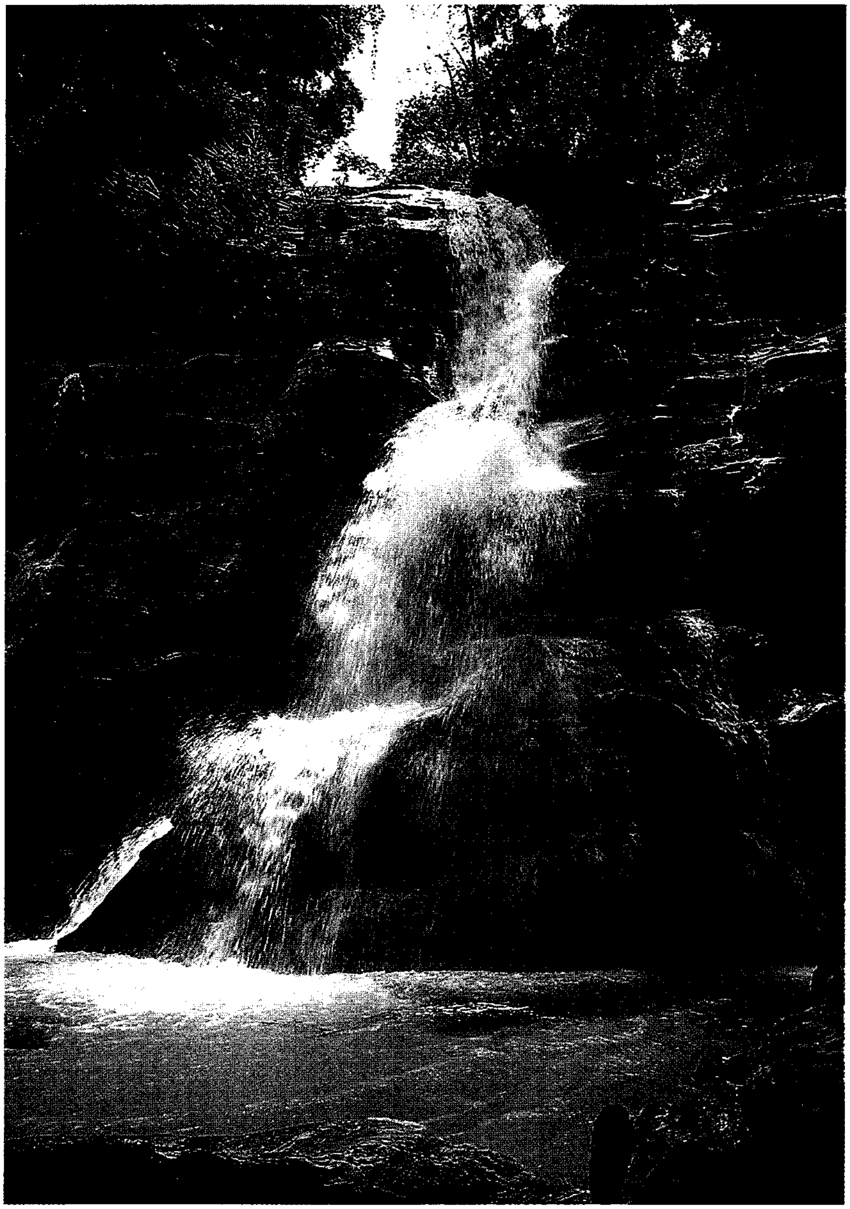
PART SEVEN

THE CHIANG MAI RESEARCH AGENDA FOR THE RESTORATION OF DEGRADED FOREST LANDS FOR WILDLIFE CONSERVATION IN SOUTHEAST ASIA

Editor

Stephen Elliott

This agenda was compiled by small discussion groups during the workshop and refined by feedback sessions and a final vote.



A reliable water supply all year round –what role can forest restoration play? (see proposal 5.2).

INTRODUCTION

Stephen Elliott[1]

The two main objectives of the workshop on Forest Restoration for Wildlife Conservation were:

1. To prepare an agenda for the advancement of research on forest restoration for wildlife conservation in Southeast Asia's seasonally dry tropical forests.
2. To establish a protocol for the exchange of information on forest restoration research throughout Southeast Asia.

These objectives were achieved by dividing workshop participants into 3 small discussion groups (comprising 15-20 persons each), which simultaneously considered each main workshop topic, following presentation of the papers printed in parts 2-6 of these proceedings. The discussion groups were provided with guidance in the form of lists of questions (see appendix) to help them to i) identify gaps in knowledge concerning each of the main workshop topics, ii) prioritise the most important areas requiring urgent research and iii) suggest outline research ideas to fill those gaps in knowledge considered to be of highest priority. Discussion group chairpersons presented the research suggestions from each group to the whole assembly for feedback. A total of 136 topics were suggested for further research. Several of these were similar in nature and have been amalgamated or grouped together in this report.

On the final day of the workshop, participants were asked to nominate 10 topics they considered were the most important and 3 requiring further research most urgently. The most important topics that the majority of workshop participants nominated for urgent attention were **plantation design** (species composition, size, positioning etc.), **seed dispersal** and **fire management.** Masakazu Kashio cautioned workshop participants on the inadequacies inherent in ranking research priorities by rapid simple vote. Therefore, the detailed research proposals presented below cover not only those topics nominated as urgent and/or important by vote, but also those that may have received fewer votes but had strong consensus across all discussion groups (revealed when discussion group chairs presented their conclusions).

Based on notes taken during discussion and feedback sessions, members of the editorial committee drafted the outline research proposals presented below. Inevitably, to make the proposals complete, the editorial committee had to add some essential details that were not fully worked through in the limited time of the workshop. However, members of the editorial committee have been in constant contact with the primary advocates of each proposed topic and we feel that the agenda is a true representation of the consensus reached at the workshop. Other topics of lower priority suggested by some (but not all) of the discussion groups and those that did not receive many votes, are briefly listed at the end.

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RESEARCH AGENDA

1. PLANTATION DESIGN

Introduction

Plantation design is a broad concept that first arose during the workshop in the session on accelerated natural regeneration (ANR) and in nearly every plenary session and discussion group thereafter. It was felt that a greater understanding of the conditions under which ANR could contribute towards forest restoration was needed (1.1), so that plantations could be designed to maximise the combined benefits of both ANR and tree planting.

In planted plots, plantation design includes which tree species are selected and their relative proportions in the planting mix, planting density, the number of different tree species planted in each plot and the positioning of plots relative to nearest forest. Whilst planting too many trees or too many species is a waste of resources, planting too few could result in poor quality, low diversity habitat for wildlife or ultimately plantation failure. The need to establish a series of experimental plots to examine the costs and benefits of these various aspects of plantation design was seen as an urgent priority (1.2).

Enhancing the value of plantations as wildlife habitat by providing specialised resources, such as refuges, nesting sites etc. could be an effective technique to ensure that newly established plantations are more rapidly colonised by plants and animals. Although such techniques have been developed for temperate countries, very little work has been done on this in Southeast Asia. Further experiments on this approach were therefore considered highly useful (1.3).

Although many tree-planting programmes are underway in Southeast Asia, almost no monitoring of wildlife in restored forest areas is being undertaken. This means that the relative success or failure of plantation designs currently in use is not adequately assessed in terms of wildlife conservation. Therefore, the benefits of restored forests for wildlife are often undervalued or ignored because they are not quantified. In order to assess the effects of the various aspects of plantation design, more efficient monitoring of wildlife was seen as essential (1.4)[2].

Stephen Elliott

[2] See also TUCKER in Part 5 of these proceedings.

1.1 Assessing the potential of degraded sites for restoration by accelerated natural regeneration (ANR)

Rationale

Accelerated natural regeneration (ANR) is a cost-effective approach to forest restoration, based on encouraging natural plant succession. However, it is only appropriate where sufficient woody regeneration already exists or where a source of seeds exists nearby. This research project is proposed to develop protocols and indices to rapidly assess sites for their potential for restoration by ANR.

Objectives

1. To determine the maximum distance from the nearest forest seed source at which ANR will be effective.
2. To determine which soil and vegetation parameters predict the potential of a site to be successfully restored by ANR.
3. To develop site assessment indices based on these parameters.

Methodology

Establish long-term sample plots within cleared areas at exponentially increasing distances from the nearest forest edge up to a distance of several kilometres. Replicate to include different levels of disturbance. In each plot, measure the number of tree seeds and species in the soil seed bank and seed rain to establish the maximum distance that seeds are dispersed from the forest. Within that distance, measure the following variables in sample plots:

1. Density and species composition of the tree seedling community; mean seedling heights (absolute and relative to weed canopy) and basal areas.
2. Soil: horizon depths, organic matter, field capacity, maximum daytime temperature, selected "indicator" micro-organisms.
3. Species diversity of wildlife and population density of key wildlife species.

Repeat seed and seedling measurements in sites of different known ages or, where possible, in consecutive years to create a dynamic model of regeneration over time. Compare seedling and soil variables to see which best predict regeneration outcome.

Expected Outputs

1. Guidelines relating ANR potential with distance to nearest seed source.
2. A protocol for surveying site vegetation (e.g. number and size of plots, variables to be recorded).
3. Interpretive index to predict regeneration rate (e.g. time to canopy coverage) from site vegetation and soil data.
4. Identification of tree species unable to establish by ANR and recommendations for enrichment planting.

Drafted by Kate Hardwick

1.2 Establishing experimental plots to determine optimal plantation design

Rationale

Many aspects of plantation design are arbitrary or inherited from commercial forestry and their effects on wildlife have not been adequately researched. For example opinions at the workshop about planting density varied from the traditional 4x4m spacing, often used in commercial forestry, to 3 trees/m^2 for the intensive Miyawaki method. Many participants felt that the basis for these densities was obscure and their effects on wildlife had not been adequately tested. Planting too densely wastes resources, whilst planting too sparsely delays canopy closure and might lead to reclamation of areas by weedy vegetation. The number of species that should be planted was also debated. Producing large numbers of tree species in nurseries is expensive, but planting too few might result in poor wildlife habitat. There was a strong consensus that all these aspects of plantation design and others should be tested by a large series of experimental plots.

Objective

To determine optimum designs that will maximise the value of restored forest areas as wildlife habitat under various conditions.

Methodology

1. Establish a series of control and experimental plots replicated in different vegetation types and in different countries. Within the treatment plots, vary the following characteristics:
   a) Tree planting density
   b) The number of tree species planted
   c) The species composition of planted trees
   d) Distance from nearest forest

   This would result in a very large set of treatment combinations and it was accepted that not all variables could be tested at every location.
2. Within the plots, monitor the following variables to assess the successfulness of the various treatments in creating wildlife habitats:
   a) Performance (growth and survival) of the planted trees.
   b) Recruitment of non-planted trees and diversity of ground flora.
   c) Species diversity of wildlife and population density of key wildlife species.
3. Compare results from treatment plots with those from non-planted control plots, to assess the effects of the various treatments.

   NB: The experimental design would be very similar to that proposed to study ANR (1.1). In fact the ANR plots could function as control plots for this research. Thus the two experiments could be combined into one set of plots.

Expected Outputs

Practical recommendations to improve plantation design and ensure that tree planting provides optimal habitat for wildlife.

Drafted by Stephen Elliott

1.3 Enhancing habitat diversity in plantations

Rationale

Most restoration methods involve tree-planting to establish a habitat matrix, in anticipation that wildlife will colonise planted areas. This can result in uniformity of habitat in the early years. To maximise the potential of plantations to attract wildlife, it is often necessary to artificially increase habitat diversity. Whilst knowledge of habitat requirements for most tropical wildlife is sparse, certain ecological principles can be used to artificially construct and introduce suitable habitat features to attract wildlife into planted sites. Such techniques are more developed in temperate habitats and may be suitable for adaptation to the seasonally dry tropics. Target wildlife species will vary geographically but will usually have high conservation value or fulfil key ecological functions.

Objectives

1. To identify habitat requirements of target wildlife species and features that could be artificially introduced into planted sites to attract wildlife.
2. To test the practicability of constructing such features under field conditions and their effectiveness in attracting target wildlife species.

Methodology

1. Identify target wildlife species and analyse available data on their habitat requirements.
2. Literature search of habitat reconstruction techniques, to identify those that can be adapted for the target species. The following suggestions might be investigated:
   a) Artificial constructs, e.g. rock-piles, perches and hibernacula.
   b) Acceleration of natural ageing processes, e.g. woodpiles, excision of bark to create rot-holes.
   c) Provision of topographical features to increase micro-climate diversity, e.g. damp hollows, basking platforms.
3. Construct and test the habitat features in new plantations by:
   a) Baseline monitoring of existing wildlife species in treatment and control plots
   b) Addition of the habitat features to treatment plots.
   c) Repetition of wildlife monitoring in the plots with particular observations of the use of habitat features.
   d) Using initial results to modify and manipulate the habitat features, followed by repeat monitoring.

Expected Outputs

1. Information on which habitat features are most effective at attracting target wildlife species into sites in the early stages of restoration.
2. A protocol for adapting techniques from other geographical areas, using ecological principles.

Drafted by Janice Kerby

1.4 Wildlife monitoring in new plantations

Rationale:

Despite a consensus on the importance of forest restoration for wildlife conservation, very little monitoring has been undertaken of colonisation of restored sites by plants and animals. Species that can be used as indicators of success for forest restoration projects have not yet been identified. Without such monitoring, it is not possible to assess and improve restoration techniques, or to justify work to funders. Identification of species that might indicate successfulness of forest restoration projects will vary among countries, but the general principle should be applicable everywhere.

Objectives:

1. To identify indicator organisms of forest health and successful restoration.
2. To improve assessments of forest restoration trials (such as those outlined in 1.1 and 1.2), by refining wildlife monitoring methods

Methodology:

1. Identify indicator organisms of forest health in different functional groups (e.g. producers, consumers, decomposers). These may include generalists, specialists and rare species.
2. Review the literature to identify and refine suitable methods to survey the identified indicator species.
3. Undertake comparative surveys in intact forest and sites subjected to different restoration regimes to test different wildlife monitoring techniques and assess the following:
   a) Plant and animal species movement into restored sites; population composition and demographics, using genetic markers.
   b) Animal behaviour when colonising new sites, including movement between intact and restored forests and interactions with existing populations.
   c) Patterns of succession in colonising flora.
   d) Whether restored forest ecosystems become fully functioning e.g. productivity, nutrient cycling, reproduction etc.
   e) Whether faunal populations are sufficiently well established to breed in the restored sites or are just utilising the area for food or shelter.
   f) Whether certain animals exist as isolated populations or as part of functioning meta-populations.
   g) Whether key seed-dispersers establish and facilitate forest regeneration.

Expected Outputs:

1. A list of indicator organisms that can be used to compare the effectiveness of different techniques to restore forests for wildlife conservation.
2. Improved techniques for wildlife monitoring in forest restoration experiments leading to improved forest restoration methods for wildlife conservation.

Drafted by Janice Kerby

2. SEED DISPERSAL

Introduction

Seed dispersal was a recurrent theme throughout the workshop, attracting particular attention in the sessions on accelerated natural regeneration (ANR) (see Part 3 of these proceedings), tree species selection for planting (Part 4) and wildlife (Part 5). In the session on ANR, seed dispersal was identified as an essential factor influencing natural regeneration. In increasingly fragmented landscapes, forest regeneration depends on dispersal of seeds, over long distances, from remnant forest fragments into cleared areas. Research on the effect of distance from a seed source on site regeneration potential was covered in research proposals on plantation design (see proposals 1.1 and 1.2). However, it was also felt that not enough was known about the mechanisms of seed dispersal, in particular the ecology of animal seed-dispersers. This research need was reiterated in the session on wildlife. The first step would be to identify important indigenous animal seed-dispersers (proposal 2.1). Research would then focus on relevant aspects of the ecology of these animals; such as the impact of habitat degradation on population levels and the likelihood that particular species would use and traverse degraded habitats.

On a more applied level, several discussion groups highlighted the need to manage sites in order to maximise seed dispersal into cleared areas. In the discussion on ANR, it was felt that more information was required on the use of isolated trees as perches to encourage bird visitation (2.2). Knowledge of the circumstances under which perches can accelerate natural regeneration was considered useful, as the effect may vary in relation to certain site conditions, such as weed cover and distance from the nearest forest.

The role of bats as seed dispersers received particular attention in several sessions. Workshop participants considered that knowledge of bats as seed dispersers was less well advanced, compared to that of birds. Therefore, it was proposed that further research on the ecology of bats and the management of sites to promote their visits was an urgent priority (2.3). In the session on tree species selection, the focus was more on the need to identify mixtures of tree species that are attractive to seed dispersers. Important traits of tree species selected for planting include regular and prolific production of fruit that are attractive to wildlife, the production of fruit at an early age and structural diversity.

Kate Hardwick

2.1 Identifying major seed dispersers

Rationale

Forest restoration projects can plant only a limited number of tree species, resulting in low species richness compared with primary forest. Natural seed dispersal must be encouraged (especially of those tree species which cannot be grown in nurseries and planted), to complete restoration and re-establish a more diverse forest ecosystem[3]. Identification of important seed-dispersing animal species is critical, so that such species can be encouraged to colonise newly planted sites. Animals migrating from natural forests will potentially carry seeds into forest restoration sites. Many animal species are involved in seed dispersal and it would be impossible to design a planting scheme that attracts them all. Thus, major seed-dispersers that feed on a wide range of forest trees or on tree species vital to ecosystem function, need to be identified.

Objectives

1. To identify plant species critical to ecosystem function, but not suitable for nursery propagation and planting.
2. To determine which animals have the greatest potential to disperse the seeds of such plant species into forest restoration sites.

Methodology

1. Review literature to identify species or families of trees that play a critical role in the full functioning of natural forest ecosystems.
2. Study intact forest to determine which tree species fall into the above category.
3. Identify which of those tree species cannot easily be propagated for planting, then determine which animals are potential seed-dispersers of such tree species.
4. Study the behaviour of the animals identified as potential seed dispersers, to detect behavioural traits which affect their efficiency as seed dispersers, e.g:
   a) presence and viability of seeds in their faeces
   b) seed burying for storage
   c) prolonged retention of seeds in gut or externally
   d) propensity to travel long distances between forest and open degraded areas
   e) rejection of seeds once the fruit has been eaten

Outputs

1. A greater understanding of which animals are critical seed dispersers for forest restoration and their seed-dispersing behaviour.
2. The potential to improve plantation designs to attract such animals into deforested areas undergoing restoration.

Drafted by Janice Kerby

[3] See TUCKER and CORLETT & HAU in Part 5 of these proceedings.

2.2 Isolated trees as perches

Rationale

Forest regeneration on degraded sites dominated by herbaceous weeds can be limited by a diminished seed rain caused by a scarcity of birds, as a result of low structural complexity of the vegetation. The presence of bird perches might reduce this problem[4]. Although isolated trees in degraded landscapes provide bird perches and increase the seed rain, the effects of tree species and architecture, landscape variables (vegetation structure, distance and amount of forest in the surrounding landscape), weed competition and seed predation on seedling recruitment beneath perch trees are less well-known.

Objectives

1. To evaluate the effects of different tree species and tree architecture on the seed rain and seedling recruitment beneath isolated perch trees in degraded areas.
2. To assess the influence of vegetation type and landscape variables around perch trees on their capacity to attract birds and enhance tree seedling recruitment.
3. To maximise tree seedling recruitment beneath perch trees by testing the effects of different weed control methods and seed predator exclusion.

Methodology

1. Identify isolated perch trees in various vegetation types, with different amounts of forest at different distances in the surrounding landscape.
2. Monitor behaviour and diet, of bird species that perch in trees by direct observation and analysis of faeces. Attempt to germinate seeds found in faeces.
3. Monitor the quantity and species composition of the bird-dispersed seed rain (with seed traps) and survey seedling recruitment beneath perch trees, compared with control points with no perch trees.
4. Analyse results to determine the effects of tree species and architecture, vegetation structure and the amount and distance of forest in the surrounding landscape on seedling recruitment.
5. Test the effects of different weeding methods and seed predator exclusion on seedling establishment.

Expected Outputs

1. Knowledge of which tree species are most effective at enhancing seed-dispersal.
2. A better understanding of how vegetation structure and landscape variables influence the capacity of perch trees to increase the bird-dispersed seed rain, leading to more efficient ANR techniques.
3. Improved plantation designs and silvicultural methods to maximise tree seedling recruitment beneath perch trees.

Drafted by Kevin Woods and George Gale

[4] See SCOTT *ET AL.* in Part 5 of these proceedings.

2.3 Investigating and enhancing the role of bats as seed-dispersers

Rational

It was generally accepted at the workshop that ANR or tree-planting could restore relatively few tree species to any particular site and that wildlife is essential to disperse the seeds of a much wider range of tree species into sites undergoing restoration. All major groups of seed-dispersers require more research, but it was felt that bats had been least researched and were a top priority. Bats have a great potential to assist forest restoration, due to their high species diversity, high biomass, and their capacity to transport both small and large seeds over long distances[5].

Objective

1. To quantify the effectiveness of bats as seed-dispersers from forest into deforested areas undergoing restoration.
2. To develop methods to encourage bats to disperse seeds into deforested areas undergoing restoration.

Methodology

1. Review literature and assess indigenous knowledge of bats in deforested areas, by interviewing local people.
2. Collect bats' faeces in seed traps and determine which seeds germinate from them.
3. Carry out surveys to identify bat species that travel between forest and deforested areas.
4. Determine which species of planted trees are most attractive to bats as food sources or roosting sites.
5. Carry out test plantings of tree species that are attractive to bats, to see if bat populations can be increased.
6. Erect bat boxes in forest restoration areas to determine if they are effective at attracting bats. Assess the effects of different box designs or positioning on the attractiveness of the boxes to bats (could be included in proposal 1.3).

Expected Outputs

1. A better understanding of the role of bats in dispersing seeds into areas undergoing forest restoration.
2. Practical techniques to encourage bats to disperse seeds into areas undergoing forest restoration.

Drafted by Stephen Elliott

[5] See CORLETT & HAU in Part 5 of these proceedings.

3. FIRE ECOLOGY AND MANAGEMENT

Introduction

Fire is a serious, but little understood, problem throughout the tropics, requiring substantial research to reduce its damaging impacts. Workshop participants recognised that fire kills vast numbers of both planted and naturally established young trees throughout the region and agreed that it was the most common cause of forest restoration failure. Many participants described essential fire prevention measures (e.g. firebreaks, patrols, education programmes etc.) to protect forest restoration sites from fire[6]. Such measures often constituted the most expensive part of forest restoration schemes.

Although the disastrous effect of fire on young trees was recognised as a major silvicultural issue, its effects on other plants and animals are largely unknown. Participants briefly discussed the likely impacts on soil micro-organisms. It was concluded that the effects of a slow burn would be particularly damaging and could degrade the soil biota. It was unknown how long it might take the soil ecosystem to recover, but it was suggested that study of land subject to rotational slash and burn systems might yield useful data. Fire also affects other plant and animal communities essential for successful forest restoration, such as seed-dispersing birds and mammals, both through direct mortality and habitat loss. Loss of vegetation also exposes animals to hunting. Indeed, this is one of the main reasons why fires are deliberately started in the region. The relationship between fires and local communities was also discussed, in relation to the causes of fires and fire prevention.

Considerable anecdotal evidence was contributed on the effects of fires, on young trees. It was observed in Thailand that pines had the highest survival after fire, as their leaf buds are so tightly wrapped that they exclude oxygen around them and so do not burn; thus they readily re-sprout after fires. Many participants recognised that coppicing after fire was common in many tree species, but that little was known about regrowth from stumps and how this affected the structural stability of the tree[7]. Whereas trees may recover by coppicing after a single fire, repeated fires deplete energy reserves, so that coppicing no longer occurs. Participants recognised that the limited research that has been undertaken to identify fire-tolerant tree species was inadequate and recommended further studies (3.1).

Several participants suggested that controlled (or prescribed) burning could prevent accumulation of dead vegetation that provides fuel for fires and thus reduce damage by uncontrolled wildfires, but research to develop effective and safe controlled burning techniques was considered inadequate or non-existent in some areas (3.2). If a site burns every year, the fuel load will be low, but tree seedlings will be killed. With longer intervals between fires, many seedlings might have grown large enough to resist fire, but the fuel load would be greater and fires would be more damaging. The issue of timing of controlled burns in relation to the dry and wet seasons was also discussed, as was the cost of effective fire-prevention versus the value of the damage caused by a fire.

Janice Kerby

[6] See especially SVASTI in Part 2 of these proceedings.
[7] See HARDWICK *ET AL.* in Part 3 of these proceedings.

3.1 Identification of fire-tolerant tree species for forest restoration

Rationale

In seasonal Southeast Asia, forest restoration often fails because planted trees are destroyed by fire during the dry season. In most areas, fire is an annual hazard that cannot be completely prevented. However, intensive fire prevention measures during early establishment of forest restoration plots, combined with use of fire-resistant tree species can maximise success. Research is needed to identify native species that are fire-resistant or resilient.

Objective

To identify native tree species, which can resist burning or rapidly recover after fire damage (subsequently referred to as fire-tolerant).

Methodology

1. Review literature to identify tree species with the following fire-tolerant characteristics:
   a) high growth rate (i.e. the canopy is quickly elevated above low-level flames);
   b) thick, insulating bark;
   c) insulated or protected buds;
   d) the capacity to resprout from burnt stumps or produce root suckers.
2. Interview local people to review indigenous knowledge of which tree species might be fire-tolerant.
3. Draft a list of species most likely to be fire-tolerant.
4. Establish field trials of such tree species in a non-protected area. Test the response of planted trees to fire at different ages, comparing different intensities and frequencies of fire.
5. Replicate study across different vegetation types and fire regimes to ensure that results generated are locally relevant
6. Subsequently, extend field trials to test the fire-tolerance of species about which there is no prior knowledge.

Expected Outputs

1. A ranked list of fire-tolerant species for each region, detailing the age and/or size at which each species becomes resistant or resilient to fire.
2. A greater understanding of the responses of trees to different frequencies and intensities of fire.
3. A greater understanding of the mechanisms of fire-tolerance in trees.

Drafted by David Blakesley and Kate Hardwick

3.2 Assessing the feasibility and effects of prescribed burning as a fire prevention method

Rationale

One way to prevent fire destroying forest restoration schemes is to reduce accumulation of dead plant material that constitutes fire fuel. Prescribed burning has been advocated as a method to reduce fuel accumulation, when weather conditions and moisture in the vegetation can minimise damage. Little research has been done on how prescribed burning might be used most effectively. More information on the impacts of the timing and frequency of burns is needed. All fires damage trees and wildlife to some extent, but it may be possible to minimise damage by careful development of this technique. Field experiments with fire will be controversial. Experimental sites must be carefully selected and experiments must be fully explained to local people, to prevent misunderstandings.

Objectives

1. To determine if prescribed burns reduce long-term fire damage to restored forests by preventing larger, uncontrolled wildfires.
2. To determine the optimal frequency and timing of prescribed burns.

Methodology

1. Identify sites, where prescribed burns can be conducted safely, which include a range of different weedy vegetation types. Establish forest restoration trials (or use existing ones); delineate treatment plots and create firebreaks around control plots.
2. Undertake baseline monitoring of planted and naturally established trees, ground flora, seed-dispersing animals, pollinators, soil invertebrates and micro-organisms.
3. Carry out controlled burns at various times of the dry season and at different frequencies in replicated treatment plots.
4. Repeat monitoring to determine the effects of the prescribed burns.
5. Allow plant biomass to accumulate for periods of 3 months to 2 years and then carry out uncontrolled burns across both treatment and control plots.
6. Repeat monitoring to determine differences in the damage caused by the uncontrolled burns between the treatment and control plots.

Expected Outputs:

1. Data on the relative impacts of controlled and uncontrolled burns on tree seedlings, ground flora and keystone animals.
2. Clarification of whether controlled fire can be used as a tool for protecting restoration sites from wildfire and if so, identification of the most effective methods to achieve this.

Drafted by Janice Kerby and Stephen Elliott

RESEARCH AGENDA

4. SPECIES SELECTION, NURSERY AND PLANTING TECHNIQUES

Introduction

Although topics under the heading of species selection, nursery and planting techniques were not strongly nominated for further research by participants in the final vote, they are an essential prerequisite for most of the other research proposals advocated in this agenda. For example, although the general principles of the framework species method of forest restoration found wide support amongst the participants, identification, propagation and field trials of framework species has only been carried out in northern Thailand[8] and Queensland, Australia[9]. Before experimental plots can be established region-wide, to test plantation design (see 1.2), it is first necessary to select appropriate tree species for each area of the region and learn how to propagate and plant them. Such basic research has not been done in most countries in the region. Neglecting to do it would severely constrain future forest restoration research efforts. Therefore, it is included in this agenda (proposal 4.1).

Forest geneticists at the workshop stressed that genetic considerations are of paramount importance, if forest restoration for wildlife conservation is to be scaled up from experimental plots to nation-wide or region-wide programmes. Participants acknowledged that in most forest restoration experiments, seeds are usually collected from a few trees that are well known to project staff. Participants acknowledged the risks of such practices, in narrowing the genetic base of future large-scale plantations. It was recognised that the low number of votes in favour of genetic research was due to low representation of forest geneticists at the workshop, but that genetics is a critical issue for the long-term viability of forest restoration programmes. A written submission, after the workshop was therefore accepted for inclusion in the agenda (proposal 4.2).

Of all the nursery and planting techniques, it was felt that direct seeding was least understood and had most potential for reducing the costs of forest restoration programmes. The results of direct seeding have been highly variable in different parts of the region and very little research has been done to refine the technique. Further research on direct seeding, therefore, was strongly endorsed by workshop participants (proposal 4.3).

Stephen Elliott

[8] See ELLIOTT *ET AL.* in Part 4 of these proceedings.
[9] See TUCKER in Part 5 of these proceedings.

4.1 Identification of framework species in different bio-regions

Rationale

Natural forest can be restored by planting mixtures of "framework tree species" to complement natural regeneration. Framework tree species attract seed-dispersing wildlife and catalyse tree recruitment, by suppressing weeds and ameliorating soil and microclimate conditions. This technique has been tested only in Queensland, Australia and Chiang Mai, Thailand[10]. Whilst the basic principles of the method are applicable throughout Southeast Asia, further research is needed to identify appropriate framework tree species for each part of the region, develop suitable propagate techniques and appropriate planting and silvicultural methods to suite the various ecological and socio-economic conditions that exist in various parts of the region.

Objectives

1. Define bio-regions within participating countries.
2. Identify appropriate framework tree species within each bio-region.
3. Develop nursery production and silvicultural methods for such framework species.

Methodology

1. Review climate, topographic and vegetation data to define bio-regions. Identify host institutions within each bio-region. Establish field stations with nurseries, forest study plots and potential restoration sites.
2. Review literature and indigenous knowledge to develop lists of potential framework species by considering:
   a) seed availability and ease of propagation,
   b) field performance and canopy structure,
   c) provision of wildlife resources (e.g. fruit, nectar, perches, etc.) at a young age.
   Identify gaps in coverage of secondary data.
3. Carry out phenology studies and nursery trials to develop efficient propagation methods for potential framework species (e.g. germination treatments, fertiliser, pruning and watering regimes etc.).
4. Carry out field trials as described in proposal 1.2. Also test silvicultural techniques such as fertiliser application, mulching and weeding methods and record time to flowering/fruiting and drought- and fire-tolerance of the planted trees.
5. Expand the study to test species that do not feature in the literature or indigenous knowledge.

Expected Outputs

1. Reference data and lists of framework tree species suitable for planting for each bio-region investigated in Southeast Asia.
2. Ultimately more successful forest restoration programmes throughout the region.

Drafted by Kate Hardwick and David Blakesley

[10] See papers by TUCKER in Part 5 and ELLIOTT *ET AL.* in Part 4 of these proceedings.

4.2 Maintenance of genetic diversity within plantations

Rationale

The 1992 Convention on Biodiversity emphasised the importance of maintaining intraspecific genetic diversity and evolutionary potential. When planting native forest trees, adaptability and maintenance of a broad genetic base must be ensured. Forest restoration is usually initiated using small populations of planted trees derived from few parent trees. Genetic variation in this founding population is critical, particularly if restored areas are far from pollen sources. Molecular techniques provide a valuable tool for measuring the genetic diversity of trees, thus enabling better genetic management for forest restoration.

Objectives

1. To establish guidelines based on current literature, to reduce genetic erosion when collecting seed or cuttings of tree species used for forest restoration.
2. To assess intraspecific genetic diversity in selected framework tree species by microsatellite (SSR) marker analysis.
3. To use SSR data to select parent trees that have maximum genetic diversity.

Methods

1. Review literature on best forestry practices and conservation biology, related to genetic maintenance. Draft genetic guidelines for forest restoration, considering:
   a) seed collection (forest floor vs. tree; seed distribution on a selected tree);
   b) distance between parent trees (seed and pollen dispersal distances);
   c) minimum number of parent trees and
   d) location of parent trees (genetic diversity within and between local populations, selection from appropriate ecotype).

   Information currently available will allow some of these questions to be answered, to immediately improve current seed collection practices.
2. Select framework tree species (see 4.1) and develop polymorphic SSR markers; identify and characterise SSR's or use suitable markers identified from the literature.
3. Collect plant material from a minimum of 25 trees in each sub-population under investigation.
4. Examine levels of genetic diversity within and among sub-populations.
5. Examine levels of genetic diversity within seed progeny to give an estimate of pollen donors.
6. Analyse data to identify groups of parent trees with maximum genetic diversity.

Outputs

1. Guidelines for the selection of parent trees for seed collection and vegetative propagation of species used for forest restoration.
2. Application of SSR's to select parent framework trees for forest restoration.

Drafted by David Blakesley

4.3 Direct Seeding

Rationale

Direct seeding could be a much cheaper method of establishing mixed plantations of framework tree species than planting saplings grown in nurseries. The technique could be used on its own or to complement ANR or conventional tree planting. However, the effectiveness of direct seeding might be limited due to seed predation, low germination rate or seedling mortality in the harsh conditions prevalent in deforested areas. Workshop participants agreed that direct seeding had not been adequately tested by controlled field trials and that further research in this area could substantially reduce the costs of forest restoration projects.

Objectives

1. To determine which tree species can be established by direct seeding.
2. To determine the site conditions under which direct seeding is most successful.
3. To develop and test pre-treatment and sowing techniques to reduce seed predation and maximise seed germination and seedling establishment after direct seeding.

Methodology

1. Select a range of tree species with different seed characteristics so that generalisations can be made as to which seed types are suitable for direct seedling.
2. Establish experimental plots to test the effectiveness of direct seeding. Replicate plots in different locations to test the effects of site conditions (e.g. vegetation, climate, seed predator populations etc.) on the outcome of direct seeding.
3. Test various treatments that might increase the effectiveness of direct seeding such as :
    a) Pre-treating the seed to accelerate germination after sowing, to reduce the time available for seed predators to attack the seeds.
    b) Pre-treating the seeds with chemicals that deter seed predators.
    c) Burying the seeds at different depths.
    d) Sowing the seeds at different densities.
    e) Weeding to remove cover for seed predators and reduce competition.
4. It was suggested that direct seeding might be particularly useful for establishing large-seeded, shade tolerant tree species, beneath the canopy of previously planted trees to enhance biodiversity. Experimental plots could be established to test the effectiveness of this hypothesis.

Outputs

1. A better understanding of the conditions under which direct seeding is successful and cost-effective.
2. A better understanding of tree species or types of seeds suitable for direct seeding.
3. Development of effective techniques to increase success of direct seeding.

Drafted by Stephen Elliott

5. SOCIAL AND COMMUNITY ISSUES

Introduction

The subject of community forestry recurred in several sessions during the workshop, highlighting its multi-disciplinary nature. The results of voting reflected the importance of social and community issues in forestry, with more research proposals arising from this session receiving a significant number of votes than from any other session. This indicates a need to develop greater understanding and skills to increase involvement of communities in the implementation of forest restoration projects. Each major category of social and community issues contained at least one sub-topic that received many votes, reflecting the need to address a diverse array of community issues, in order to work more effectively with local people. Although most participants did not consider any social and community topics as urgent, three areas of research were nominated as important: determining the factors which motivate villagers to become involved in forest restoration; the effects of forest restoration on water supplies and sustainable harvesting of forest products.

Throughout the workshop, integration of forest restoration for wildlife conservation with local community needs was stressed. Providing incentives for local people to become involved in forest restoration was seen as essential, but many participants felt not enough was known about the factors that motivate villagers to become involved in forest restoration. Many motivating factors were suggested, such as increasing income through employing paid labourers, improving food security, security of land tenure, reducing erosion and bringing value and pride back to communities. Further study of these and other incentives was considered important (proposal 5.1).

Several speakers identified improved water resources as one of the most important advantages of forest restoration for local communities. The issue of watershed conservation was raised throughout the discussions as it encompasses many components of forest restoration, but participants considered that the relationship between forest restoration and water supply had been poorly researched and that further research in this area would be useful (5.2).

The right to harvest products from the forest was also seen as a strong incentive for local people to become involved in forest restoration. However, the need to ensure that harvesting is sustainable and does not impact on wildlife was also considered to be important. Ascertaining the carrying capacity of restored forests was voted as the third most important topic of the workshop, but it was recognised that little work has been done on this (5.3).

Kevin Woods

5.1 Motivating local people to become involved with forest restoration

Rational

Most areas where forest restoration for wildlife conservation has been implemented are small and experimental. Once suitable technologies to restore forests for wildlife have been developed, it will be necessary the scale-up activities to cover large areas. This will involve enlisting the support of local communities, if forest restoration is ever to significantly increase wildlife. Restoring forests for wildlife conservation might appear to offer few rewards to local communities and might even conflict with the requirements of rural villagers for agricultural land. However, workshop participants identified a wide range of reasons why local people become involved in forest restoration programmes, from the provision of water and forest products to the development of ecotourism, new employment opportunities and greater political recognition. There was general consensus that these needed further study, to determine which incentives created greatest motivation and whether incentives that worked in some countries might be transferable to others.

Objective

To identify the most important incentives and disincentives for local communities to accept or reject forest restoration projects in their vicinity.

Methodology

1. Select communities throughout Southeast Asia that actively participate in forest restoration programmes and those that have rejected such programmes.
2. Identify the main incentives and disincentives for local people to become involved in forest restoration programmes through participatory appraisal.
3. Transfer incentives from communities that participate in forest restoration to those that have rejected it.
4. Monitor changing attitudes within the selected communities as a result of the introduction of new incentives.

Expected Outputs

1. A better understanding of the factors that motivate or deter local communities from becoming involved in forest restoration.
2. Ultimately a greater acceptance and understanding of forest restoration for wildlife conservation in more communities throughout the region

Drafted by Stephen Elliott

5.2 The effect of forest restoration on seasonal yield of water

Rationale

Emphasising the link between forest restoration and reliability of water supplies provides a strong incentive for communities to support forest restoration. However, there is much controversy over the effects of reforestation on seasonal water yield in the seasonally dry tropics. One argument is that forest restoration increases the water-holding capacity of soil and prevents soil erosion, thus increasing infiltration and storage. This results in increased flow during the dry season. Another view is that tree-planting increases net evapo-transpiration, which decreases yield in all seasons. More quantitative evidence from the seasonal tropics is required to resolve this debate. The problem requires broad-based studies of water yield in areas that have already undergone forest restoration as well as in-depth analyses of how water yield changes as forest restoration progresses.

Objectives

To test the hypothesis that forest restoration decreases catchment water yield during the rainy season, but increases yield during the dry season.

Methodology

1. Broad based studies of existing forest restoration plots.
   a) Identify water catchments that have already undergone forest restoration in a broad range of environmental conditions.
   b) Identify suitable paired control plots, which have remained deforested.
   c) Measure hydrological parameters that affect water yield. Analyse data to determine differences between restored forest plots and deforested plots.
2. In depth study of the mechanisms by which forest restoration affects water yield over time.
   a) Select paired deforested catchments in various locations with different environmental conditions.
   b) Measure hydrological parameters that affect water yield for several years to determine baseline conditions.
   c) Carry out forest restoration by tree planting or ANR in one catchment of each pair, whilst leaving the other one to regenerate naturally.
   d) Continue monitoring hydrological parameters for several years to determine changes in water yield as the canopy closes.

Expected Outputs

Statistical evidence of the effect of forest restoration on seasonal water yield in the seasonal tropics and how this varies according to factors such as bedrock and forest type.

Drafted by Kate Hardwick and Stephen Elliott

5.3 Sustainable harvest of products from restored forests in non-protected areas

Rationale

Restored forests in buffer zones or other areas outside national parks and wildlife sanctuaries can both support wildlife and provide products for local people. However, in order to maintain a healthy forest ecosystem that will continue to provide products in the long term, it is essential that harvesting of forest resources be carefully managed within sustainable limits. Local managers will need to develop methods to assess the productivity of forest resources, devise ecologically and socially acceptable harvesting strategies, monitor and evaluate levels of product extraction and implement a system of disincentives for those who over-harvest. The research proposed here aims to develop the knowledge that would be needed to implement such schemes.

Objectives

1. To identify target products.
2. To identify the type and age of restored forest that can support each product.
3. To determine the effects of product extraction on the ecology of restored forest.
4. To develop sustainable harvesting methods.

Methodology

1. Review existing literature and use participatory rural appraisal to identify target products that are desired by local communities but cannot be cultivated.
2. In restored forests outside protected areas, select study sites, which vary in age and species composition and are subject to low or no usage.
3. Survey the sites to determine
   a) initial condition of the forest and status of wildlife and
   b) productivity of the products to be harvested.
4. If absent or slow to establish, introduce the products to the sites.
5. Develop sustainable harvesting strategies with local people, by further participatory rural appraisal.
6. Implement experimental harvesting regimes for several years, to determine the sustainable yield.
7. Monitor the effects of product extraction on the forest and wildlife.

Expected Outputs

1. Best practice guidelines for product introduction and extraction in restored forests, which could be adapted by local managers to suit their particular natural and social environment.
2. Practical indices by which the sustainability of harvesting could be judged.

Drafted by Kate Hardwick

OTHER RESEARCH SUGGESTIONS

Accelerated natural regeneration

Effects of fire on wildlife habitats

Research to assess the affects of fire on the wildlife habitat value of sites undergoing forest restoration was suggested.

Effects of different weeding regimes on fire risk in forest restoration

Prolific growth of weeds in deforested areas provides fuel for fires. Weeding is necessary not only to reduce competition with planted trees, but also to reduce fire risk. The effects of different timing and methods of weed control on fire risk should be investigated.

Interactions between weeds and other wildlife

Weeds provide habitat for many wildlife species, but weeding is essential to maximise performance of planted trees and reduce fire risk. Experiments should be conducted to minimise any deleterious effects of weeding on wildlife.

Edaphic factors that limit forest regeneration

Forest regeneration is often limited by the hot, dry sunny conditions prevalent in deforested areas. Identification of the main limiting factors could lead to the development of better site management techniques to accelerate natural regeneration or improve the performance of planted trees. More research on light and soil factors was suggested with emphasis on soil moisture. Participants also suggested experiments to test new management techniques to overcome the identified limiting factors.

Disturbance

Forest restoration is often limited by disturbances such as fire, chopping and browsing. Experiments were suggested to determine how much disturbance could be tolerated before forest restoration would be inhibited.

Keystone species

Keystone tree species provide essential resources to wildlife, especially seed-dispersers and pollinators, in seasons of shortage. Research to determine the minimum viable populations of keystone tree species was suggested.

Fragmentation

Forest fragmentation was recognised as a major factor limiting pollination, seed dispersal and causing inbreeding in isolated wildlife populations. More research on the effects of fragmentation on forest restoration was suggested. Determination of the minimum viable size of restored forest patch, to minimise edge effects and maintain viable populations of wildlife, was also suggested for further study.

Soil seed bank

Research to assess the contribution of the soil seed bank to forest restoration and to develop management techniques to minimise damage to the soil seed bank and encourage germination was considered important by some workshop participants.

Existing vegetation

The existing vegetation on any restoration site can facilitate or hinder restoration efforts. More research on the interactions between planted trees and existing weeds or naturally established trees was suggested. Identification of plant species that might be antagonistic to forest restoration was suggested. The relationship between the age of a site and species diversity could be used to indicate the potential for restoration by ANR. This research would yield more effective weed control methods and improved ANR techniques.

Stump propagation

Tree stumps can be an important source of natural regeneration in forest restoration projects. Treatments to encourage tree stumps to sprout and grow well should be developed.

Models of forest regeneration

Develop models to predict the rate of natural regeneration based on soil factors, the seed bank and seed rain and the demography and species richness of naturally established trees.

Seed dispersal mechanisms

For many tree species, seed dispersal mechanisms remain unknown. Knowledge of seed dispersal mechanisms and distances can help to assess the likelihood of a tree species dispersing naturally into deforested areas and hence the need to plant it. Simple observational studies on seed dispersal mechanisms were suggested.

Species Selection

Criteria for species selection

Many characteristics were suggested as criteria for the selection of tree species for propagation and planting for forest restoration. Most of these characteristics are not known for the vast majority of forest tree species native to Southeast Asia. Therefore research to assess these characteristics for a wide range of species would be useful. The characteristics suggested included:

Drought tolerance – after fire, seasonal drought is the main cause of mortality of planted trees.

Multiple uses –tree species that provide products for local communities, as well as habitat for wildlife. The inclusion of domestic fruit trees in the planting mix was suggested for testing.

Species that provide specific food resources for wildlife[11].

[11] See also proposal 2.3.

Rapid maturation –tree species that flower and fruit at a young age.

Keystone species – trees that provide a reliable supply of food for wildlife during seasons of shortage

Limited seed dispersal –tree species with large seeds or those for which seed dispersal agents (e.g. large mammals) have become extirpated.

Resilience –species most able to regrow after damage (e.g. fire, chopping or browsing etc.).

Tree propagation

Fruiting phenology

More studies of the reproductive phenology of tropical tree species were suggested to help plan seed collection programmes.

Seed storage

Seed storage could greatly increase nursery efficiency and is essential for the distribution of tree species useful for forest restoration. It was recognised that little information is available on which species can be stored and for how long, before viability declines. More research in this area was recommended.

Seed Germination

More research on germination of native tree species that are difficult to germinate was considered to be useful. Testing of mechanical, chemical and thermal treatments to break dormancy was suggested.

Vegetative propagation

For all but a few commercially valuable tree species, vegetative propagation techniques have not been developed. Research to develop vegetative propagation techniques was considered important for species that cannot be propagated from seed. Research to establish hedges as sources of material for vegetative propagation was also seen as a priority.

Wildling propagation

Transplantation of tree seedlings from forests into nurseries or directly into forest restoration sites may provide a cheap alternative to raising planting stock from seed. However, transplantation methods have not been tested. Such factors as the optimum size of wildling for transfer and pruning methods, to reduce the shock of transplantation, need to be developed.

Improving the quality of planting stock

Various nursery techniques to improve seedling propagation were considered to be in need of further research. Determining optimum container size, potting medium, and regimes for watering, fertiliser application and root pruning were all identified as requiring further studies. The efficacy of using mycorrhizae to improve seedling growth was considered to be a priority. Improved nursery hygiene should also receive attention. Cost-benefit analyses were seen as an essential counterpart to the scientific research.

Planting and aftercare

Weeding methods

Weeding is one of the most costly aspects of forest restoration programmes. Research aimed at developing and evaluating simpler cheaper weeding techniques (such as flattening weeds with boards) should be carried out.

Effects of herbicides on soil micro-organisms

Non-residual herbicides (e.g. glyphosate) can provide a cost-effective method to control weeds in planted areas. Concern was expressed that such chemicals might inhibit soil micro-organisms (e.g. mycorrhizae) beneficial to trees or interfere with nutrient cycling. Research to monitor such effects should be initiated.

Evaluate impacts of pests and diseases in the field

Almost no information is available about the effects of pests and diseases on the performance of the vast majority of native forest tree species after they are planted out in deforested areas. Identification of pest or disease problems, assessment of their potential impact and, if necessary, the development of control methods was suggested for further research.

Community and Social Considerations

Forest restoration to reduce crop pests

In some circumstances, provision of forest habitat reduces the incidence of crop damage by wild animals. The potential for this effect in Southeast Asia should be investigated.

Markets and financial gains

The ability of local communities to make use of restored forest areas might depend on market conditions. Social research to identify interactions between local communities, forest use and financial gains should be implemented.

Information exchange

One of the main reasons why forest restoration programmes fail to be accepted by local communities is lack of communication between project implementers and key local people. Research to develop and test better methods of communication should be carried out.

Government policies

The effects of various government policies on forest restoration and how local people might benefit from them are not fully understood and are constantly changing. Continual research to provide feedback to governments on the effects of their policies on local communities and on wildlife conservation was seen as a necessity.

Zoning

It was felt that existing land zoning systems do not provide adequately for forest restoration areas and often disenfranchise local people. Further research to re-evaluate current zoning systems and develop improved systems was suggested.

Monitoring

Develop appropriate criteria and indicators to assess the results of community forest restoration programmes.

Drafted by Stephen Elliott

Appendix – guiding questions to assist discussion groups to identify important or urgent areas needing further research

SESSION 3 - THE ECOLOGY AND MANIPULATION OF NATURAL REGENERATION

1. What are the main ecological factors limiting natural forest regeneration in seasonally dry forests in SE Asia?
2. How can these ecological constraints be reduced or removed to accelerate regeneration of original forest ecosystems?
3. What experiments have already been carried out to manipulate natural regeneration or remove limiting factors? What techniques have been successful or unsuccessful?
4. For which of the processes of natural regeneration (seed production, dispersal, seed predation, germination, seedling establishment etc.) is knowledge least advanced?
5. Of those processes, which ones require further research most urgently or would result in the greatest advance in forest restoration programs? What would be the most useful experiments to establish in the near future?

SESSION 4 - SPECIES SELECTION AND TECHNOLOGIES FOR GROWING SEEDLINGS

1. What criteria should be used to select tree species for wildlife conservation?
2. What further work is required on species selection?
3. What methods of seed collection should be used to maintain genetic diversity within tree species being planted?
4. What techniques have participants used and found to be most effective at growing native forest trees in nurseries for planting in restoration projects? Discussion could consider different methods of seed collection, germination, potting techniques, fertilisers, pest control etc.
5. What nursery propagation techniques for native forest trees are least developed or least understood?

6. For which of those techniques, identified in 5, is further research most urgent or important?

SESSION 5 - PLANTING TREES AND SILVICULTURE

1. Which methods of tree planting and silviculture have participants used for forest ecosystem restoration; which ones work best and which have failed? This could include consideration of size at which saplings are planted, spacing, methods and frequency of weed control, fertilizer application, mulching, pruning, thinning etc.
2. What are the most important gaps in our knowledge of the ecological factors determining the performance of planted trees?
3. What would be the most useful scientific experiments to establish to fill these gaps in knowledge?

SESSION 6 - INTERACTIONS BETWEEN WILDLIFE AND FOREST RESTORATION

1. What are the positive effects of wildlife on forest restoration programs? How can these effects be encouraged?
2. What are the damaging effects of wildlife on forest restoration programs?
3. How can forest restoration programs be designed to provide habitats for wildlife?
4. What might be some adverse effects of forest restoration programs on wildlife?
5. What methods should be employed to monitor wildlife in restored forests and what key plants or animals should be monitored?
6. What experiments should be established to investigate interactions between wildlife and restored forests?

SESSION 7 - COMMUNITY INVOLVEMENT IN FOREST RESTORATION FOR WILDLIFE

1. How can information exchange among scientists, practitioners and local communities be facilitated?
2. How do forest restoration programs benefit or disadvantage local communities?
3. Why do communities become involved in forest restorations programs?
4. Why do local communities sometimes oppose or destroy forest restoration programs?
5. What further research is required to investigate inter-actions between local communities, areas of restored forest and the wildlife they contain?

Stephen Elliott

ESTABLISHING A REGIONAL CONTACT NETWORK FOR FOREST RESTORATION FOR WILDLIFE CONSERVATION

Janice Kerby[1]

The second objective of the workshop was to consider whether to establish a regional contact network of practitioners and scientists involved in forest restoration for wildlife conservation. Janice Kerby proposed a series of issues to be addressed (listed in the appendix). These issues were initially considered in the small discussion groups, then consensus was sought from the whole assembly. The principal questions raised were as follows:

Is a network necessary?

As the workshop progressed and the interchange of ideas and experiences among participants from different countries developed, the need for more formal networking became clear. In several cases, new and constructive contacts were made between researchers working on very similar subjects, who had not previously been aware of each other. Participants identified the following reasons for establishing a network:

1. Concerns were expressed that, with the current lack of co-ordination the risk of "reinventing the wheel" and thus wasting scarce financial and human resources was high. Conversely, important areas of research may be neglected because it is assumed that someone else is already undertaking that work. Deficiencies in current systems of disseminating research results and transferring knowledge and expertise were identified as follows:

   a) The time lag between completion of research and publication of results is often considerable.
   b) Many researchers are too busy to commit the substantial time needed to prepare a paper for publication.
   c) Many journals are prohibitively expensive and consequently not accessible to researchers in developing countries.
   d) Reports or technical documents produced in the language of one country in the region will not be readable in most other countries.
   e) International workshops on relevant subjects are often expensive and if the proceedings are not published, there is no further dissemination outside the elite group of attendees.

[1] Forest Restoration Research Unit, Biology Department, Faculty of Science, Chiang Mai University, Chiang Mai, 50200, Thailand.

2. The need for a unified voice to promote forest restoration for wildlife conservation:

   a) To governments, to engender increased political support.
   b) To funding organisations, to draw attention to areas of essential research, and to ensure parity with the other forestry sectors

3. To strengthen and promote forest restoration research in the tropics, as there is currently a bias towards research on forest restoration in temperate countries.

Could existing networks serve this purpose?

The current status of existing networks was discussed, several were identified as being of interest to researchers in this field, but with the following limitations;

a) The Asia Pacific Association of Forestry Research Institutions (APAFRI), has an informal network, and a fundamental objective of its "Treelink" project (funded by CIDA) is to disseminate results, but this is currently at an early stage of development.
b) The International Union of Forestry Research Organisations (IUFRO) has an informal network and wide-ranging access to information, but it is often dominated by commercial forestry interests and there is no clear route for rapid dissemination of information relevant to this subject.
c) The International Tropical Timber Organisation (ITTO) could support this type of research and would possibly support a network, but is established to facilitate implementation of projects rather than to run them.
d) The United Nations Food and Agriculture Organisation (FAO) works extensively in general forestry issues, both with regard to policy and research. Under the aegis of FAO, the Forestry Research Support Programme for Asia and the Pacific (FORSPA) has been running a Network on Forestry Information Services in Asia-Pacific, which is intended to be subsumed by Treelink when that becomes established. This network has access to a wide range of sources but restoration for wildlife is not a priority.
e) The Forestry Research Institute of Malaysia (FRIM) and the Centre for International Forestry Research (CIFOR) are supporting some relevant work. The latter has an informal network for contacts among researchers via its web page covering all aspects of forestry.
f) The Regional Community Forestry Training Centre (RECOFTC) and the International Centre for Research in Agro-forestry (ICRAF) have existing informal networks, but restoration for wildlife is not a priority.

Thus it was concluded that in their current forms, none of the above can provide the services and support that would be needed for the type of network to which the participants aspired.

Who should be involved and how could such a network be organised?

All of the discussion groups felt that a new network should be formed and there was considerable enthusiasm for its rapid establishment. Two options were proposed initially:

Option 1 – set up the network as a sub-working group of IUFRO specifically for South East Asia, utilising the existing contacts and structure, and undertaking a more proactive role in networking and circulation of information. One of the discussion groups favoured this option.

Option 2 – benefit from existing networks such as APAFRI, FAO, CIFOR and IUFRO for information and contacts, but co-ordinate a specific network through a paid central co-ordinator based in FORRU, who could liase with voluntary representatives in the other countries. Two of the discussion groups initially expressed a preference for this option.

John Parrotta contributed a short presentation on the structure of IUFRO, which aims to promote international co-operation in forest research and related sciences. IUFRO seeks to strengthen linkages between forestry researchers and to aid in dissemination of results. The organisation is composed of 8 divisions, the principal one of relevance to this workshop being "Division 1 – Silviculture". Each division has a key contact person and runs several meetings each year. There are 681 member organisations from 106 countries. IUFRO does not have funding to directly support research costs, but contributes to relevant workshops and meetings where possible, the average number of meetings for the last 5 years has been 70. Within each of the divisions, several units or working groups pursue particular areas of research. David Lamb, the current co-ordinator for the working group on "Rehabilitation of degraded and secondary tropical forests" (1.17.03), offered to adapt the existing system to accommodate the needs of this network. The contact list derived from this workshop could form the basis of the network. It was emphasised that many people must be prepared to contribute material to make such a system actually function and that the network needs to be small and creative not large and bureaucratic. An informal ballot was taken and Option 1 was carried by majority.

How would the network function?

There was a consensus that the network should be tested for effectiveness and commitment for 1 year then reviewed and the future status decided. A first step would be to identify relevant experts in various disciplines to feed information to the central co-ordinator. Masakazu Kashio pointed out that there was a need for translation of documents, as they would not be accessible to many (particularly junior) researchers if they were circulated in English. Thus it would be necessary to have voluntary in-country representatives to help with translation and editing of documents. The central co-ordinator would need to allocate these tasks accordingly.

Steve Elliott proposed that a web-site could be linked to the existing IUFRO web page that would facilitate access to papers and the results of discussion groups and workshops. In addition Janice Kerby proposed that there should be a database of contacts, research interests and current research projects, and a means for fast dissemination of summarised research results (without compromising publication rights) such as technical notes and a newsletter. Where members do not have access to e-mail or the Internet, there would need to be in-country peripheral linkages by land-mail.

The Requirement for Funding and Local Representatives

Three views on the need for funding emerged from the discussion groups:

Option 1 – that the person is more important than money, and the co-ordination can be undertaken voluntarily, as is currently done in IUFRO.

Option 2. – that it is necessary to apply to external funding bodies for a grant for the co-ordinator post. The co-ordinator could seek funding for ongoing costs, workshops and special training events, possibly approaching ITTO, IUFRO, CIFOR, EU etc. Apichart Kaosa-Ard said that in his experience of running the Teak Network, it was necessary to have membership fees to support the costs of the administration.

Option 3 – that the co-ordinator could approach APAFRI to see if the network can be linked to the Treelink programme, which has some similar aims, and thus receive suitable funding.

There was a consensus that if David Lamb were to take on the role of co-ordinating the network through the existing IUFRO working group structure, then at this stage there may be no need to apply for funding. When the network is reviewed after one year, this will be one of the issues to reconsider.

Billy Hau expressed concern that the momentum of this workshop would be lost if no decisions were made immediately on who would be actively involved in feeding information to David Lamb. Billy then offered his services as a voluntary contact for China. Sein Maung Wint from Myanmar observed that although he was a representative of an NGO rather than Government, he could co-operate in information provision. Ulfah Siregar and Yadi Setiadi offered their help with circulating information on Indonesian forest research, and with liaison with CIFOR and IUFRO respectively.

Bharat Lal observed that there is a great diversity of ecosystems covered by the countries in the region, but in India there has been more than 25 years of forest restoration which can contribute to research in many of those ecosystems. In his role in government Bharat has access to a wide range of forest research information and will help in this way. Steve Elliott offered to feed information from FORRU into the network, and Laura Johnson offered her help in liasing with APAFRI through the Treelink Project.

Conclusion

The participants of this workshop identified the need for a regional network specifically for forest restoration for wildlife conservation. Such a network would facilitate the rapid transfer of knowledge and expertise among members and countries, and would prevent duplication of research. In addition, the combined voices of the network members could more effectively advocate the importance of this work and help in securing political and financial resources. During the 12-month trial period it would be necessary for the other questions raised in the appendix to be given due consideration.

Appendix - Considerations for Establishing a Regional Contact Network for Forest Restoration

What would be the aims and objectives of such a network?
Is a new network necessary? Are there other networks that could serve this purpose?
How would the aims and objectives be decided?
How would they be updated and amended and by whom?

Who would be involved?
Only countries in the region? Colleagues from other regions with relevant expertise?
Formal/informal network?
1 central co-ordinator or representatives from each country, who takes responsibility?
How to decide who should be the co-ordinator or representatives?

What would a regional database of contacts involve?
Contact details? Research interests? Current research projects?
Who would update this and how often? Is it the responsibility of all to do this?
Recommended references?

Sharing information?
How can research results be shared without affecting publication status?
Would members be prepared to produce interim technical notes?
Could there be a "library" of relevant papers, notes, information sheets?
How would this be managed/updated/circulated?
Links with researchers/practitioners in other regions?
Would members share information on fundraising for research?

Communicate how ?
E-mail? What proportion of members have access?
Web-page, same access considerations?
By normal mail? Meetings/workshops? Newsletter?
Whose responsibility is it to produce and update the above?

Funding of the network?
What would be necessary? Who would raise it and manage it?
How could costs be minimised? From where?

Janice Kerby

IMPLEMENTING THE AGENDA

Stephen Elliott[1], Janice Kerby[1], Visut Baimai[2] and Apichart Kaosa-ard[3]

The Chiang Mai Agenda presented in these proceedings has substantial credibility, having been drafted by discussion and agreed upon by a quorum of forest restoration scientists and practitioners in the region. The agenda proposes research on a wide range of subjects that will take many years to complete. Implementation will depend on the commitment of individual scientists and organisations throughout the region and the support of funding agencies. It is hoped that funding agencies will recognise the importance of the consensus reached at the workshop and will give high priority to activities proposed in the agenda. Researchers are therefore encouraged to quote the Chiang Mai Agenda as a reference when writing grant applications.

The agenda contains suggestions for research that could be implemented as small-scale pilot projects by individual researchers or as larger international projects. For example the research proposed on bats as seed dispersers (4.2) or isolated trees as perches (4.1) would make ideal graduate student thesis projects. In contrast, establishment of series of plots to test ANR (1.1) or plantation design (1.2), identification of framework species in different bio-regions (4.2) and the investigation of motivating factors for communities to become involved in forest restoration (5.1) would require organisation of large teams of researchers in many disciplines. Such projects would have little meaning, unless they were replicated across different environments in different countries, making international collaboration essential. An important consideration is to avoid duplication of research and this can be achieved by better communication among researchers via the network proposed in the preceding paper. Collaboration among institutions allows effective transfer of skills and knowledge and builds on the relevant strengths of organisations in different subject areas.

The workshop identified the need for small round-table planning meetings to prepare project plans to implement research proposals outlined in the agenda. When projects are replicated in different countries, co-ordination would be essential to ensure standardisation of methods used and thus comparability of results. Steering groups should be formed to both apply for funding and to manage the research. Such groups would be able to effectively allocate areas of responsibility, manage the research and identify requirements for external support.

Participants willing to help co-ordinate research in particular areas included Billy Hau for ANR (1.1) and plantation design (1.2), Arthur Wright for sustainable harvest of

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products (5.3) and Somsak Sukwong for any projects related to the development of silvicultural methods based on local knowledge.

The global Convention on Biodiversity (CBD) has helped to focus the attention of funding agencies on conservation issues. Forest restoration for wildlife conservation is covered under Article 8 of the convention on *in situ* conservation, in which signatories agree to "rehabilitate and restore degraded ecosystems and promote recovery of threatened species". The importance of involving local people in this process is emphasised in Article 10, which covers sustainable use of components of biodiversity. In that article, signatories agree to "support local populations to develop and implement remedial action in degraded areas where biodiversity has been reduced" (GLOWKA, 1994). Forest restoration is one of the most effective mechanisms to both conserve existing biodiversity and increase it. Therefore, funding agencies seeking to implement projects in accordance with the CBD should enthusiastically support forest restoration. The type of funding agency that should be approached to support any of the research projects proposed in the agenda depends on the scale of the project and the sum required. Funding agencies can be divided into 4 broad categories:

1. Private sector – companies usually fund projects to improve their public image. Small- to medium-scale projects are supported. Funding is often available rapidly. Compared with other funding options, administration requirements are usually low.
2. Large international aid agencies - the application and reporting procedures are Complicated and time consuming, but the grants are usually substantial. These grants are only suitable for very large projects or international projects with a large administrative staff.
3. Charities and Foundations - smaller grants but usually require low administration. Ideal for student thesis research. Charities and foundations often have very specific objectives and one can usually be found to fit the project being proposed.
4. Government or national agencies – several countries in Southeast Asia have a national research council or other government organisations established to implement national conservation programmes or the CBD. Administration required is usually high and international projects are usually not supported.

Contact details for some funding agencies are provided in the appendix.

Thailand's Biodiversity Research and Training Programme (BRT) provides an example of how a semi-autonomous national agency can work effectively to support biodiversity conservation, including forest restoration. Established to prepare Thailand for ratification of the CBD, the BRT programme supports small- to medium-scale projects in universities and other research establishments all over the country. Between 1996-99 BRT supported 427 projects with a total budget of 218.7 million baht. A particular feature of the programme has been strong support for student projects. The programme has prepared a new generation of young scientists to advance this crucial field of research. The most important achievement of the BRT programme has been to establish research on biodiversity in

Thailand as a legitimate and respectable area of scientific investigation. The BRT programme has encouraged more scientists to become involved in biodiversity research than ever before. The institution- and capacity-building aspects of the programme will have long-lasting benefits for Thailand's biodiversity, well beyond the program's closing date. The BRT programme has specifically supported research on forest restoration for biodiversity conservation, by funding field trials to test various new techniques of forest restoration carried out by the Forest Restoration Research Unit at Chiang Mai University. Although the programme is coming to the end of its 5-year life span, it is hoped that other similar initiatives will emerge to take its place.

Forest restoration for wildlife conservation requires long-term research funding. The success of forest restoration experiments will not be known for many years after establishing experimental plots. Funding agencies rarely commit themselves to supporting projects for longer than 3 years. Therefore, researchers who are interested in implementing proposals outlined in the Chiang Mai Agenda are encouraged to establish a portfolio of sponsors from the private sector, government sector and international agencies. Governments come and go; companies boom and bust, so gaining support from all types of sponsoring agencies is an insurance against interruption of sponsorship causing project failure.

REFERENCE

GLOWKA, L., 1994. A Guide to the Convention on Biodiversity. IUCN Gland and Cambridge, xxi+161 pp.

Appendix - some suggested funding agencies

A good source of names and addresses is the "Guide to Grants, Fellowships and Scholarships in International Forestry and Natural Resources" by Damon A. Job. Write to USDA Forest Service, P. O. Box 96090, Washington, DC 20090-6090, USA fax-(202) 273-4749, or, to obtain a copy by anonymous File Transfer Protocol, access the following home page: USDA Forest Service World Wide Web Home Page: URL=http://www.fs.fed.us/

Asia Development Bank, Education Division, PO Box 789, 1099 Manila, Philippines

The Asia Foundation, 550 Kearny St., San Fransisco, California 94108, USA

The Biodiversity Research and Training Programme, 15th Floor Gypsum Metropolian Tower, 539/2 Sri Ayuthaya Rd., Rajdhavee, Bangkok 10400 (only for research in Thailand)

The British Ecological Society, 26 Blades Court, Putney, London, SW15 2NU, U.K.; e-mail general@ecology.demon.co.uk; http://www.demon.co.uk/bes (small projects only)

The Centre for Field Research, 680 Mnt. Auburn St. PO Box 403, Watertown, MA 02172 USA (for research involving foreign volunteeers)

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IUFRO c/o Federal Forest Research Centre, Seckendorff-Gudent-Weg 8, A-1131, Vienna, Austria (iufro@forvie.ac.at)

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Thai-German Foundation, c/o PDA, Sukhumvit Rd. Soi 16, Bangkok 10110
Fellowships Division, UNESCO, 7 Place de Foutenoy, 75700 Paris, France (research in Thailand only)

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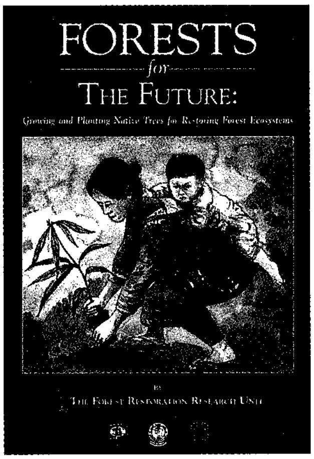
PUBLICATIONS AVAILABLE FROM THE HERBARIUM AND FOREST RESTORATION RESEARCH UNIT OF CHIANGMAI UNIVERSITY

For ordering information, please contact Dr. Vilaiwan Anusarnsunthorn or Dr. Stephen Elliott, Biology Department, Science Faculty, Chiang Mai University, Thailand 50200. Fax +66 (0)53 892259; e-mail scopplrn@chiangmai.ac.th.



Forests for the Future: Growing and Planting Native Trees for Restoring Forest Ecosytems

All over Thailand, people who are concerned about the rapid destruction of Kingdom's once magnificent forest are banding together to plant trees. Nowadays, with ecological awareness on the increase, there is growing interest in re-establishing natural forests for watershed protection and wildlife conservation. Unfortunately the recent surge in public enthusiasm for planting native forest trees, has not been supported with sound technical advice. Seedlings planted are often of poor quality, or are of inappropriate species and care for them after planting is often insufficient. This book, based on the work of the Forest Restoration Research Unit (a joint initiative between Chiang Mai University and Doi Suthep-Pui National Park) since 1994, offers a basic introduction to growing and planting native trees to restore natural forest ecosystems. It provides practical advice on which tree species to plant; how to grow them in a nursery and how to organize and monitor a tree-planting event. If you are already involved in reforestation activities or if you are thinking of starting a new tree-planting group, this book will be of interest to you. 60 pages A4, richly illustrated with line drawings and full colour plates. Available in English or Thai.

Tree Seeds and Seedlings for Restoring Forests in Northern Thailand

An essential part of any tree-planting project is recognition of the tree species being planted. However, identifying tree seedlings is difficult, because they have different characteristics to those of adult trees. Based on a research programme, carried out by the Forest Restoration Research Unit (a joint initiative between Chiang Mai University and Doi Suthep-Pui National Park), this book provides essential information about 45 native forest tree species, known to be useful in forest restoration projects. Detailed descriptions of fruits, seeds and seedlings, a key to aid seedling identification and tips on propagation and planting are presented in this handy book for use in the nursery or in the field. Line drawings, full colour illustrations and an extensive glossary of technical terms complement the text. 151 pages (18 full colour), 14 x 21 cm. This book comes with a large, full colour poster of a nursery production schedule. Available in English or Thai.

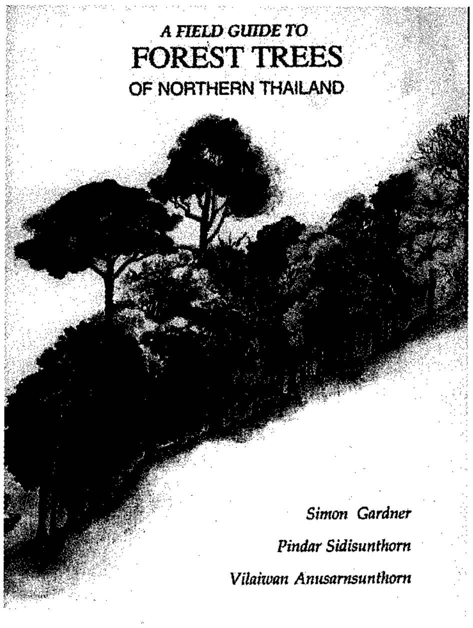
FORRU Newsletter

Keep up to date with the latest research results and educational activities of the Forest Restoration Research Unit by adding your name to the circulation list of FORRU's Newsletter, distributed 3 times per year.

A Field Guide to Forest Trees of Northern Thailand
By Simon Gardner, Pindar Sidisunthorn and Vilaiwan Anusarnsunthorn

- 430 species in detail, plus notes on further 450 species
- covering over 75% of the total native tree flora
- fully illustrated with over 1600 photos and 330 drawings
- non-technical language
- identification keys for all major families and genera
- comparison tables for difficult groups
- habitat & flowering/fruiting times
- local names and uses
- distribution in neighbouring countries
- synonyms and cross-references in regional floras

Available in Thai or English



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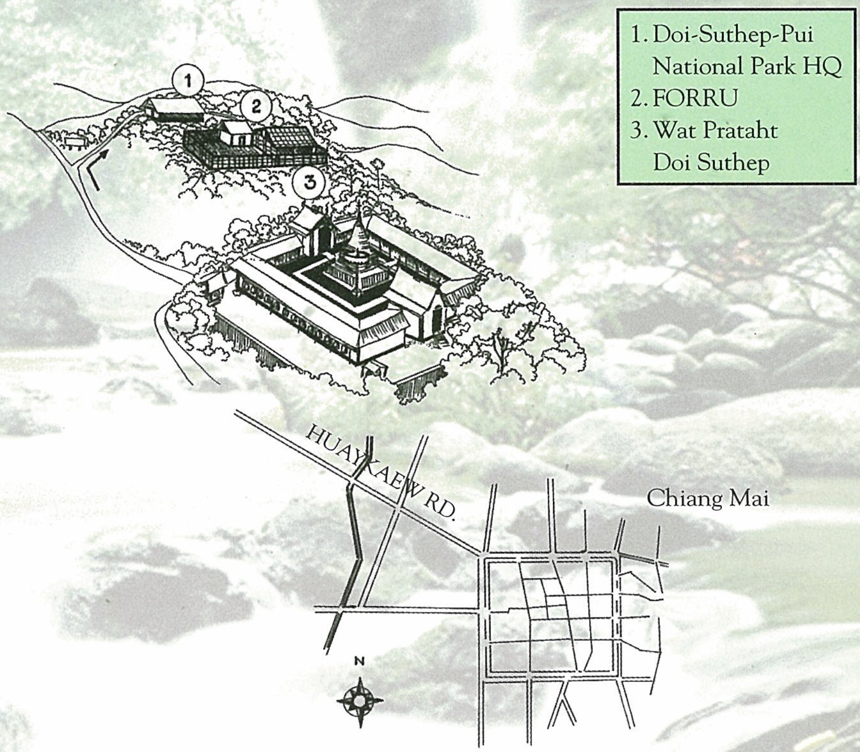

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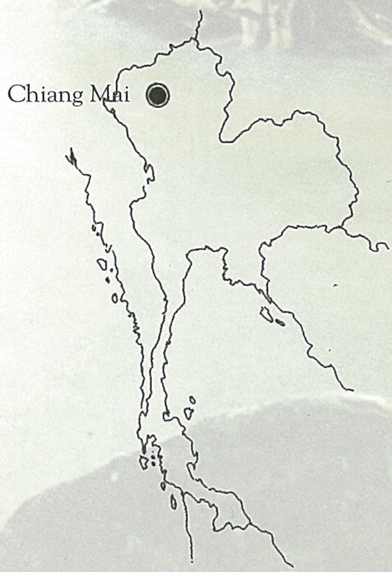

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This book presents the proceedings of 'A Scientific and Technical Workshop on Forest Restoration for Wildlife Conservation', held in Chiang Mai, Thailand, 30th January-4th February 2000, organised by the Forest Restoration Research Unit of Chiang Mai University and sponsored by the International Tropical Timber Organisation. The volume includes 28 peer-reviewed papers, summarising the status of forest restoration in the region and covering a wide range of technical subjects from seed collection to silviculture, as well as social issues. A fascinating array of projects is presented from restoring forests for Asiatic Lions in India to planting wildlife corridors in Australia. A wide range of examples of innovative techniques and best practice are included, which will be of interest to both scientists and practitioners of forest restoration. The workshop culminated in the production of the Chiang Mai Research Agenda to Restore Degraded Forestland for Wildlife Conservation in Southeast Asia, which will help forest researchers, policymakers and funding agencies focus on the most important areas requiring further study.

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